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The International Palm Society

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57

An Informal Check on the Health of the Endangered Palms of Fiji

M. LOCK, M. LOCK & D. WATLING

83

***Cocos nucifera* var. *palmyrensis*, a Unique Native Coconut from Palmyra Atoll**

M.P. GRIFFITH, F. STAUFFER, K. McLAUGHLIN, J. GERRISH & R. BALDINI

Features

Palm News	56, 102
Palm Profile	82
Patrons of the IPS	103

**FRONT COVER**

Cocos nucifera var. *palmyrensis*, a poorly known endemic palm of Palmyra Atoll. See article by M.P. Griffith et al., p.83. Photo by M.P. Griffith.

BACK COVER

The formal, almost regal, crown of *Hydriastele vitiensis* rises above the forest on Viti Levu, Fiji. See article by M. Lock et al., p. 57. Photo by M. Lock.



Pratichardia thurstonii grows in the most improbable places on limestone islets in the Lau Islands of Fiji. See article by M. Lock, p. 82. Photo by M. Lock.

PALM NEWS



Scott Zona

Just as the last issue went to press, we were saddened to learn of **the unexpected passing of Emory “Don” Evans**, a long-time member of the IPS and former member of the Board of Directors. After a stint in the Army, Don joined the horticulture team at Fairchild Tropical [Botanic] Garden in 1970. A few years later, upon the retirement of Stanley Keim, Don became the superintendent and oversaw the care and growth of the Garden. Don planted or supervised the planting of most of the mature palms (and other plants) that grace the Garden today. Don managed the horticultural recovery of Fairchild after the devastation of Hurricane Andrew in 1992 and retired from the garden in 2004, after a remarkable and eventful 34 years. As reported by *The Miami Herald*, Don was “a lover of rare plants and good dogs” and his garden in Homestead, the rural community just south of Miami, was like Fairchild Garden in miniature—with dogs. Don was a friend to the entire plant-loving community in South Florida. All of us, from the orchid fanatics to the aroid aficionados and the palm nuts, will miss him.

Salacca vermicularis, an understory palm endemic to Borneo, was the subject of a recent study by WS Ng and SY Wong, who examined its reproductive biology, i.e., its **pollination and seed dispersal ecology**. They found that pollination is necessary for seed production, that the palm attracts a variety of insect visitors but that weevils and flies were the most likely pollinators. Seed dispersal is brought about by mousedeer, ground squirrels and porcupines, which eat the fruits and scatter the seeds. The study, with fantastic close-up photos of the palm’s red flowers, is open-access and available here: Ng, WS & Wong, SY. Floral biology and pollination mechanism of *Salacca vermicularis* Becc. (Arecaceae: Calameae). 2025. *Journal of Tropical Forest Science* 37: 36–48. <https://jtfs.frim.gov.my/jtfs/article/view/3076>.



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Dr. Andrew Henderson has produced **an extensive new monograph of the SE Asian genus *Iguanura***. His treatment recognizes 31 species, of which nine are newly described. *Iguanura* species are understory, pinnate-leaved palms with spectacular foliage (many have undivided leaves). The monograph is well illustrated with photos of living plants and herbarium specimens and will surely become the standard taxonomic reference for the genus. The citation is: Henderson, A. 2025. A revision of *Iguanura* (Arecaceae, Arecoideae, Areceae). *Phytotaxa* 690: 135–188.

Continued, p. 102

An Informal Check on the Health of the Endangered Palms of Fiji

MICHAEL LOCK¹, MARY LOCK¹ AND DICK WATLING²

The island nation of Fiji is home to at least 23 endemic palm species, 13 of which are categorized as Vulnerable (n=3), Endangered (n=5) or Critically Endangered (n=5) in the IUCN Red List of Threatened Species (Watling 2005, IUCN 2024). The distributions of all of Fiji's palm species were last assessed systematically by Watling (2005) and Fuller (1997), and in 2008 Hodel (2011) managed to track down and visit all but one of the palm species native to Fiji. In September and October of 2024, two of us (the Locks) set out to see which palm species could still be found in habitat on two of the three largest islands in Fiji and to assess how their populations had fared over the 16 years since Hodel's visit. We also compared what we saw on the ground with the latest conservation assessments for Fijian palms in the IUCN Red List.

The Fiji archipelago comprises more than 300 islands nestled in the southwest corner of the Polynesia-Micronesia biodiversity hotspot, a region characterized by its high concentration of endemic plant species (Myers et al. 2000). The largest and most populous Fijian island is Viti Levu with an area of 10,531 km², almost

the same size as the island of Hawaii, i.e., the Big Island. The island's size, varied terrain, and different climate zones accommodate eight species – *Balaka diffusa*, *B. longirostris*, *B. microcarpa*, *Cyphosperma naboutinense*, *C. tanga*, *Heterospathe phillipsii*, *Metroxylon vitiense* and *Neoveitchia storckii* – that are endemic or nearly endemic to the island (Fig. 1). All but one of these, *B. longirostris*, are assessed by the IUCN as Endangered or Critically Endangered (Table 1). Thus, we decided to concentrate first on finding the rare palms of Viti Levu.

Our first target species on Viti Levu was *Balaka diffusa*, the most recently described species in the genus (Hodel 2010). It is a slender, elegant palm with a crown of 4 or 5 arching leaves

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1. Map of eastern Viti Levu showing locations of palm populations visited by the authors. Also shown are villages, roads, streams and protected areas mentioned in the text.

each with broad, stiff, sparsely spaced leaflets (Fig. 2). The rachillae of the inflorescence spread from below the crown in a diffuse whorl, lending the species its epithet (Fig. 3). Hodel described *B. diffusa* primarily as an understory palm, but it is occasionally emergent. We saw more than a dozen individuals rising above lower points in the forest canopy during three separate trips to its known range along the road from Nabukavesi

to Namosi in southern Viti Levu. As we traveled inland, plants first began to appear at 9 km from the Queen's Road and could be seen sporadically for a distance of about 9 km along the road until it reached its highest point before descending into the pastoral valley around the village of Namosi. The species was never abundant anywhere along this stretch, but we saw one cluster of a half a dozen mature trees within an area the size of

Table 1. Current (2024) IUCN assessment of all indigenous palm species of Fiji.

Scientific Name	IUCN Red List Category	Occurrence (Islands in Fiji)
<i>Balaka diffusa</i>	Critically Endangered	Viti Levu
<i>Balaka longirostris</i>	Least Concern	Viti Levu
<i>Balaka macrocarpa</i>	Endangered	Vanua Levu
<i>Balaka microcarpa</i>	Critically Endangered	Viti Levu
<i>Balaka seemannii</i>	Least Concern	Taveuni, Vanua Levu
<i>Balaka streptostachys</i>	Critically Endangered	Vanua Levu
<i>Calamus vitiensis</i>	Unassessed	Viti Levu, Taveuni
<i>Clinostigma exorrhizum</i>	Least Concern	Viti Levu, Taveuni, Vanua Levu, Gau
<i>Cyphosperma naboutinense</i>	Critically Endangered	Viti Levu
<i>Cyphosperma tanga</i>	Critically Endangered	Viti Levu
<i>Cyphosperma trichospadix</i>	Vulnerable	Taveuni, Vanua Levu
<i>Heterospathe longipes</i>	Endangered	Taveuni, Vanua Levu
<i>Heterospathe phillipsii</i>	Endangered	Viti Levu
<i>Hydriastele boumae</i>	Least Concern	Taveuni
<i>Hydriastele vitiensis</i>	Vulnerable	Viti Levu, Vanua Levu
<i>Metroxylon vitiense</i>	Endangered	Viti Levu, Ovalau
<i>Neoveitchia storckii</i>	Endangered	Viti Levu
<i>Physokentia petiolata</i>	Near Threatened	Viti Levu, Gau
<i>Physokentia thurstonii</i>	Near Threatened	Taveuni, Vanua Levu
<i>Pritchardia thurstonii</i>	Vulnerable	Islets on Vanuabalavu, Fulaga, Ogea
<i>Veitchia filifera</i>	Least Concern	Taveuni, Vanua Levu
<i>Veitchia joannis</i>	Least Concern	Widespread across Fiji
<i>Veitchia simulans</i>	Data Deficient	Taveuni
<i>Veitchia vitiensis</i>	Least Concern	Viti Levu, Ovalau, Beqa, Kadavu

a football field. A drone flight up Wainikovu Creek, one of the larger streams in the area, revealed no other emergent trees.

Hodel noted that the pinnae of *B. diffusa* in habitat were often heavily damaged or skeletonized by an unidentified insect. We noticed this type of damage on smaller understory plants, especially on older leaves. Leaflets of emergent trees looked healthy and generally unscathed. Mature trees typically held multiple inflorescences with flowers or fruit in bud, but mature fruits were rare and those seen were old and likely nonviable. The masked shining parrot, *Prosopeia personata*, is common in the area and may be acting as a major predator on the seeds of the palm, eating the fruits and destroying the seeds before they reach full maturity (Watling 2005). Seed predation could help explain the lackluster regeneration we observed.

Balaka diffusa currently has an IUCN extinction risk designation of Critically

Endangered. This seems completely appropriate if for no other reason than the species had the same designation when, prior to the most recent revision of the genus, it was still considered as a disjunct subpopulation of *B. macrocarpa*. The total population of *B. diffusa* was estimated at about 200 individuals in 1996 (Fuller 1997) and its habitat enjoys no official protected status. Although we saw no active logging in the area, there was abundant evidence of cattle grazing throughout the habitat. Some small farms had also been recently established. These more informal land use practices have clearly been facilitated by maintenance and improvements to the Nabukavesi–Namosi Road allowing residents of the lowlands to make their way more readily into the mountains to tend cattle or small farms.

