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PALM NEWS

An interesting investigation from M. Tromp and J.V. Dudgeon revealed **no evidence that inhabitants of Rapa Nui (Easter Island) ate the extinct palm, *Paschalococos disperta***. The report (Jour. Archaeological Sci. 54: 54–63. 2015) investigated microfossils of palm silica bodies (phytoliths) embedded in dental calculus recovered from human teeth ca. 200–700 years old. Although palm phytoliths are abundant in the calculus, the teeth show no signs of micro-abrasion that would normally result from a diet rich in phytolith-containing material. Moreover, there is no other archaeological evidence that the people of Rapa Nui consumed any part of the palm (i.e., heart of palm or palm flour). The authors concluded that sweet potatoes (*Ipomoea batatas*) were the major dietary staple of the islanders, based on fossil starch granules in the calculus, and that the palm microfossils were simply incorporated into the sweet potato tubers as they grew in soil containing the silica bodies. The authors demonstrated how modern sweet potato skins incorporated phytoliths present in their growing medium.

An assessment of genetic variation using microsatellites found that populations of *Phoenix canariensis* are less diverse in the western, younger islands and more diverse in the eastern, older islands of the Canary archipelago. Recent work published by I. Saro and colleagues (Tree Genetics & Genomes 11. 2015. DOI 10.1007/s11295-014-0815-0) found evidence that suggests a sequential, stepping-stone model of island colonization: **as islands emerged from the sea and became hospitable to plant life, *Phoenix canariensis* colonized them**. Moreover, the genetic evidence supports the idea that the population of palms on the island of Lanzarote is anthropogenic in origin. The study is significant for both its insight into the evolutionary history of the species and the conservation of this horticulturally important palm.



A number of **fascinating palm-related videos are available on You-Tube**, including a recent posting from Dr. Rodrigo Bernal, of Colombia. The videos is “La Palma de Cera del Quindío-The Quindío Wax Palm” and is a fascinating glimpse into the ecology and importance of *Ceroxylon quindiuense* and efforts being made to conserve it. It also has some breathtaking views of the palms in their Andean habitat. The beautifully produced video (in Spanish with English subtitles) can be viewed at <http://youtu.be/ezZqaZdiZKU>.



An interesting study of *Lodoicea maldivica* by P.J. Edwards et al. (New Phytologist. 2015. DOI 10.1111/nph.13272) investigated the paradox that a palm growing on very poor soils invests such a huge amount of resources in reproduction, with the females producing massive flowers and huge fruit and the males producing copious pollen. The authors studied the trees' allocations of dry matter, nitrogen (N) and phosphorus (P) to above-ground growth and reproduction, and quantified stem-flow and through-fall and compared these measurements to the N and P available from the soil. They concluded that the palm's leaves form a huge litter-trapping funnel that intercepts particulate material, especially pollen, which is flushed to the base of the trunk and into the root zone when it rains. In this way, *Lodoicea maldivica* improves its nutrient supply.

***Adonidia dransfieldii*, a Threatened New Palm from Sabah, Borneo**

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Recent clarification of the taxonomic status of *Adonidia*, which has had a somewhat checkered history, now permits appropriate assessment of an interesting, second species, herein described as new to science. With a small population that is likely threatened in the wild, this elegant palm has fortunately been conserved *ex situ* on the grounds of Sabah's Forest Research Centre (Figs. 1 & 11).

Adonidia is a palm genus with an interesting taxonomic history. Established by the Italian naturalist Beccari (1919), it is based on *A. merrillii* (Becc.) Becc. from Palawan, the sole species for almost a century. In 1957, the palm taxonomist H.E. Moore had considered *Adonidia* to be insufficiently distinct from the earlier named Pacific genus *Veitchia*, and this position was followed in the first edition of *Genera Palmarum* (Uhl & Dransfield 1987). In

the second edition of *Genera Palmarum* (Dransfield et al. 2008), however, the two genera were distinguished, so that *Adonidia* once more became a distinct monotypic genus. Then a second species, *A. maturbongsii* W.J. Baker & C.D. Heatubun was described (Baker & Heatubun 2012) but following closer review of the molecular relationships of this alliance of ptychospermatoid palms (subtribe Ptychospermatinae) (Alapetite et al. 2014), this



1 (left). *Adonidia dransfieldii* in bloom. 2 (right). *Adonidia merrillii*, the Manila Palm, has a more robust trunk with more spreading inflorescences compared to *A. dransfieldii* (Photos: K.M. Wong).

species was reassigned to a new genus *Manjekia* (Heatubun et al. 2014). So once again, *Adonidia* is recognized as a monotypic genus.

The latest scheme of classification that distinguishes these two genera (Heatubun et al. 2014) identifies the nature of the leaflet tips as a reliable difference (“bifid, not praemorse or inconspicuously so” in *Adonidia*; “not bifid, conspicuously praemorse” in a cluster of three genera that includes *Manjekia*). The leaflet tips of *Adonidia* often have irregular, small and somewhat inconspicuous jaggedness, which represents an extreme reduction of the praemorse condition. The leaflet tips are, however, quite clearly cleft or bilobed.

In this paper we describe a ptychospermatoid palm with cleft or bifid leaflet tips as a new species of *Adonidia*. It has, following the distinguishing features of *Adonidia* given by Heatubun et al. (2014) in their key to the genera of subtribe Ptychospermatinae, pinnate leaves with linear to wedge-shaped leaflets that are not further divided into secondary segments, an inflorescence peduncle shorter than the rachis, seeds that are terete in cross section, with rounded straw-colored endocarp lacking a single flattened ridge, and ruminant endosperm.

We name this elegant new palm after the great palm taxonomist John Dransfield, who is both friend and inspiration. We foresee that this latest palm discovery is of likely interest to horticultural circles, possibly even leading to indiscriminate collection of seed and plants from its rather restricted natural population. As such, the formal naming of this new palm only after it has been brought into cultivation by the Forest Research Centre of the Sabah Forestry Department would seem to be a fortunate circumstance, because the species is now both represented by *ex situ* living collections as well as a cultivated potential seed source.

Nevertheless there are interesting parallels between the new species and *A. merrillii* (Fig. 2). Beccari (1909) first described the Philippine palm as *Normanbya merrillii*, stating that, at the time, it was already a commonly cultivated ornamental palm in Manila (hence its common name, Manila Palm) and that botanically “it has not been collected in a wild state anywhere in the Philippines.” It was only later (Beccari 1919) that the genus *Adonidia* was established to accommodate *A. merrillii*, by then known to occur in Palawan. Thus both species of *Adonidia* were first brought into cultivation before their botanical diagnosis,

perhaps a testament to their attractiveness in horticultural terms. In a way, these special palms were first discovered for their potentially ornamental value before botanical science found them.

Adonidia dransfieldii K.M.Wong, J.B.Sugau & Y.W.Low, **sp. nov.** Type: Malaysian Borneo, Sabah, Sandakan, Forest Research Centre, Herbarium compound, cultivated from material from a coastal village on the west Sabah coast, 26 August 2013, *Joel SAN 155814*, (holotype SAN, isotypes K, KEP, SING).

Diagnostic characters: This new palm is distinguished from *Adonidia merrillii* Becc. by its more slender mature stems that do not develop conspicuous vertical-wavy striations across internodes, leaflets typically with a more pronounced distal taper (leaflet apical portions commonly just a sixth the width of the widest leaflet mid-portion), a more upright inflorescence (held ca. 45° from horizontal), a shorter peduncle (4–6.5 cm long) that is glabrous even at the newly emerged stage, and fewer (25–35) stamens in the male flower (Figs. 5–7). In contrast, *A. merrillii* has more robust stems that develop conspicuous, fine vertical-wavy striations across mature stem internodes (Fig. 4), leaflets with broader tips that are commonly a quarter to a third the width of the widest leaflet mid-portion, a more spreading inflorescence (held ca. 10–20° above the horizontal), a longer peduncle (10–15 cm long) that is densely pale tomentose when young, and more numerous (45–50) stamens in the male flower.

Medium-sized solitary, unarmed, pleioanthic, monoecious palm to 6–7 m tall. *Stem* 10–13 cm diameter, ringed with close leaf scars 1.5–2.5 cm apart, quite smooth and without conspicuous vertical-wavy striations across internodes, gray. *Leaves* pinnate, strongly curved, the whole leaf to ca. 150 cm long; sheaths forming a prominent pale glaucous green to yellowish green crownshaft ca. 45 cm long (Fig. 3), covered with deciduous gray minute tomentum and scattered dark scales, with two short triangular auricles ca. 1 cm long at the base of the petiole; petiole short, to 19 cm long, adaxially channeled, abaxially rounded, quite smooth; rachis elongate, adaxially channeled in the lower and middle portions and then flat distally, abaxially rounded, covered in minute hyaline to gray-brown scales; leaflets 45–53 per side, 42–50 cm long and up to 2.6–3 cm wide at mid-rachis, shorter and narrower more basally and apically

along the rachis, regularly arranged, but diverging in slightly different planes, strongly curved with their apical portions bent downwards and towards the leaf apex, single-fold, tapered from middle to base and usually to the apex, apically oblique, truncate, acute, acuminate and conspicuously cleft or bilobed, the lobes not to variously toothed, the upper margin usually longest, midrib and marginal veins prominent, midrib occasionally bearing dark brown to blackramenta abaxially near the base, otherwise abaxial surface smooth to the touch but covered in minute hyaline to pale gray or brown scales, transverse veins not evident. *Inflorescences* infrafoliar, 75–90 cm long, branched to 3 or 4 orders basally, fewer orders distally, peduncle and branches quite glabrous when newly emerged, white to pale green (Figs. 5, 7 & 8); peduncle very short, 4–6.5 cm long, stout, dorsiventrally compressed; prophyll and peduncular bract caducous, not seen but their scars conspicuous at the inflorescence base, scar of an incomplete peduncular bract also present above these; rachis tapering, stiff, bearing very short bracts

3. The crownshaft, petioles and leaf rachises of *Adonidia dransfieldii* are typically pale green to yellowish green (Photo: K.M. Wong).





4 (left). *Adonidia merrillii* trunk showing characteristic vertical-wavy fine cracks across internodes, and the inflorescence base with its initial cover of pale tomentum that sloughs off with age. 5 (right). Inflorescence of *A. dransfieldii* with male flowers beginning to open (Photos: K.M. Wong).

subtending branches and rachillae; rachillae short, 8–15 cm long, slender, slightly flexuous, bearing spirally arranged clusters of 2 or 3 flowers at the base, to sub-distichously arranged flowers or pairs of flowers distally; floral bracteole very small, 2–3 mm long, 3–4 mm wide, rounded, margin entire. *Staminate flowers* bullet-shaped in bud, maturing before the pistillate flowers; sepals 3, when fresh 3.5–4.5 mm long, 4.5–5.5 mm wide, imbricate, rounded, $\pm$ hooded; petals 3, symmetrical, valvate, when fresh 8.5–10 mm long, more than twice as long as the sepals, 4.5–5.5 mm wide, hooded; stamens numerous, 25–35, filaments awl-shaped, 4.5–5 mm long (fresh material), slender, not inflexed apically, anthers linear, 4.5–5.5 mm long (fresh material), dorsifixed, the bases deeply sagittate, bifid or acute apically, dehiscence latrorse; pistillode attenuate from a bulbous base, as long as the stamens, bifid or trifid apically. *Pistillate flowers* (Figs. 8 & 9) ovoid; sepals 3, when fresh 4.5–6 mm long, 6.5–8 mm wide, distinct, thick, imbricate, margins entire with occasional slight tears; petals 3, distinct, broadly imbricate, when fresh 8–9 mm long, less than twice as long as the sepals, 6–7.5 mm wide, apices shortly valvate, margins notched; staminodes 6, tooth-like, variously connate;