Finding *Cyphosperma naboutinense* proved significantly more challenging due to its small range of only 6 square kilometers and a



2. A single *Balaka diffusa*, likely still a young adult tree, emerges from the brush along the road from Nabukavesi to Namosi.

correspondingly small population estimated to contain only 50 mature plants (Watling 2005). Its known range exists entirely within

a mahogany plantation managed by the government-owned Fiji Hardwood Corporation Ltd (FHCL) and we found three



3. The rachillae of *Balaka diffusa* spread from below the crown in a diffuse whorl.

mature plants by following rough logging roads through the plantation inland and uphill from the village of Naboutini (Fig. 4). All three were growing within 10 m of a stream in a



4. Two *Cyphosperma naboutinense* palms, one in front of the other, grow in a small fragment of riverine forest within an actively logged mahogany plantation.

fragment of forest that apparently had not been planted or logged. As we snapped a couple of quick pictures, a manager of a log-hauling company stopped his pickup truck to explain enthusiastically that he knew that the palm was special and that many other specimens could be found along the stream. After an hour's reconnaissance we realized that we would be unable to verify this claim with our own eyes mostly due to the lack of a sharp machete and sufficient time.

The mahogany plantation encompassing the few individuals of *C. naboutinense* that we saw was being actively logged during our visit. The area was laced with rough roads, some of which had been either built or widened quite recently. In some places, the width of the road and the debris, including uprooted trees still holding green leaves, measured more than 50 m across. Intensive harvesting of large mahogany trees was occurring within a half a kilometer of the trees we saw and the fragment of forest that contained the putative population of others. Based on its small population and limited range, *C. naboutinense* clearly warrants its current IUCN assessment of Critically Endangered. The proximity of machine-intensive, large-scale logging currently underway adds even greater risk suggesting a precarious future for this species in habitat.

Another species with a restricted range in southern Viti Levu is *Balaka microcarpa*. Like *B. diffusa*, *B. microcarpa* is a slender understory palm with relatively few, broad, widely spaced pinnae (Fig. 5). The leaves have no petiole or only a short one, and the pinnae of emergent trees are often held stiffly at a 45-degree ascending angle from the rachis, giving the plant an odd, formal profile more like a giant ginger than a palm (Fig. 6). The plant has a smooth crownshaft and a very thin stem not exceeding 8 cm (Hodel 2010).

B. microcarpa is readily seen at its most visited location, the Colo-i-Suva Forest Reserve, about a half-hour drive from the center of Suva, the capital and largest city of Fiji. We also located a few trees in pockets of rainforest several kilometers to the west of the reserve. Although we saw trees of all ages, only a few held inflorescences and only one bore mature fruit. This could be simply a seasonal phenomenon or perhaps a consequence of slow growth since *B. microcarpa* has been estimated to begin flowering at 40 years of age (Ash 1988).

The abundance of *B. microcarpa* within a forest reserve may imply an overly optimistic view



5. A young *Balaka microcarpa* in the dense understory of the rainforest, Colo-i-Suva Forest Reserve.

of its conservation status since the Colo-i-Suva Forest Reserve is actually a mahogany plantation. It was established in 1952 when about 4 km² of previously logged and cleared land was set aside to be replanted with mahogany (Fiji Ministry of Forestry 2020). There have been no mahogany harvests since then allowing a rich, diverse understory to develop, replete with both native and non-native plants. About a quarter of the reserve is managed as a recreation area with many walking paths, natural pools and waterfalls, popular with both tourists and local residents. Perhaps this recreational use will provide additional incentive for forest managers to maintain the forest at this site. Still, only a quarter of the reserve is devoted to recreation and there is no guarantee against future logging especially in the non-recreational portions of the reserve.

Somewhat to our surprise, the most common understory palm seen in the reserve was not the native *Balaka*, but an invasive non-native species, *Pinanga coronata*, which was likely introduced to Fiji as an ornamental garden plant (Watling 2005). A team of researchers has been studying the effects of *P. coronata* on



6. A fruiting specimen of *Balaka microcarpa* in the Colo-i-Suva Forest Reserve holds its leaflets at a sharp angle to the leaf rachis.



7 (left). A healthy *Neoveitchia storckii* fights its way to the sun through vines within the Waidina River drainage. 8 (right). Vili Masibalavu inspects recent damage to a specimen of *Neoveitchia storckii* along the roadside in the Waidina River valley.

the ecosystem of Colo-i-Suva since 2014 and has provided evidence that an increase in the density of *P. coronata* correlates with a decrease in the richness of other species (Forey et al. 2023). We could see this effect quite clearly in forest areas outside and to the west of the reserve where dense stands of *P. coronata* completely dominated small pockets of forest of about 25 m² in area. The impact of *P. coronata* is felt most acutely by native plants in the herb and shrub layers of the forest, and thus, could have a more pronounced effect on the regeneration of a slow-growing palm like *B. microcarpa*. As yet there has been no formal governmental effort to control or slow the spread of *P. coronata*.

Given its miniscule range of only about 10 km², its slow growth and regeneration, the threat of future logging and development, the impacts of invasive species and the lack of effort to mitigate those impacts, *B. microcarpa* clearly warrants its current status of Critically Endangered.

One candidate for the most impressive of the rare palms of southern Viti Levu must be

Neoveitchia storckii, a robust tree that reaches 12 m or higher (Watling 2005). It sports a crown of 12 to 15 leaves up to 5 m long each with tightly spaced pinnae. The glossy dark crownshaft, which ranges from mocha to almost black, contrasts strikingly with its light-colored inflorescence and red fruit, and is one of the main reasons that the palm has become popular with growers and collectors in tropical climes.

Unlike most other Endangered palms of Viti Levu, *N. storckii* can be found in several disjunct pockets, relics of a once more continuous forest, mostly in proximity to the Rewa River in the southeast corner of the island. Given that Hodel had surveyed the Rewa River area in 2008, we decided to explore areas to the west where the species had been recorded previously along the Waidina River drainage. We were accompanied on this and an earlier visit by Vilikesa Masibalavu – Vili, for short – Fiji's most prominent field ornithologist and a native of the region. Within 15 km of Naqali we located two mature trees near roads and several juvenile specimens



9. A small cluster of *Metroxylon vitiense* in fresh water at 160 m in elevation. A spent palm that has already flowered and died can be seen at right.



10. A small, isolated stand of *Metroxylon vitiense* grows in low swampy land amid typical coastal shrubs.

within nearby forest. While one tree was robust and healthy, the second had clearly been seriously damaged and nearly uprooted by recent groundwork (Figs. 7 & 8).

The damaged palm hit close to home literally for Vili: the tree was within a few kilometers of his home village. Vili had been exploring with us primarily to improve his skills in locating and identifying the rare palms in the region. He has worked extensively with biological survey teams and has trained guides and villagers throughout the southwest Pacific on bird identification and conservation. He was eager to add endemic palms to his naturalist toolkit and was already making plans to include *N. storckii* in his next training session with villagers in the area.

In addition to habitat loss and degradation, *N. storckii* is apparently susceptible to coconut rhinoceros beetle (CRB, *Oryctes rhinoceros*). One of us (DW) witnessed CRB repeatedly attacking and eventually killing a 12 m high specimen of *N. storckii* in his garden in Suva. It is likely that CRB had a considerable impact on *N. storckii* in the wild in the past. A survey between November 1972 and January 1973

uncovered only a single population of no more than 200 mature trees, with severe CRB damage apparent on two individuals (Gorman & Siwatibau 1975). Release of a biological agent, the *Oryctes rhinoceros* nudivirus, in Viti Levu in the early 1970s led to a marked decrease in damage to coconut palms that persisted for at least 35 years (Bedford 2013). The virus may have also saved *N. storckii* in the wild. However, a new outbreak of CRB was detected in Guam in 2007 and has since spread with damaging results to other Pacific islands including Papua New Guinea, the Solomon Islands and the Hawaiian Islands (Marshall et al. 2017). DNA sequencing revealed that a previously unknown biotype of the beetle, known as CRB-G, is responsible for the new outbreak, and unfortunately for rare palms, CRB-G has been shown to be tolerant of *Oryctes rhinoceros* nudivirus. This could be a new, or more accurately, recurring threat to *N. storckii*.

One potential ray of hope for the future of *N. storckii* is that its known range is quite close – only a handful of kilometers – to the Sovi Basin, the largest tract of uninhabited and undisturbed lowland (100–600 m elevation) tropical rainforest in Fiji (Keppel et al. 2012a).



11 (left). A coconut palm is smothered under a blanket of *Decalobanthus peltatus* on the island of Taveuni. 12 (right) *Hydiastele vitiensis* with inflorescence on the edge of a forest cut in southern Viti Levu.

Some 163 km² of the basin, about 1.5% of the entire land area of Viti Levu, are protected for conservation purposes while still allowing surrounding villagers access for traditional harvesting, hunting and fishing. Crucially, the protected area is secured by a 99-year lease and multimillion-dollar endowment that provides income to traditional owners to offset revenue that could be generated by logging concessions. The size and environmental diversity of the basin would seem to afford suitable habitat for *N. storckii*, but neither of two botanical surveys, one wholly within the protected area and a second on the periphery of the basin, reported finding the species (Keppel et al. 2011, Tuiwawa et al. 2021). A more specific search might turn up evidence for extending the current range of this Endangered species or the basin could afford an out-planting site more distant from commercial coconut plantations and potential CRB infestations.

The second contender for most impressive, Endangered palm in Viti Levu is *Metroxylon vitiense*, which can reach 15 m in height. Like most other species in the genus, *M. vitiense* is

hapaxanthic; that is, the tree produces no fruit or flowers until it nears the end of its lifespan when it sends up a large compound inflorescence from its crown. After fruiting the tree dies (Fig. 9). Once abundant along the coast and river deltas of Viti Levu, the range of *M. vitiense* has dwindled to only about 15 small, isolated populations due principally to land drainage for residential and agricultural development, growth in the non-traditional consumption of palm heart, and thatch harvesting for the tourist industry (Morrison et al. 2012).