gynoecium ovoid, when fresh 9.5–11 mm long, 7–8 mm wide, unilocular, uniovulate, style thick, stigmas 2 or 3, sessile, recurved at anthesis. *Fruit* ovoid, beaked, when dry 25–30 mm long, 14–18 mm diameter, red at maturity (Fig. 10), perianth whorls persistent, dry sepals 3–4 mm long, 6–7.5 mm wide, dry petals 5.5–7 mm long, 10–12 mm wide, only slightly convex to spreading, stigmatic remains apical; epicarp thin, sometimes appearing minutely pebbled when dry, mesocarp yellowish, fibrous when dry (thin-fleshy when fresh), endocarp thin, with a glossy inner surface, fragile. *Seed* ovoid, truncate basally, pointed apically, 15–17 mm long, 13–14 mm in diameter at the widest part, attached laterally, hilum elongate, raphe branches irregularly vein-like and descending from the apex and sides, simple, forked, or branched and much anastomosed, endosperm ruminant; embryo basal. *Germination* adjacent-ligular; eophyll bifid, each lobe to 12–18 cm long, 2–2.8 cm wide.

Adonidia dransfieldii is altogether a more elegant palm compared with *A. merrillii*. It has a uniformly slender stem arising from a 10–20 cm broad base. *Adonidia merrillii*, on the other hand, has a more robust stem, which very often tapers from the base right up to over a



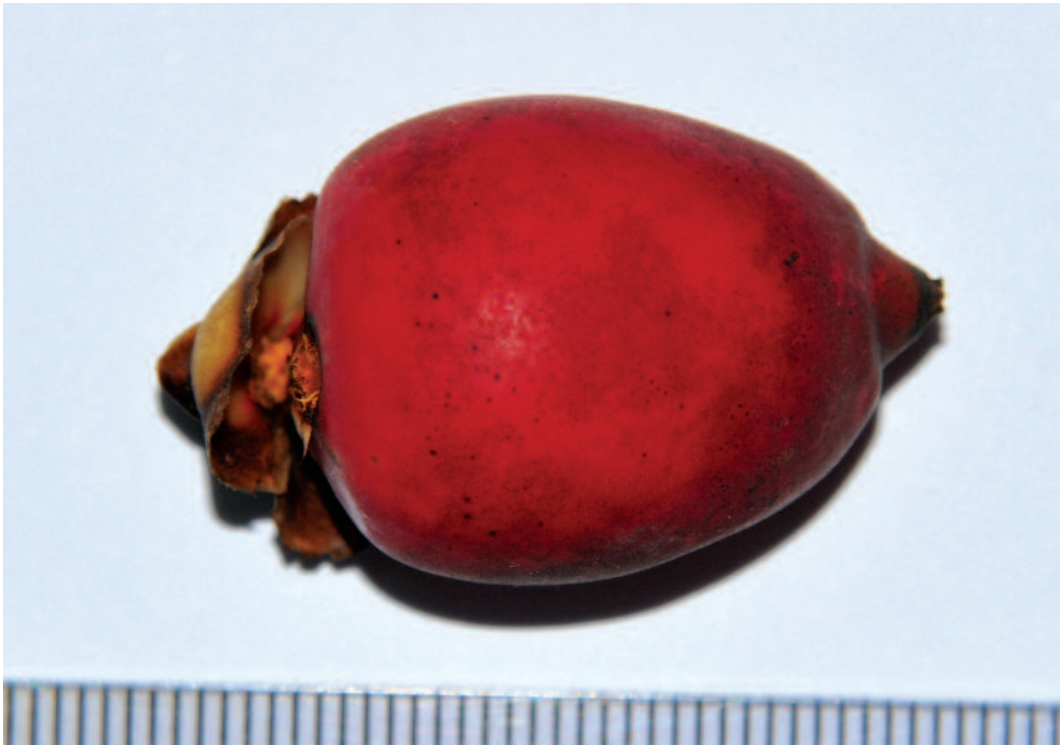
6 (top). Open male flowers of *Adonidia dransfieldii*. 7 (bottom). *Adonidia dransfieldii* inflorescence with male flowers opening, January 2014. (Photos: K.M. Wong).



8 (top). *Adonidia dransfieldii* inflorescence with female flowers, February 2014. 9 (bottom). Female flowers of *Adonidia dransfieldii*. (Photos: J.B. Sugau).

meter high and even noticeably to the crownshaft in younger palms. This attribute, together with the laxer leaf arrangement, more attenuated leaflet tips, and more erect inflorescences, make the palm quite distinctive (Fig. 11).

Other material seen. Malaysian Borneo, Sabah, Sandakan, Forest Research Centre, Herbarium compound, cultivated from material from a coastal village on the west Sabah coast, 6 May 2005, *John & Diwol* SAN 144735 (KEP, SAN).



10. A ripened fruit of *Adonidia dransfieldii* (Photo: Ubaldus Majawal).

Observations on *Adonidia merrillii* were made on cultivated palms in Singapore Botanic Gardens and in cultivation in Kuala Lumpur.

Distribution and conservation status. *Adonidia dransfieldii* was discovered by scientists from the Forest Research Centre in 1998 from a single wild population of 14 individuals near a village along the west coast of Sabah in northern Borneo. As that part of the coastline is heavily impacted by development and settlement, and botanical collecting has so far not turned in further records, it appears that this palm is not at all common in the wild. The IUCN conservation status assessed using GeoCAT (Bachman et al. 2011) categorized *Adonidia dransfieldii* as Critically Endangered (IUCN 2001), with the designation B2ab(iii). The 'B2' designation results from an area of occupancy estimated to be less than 10 km² (only 4 km² for *Adonidia dransfieldii*); 'a' is due to the fact that *Adonidia dransfieldii* is at the moment known to exist in only a single location; and 'b(iii)' considers the likelihood of continuing decline of the quality of the habitat. The west coast region of Sabah has seen much human alteration of the landscape, and rather special conservation action would need to be taken to protect the remaining population.

Fruiting habit and ornamental value. The ten cultivated palms at the Forest Research Centre at Sepilok (Fig. 11), Sandakan in Sabah were raised from seed in 1998 and have been flowering and fruiting for a number of years now. Our latest observations were of fruits produced in August 2013 (Fig. 12), followed by flowering again in late January (male flowers) that lasted until early February 2014 (female flowers). This annual flowering and seeding will assure of a convenient and dependable future supply for both conservation and ornamental plantings.

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11. Planted *Adonidia dransfieldii* palms in front of the Sandakan Herbarium building at Sepilok, Sandakan, Sabah (Photo: Ubaldus Majawal).



12. Infructescence of *Adonidia dransfieldii* (Photo: Ubaldus Majawal).

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A 19th Century Endocarp of the Chilean Wine Palm (*Jubaea chilensis*) in the Netherlands

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1. Fruit fragment (endocarp) of the Chilean wine palm (*Jubaea chilensis*) from Vlissingen, The Netherlands (left) and a modern fragment (right). Photo by Dirk Fennema.



Archaeobotanical research, an important branch of archaeology focusing on the relationship between humans and plants in the past through botanical remains, can contribute greatly to understanding large routes of former trade connections, especially in the trans-Atlantic trade.

In 2010, during excavations in the old town center and near the old harbor entrance of Vlissingen (province of Zeeland, the Netherlands), a city that flourished during the 17th century (Silkens 2008), archaeobotanical remains revealed details about the former food

economy, including the social status of its former inhabitants. Archaeobotanical samples, dated from the 16th to the 20th century, were taken from cesspits and wells. Cesspits and wells usually contain a high concentration of well-preserved plant remains, making it

possible to identify them to the species level. Most of the plant remains from Vlissingen were made up of common food crops along with a large number of native wild plant species. However, one of the samples that was taken from a cesspit contained a fruit fragment of an exceptional species: the Chilean wine palm (*Jubaea chilensis* (Molina) Baillon; Fig. 1). As far as we know, this is the first archaeological evidence of the presence of *Jubaea chilensis* in Europe.

Archaeological context of the find

The endocarp of *Jubaea chilensis* was found in a probably private cesspit (Fig. 2). It is difficult to interpret the social status of the former users solely with botanical remains. In the same sample, an almond (*Prunus dulcis*) – quite uncommon for this century – was found, and in general a varied range of exotic food (pomegranate (*Punica granatum*), rice (*Oryza sativa*), etc.) were part of the sample. However, this is not very surprising, since the cesspit is located in a neighborhood near the harbor of Vlissingen, a place through which overseas products passed constantly.

In addition to several meals (including skeletal remains of sheep, rabbit, fish and several shell fragments), objects made of glass such as drinking glasses and several types of bottles (18th–19th century), remains of clay smoking pipes and ceramic objects (both 18th century) were found in the cesspit (pers. comm. Archeodienst BV.). Using archaeological objects with a limited and known appearance in time, in the same layer, the Chilean wine palm endocarp was dated.

Geographical distribution

The monotypic palm *Jubaea chilensis* is endemic to Central Chile, being one of the southernmost palms of the world (Chester 2008). The palm originally grew in a relatively restricted area at the Andean foothills in dry river valleys or open hillsides in seasonally dry regions with a Mediterranean climate and at low elevations (Henderson 1995). *Jubaea chilensis* is a tall palm. The tree can reach a height of 25 m and has a massive trunk, hence its qualification as the “Incredible Hulk” of the palm world (Fig. 3). Several names are given to *Jubaea chilensis* including *kan-kán*, *coquito* and pygmy coconut palm (Chester 2008).

At the time that the *Jubaea* fruits were shipped to Vlissingen, there was a considerable population of *Jubaea chilensis* in Central Chile.



2: A section photo of an archaeological cesspit containing a 19th century *Jubaea chilensis* fruit, Vlissingen (Netherlands). Length ranging pole: 2.00 m. Photo by ARC BV and made available by Archeodienst BV.

Today, the tree is endangered due to its extreme exploitation particularly for two products that can be obtained from the tree and because of its rather small populations in a restricted area. From the 20th century onwards, this area became protected and the harvest came under the management of the Campana National Park (Gonzales et al. 2009).

We do not know the exact source of origin of the archaeological palm fruit. Nevertheless, as the current geographical distribution of *Jubaea chilensis* is confined to an area ranging from the South of the Limari river (IV Region) to the areas surrounding Curicó (VII Region) along the coast of Chile (Gonzales et al. 2009), the provenance options are limited (Fig. 4). The region around Coquimbo (IV Region) is an important area for the cultivation and harvest of these trees. In addition the area of Valparaíso (V Region) was and still is, populated with the palm. The fact that the major harbor of Valparaíso is located within this region, makes this city a probable place of origin and export of the 19th century *coquito*.

Nevertheless, *Jubaea chilensis* has also been cultivated, though on a smaller scale, in 19th century Europe. For example in the south of



3. *Jubaea chilensis* in the protected Parque Nacional La Campana, Chile. Photo by Scott Zona.

France, at the Côte d'Azur, *Jubaea chilensis* was planted as a beautifying feature and flowered and fruited in the late 1800s. Afterwards, these *Jubaea chilensis* became a seed source for additional plantings along the Côte d'Azur (Zona 2011). Even elsewhere in Europe, planted *Jubaea chilensis* trees, including those in botanical gardens in the Netherlands (Amsterdam, Leiden, Utrecht and Rotterdam; Zona 2011) could have fruited.