Led by NatureFiji-MareqetiViti, a Fijian conservation organization, a species recovery plan for *M. vitiense* has been developed and endorsed by both community stakeholders and the Fiji government (Watling 2018). The plan included alerting hotel executives that the roof thatching and periodic re-thatching that gave their resorts an authentic South Seas appearance relied on unsustainable harvesting of the Endangered palm. Another interesting aspect of the plan was the introduction of the seeds of the peach palm, *Bactris gasipaes*, to provide a more sustainable alternative to wild-



13. *Cyphosperma tanga* looks a bit like a *Johannesteijsmannia* palm perched on top of a pole.



14. The impressive crown of a mature *Cyphosperma tanga* on the middle slopes of Mt Tomaniivi near the village of Navai.

collected *M. vitiense* for the palm heart trade. There have now been several successful harvests of palm heart following this initiative.

We did not explicitly set out to find populations of *M. vitiense* but stumbled upon small groups of trees along the island's southern coast and at a couple of locations within 5 kms of the coast. Figure 10 shows a small, isolated stand of regenerating trees growing in low swampy land amid typical coastal shrubs such as *Hibiscus tiliaceus*. Any young trees growing along the coast or in lowland elevations exposed to direct sunlight would need to fight through a virtual carpet of aggressive vines such as *Decalobanthus peltatus* and *Mikania micrantha* to survive. These vines could easily smother young individuals of *M. vitiense* or even coconuts (Fig. 11). One final insult: even with the availability of palm heart from *B. gasipaes*, we very occasionally spotted the heart of an *M. vitiense* palm – unmistakable by its girth – in roadside fruit stands.

A third impressive palm on Viti Levu is *Hydriastele vitiensis*, which can reach up to 15 m in height (Essig 1982). It bears stiff, recurved leaves, a light brown crownshaft, and

inflorescence shaped like a horsetail (Fig 12). Hodel described *H. vitiensis* as “abundant, conspicuous, and relatively easy to access” and he encountered “vast stands” of the palm on the road inland from the town of Galoa on the southern coast (Hodel 2011). On the same road 16 years later, the palm was still conspicuous, but we did not find it to be abundant. We also spotted the palm some 19 km to the west on the road inland from Naboutini. The relatively scattered and sparse occurrence of specimens made it difficult to assess the health of the species, but its apparent decrease in abundance since 2008 supports IUCN's classification of Vulnerable.

Having explored southern Viti Levu for as long as our schedule could be stretched, we set off on a quest to the north to get a firsthand look at *Cyphosperma tanga*, surely one of the most stunning palms of Fiji. Its appeal stems mostly from its crown of flat, 3 m-long leaves, that remain entire or mostly entire until well into adulthood. Adding to the wow factor, the newest leaves on the palm extend skyward nearly vertically from the crown giving the impression of a *Johannesteijsmannia* perched on top of a thin power pole (Fig. 13).



15. *Cyphosperma trichospadix*, with a gracefully curving trunk, in rainforest at an elevation of 1000 m on Des Voeux Peak on Taveuni.

Following the example of Bacon (2011), we decided to spend a couple of days in a homestay in Navai village on the western slopes of Mt Tomaniivi, also called Mt Victoria and the tallest peak in Fiji. A steady trickle of visitors finds its way to Navai, most of them intending to hike to the top of Mt Tomaniivi following the trail that leaves directly from the village. While the hike is justifiably famous for its excellent birding, as well as the possibility of a stunning view from the top, fewer tourists are aware that its higher reaches are also home to Fiji endemic palms such as *Physokentia petiolata*, *Balaka longirostris* and *Clinostigma exorrhizum* (Bacon 2011).

We were fortunate to have a little extra time in Navai since the guide with the best handle on the whereabouts of *C. tanga* was unavailable. His stand-in, Naseu, had boundless energy and a sharp machete, but had never seen the palm before and had only second-hand, approximate directions about where to look for it. We drove north from the village on a disused logging road until it became unpassable even for our 4-wheel drive truck. From there, *C. tanga* can be found within a half hour of fairly easy hiking, but none of us

knew that at the time. Instead, we thrashed up and down the mountainside while Naseu worked to reconcile the fuzzy directions he had been given with the reality of dense forest, steep slopes and thick brambles. We spotted our first *C. tanga* – an immature plant posed neatly on a stream bank – after about 90 minutes of searching. Naseu himself then found a small grove of at least a dozen trees of all ages, including adults with maturing fruit, nearby (Fig.14). Our guide seemed at least as elated as we were to have found the trees.

In fieldwork during 1965 that led to the naming of the species (as *Taveunia tanga*), Moore (1966) described its distribution as “fairly abundant among rocks in forest.” Unfortunately, logging later destroyed one of the only two known populations of the palm and a 1995 survey estimated that there were only 300 to 400 *C. tanga* adult trees still surviving in the area (Fuller 1997). Although two reserves – the Tomaniivi Nature Reserve and the Wabu Forest Reserve – are nearby, the range of *C. tanga* is outside their boundaries. A second population of *C. tanga* was found about 40 km to the south during surveys conducted in 2011 and 2012 (Tuiwawa et al. 2013). This population occurs outside the bounds of any protected area in upland rainforest in the catchment of Waikarakarawa creek. *C. tanga* is classified by IUCN as Critically Endangered.

Naseu recounted a piece of village lore about how *C. tanga* grew only in the place near Navai where village chiefs had once buried a sperm whale's tooth. This legend is related in more detail in Watling (2005) and was also reported with additional details in Bacon (2011). Our host at our homestay in Navai also knew the story well. It seems that the story is firmly entrenched in village lore, but the exact location of the trees may be fading as post-logging forest growth has obscured roads and paths that once made access more straightforward. We encouraged Naseu to improve and maintain the path he had blazed to the small grove of trees we visited since other tourists, birders or hikers may be interested in seeing such a singular and rare tree. Given the cultural significance of *C. tanga* to nearby villages, and the lack of an officially protected habitat, the best hope for preserving the species may lie with the actions and decisions of the local community.

Time constraints and airline itineraries forced us to shift ourselves and our focus to the island



16. *Cyphosperma trichospadix*, with flowers and ripening fruit, along the trail from Somosomo.



17. *Clinostigma exorrhizum*, a majestic palm found at higher elevations on Des Voeux Peak.

of Taveuni, about an hour's flight by Twin Otter turboprop from Viti Levu's main international airport in Nadi. Taveuni bills itself as Fiji's garden isle and statistics back up its claim. In particular, about 75% of the island is covered with forest of which 2/3 is considered undegraded rainforest with a contiguous canopy (SPREP 2020). About 34% of the island is conserved in two protected areas: the Taveuni Forest Reserve and the Ravilevu Nature Reserve. The Bouma National Heritage Park, a community-managed area described in more detail below, covers another 9% of the island. Taveuni also has a reputation as one of the wettest places in Fiji with precipitation increasing greatly and rapidly with elevation. A weather station at the summit of Des Voeux Peak, the second highest summit on Taveuni at 1195 m, averages almost 10 m of rainfall with no major seasonal trends (Ash 1987).

Although it's the third largest island in the Fiji archipelago, Tavenuni is still relatively small; Viti Levu is about 25 times bigger. However, the island punches above its weight when it comes to palm diversity. It is home to two island endemics (*Hydriastele boumae*, *Veitchia simulans*); four species in common with neighboring Vanua Levu island (*Balaka seemannii*, *Cyphosperma trichospadix*, *Heterospathe longipes*, *Physokentia thurstonii*); and four other species more wide-spread throughout Fiji.

Our first encounter with one of Taveuni's rarest palms was with a single, elegant specimen of *C. trichospadix*. We had started the day admiring majestic *Clinostigma exorrhizum* palms at the higher elevations of Des Voeux Peak, but driving rain and punishing wind pushed us back down the mountain toward Wairiki. Retreating into the forest along a path often used by birders, we spotted the solitary *C. trichospadix* 360 m southeast from the road at about 1000 m elevation. The palm resembled nothing so much as a miniature coconut complete with a long, thin stem that paralleled the ground for most of its length before gracefully curving upward to hold the crown (Fig. 15). Like its larger sibling, *C. naboutinense*, it had no true crownshaft but each older leaf clasped the entire base of the next younger leaf, like Russian nesting dolls. We didn't have enough time to explore this area but suspect that a larger population was lurking in the surrounding forest.

We met *C. trichospadix* again, this time in a small but vibrant population, about 5 km to

the northwest along the trail from Somosomo to Lake Tagimaucia, the track that Hodel described as "a classical and fabled locale with a rich assemblage of palms" (Fig. 16) (Hodel 2011). We found this description apt as we saw more palm species on this route than on any other in Fiji including *Calamus vitiensis* at lower elevations, *Clinostigma exorrhizum* at middle and higher elevations (Figs. 17, 18), and *B. seemannii* and *Veitchia simulans* (Fig. 19) scattered everywhere through the forest. The trail, though, is a rough one and can be slippery and treacherous especially in the rain.

These were the only two locations where we saw *C. trichospadix* on Taveuni. Given its scarcity and small range on the island, it is a bit surprising to see that it is not considered Endangered but merely Vulnerable. Presumably this is because the species also occurs on the larger landmass of nearby Vanua Levu. Another mitigating factor is that the population on Taveuni grows entirely within a nominally protected area, the Taveuni Forest Reserve. We saw evidence of small agricultural operations creeping up the mountainside toward the reserve, but none had reached within a kilometer of the palms we saw. So perhaps there is some security for the species overall. However, the population of *C. trichospadix* on Taveuni island should be considered at high risk of local extinction if for no other reason than its small range.

We found *C. trichospadix* only on the west side of Taveuni although it seems likely that the species occupies similar habitat on the east side of the island. Strangely, we encountered another rare species, *Heterospathe longipes*, originally described as *Alsmithia longipes*, in similar habitat, only on the eastern side of the island. The east side of Taveuni faces the prevailing trade winds and is reputed to be even wetter than the west side where we were drenched for several days on end. Remarkably, we found this to be true, at least at the first site where we located *H. longipes* at Navuga, a now-abandoned village 3 km inland from Vidawa near the coast. The first specimen we spotted was immature and trunkless, but its brilliant, new red leaf announced its presence unmistakably even through a steady downpour (Fig. 20). A few adult trees were nearby but none had fruit or flowers.