Exploitation

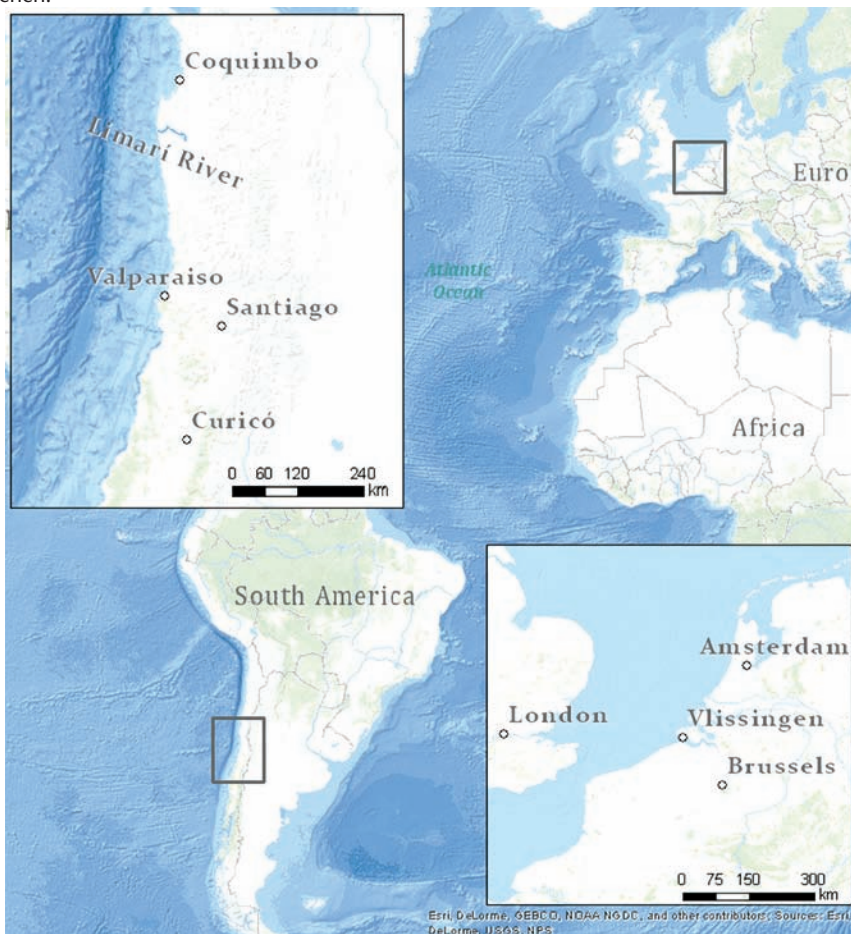
Several products can be obtained from the tree; *miel de palma* or palm honey has been boiled from the juice of palm for about two centuries (Gonzales et al. 2009). From each tree, 400 liters of juice can be tapped, which can be converted into 90 kilograms of sugar concentrate. The juice can also be fermented into palm wine (Haynes & McLaughlin 2000). In addition, the leaves are harvested and used to make baskets (Royal Botanical Gardens Kew

cited by Wildscreen ARKive 2014). Finally, the fruits, now mostly labelled as *coquitos*, have been harvested for centuries to sell as a snack or nut. Today *coquitos* are offered for sale in specialized shops in Europe and on the internet (Fig. 5). Evidence of the importation and consumption of the palm syrup or *miel de palma* is difficult to obtain in the archaeological record as liquids can only be detected through residue analysis (Evershed et al. 1999).

Commercial export of the *Jubaea* fruit

According to Bahre (1979), *coquitos* were important trade products during the Colonial Period in Chile (1536–1818). Besides products such as chinchilla skins, butter, tallow, quartz, olives, wine, wool, hides, beer, goats, cheese, dried fruit, chilies, barley, flour, potatoes, medicinal plants and several metals, Chile also exported *coquitos*. When Chile declared independence from Spain in 1810, it opened

4. Plausible provenance in Chile and place of discovery in Vlissingen (the Netherlands). Map composed by T.H.W. Trienen.





5. A package of recently sold seeds of *Jubaea chilensis* (Neef et al. 2012).

its doors to foreign capital, technology and markets. At this point, merchants came from all over the world to Chile for agricultural products. There is a chance that the archaeological *coquito* dates from the early 19th century Colonial Period, but more likely it dates from the following period. In the late 19th century, this fruit became very popular as a food. Trade statistics from 1898 showed that Chile exported 220 tons of palm nuts to countries such as Great Britain, Peru, France, Ecuador, Colombia and Argentina (Bahre 1979).

Other palm finds in the Netherlands

In 2008, archaeobotanists unearthed fragments of a 17th-century coconut (*Cocos nucifera*) at Vlissingen. The find of this palm species in Vlissingen has been named “a silent witness of trade with tropical areas” (De Roller 2003). From its fruit, consisting of a fibrous husk surrounding a hard stony endocarp that encloses a large, oily seed, a variety of products were produced including oil, soap, fiber and pig feed (Nederlands Instituut voor Beeld en Geluid 1947). Well before the 19th century, coconuts were imported from Suriname (Dutch Guyana), which was a colony of the

Netherlands at that time. The occurrence of coconut in an archaeological context was extraordinary, but already well-known in Europe, and it is the only palm species reported from multiple archaeological sites in the Netherlands (Rijkelijkhuizen & Van Wijngaarden-Bakker 2006). Direct evidence of the trade of palm fruits comes from 17th century shipwrecks along the Dutch coast, where fruits of the piassava palm (*Attalea funifera*) were found. The final palm group that is known from historical context only, are those that produce the so-called “vegetable ivory”, or tagua (Rijkelijkhuizen & Van Wijngaarden-Bakker 2006). Buttons are known to have been made from this material in the 19th century, but these have not yet been found (or recognized) archaeologically. Three palm taxa have been found in archaeological contexts, being *Attalea funifera*, *Cocos nucifera*, and *Phoenix dactylifera*. *Jubaea chilensis* can now be added to this list. Both historical and archaeological evidence suggest that palm species should primarily be expected in post-medieval deposits. A general lack of interest in this (in archaeological terms) late period may be part of the reason that few palm remains have been recognized. *Phoenix dactylifera* is the only palm species recorded from much earlier time, not surprisingly being the Roman period. The Roman finds of this palm, however, are restricted to a single site, being a temple complex, which might be seen as an indication for the luxury and extraordinary character of this species in this period (Hänninen & Vermeeren 1997).