Navuga and Vidawa are both part of the Bouma National Heritage Park, which is actively managed for ecotourism and conservation by local communities. The most



18. *Clinostigma exorrhizum* often forms gregarious clusters in high-elevation rainforest on Taveuni.



19. *Veitchia simulans* an elegant, mid-size palm in high elevation (660 m) forest on Taveuni.

popular tourist attraction in the park is the Tavoro Waterfalls, a series of three dramatic waterfalls each with a swimmable, natural pool at its base. The local community has built and maintains an excellent path that visitors can use to reach each of the falls, and, as it turns

out, get a good look at *H. longipes*. We found many of these palms of varying ages, including some flowering and fruiting, right along the trail just above the second waterfall at an elevation of about 150 m. The tallest had 5 m of clear trunk, pinnate leaves with long



20. A young *Heterospathe longipes* showing off a red new leaf near the abandoned village of Navuga in the Bouma National Heritage Park, Taveuni.

petioles, and a very robust inflorescence with mauve-colored branches (Fig. 21).

Heterospathe longipes and *C. trichospadix* are currently known to occur only within a small



21. A mature *Heterospathe longipes* displaying its massive inflorescence with robust, plum-colored rachillae.

area of protected forest and both species are also present on nearby Vanua Levu. The current IUCN classifications for the two species differ somewhat: Endangered for *H. longipes* and Vulnerable for *C. trichospadix*. While the *H. longipes* populations we saw were regenerating, its narrow known range still warrants its Endangered status.

Discussion

We were heartened that we could still find populations of nearly all of the rare palm species that Hodel had seen on Viti Levu and Tavenuni 16 years ago. The one exception was *Heterospathe phillipsii*, which we opted to skip due to delays in obtaining permission to explore its narrow range in southern Viti Levu. It is also encouraging that three of these species – *B. microcarpa*, *H. longipes* and *C. trichospadix* – can be found in protected areas. However, most of these areas, and most protected areas in Fiji, were not developed to conserve biodiversity. Some of Fiji's protected areas have questionable legal status and typically do not have species management plans (Myron & Ahmed 2019). Political pressure has led to the de-reservation of some protected areas and the legal underpinnings of nature reserves are not considered acceptable by the government agency representing native landowners (O'Brien et al. 2021). Or to put it succinctly, Fiji's protected area system is weak on paper and far weaker in reality.

Consider the Bouma National Heritage Park on Taveuni, home to populations of *H. longipes* and *C. trichospadix*. Indigenous communities, with help from the Fijian government and the New Zealand Overseas Development Agency, created the park to protect their traditional forest lands and generate sustainable income for villagers (Vukikomoala et al. 2012). However, the term “national heritage park” has no legal status in Fiji leaving many open questions about the limits and strength of protection for forestry assets. For example, a private company is currently planning a hydroelectric project within the park boundaries. The company's managing director stated that the clan owning the proposed power plant area has already signed a development lease (Tuilevuka 2024). The environmental impacts of such a development are unknown at the time of writing.

Outside protected areas some species appeared to be facing increasing external pressures. This was especially the case for *C. naboutinense* and

N. storckii. The small population and very narrow range of *C. naboutinense* coupled with the proximity and scale of current logging operations is a risky recipe for conservation. Although *C. naboutinense* is marked on FCHL's harvesting map (Fiji Ministry of Forestry 2022), even minor miscalculations or carelessness could inflict major damage on remaining populations. Surely the species warrants more vigilant monitoring and a bigger buffer zone to protect it. Populations of *N. storckii* have been greatly reduced by decades of logging, mahogany plantation establishment and land development, and the species appears to be particularly susceptible to infestation by CRB. It now faces the possibility of an invasion by a new biotype of CRB that tolerates the biological control that has kept damage to palms in check on Fiji for the last 50 years. Ongoing vigilance for signs of CRB damage on *N. storckii* is needed and testing new biological controls should be a high priority.

Beyond these immediate risks to *C. naboutinense* and *N. storckii*, the primary threat to palms and other terrestrial plant and animal species in Fiji is the loss of forest cover especially due to land clearing for agriculture (O'Brien et al. 2021). Forest management in Fiji hinges on the customs and objectives of indigenous landowners who control 88% of the country's terrestrial land area and have primary authority over its use (Keppel et al. 2012b). Any successful strategy for conserving forest resources will necessarily depend on both the commitment of the landowners and monetary compensation to offset potential income from logging, agriculture or other development. Ensuring that landowners benefit from conservation is key to preserving Fiji's exceptional biodiversity, including its rare endemic palms, in the long term.

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Palm Profile

Pritchardia thurstonii in the Lau Islands of Fiji



While *Pritchardia thurstonii* thrives in gardens and streetscapes throughout the tropics, its natural distribution is quite small and decidedly curious. It is one of only five species of *Pritchardia* to occur naturally outside of Hawaii and is native to one island in Tonga and three others in the Lau Island group of Fiji. More accurately, in Fiji *P. thurstonii* is found on small islets just offshore from three larger islands. These islets are made of hard coralline limestone that the ocean sometimes sculpts into fanciful mushroom shapes. Palms often dominate these islets sharing the habitat with only a few other plant species such as *Pandanus tectorius* and *Scaevola taccada*.

There are dozens of palm-covered islets scattered throughout the lagoon encompassed by Fulaga Island in Fiji, but *P. thurstonii* does not grow naturally on Fulaga itself. One possible explanation for this odd pattern could be the presence of rats – well known predators of palm seeds – on the inhabited main island and their absence on the small, uninhabited islets. If that explanation is correct, then the range of *P. thurstonii* must have been more continuous and extensive before the arrival of humans on these remote Pacific islands several thousand years ago.

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***Cocos nucifera* var. *palmyrensis*, a Unique Native Coconut from Palmyra Atoll**

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Here we document *Cocos nucifera* var. *palmyrensis*, which we systematically evaluated via a dedicated field project. We also discuss the history of the Palmyra coconut and provide a more complete description to complement its protologue. Separating the two varieties *C. nucifera* var. *palmyrensis* and *C. nucifera* var. *nucifera* best reflects the differences between the isolated taxon known from Palmyra Atoll and the widespread, widely-domesticated coconut. We present the evidence for this palm's native status on Palmyra Atoll and offer recommendations for its continued conservation.

Cocos nucifera var. *palmyrensis* is a unique but poorly documented variety of coconut palm, thus far known only from Palmyra Atoll. The Palmyra Coconut was first described in 1916 by the renowned palm specialist Odoardo Beccari, based on scant material collected and

sent to him by Joseph F. Rock. Rock's original account (1916) offers an apt description of the most obvious distinguishing character: "The nuts of the Palmyra coconut are the finest and the biggest the writer has ever seen, which testimony is also given by the eminent authority, Dr. O. Beccari of Florence, Italy."

The formal description of *Cocos nucifera* f. *palmyrensis* Becc. (Rock 1916), later elevated to *Cocos nucifera* var. *palmyrensis* (Becc.) Becc. (Beccari 1916b) was based only upon the four fruits Beccari received from Rock. Of those four fruits, only two are currently located in the Museum of the Natural History herbarium (FI) of the University of Florence and one of those has been designated as the lectotype for the

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1. *Cocos nucifera* var. *palmyrensis* forms a dense stand at the north end of Ka'ula Island (foreground), Palmyra Atoll. *Pisonia* forest can be seen on other islets in the background.

variety (Harries et al. 2020). Survey of and correspondence with other herbaria has not located any other specimens of the palm from Palmyra – that single, incomplete specimen at the Florence herbarium was the only physical record of this rare, endemic palm for over 100 years.

A complex history for Palmyra's palms

Palmyra Atoll lies in the Line Islands 1,600 km (1,000 miles) south of Hawaii and central in the Pacific Ocean – nearly halfway between California and New Zealand. Current consensus is that before its charting in early modern times, Palmyra was possibly explored by Polynesians but definitely not inhabited (Dawson 1959, Hathaway et al. 2011). Palmyra's first confirmed landing by a western vessel occurred in 1802 when the American trading ship *Palmyra* wrecked upon the reef. Recollection by her Captain, Cornelius Sowle, highlights the palm there: "There are no inhabitants on the island; nor was any fresh water found; but cocoa nuts of very large size are in great abundance. (Jacob 1805)." The fact

that a shipwrecked mariner would devote one line of his very brief report to Palmyra's coconuts is solid testament to the fruits' prominence and superlative size before inhabitation. Another early record (1810) also mentions coconuts (Mackay 1813) and an 1848 visit describes some of Palmyra's islets as hosting *Cocos* exclusively (Lucett 1851), all of these descriptions dating well before any attempt at commercial production of copra (i.e., dried coconut endosperm). Extractive copra efforts were first noted in 1873 (Jones 1889), but the first record of active *Cocos* planting dates to 1885 (Dawson 1959).

That first 1885 coconut planting – 200 fruits in total – was also noted by Rock (1916), which includes the formal description of *Cocos nucifera* f. *palmyrensis*. Joseph Rock's account of his 1913 botanical expedition, financed and accompanied by the Hon. Henry E. Cooper, Palmyra's then-owner, describes Cooper Islet as having coconuts covering the ground to a depth of several feet. Beccari (1916a) contributed the description in Rock's account, which is (alas) limited to the fruit and seed, as



2. *Cocos nucifera* var. *palmyrensis*, Fern Island, Palmyra.

no leaves, inflorescences or flowers were collected. In addition to that protologue and its accompanying plate, the upper part of Plate IV (Rock 1916, page 15) also depicts a palm bearing *C. nucifera* var. *palmyrensis* fruit, but without any detail in the text.