Jubaea chilensis and Vlissingen

If there was importation of *Jubaea* fruits in the 19th century on a regular basis, they probably entered the transit harbor of Vlissingen, through a trading route from Valparaíso to one of the European harbors, where the fruits could have been distributed to other European harbors and cities. However, one fruit cannot be evidence for intercontinental trade, though real archaeobotanical evidence for European – conscious or unconscious – importation of (parts of) *Jubaea chilensis*. It could have been a failed attempt at growing the palm or a curiosity from an individual traveler or merchant, but why would this end up in a cesspit? What provenance it may be, due to its very limited natural distribution and the level of intercontinental trade connections in the 19th century, the archaeological *coquito* in Vlissingen is considered as truly extraordinary.

Acknowledgments

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Red Palm Weevils – Food or Foe?

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1. Red palm weevil color morphs.

In October 2010, what was thought to be red palm weevil, *Rhynchophorus ferrugineus*, was discovered inside a dying Canary Island date palm in Laguna Beach, California, USA. This was the first record of this highly invasive palm pest in the USA. Subsequent work indicated that the weevil was actually *Rhynchophorus vulneratus* and that the invading population likely originated from Indonesia, possibly from around Bali. How this weevil made its way to the relatively isolated community of Laguna Beach is largely a matter of speculation. Here I suggest that *Rhynchophorus vulneratus* was deliberately introduced in an attempt to satisfy demand for a traditional food that is eaten in some regions of Southeast Asia.

Red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae), is a notorious palm pest that has been particularly devastating where it has established in areas outside of its native range. Native to Southeast

Asia, this large and very attractive looking weevil, is a well-recognized menace of coconut palms in its home range. International trade in live palms resulted in the accidental exportation of this pest from its native range,

which resulted in its inadvertent introduction into the Middle East in the 1980s. From here it was again unintentionally redistributed via movement of infested live palms into the Mediterranean and the Caribbean (Faleiro 2006, Longo et al. 2011, Murphy & Briscoe 1999). The impact of this weevil in invaded areas has been particularly severe on date palms, *Phoenix dactylifera*, and Canary Island date palms, *P. canariensis*. To a lesser extent other palm species are attacked in invaded areas probably because they are not as highly preferred (Longo et al. 2011).

Red palm weevil was officially detected in Laguna Beach, Orange County, California USA in October 2010 when an adult was recovered from a heavily damaged Canary Island date palm in a private garden (Hoddle 2010). There were several very curious things about this find. First, Laguna Beach is a small (ca. 23,000 inhabitants), somewhat secluded, wealthy residential area that, as its name would suggest, is nestled between the Pacific Ocean on the west and the very dry and relatively undeveloped and uninhabited San Joaquin

Hills to the east. There are few roads in and out of Laguna Beach, there are no airports, seaports or interstate border crossings, which are important infrastructure assets often correlated with invasion likelihood. However, tourism, another indicator of invasion vulnerability, is high in Laguna Beach, with ca. 3 million people visiting the community annually. There was no evidence around invaded areas of large new plantings of ornamental palms, and live palm tree imports into the USA had been banned by the USDA specifically to prevent entry by red palm weevil. Collectively, these characteristics made Laguna Beach a highly unlikely incursion point for red palm weevil into the continental USA. Experts predicted that the likely point of entry and initial area of establishment by red palm weevil would be Florida, with invading populations originating from infested Caribbean Islands. The second thing that was odd about the red palm weevil invasion in Laguna Beach was the color morph of the weevil that was detected; it was black with a red stripe on the thorax. The color morph of the global invader is predominantly orange

2. Red palm weevil larvae (and pupae) may be eaten deep fried. Sometimes larvae are eaten alive after marinating (i.e., swimming!) in soy sauce.





3. Farm-fresh red palm weevil larvae stir fried with a traditional sauce of Thai herbs and spices – an excellent accompaniment to steamed rice.

with black markings, and this color form of the weevil was expected to be found in the USA should a successful incursion occur (Fig. 1). The red and black morph (now known as *Rhynchophorus vulneratus*) had not been previously collected outside of its native range (also Southeast Asia), and both color morphs were considered to be color variants of the same species, *R. ferrugineus* (Hallett et al. 2004). Three major research questions needed to be answered following the red palm weevil invasion in Laguna Beach: (1) was this red and black weevil really *R. ferrugineus* as suggested by Hallett et al (2004) or was it *R. vulneratus*, which Hallett et al. (2004) synonymized with *R. ferrugineus*? (2) Where did the invading population in Laguna Beach originate? and (3) how was this weevil introduced into southern California?

To determine the taxonomic identity of the black and red color morph in California (question 1), extensive collecting was done throughout the native range of the red palm weevil, and colleagues in Europe, the Middle East, and North Africa graciously provided samples of invasive red palm weevils from a variety of different countries. These samples

were subjected to two forms of analysis, (1) morphological measurements, similar to those used by Wattanapongsiri (1966), and (2) molecular analyses of the mitochondrial cytochrome oxidase subunit I (COI) gene and additional nuclear gene regions from sampled populations throughout the native and invaded ranges.

Statistical analyses of key morphological features failed to provide evidence to identify populations or species collected from different areas. The DNA analyses on the other hand were extremely informative. Analyses of COI haplotype data provide conclusive support, corroborated by analyses of nuclear gene sequences, for the existence of at least two predominantly allopatric species of palm weevil in the native range. The true *R. ferrugineus* is native only to the northern and western parts of continental Southeast Asia, Sri Lanka and the Philippines and is the culprit in almost all invasive populations worldwide. In contrast, the second species, which has been resurrected under the name *R. vulneratus*, has a more southern distribution across Indonesia and is responsible for only one invasive population, that in California, USA (Rugman-



4. Harvesting red palm weevil first requires locating a coconut palm exhibiting signs of infestation.

Jones et al. 2013). These two species, given their current geographic distributions may have evolved from a common ancestor after the splitting of the Isthmus of Kra in Thailand by ancient seaways.

Another interesting result from these studies pertains to the taxonomic work by Hallett et al. (2004) in which *Rhynchophorus ferrugineus* and *R. vulneratus* were synonymized. In these studies, which were conducted in Java,



5. Harvesting red palm weevil requires felling and dissecting the trunk with a chain saw.

Indonesia, Hallett et al. (2004) correctly determined that they were working on just one species, despite pronounced color variations, as their test weevils mated, produced offspring, were sympatric in infested coconut palms and responded to the same aggregation pheromone. DNA analyses showed no differences to imply different species were being studied. The problem with this work was that Hallett et al. (2004) were actually studying *R. vulneratus*, not *R. ferrugineus* (which is not present in Indonesia) as they assumed, and their recommended synonymy was incorrect.

A further issue that arises from this error pertains to the aggregation pheromone that is available commercially and used to monitor and, in some instances, help control invasive *Rhynchophorus ferrugineus* populations (Hoddle et al. 2013). The pheromone was actually derived from *R. vulneratus* and not *R. ferrugineus* (Hallett et al. 1993). The identity of the aggregation pheromone for *R. ferrugineus* is currently unknown, and its identification could possibly improve detection, monitoring and control programs for this pest, assuming it is different to the pheromone produced by *R. vulneratus*.

The DNA analyses conducted by Rugman-Jones et al. (2013) also helped to answer the second question pertaining to the potential geographic area of origin for the *R. vulneratus* population that was detected in Laguna Beach. Results of molecular studies indicated that the California population is of Indonesian origin, and specimens collected from Bali, an island that lies to the east of Java, most closely (but not exactly) match weevils collected in Laguna Beach.

If *Rhynchophorus vulneratus* in California originated from Bali or an island close by (e.g., Lombok which lies to the east of Bali), how did it arrive in Laguna Beach? The possible answer to this third question presented itself somewhat unexpectedly while my colleagues and I were collecting weevils in Indonesia and Thailand and our hosts informed us that larvae and pupae are considered by some to be culinary delicacies (Figs. 2 & 3)!

A video, with commentary, showing the eating of these cooked weevil larvae in Sumatra Indonesia is available (www.youtube.com/watch?v=-8m__ijKqNI). To find larvae in



6. Extracting larvae from the infested trunk.

nature is time consuming, as it means doing one of two things: (1) cutting down infested coconut palms and dissecting them with a chainsaw to access the larvae living within the apex of the trunk (Figs. 4–7), or (2) deliberately felling sago palms (*Metroxylon sagu*) to promote weevil colonization, after which larvae can be

reliably harvested for several months (see video https://www.youtube.com/watch?v=aL8nAzTTY_M). Unfortunately when I made the title for this video I misidentified the palm from which weevil larvae were being extracted as a nipah palm, *Nypa fruticans*, when it was actually *M. sagu*.



7. Larvae are stored temporarily until they can be cooked.

An alternative and much more efficient approach is to farm red palm weevil. This is a commercial enterprise in Thailand (see this video from Thailand – even though it is in Thai it is still fascinating and basically self-explanatory www.youtube.com/watch?v=mmTOXLwJELI).

Red palm weevil farms (Fig. 8), are as the name suggests, places where weevils are commercially mass reared (interestingly, commercially farmed insects are sometimes referred to as “micro-livestock.”) Red palm weevil larvae are ideally suited to farming in closed plastic containers – after all this is pretty much how they live inside an infested palm trunk, which is in reality a large rearing container! The farming process is relatively straight-forward; coconut palm fronds are ground up using a mechanical grinder, and this “saw dust” is then soaked in water. Excess water is squeezed out to make a palm mash and amended with pellets of pig food (I suspect these may provide a necessary protein supplement). The amended palm mash is packed into large plastic

containers (Fig. 9) and adult weevils are added and left to oviposit (slabs of palm wood and bark are placed on top of the packed palm mash to provide shelter for the adult weevils and to later provide palm fibers for larvae to spin cocoons). An alternative approach is to inoculate palm trunk “cookies,” which are essentially cut disks of palm trunk that are stood vertically and inoculated with adult palm weevils – which surprisingly do not abandon these uncaged logs as long as slabs of palm wood are placed on top of the log for shelter (Fig. 10). Adults lay eggs, which hatch, and the tiny grubs burrow into the logs. They are later harvested as they approach the pre-pupal stage (Hoddle 2013a).

The really neat thing about these farming practices is that the “waste” products are very useful and can be sold as well. For example, waste water which drips from plastic containers can be harvested and sold as fertilizer. The mash from which weevil larvae are extracted can be sold as a soil amendment, and the hollowed out palm trunks can be sold



8. A roadside sign advertising red palm weevil larvae for sale in Thailand.

as containers for growing plants! It is not surprising therefore that the FAO is promoting insect farming as a cheap and efficient alternative to rearing pigs, cows and goats for protein (van Huis et al. 2013).

So this brings us to our conclusion and the answer to research question 3 – how did *R. vulneratus* arrive in Laguna Beach? One hypothesis (for which there is no evidence!) is that this pest was deliberately introduced for food so it could be harvested locally without the need for smuggling through customs at airports. Live red palm weevil larvae, as a traditional food item, are impossible to source commercially in southern California. For certain ethnic groups in and around the Laguna Beach area, palm weevil larvae may have high cultural significance, as they are an important food for family gatherings, festivities and some religious observances. At one weevil farm in Thailand, we were told by a customer that cooked larvae are a traditional monthly treat for his family, and for this, he was willing to pay more per kilo than chicken or fish at the local supermarket. Humans are notorious for introducing desirable food items into areas where they do not exist naturally; smuggling of fruit, for example, is a common problem. So

it is not too much of a stretch to imagine people smuggling food insects into new areas with the intent of establishing them as a local food source where they do not currently exist. California after all has a bewildering number of palms and a high diversity of palm species in urban and natural areas – some of which would be excellent hosts for red palm weevil.