Rising prices for copra in the Pacific region impacted Palmyra by at least 1920, when commercial interests had cleared land on the Atoll to expand the productive acreage. This closely coincided with the global peak of the copra market (Foale 2003) which initially



3. *Cocos nucifera* var. *palmyrensis* inflorescence showing few female flower buds at the base and densely packed male flower buds at mid-length and apex of each of the numerous rachillae.

collapsed in 1929 and thereafter declined over the last hundred years (*ibid.*). Modern agribusiness logistics make Pacific atoll copra more expensive than copra from continental locations and many atoll plantations have now gone feral (Burnett et al. 2024).

The US Navy built up Palmyra as an active garrison starting in 1941, with an average population above 1,500 persons during the war years (Johnson 2020). This major land use change also saw introduction of non-native rats. Introduction of highly-productive *Cocos nucifera* cultivars from Hawaii was first docu-

mented in 1950 (Dawson 1959). Following purchase of the atoll by The Nature Conservancy in 2000, a massive rat eradication program was finally successful in 2011 (Wolf et al. 2018). Once that main seed predator was removed, an explosive increase in *Cocos* recruitment ensued (Young et al. 2017), which brought some controversy upon the coconuts on Palmyra.

Native or introduced?

The historic records reviewed above show a complex history for the Palmyra coconut, with an abundant pre-contact population of large-



4. *Cocos nucifera* var. *palmyrensis* inflorescence bearing four young fruits, already displaying the characteristic elongated triangular shape and few fruits per inflorescence.

fruited *Cocos*, followed by a history of copra development and major landscape change. This historic record on Palmyra parallels the overall genetic history of the genus, which shows a long period of isolation in both the Pacific and Indian Oceans, prior to human transport and selection (Gunn et al. 2011). Determining native origin for *Cocos* in any location is made difficult by its long history of human use (e.g. Ward and Brookfield 1992).

The extensive canon of coconut literature highlights both the superlative ability of buoyant *Cocos* fruits to disperse long distances upon the ocean and establish on distant shores (e.g. Harries and Clement 2014), as well as the prominence of *Cocos* as the most vital “canoe plant” carried by pre-contact Pacific and Indian Ocean voyagers to new horizons (e.g. Whistler 1991, Beaujard 2011). Corner (1966) stated the problem succinctly: “[*Cocos*] has

achieved a mechanism for long distance dispersal, yet it is nowhere wild!” With that “dispersal paradox” in the background, Young et al. (2010) expertly summarize the challenges with determining native origin for *Cocos* on Palmyra:

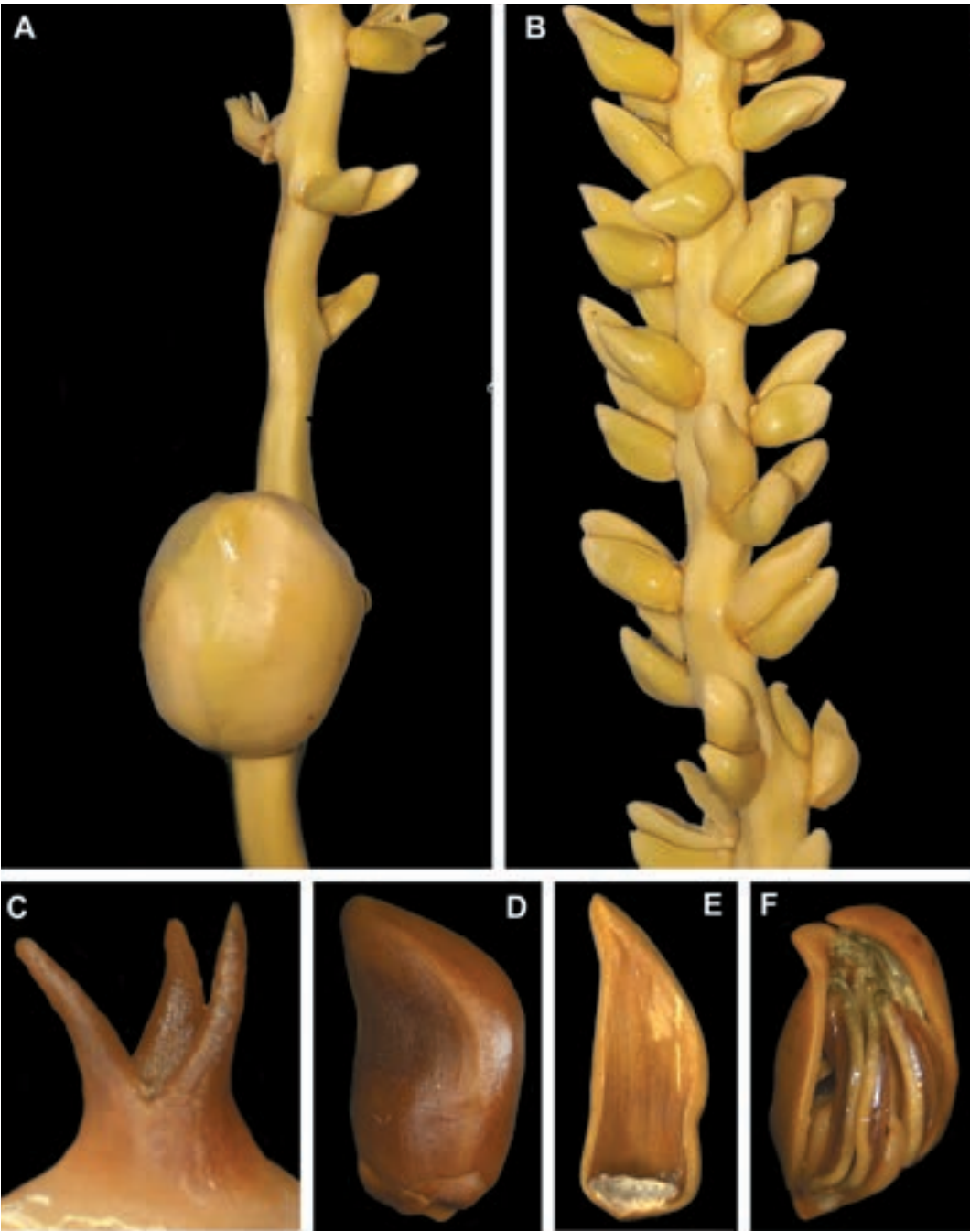
The history of the coconut palm at Palmyra is unclear. Several early botanists presumed that it was introduced to the area by the early Polynesians (Merrill 1946; Fosberg 1960) but others have suggested it might have arrived naturally by floating, long prior to Polynesian arrival (Harries 1978). In more recent history, aerial photographs, historical reports and oral history strongly suggest the palm has expanded its range on the atoll in the past 150 years (Dawson 1959).

Rapid increase and overabundance of germinating coconuts in the years after rat

removal had a negative impact on seabird rookeries (Young et al. 2017) and that rapid change prompted management actions to reduce the number of *Cocos* throughout the Atoll. During this period, there were a number of important ecological studies that labelled Palmyra’s *Cocos* as non-native, but without

detail on how that exoticness was determined. We highlight here the distinction between non-native and invasive; while *C. nucifera* var. *palmyrensis* displayed rapidly “invasive” recruitment demographics following rat eradication, invasiveness does not equate to exotic origin (Valery et al. 2009). Assessing the

5. Flowers of *Cocos nucifera* var. *palmyrensis*. A. Female flower at base of rachilla. B. male flowers at mid-length of rachilla, mostly borne in pairs. C. Three-lobed stigma. D. Male flower in bud. E. Petal from male flower. F. Male flower with one petal removed. See description in text for measurements.





6. Mature *Cocos nucifera* var. *palmyrensis* (p) and *Cocos nucifera* var. *nucifera* fruits. Ruler is 1 m (39.4 inches). *Cocos nucifera* var. *nucifera* fruits here include (upper image, clockwise from upper left) 'Maypan' (Montgomery Botanical Center accession 935*A), 'Red Spicata' (83464*K), 'Panama Tall' (944*C), 'Dwarf x Tall' (941556*B), 'Fiji Dwarf x Golden Malayan' (84192*C), 'Jamaica Tall' (91628*C) and 'Fiji Dwarf' (20060300*A).

native origin of *Cocos nucifera* var. *palmyrensis* is of critical importance, given the complex task of managing the recovery of Palmyra Atoll into a healthy, high-functioning ecosystem. Overabundance of feral copra stands have a demonstrated negative effect on wildlife habitat, nutrient cycling, soil formation and even reef ecosystems (Burnett et al 2024). Management of *Cocos* on Palmyra can be better

informed if native origin is clearly known and if native palms can be readily distinguished from exotic ones. We aim to address the question of native origin here.

A need for further documentation

With the above history reviewed, we sought to fill in the missing botanical information about this poorly-known palm and properly

document the taxon. To understand this unique palm better, we aimed to collect and curate complete and informative herbarium specimens. We planned for specimens to include sufficient vegetative and reproductive material to offer robust documentation of structural biology, as well as detailed measurements as label data to fill in aspects of the palm that cannot be preserved in herbarium specimens. We also sought to gather leaflet specimens for population genomic analysis, as to date no DNA-based studies have included material from Palmyra (e.g. Gunn et al. 2011). In parallel, we also aimed to collect sufficient fruits to establish off-site living collections. Living collections are vital for studies of growth and development, pollination biology, physiology and other disciplines which help to fully document biological diversity. Off-site living collections are also important to provide assurance against extirpation or genetic erosion. Finally, we also aimed to photograph the palm in its habitat, which can supplement the physical and genomic documentation detailed above and allow communication about this unique member of the atoll's flora. To meet these goals, we traveled to Palmyra in November 2024.

Observation and Description

Through comparison to Beccari's 1916 description and its associated specimens, we confirm that *C. nucifera* var. *palmyrensis* remains extant on Palmyra Atoll and is even fairly abundant in some areas (Fig. 1). For example, we noted the palm forms a closed-canopy stand on Fern Island to the exclusion of *C. nucifera* var. *nucifera* (Fig. 2) and is also abundant on Ka'ula Island, especially on the north end (Fig. 1), and in the North Beach Road area of Cooper Island. Diversity in other plant species is remarkably low at these first two locations, outcompeted by the rapid growth of the palms. Seaborne fruits of *C. nucifera* var. *palmyrensis* are also found washed up on many other islets, including Strawn Island.

Fruits of this palm were often above 35 cm in length, and the longest we measured was 46 cm. These fruits were consistently and sharply triangular in cross section. From our measurements and specimens, we offer this full botanical description of the variety, which can supplement Beccari's (1916a) protologue and Rock's (1916) account.

Cocos nucifera var. *palmyrensis* (Becc.) Becc.

Cocos nucifera f. *palmyrensis* Becc. in Rock, Bull. Coll. Hawaii Publ. 4: 44. 1916. (April 1916). *Cocos nucifera* var. *palmyrensis* (Becc.) Becc., Agric. Colon. 10: 588. (December 1916). *Cocos nucifera* var. *palmyrensis* (Becc.) Pignotti & Baldini, Candollea 75: 28 (20200), nom. illeg. Type: NORTHERN LINE ISLANDS (USA). Palmyra Atoll: "Palyra [sic!] Islands (Oceano Pacifico)", 1914, Rock s.n. (lectotype FI [FI018792]!, designated by Harries et al. 2020). Epitype (here designated): USA. Palmyra Atoll: Fern Island, south-east edge of the East Lagoon, 5°52'35.5"N, 162°03'43.6"W, 1 m alt., 8 November 2024, Stauffer et al. PA-01 (epitype G! [G00644013]; iso-epitype FI!).

Palm solitary, monoecious (Fig. 2). Stem up to 15 m tall, 27–30(–35) cm in diameter, straight to slightly curved, gray-brown; ring scars prominent, distanced 15–20 cm at basal height, 8–10 cm at mid-height, 4–5 cm towards the apex of the stem; vertical cracks very conspicuous, 3–8(–12) cm in length. Roots forming a well-developed basal cone, about 50–100 cm in height, each root of 5–10 mm in diameter. Leaves 15–25 in the crown, regularly pinnate, light green; leaf sheath 10–15(–20) cm long, 20–30 cm wide, smooth, with an entire margin; petiole 0.6–0.75(–1.5) m long, 7–8 cm wide towards the apex, slightly channeled in cross-section, smooth, green-yellow; leaf rachis 2.6–2.9 m long, 8 cm wide towards the base, 2–3 cm wide towards the apex, smooth, green-yellow, slightly curved towards the apex of the rachis. Leaflets 80–85 pairs, inserted every 2.5–3 cm, more or less at the same plane, mostly opposite but some sub-alternate, linear-lanceolate, apex acute; basal leaflets 0.5–1 m long, 2–5 cm wide, middle leaflets 48–90 cm long, 1–4 cm wide, apical leaflets 35–56 cm long, 1–2 wide; main vein almost-yellow, prominent in the adaxial side. Inflorescences and infructescences interfoliar, growing simultaneously in the same plant and at different stages of development. Inflorescences (Fig. 3) once-branched, protandrous, occasionally entirely staminate; prophyll 40 cm long, 15–17 cm wide, conspicuously bicarinate; peduncular bract 1, slightly woody, 70–80(–100) cm long, 10 cm wide, green-yellow on the inner side, brown-green outside; peduncle 40–50 cm long, 3–4 cm wide, dorsiventrally compressed, light yellow; inflorescence rachis 20–25(–30) cm long, 1.5–3 cm wide; rachillae 28–30, spirally arranged, inserted at more or less 70° with



7. *Cocos nucifera* var. *palmyrensis* (p) and *Cocos nucifera* var. *nucifera* fruits. Upper image cross sections show sharply triangular fruit shape, large husked, thick-coated seed of *Cocos nucifera* var. *palmyrensis* vs. rounded fruit, thin-husked, thin-coated seed of *Cocos nucifera* var. *nucifera* in cross section. Longitudinal section of *Cocos nucifera* var. *palmyrensis* highlighting elongated seeds in lower image.

respect to rachis; basal rachillae 27–30(–38) cm long (8 cm sterile portion, 30 cm fertile portion), middle rachillae 35–43 cm long (8

cm sterile portion, 35 cm fertile portion), apical rachillae 30–45 cm long (5 cm sterile portion, 40 cm fertile portion), all of them 6–7 mm

thick, more or less irregularly dorsi-ventrally compressed in cross section. Inflorescences each commonly bearing 4 or less mature fruits (Fig. 4). Flowers unisexual. Male flowers (Fig. 5) mostly growing in pairs, spirally inserted in the rachilla, 0.8–1.2 cm in length, 0.4–0.6 cm wide, oblong-elongated, light green at bud stage, pale yellow at anthesis, with a more or less acute apex, densely packed in the middle and apical region of the rachillae; sepals 3, ovate and slightly concave, less than 1 m long, thicker towards the apex, petals 3, ovate-elongated, 8–9 mm long × 4 mm wide, thicker towards the apex, margins entire; androecium composed of 6 stamens, congenitally fused in a 1 mm high, basal staminodial tube, filament 4–5 mm long; anther basifixed, 4–5 mm in length, pistillode composed of 3 well-developed stigmatic branches, each one up to 2 mm in length, reflexed, papillae lacking on the surface, the basal region of the pistillode with no evidence of nectary ducts. Female flowers (only late buds available for our study; Fig. 5) mostly solitary or sometimes flanked by two male flowers, 3.2–3.6 cm in diameter, irregularly globose, pale yellow, only one per rachilla and always occupying a basal position, the female flowers usually restricted to the mid-length rachillae and completely absent in basal and apical rachillae; the total number of female flowers usually less than ten per inflorescence (Fig. 3), but some apparently completely sterile as no development of the ovary and the ovules was observed; flower subtending bracts 2 or 3, imbricate, all of them irregular to broadly triangular, 1 cm in height × 1.8–2 cm wide, margins entire, sepals 3, all of them strongly concave and very thick, 1.6–1.8 cm in height × 2–2.2 cm, the outermost sepal much larger than the innermost ones, margins entire, with a very smooth surface; petals 3, imbricate, much thinner than the sepals, strongly concave, 1.2–1.4 cm in height × 1.6–1.8 cm wide, ovary asymmetrically globose, 1.2–1.4 cm in height × 1.4–1.6 cm wide, stigmatic branches very short, still connivent at bud stage, directly inserted to the top of the ovary; staminodes or staminodial ring apparently absent, nectar ducts not detected. Fruits 1-seeded, only 2–4 per infructescence, up to (28–)29–32(–46) cm long and (16–)19–23(–30) cm wide, oblong, conspicuously triangular in cross section, with three well-developed basal bulges nearly occluding the pedicel and three conspicuous keels towards the apex, green in development, gray-brown at maturity, (2.3–)3.0–3.7(–5.5) kg in weight; mesocarp fibrous, brown, 3–5.5 cm

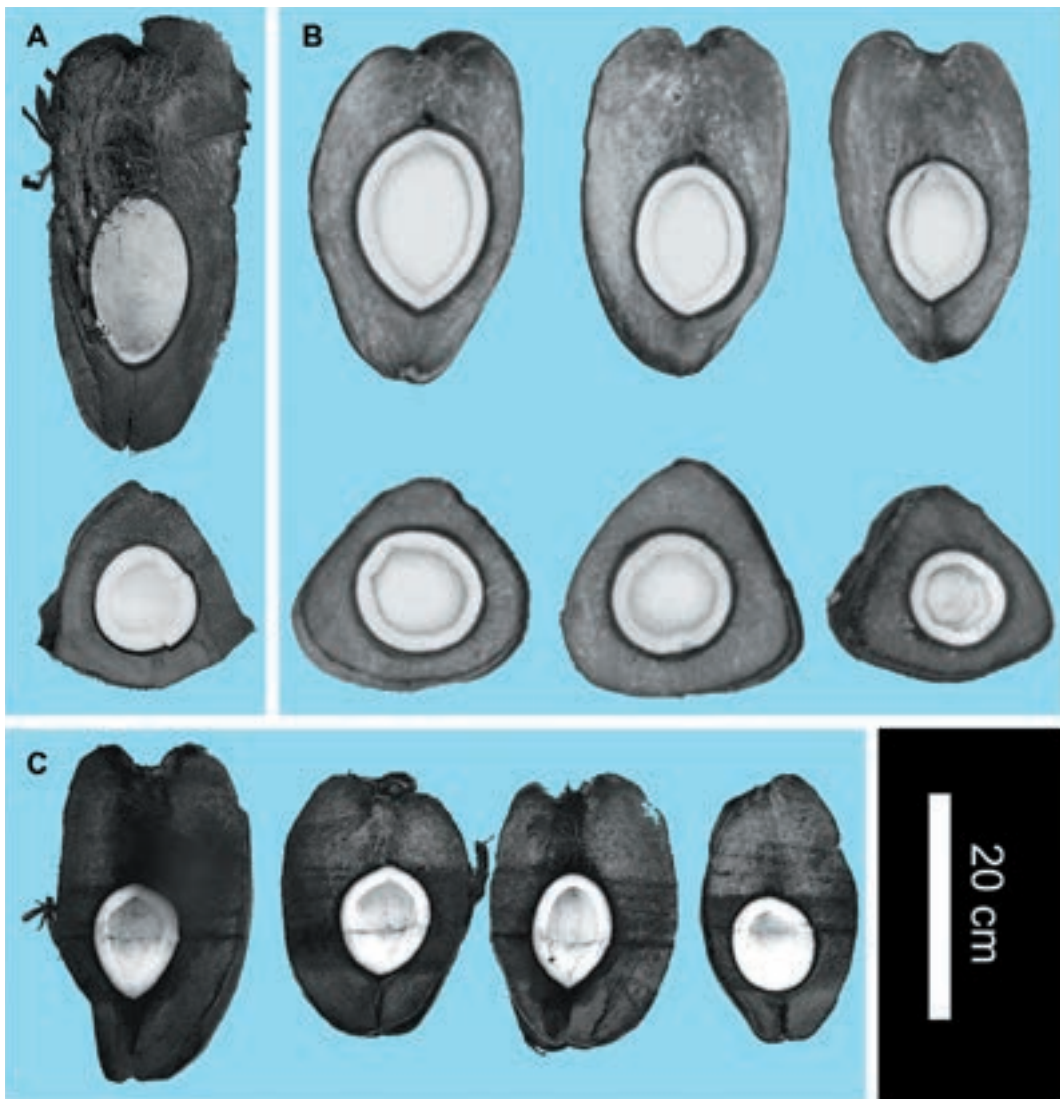
thick (Figs. 4, 6 and 7). Seeds oblong, 11–14 cm in length, 7–9 cm in diameter; seed coat 5 mm thick, dark brown; endosperm white, 1 cm thick, thicker at the distal end of the fruit (Fig. 6). Eophyll entire-bifid, green.

Specimens examined: NORTHERN LINE ISLANDS (USA), Palmyra Atoll: Palmyra [sic!] Islands (Oceano Pacifico), 1914, *Rock s.n.* (FI! [FI018792, FI018793]); USA National Wildlife Refuge, Fern Island, south-east edge of the East Lagoon, 1 m alt., 5°52'36.3"N, 162°03'44.2"W, 8 November 2024, *Stauffer et al. 01* (G, FI!); Fern Island, south-east edge of the East Lagoon, 1 m alt., 5°52'35.5"N, 162°03'43.6"W, 8 November 2024; *Stauffer et al. PA-02* (G! [G00644014], FI!); Ka'ula Island, south edge of the West Lagoon, 1 m alt., 5°52'28.9"N, 162°05'12.6"W, 10 November 2024, *Stauffer et al. 03* (G! [G00644015], FI!).

Notes: Our visit to the atoll did not allow detailed studies on the reproductive biology of the palm; however, some interesting observations are worth mentioning. Bees, regarded among the most common insects visiting coconut flowers in the tropics, were not observed by us during the collection of several palms. On the contrary, abundant individuals of the Black Earwig (*Chelisoches morio* (Fabr.), Chelisochidae, Dermaptera) were observed on several inflorescences at male stage. This omnivorous insect has been reported to play a role as a biological control agent of pest insects in coconut plantations (Winotai 2014). Its presence on Palmyra may help protect the Palmyra coconut against a diversity of pests that may threaten wild populations of the palm, which may have been introduced alongside cultivated *Cocos nucifera*.

Comparison with other *Cocos*

Cocos nucifera var. *palmyrensis* is consistent with the superlatives that Beccari and Rock (1916) offered, with exceptionally large, triangular fruits as a consistent character. The other variety in *Cocos*, *C. nucifera* var. *nucifera*, has a very skeletal protologue and type (Linnaeus 1753), but benefits from a voluminous canon of more recent surveys, descriptions and characterizations (e.g. Bourdeix et al. 2010, Adkins et al. 2024b). *Cocos nucifera* includes a large number of formally named varieties that are all considered synonyms for the species, with most of these authored by Blume (1847). A complete monograph of *Cocos nucifera* is beyond the scope of this study, but comparison of *C. nucifera* var. *palmyrensis* within the range of morphological diversity within the genus



8. Comparison of (A) *Cocos nucifera* var. *palmyrensis*, (B) *C. nucifera* Niu kafa, and (C) *C. nucifera* wild type fruits at the same scale. Among *C. nucifera*, the cultivar 'Niu kafa Tall Tonga' is documented as producing the largest fruits; image B is adapted from Bourdeix et al. (2010). *Cocos nucifera* from North Cocos Island is considered a wild native population; image C is adapted from Leach et al. (2003). *C. nucifera* var. *palmyrensis* fruits are consistently larger, more elongated and more sharply triangular than *C. nucifera* var. *nucifera* fruits. *C. nucifera* var. *palmyrensis* fruits have the pedicel nearly occluded by three protuberances of husk tissue associated with each carpel. *Cocos nucifera* var. *palmyrensis* seeds are relatively longer compared to width.

Cocos can help illuminate its diagnosis and demonstrate how *C. nucifera* var. *palmyrensis* is morphologically consistent, unique and distinct within *C. nucifera*. Below we offer an overview of *Cocos* diversity, along with several specific comparisons which establish the uniqueness of *C. nucifera* var. *palmyrensis*.

Overview of *Cocos* diversity: The most important difference between the two varieties of *Cocos* is that *C. nucifera* var. *palmyrensis* displays characters and phylogeography highly

consistent with a wild origin, while *C. nucifera* var. *nucifera* is, with few exceptions, a semi-domesticated, domesticated or feral crop. *Cocos nucifera*, as one of the most widely used and widely cultivated plant species in the world (Leff et al. 2004, Gunn et al. 2011) shows abundant variation in fruit morphology, with robust germplasm conservation efforts holding extensive diversity of cultivars and landraces with fruits of various sizes, shapes and colors (Batugal et al. 2005). Many *C. nucifera* fruits show clear domestication syndrome from the



9. Inflorescence diversity in *Cocos*. A: *C. nucifera* var. *palmyrensis*. B: *C. nucifera* 'Fiji Dwarf X Golden Malayan' (84192*E). C: *C. nucifera* 'Red Spicata' (83464*G). Among *Cocos*, the Palmyra coconut holds the fewest female flowers and heavily domesticated *C. nucifera* 'Spicata' types hold the fewest male flowers (Table 1). For broader comparison please see illustrations throughout Bourdeix et al. (2010).

extensive history of use by people (Harries 1990, Clement 1992), also seen in the genetic signature of long-distance transport by humans (Baudoin & Lebrun 2009). Genetic study of coconut cultivars shows a broad and ancient division between Indian Ocean and Pacific Ocean groups (Lebrun et al 1998, Gunn et al. 2011), further dispersed into the Atlantic through trade and transport starting in 1499 (Clement et al 2013). *Cocos nucifera* palms have been broadly divided into two major types, "tall," heterogenous, less-selected, less-domesticated, semi-wild or feral populations, and "dwarf," often autogamous types, bearing fruit at a conveniently shorter height and showing clear signs of domestication (Foale 2003, Xiao Yong et al. 2017). Harries (1978) classified coconut fruits into two broad types based on domestication syndrome, borrowing the Samoan terms to describe smaller-husked, spherical, domesticated fruits (Niu vai) vs. undomesticated, larger-husked fruits (Niu kafa or Niu 'afa).

Comparison with the most similar and proximal cultivar: Drawing from extensive and wide expertise as a coconut germplasm conservator, Bourdeix (2010) asserted that the Samoan and Tongan Niu kafa is the largest of all coconuts (Bourdeix et al. 2010) and based on that similar morphology and proximal geography we therefore select that cultivar for detailed comparison with *C. nucifera* var. *palmyrensis*. Recent work has updated the record, showing that in Samoa, Niu kafa is a long-fibered cultivar preferred for coir or sennit

production, and its thick-husked phenotype is the result of human selection (Rao et al. 2015, Bourdeix et al. 2023). *Cocos nucifera* var. *palmyrensis* shows some superficial similarities with Samoan *C. nucifera* Niu kafa, being green and long-fruited; however, fruits of *Cocos nucifera* var. *palmyrensis* are much more sharply triangular and the seeds are much less spherical (Fig. 8). *Cocos nucifera* Niu kafa (sensu Bourdeix) also appears to be a precocious cultivar, flowering at an ergonomic height within seven years of planting and bearing up to six fruits per infructescence (Bourdeix 2010). In contrast, *Cocos nucifera* var. *palmyrensis* holds fruits high above ground and these palms usually bear up to four fruits per infructescence. *Cocos nucifera* Niu kafa displays a distinctive "equatorial belt" in mature fruits (Bourdeix et al. 2010), which is not observed in *C. nucifera* var. *palmyrensis*. One very consistent character for the Palmyra coconut is the three prominent raised protuberances at the proximal end of the fruit associated with each carpel, which nearly occlude the pedicel (Figs 4 and 6). These protuberances are not present or only slightly visible in most *C. nucifera* forms. In *C. nucifera* Niu kafa, these protuberances are inconsistently visible (Fig. 8) and do not occlude the pedicel (Bourdeix et al. 2010). We are also aware of other "largest coconut" examples posted on the internet, which appear to be one-off, inconsistent phenotypes.

Comparison with wild *Cocos nucifera*: While cultivars and landraces comprise the vast

majority of *C. nucifera* diversity, there remains an extant population of coconuts on North Cocos Island (aka North Keeling Island) which has been well-established as an unintrogressed, native, wild population in the Indian Ocean (Foale 2003, Leach et al. 2003). Comparison of *C. nucifera* var. *palmyrensis* with the North Cocos Island population can offer a view of differences between varieties without the complication of cultivars or human selection (Fig. 8). Fruits from North Cocos Island are documented as reaching 24 cm in length (Leach et al. 2003) and appear less elongated and less triangular than *C. nucifera* var. *palmyrensis*. Harries and colleagues also identified at least two populations of “self-sown, wild type” coconuts – i.e. Niu kafa *sensu* Harries – in Australia (Buckley and Harries 1984) and the Philippines (Gruezo and Harries 1984). Coconuts recorded in both studies reached no longer than 25 cm and showed a rounder cross section than the sharply angular *Cocos nucifera* var. *palmyrensis*, which grows up to 46 cm in length.

Comparison among inflorescences: While the majority of coconut classification has focused on fruit and seed characters, we also observe major differences in inflorescence arrangement and morphology in *Cocos*. *Cocos nucifera* var. *palmyrensis* produces inflorescences that are either entirely staminate or monoecious. Monoecious inflorescences of *C. nucifera* var. *palmyrensis* hold fewer female flowers than those of *Cocos nucifera* var. *nucifera* (Bourdeix et al. 2010). As discussed above, we observed only up to ten female flowers per inflorescence on the Palmyra coconut, whereas typical *C. nucifera* inflorescences have been described as producing from 15–50 female flowers per inflorescence (Perera et al. 2008), around 50 female flowers per inflorescence (Adkins et al. 2024a), or 40–60 female flowers per inflorescence (Chan & Elevitch 2006). Some cultivars of *C. nucifera* show an even greater increase in female flowers and reduction in male flowers; the most extreme expression is found in the ‘Spicata’ cultivars, in which inflorescences do not bear obvious rachillae, can hold up to 500 or more female flowers along the main rachis (Perera et al. 2008, Bourdeix et al. 2010) and hold much fewer male flowers. This increase in female flowers and reduction in male flowers and male flower parts is often associated with plant domestication, as seen also in *Ficus* (Kislev et al. 2006), *Helianthus* (Heiser 1978), *Silphium* (Prasifka et al. 2022) and *Zea* (Hake & Ross-

Ibarra 2015), among others. We interpret the relatively abundant staminate flowers and relative paucity of pistillate flowers in *C. nucifera* var. *palmyrensis* as a signal of no human selection, showing a lack of domestication syndrome relative to *C. nucifera* and consistent with a native, endemic origin for *C. nucifera* var. *palmyrensis* (Fig. 9).

Summary of morphological comparisons: Table 1 summarizes morphological data from published descriptions of *Cocos nucifera* in comparison with the observations presented in this paper. The values presented in Table 1 are consensus values from review of monographs, regional and local floras and other descriptive material, global in scope (Blatter 1926, Menon & Pandalai 1958, Woodruff 1979, Dowe 1989, Tuley 1995, Renuka 1999, Stevens et al. 2001, Comeau et al. 2003, Lorenzi et al. 2004, Watling 2005, Chan & Elevitch 2006, Perera et al. 2008, Bourdeix et al. 2010, Galeano and Bernal 2010, Shengji et al. 2010, Bhat 2011, Renuka and Sreekumar 2012, Henderson et al. 2019, Stauffer et al. 2021, Adkins et al. 2024a, Baker et al. 2024). These observations of *C. nucifera* are consistent with our own observations in fieldwork. Based on all of the above differences which distinguish *C. nucifera* var. *palmyrensis* from *C. nucifera* var. *nucifera*, we recognize two varieties of *Cocos* as distinct taxa.

Feral coconuts on Palmyra

During this survey we also observed large numbers of feral *C. nucifera* var. *nucifera* on Palmyra, showing a more spherical fruit, more spherical seed, bearing up to a dozen or more fruits per infructescence and displaying a variety of fruit and infructescence colors, e.g. yellow, orange and bronze in addition to green (Fig. 10). These were most consistently observed on Cooper Island and Aviation Island, in areas more proximal to the heavily inhabited zones of the 1940s (Fig. 11). These are likely the legacy of copra plantation efforts, or descendants of other coconuts brought by visitors before or after that timeframe. We also observed some palms that appeared to show intermediate characters between *C. nucifera* var. *palmyrensis* and cultivated Niu vai types, which can be expected in an open pollinated zone of overlap between feral copra and *C. nucifera* var. *palmyrensis*, but is a serious conservation concern (cf. Clugston et al 2024). Hybridization between closely related palm taxa has been documented (Bacon and Hill 2024) and is especially noted among Cocoseae

(Henderson 2022). The hybridization seen for *Cocos* on Palmyra parallels the hybridization seen in *Phoenix* L., between a widely used crop species and a more narrowly distributed congeneric (Gros-Balthazard et al. 2013)

The wildest of all coconuts

Harries’ extensive body of work, bibliographed in the pages of this journal (Dransfield and Illingworth 2019), postulated a “wild type” coconut that dispersed without human aid over long distances, arising in the Indo-Pacific and spanning to East Africa and Panama. Harries and Clement (2014) demonstrated that large fruit size and volume, low specific gravity and triangular shape would be the most important characters for long distance dispersal. Beccari himself noted the very low specific gravity of his *Cocos nucifera* var. *palmyrensis* specimens (1916a) and in fact also postulated about *C. nucifera* var. *palmyrensis* exemplifying the origin and dispersal of *Cocos* (1917).

Cocos nucifera var. *palmyrensis* takes that archetype of the “blue-water coconut” to its most extreme expression – with thick husk, sharp wind-catching angles and unrivalled buoyancy, it is built for the Pacific voyage. If the long crossing to Palmyra selected for only the most seaworthy of fruits, then *C. nucifera* var. *palmyrensis* would be the phenotypic result of that natural selection process. In context with the lack of evidence for early habitation on Palmyra, we thus determine that the

morphology, phytogeography and lack of ethnobotanical knowledge of *C. nucifera* var. *palmyrensis* is most consistent with it being a native taxon, endemic to Palmyra so far as known (Beccari 1917).

An alternative hypothesis is that *Cocos nucifera* var. *palmyrensis* was introduced by voyagers prior to the 19th century. This hypothesis is refuted by a lack of *C. nucifera* var. *palmyrensis* collected elsewhere or known in germplasm collections – if it was brought to Palmyra by people, why does it not persist on other, inhabited islands? Why would early voyagers bring the most voluminous, most difficult to husk and least productive coconuts to only one remote place, while carrying agronomically “efficient,” space-saving, highly productive coconuts to all other islands? The simplest explanation for the unique morphotype of *C. nucifera* var. *palmyrensis* is as a naturally-evolved wild taxon, endemic to Palmyra.

Conclusions and recommendations

We realize that more than one generation of botanists has grown up with only a single widespread, diverse and familiar *Cocos nucifera* and thus we anticipate that *C. nucifera* var. *palmyrensis* may generate some discussion. We note that the variety is generally treated as a synonym of *Cocos nucifera* (e.g. POWO 2025), but here we resurrect it as an accepted taxon. The autonym *C. nucifera* var. *nucifera* is the only other variety that we recognize. With that

Table 1. Comparison of *Cocos nucifera* var. *palmyrensis* and *C. nucifera* var. *nucifera* morphological characters. Character values presented here are our observations (*C. nucifera* var. *palmyrensis*), or a consensus of character ranges published in monography, floras and descriptions (*C. nucifera* var. *nucifera*; see text).

Character	<i>Cocos nucifera</i> var. <i>palmyrensis</i>	<i>Cocos nucifera</i> var. <i>nucifera</i>
Stem diameter	27–30 (–35) cm	(20–) circa 30 (–50) cm
Stem height	to 17 m	20–30 m
Leaf length	3–5 m	(2–) 5–7 m
Number of leaves	15–25	25–30
Number of leaflets	160–170	150–250
Inflorescence length	60–80 cm	1–2 m
Prophyll length	ca. 40 cm	45–50 cm
Prophyll width	15–17 cm	10–15 cm
Inflorescence sex	monoecious or staminate	monoecious
Fruit length	28–46 cm	to 30 cm, rarely larger
Fruit width	To 30 cm	to 20 cm
Male flower length	8–12 mm	10–13 mm
Female flower diameter	32–36 mm	21–30 mm
Female flowers per inflorescence	to 10	(15–) 40–60 (–500)



10. *Cocos nucifera* var. *palmyrensis*, Ka'ula Island, Palmyra Atoll. View to the south from the north side of the island. This area hosts a robust population of *C. nucifera* var. *palmyrensis*, but a few feral *C. nucifera* var. *nucifera* were observed toward the south shore.

background, we offer the following conclusions and recommendations:

1. *Cocos nucifera* var. *palmyrensis* is a distinct taxon, morphologically disjunct from other coconuts and native to Palmyra Atoll.

2. *Cocos nucifera* var. *palmyrensis* is the best documented example of a wild coconut population and thus is globally significant as a vital crop wild relative as well as a key piece of information the origin of the coconut.



11. *Cocos nucifera* var. *palmyrensis* and *C. nucifera* var. *nucifera*, Cooper Island, Palmyra Atoll. Cooper Island was essentially cleared of vegetation in the 1940s. *Cocos* observed here in 2024 were of both varieties, suggesting recruitment of each type has been successful over the past eight decades.

3. We are concerned that *Cocos nucifera* var. *palmyrensis* is under threat of genetic dilution from introduced and feral *Cocos nucifera*.

4. We recommend that removal of feral and introduced *C. nucifera* on Palmyra –

already underway – should continue through to completion.

5. We suggest that exploration for range, extent and census of *Cocos nucifera* var. *palmyrensis* on Palmyra and other islands is essential for conservation management.

6. We encourage that the most exemplary stands of *Cocos nucifera* var. *palmyrensis* be managed in a way that conserves the taxon.

7. We anticipate that further studies of *C. nucifera* var. *palmyrensis*, including population genomic analysis, will explore hypotheses about its isolation and uniqueness.

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Continued from p. 56



Areca triandra may be popular in tropical gardens, but it has a dark side: The species is escaping cultivation and naturalizing in places outside its native home. A recent study of *A. triandra* in Sri Lanka, where the palm is not native, found that prolific seed production and rapid growth combine to make this species a potential threat. Currently, the palm invades disturbed forest edges, but under the right conditions, it could penetrate intact forest. There is also concern that the non-native species will be confused with the endemic *A. concinna*, a species recorded from only two sites and in urgent need of conservation. The paper is D.L. Wickramasinghe et al. 2025. The non-native *Areca triandra* palm is a potential threat to the southwestern rainforests of Sri Lanka. *Nordic Journal of Botany*. <https://doi.org/10.1002/njb.04508>.

A beautifully illustrated account of *Copernicia macroglossa*, the Cuban petticoat palm, has been published by a team of researchers led by A. Navarro (Navarro et al. 2025. *Copernicia macroglossa* Schaedtler. *Curtis's Botanical Magazine*. <https://doi.org/10.1111/curt.12628>). The article discusses the typification of the name, its conservation status, current distribution and potential geographical range. Founded in 1787, *Curtis's Botanical Magazine* is the world's longest-running, continuously published periodical and is famous for its original color illustrations of cultivated plants. The illustrator for this new account of *C. macroglossa* is Julio Figueroa.



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