So what is the status of the *Rhynchophorus vulneratus* incursion in Laguna Beach? In early 2015, monitoring programs failed to detect a single live adult weevil for three consecutive years. Enhanced trapping trials using cut date palm logs and aggregation pheromone, have failed to capture *R. vulneratus* (Hoddle 2012). There appears to be no problem with the commercially-available aggregation pheromone used in trapping trials, as it was shown to be very attractive to *R. vulneratus* in its home range, Sumatra, Indonesia (Hoddle, unpublished). It is highly likely that *R. vulneratus* has been eradicated from Laguna Beach as a result of swift actions by the California Department of Food and Agriculture, the USDA, Orange County Agricultural Commissioner's Office and the University of California. This rapid multi-agency response



9. A bowl of palm mash tipped out to show the developing larvae.

identified infested palm trees and treated them with contact and systemic insecticides (Hoddle 2011a & b). Later examination of treated palm trees that were felled and dissected failed to detect any evidence of *R. vulneratus* activity (Hoddle 2013b). If *R. vulneratus* is declared to

have been eradicated after three years of no detections this will be a significant achievement. However, California's palms are likely to come under assault from the South American palm weevil, *Rhynchophorus palmarum*, which is being detected with



10. Palm trunks being used to grow larvae at a red palm weevil farm in Thailand.

increasing frequency as it enters southern California from Mexico (Hoddle 2011c).

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Photo Feature



I was so excited to capture a photo of these Western Bluebirds (*Sialia mexicana*) feeding on *Washingtonia filifera* fruits in Borrego Springs, California. They hit the jackpot with these palm fruits, darting in to eat as many fruits as they could, as fast as they could. This photo was taken on December 2, 2012, as the birds were migrating. Stands of native palms, such as this one, are important “re-fueling” stops for migratory birds, as well as a reliable food source for winter residents. *Washingtonia filifera* seeds are dispersed by birds, including this species, the Mountain Bluebird and Cedar Waxwings; foxes and coyotes feast on fallen fruits and also disperse the seeds (see: Bullock, S.H. 1980. Dispersal of a desert palm by opportunistic frugivores. *Principes* 24: 29–32).

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The Oil Palm (*Elaeis guineensis*): Research Challenges Beyond Controversies

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Scientists certainly have a part to play in the debate over oil palm (*Elaeis guineensis* Jacq.) cultivation, which has captured and polarized public opinion, kindled and undoubtedly shaped by the media. How can this palm be viewed as a “miracle plant” by both the agro-food industry in the North and farmers in the tropical zone, but a serious ecological threat by non-governmental organizations (NGOs) campaigning for the environment or the rights of indigenous peoples? The time has come to move on from this biased and often irrational debate, which is rooted in topical issues of contemporary society in the North, such as junk food, biodiversity, energy policy and ethical consumption.

One of the reasons the public has developed such fixed ideas is that there has been a lack of accurate information on the sector and its actors and a clear-headed analysis of what is at stake. We point out that the production and processing of palm oil are part of a complex globalized agrom-industrial sector shared by multiple actors and stakeholders with often conflicting interests. For the first time ever, it is not a major technological innovation (such

as nuclear energy, genetically modified crops or shale gas) that is causing controversy but an entire agrom-food sector that has come to symbolize the conflict between the conservation of natural spaces and development. Consumers, elected representatives and scientists are finally forced to take sides for or against palm oil, with no room for ifs and buts, and very few of them are willing to switch positions.



2. Harvesting of oil palm fruits in North Sumatra, Indonesia. Old stands providing low oil yields and being more difficult to exploit are replaced by new plantations with improved cultivars with slower growth, better disease tolerance and higher oil yield.



3. The oil palm fruit.

highest yielding genetic trials currently underway in research institutes. Such yields place the oil palm at the head of industrial oil crops (Fig. 3).

The proportion of palm oil in worldwide production of vegetable oils has continued to grow over recent decades to reach the number one spot, ahead of soybean. Today, it accounts for over a third of the vegetable oil produced worldwide (Fig. 5).

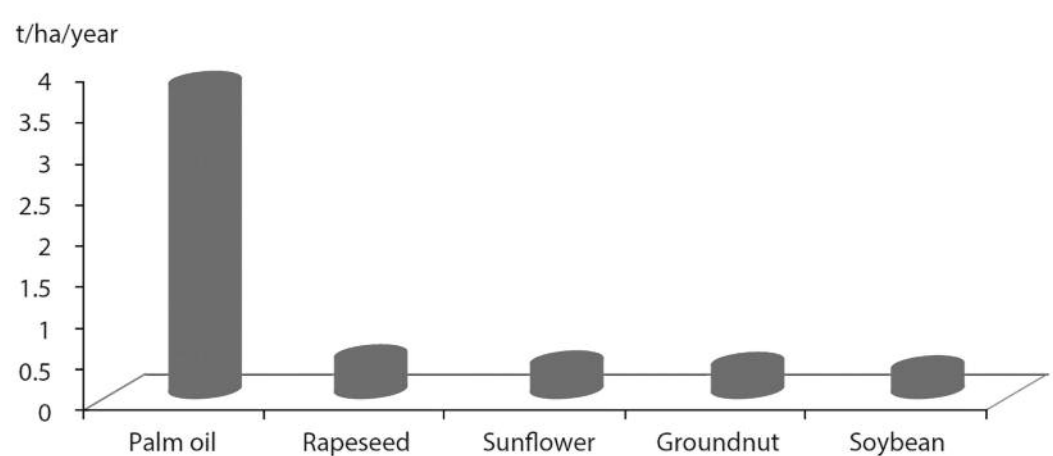
Although it occupies only 7% of agricultural land devoted to oil-producing plants (Caliman 2011), oil palm provides 39% of world's production of vegetable oil on a much lower proportion of this land than that devoted to soybean (61%), rapeseed (18%) and sunflower (14%). Palm oil also has the lowest production costs of all vegetable oils, 20% lower than soybean.

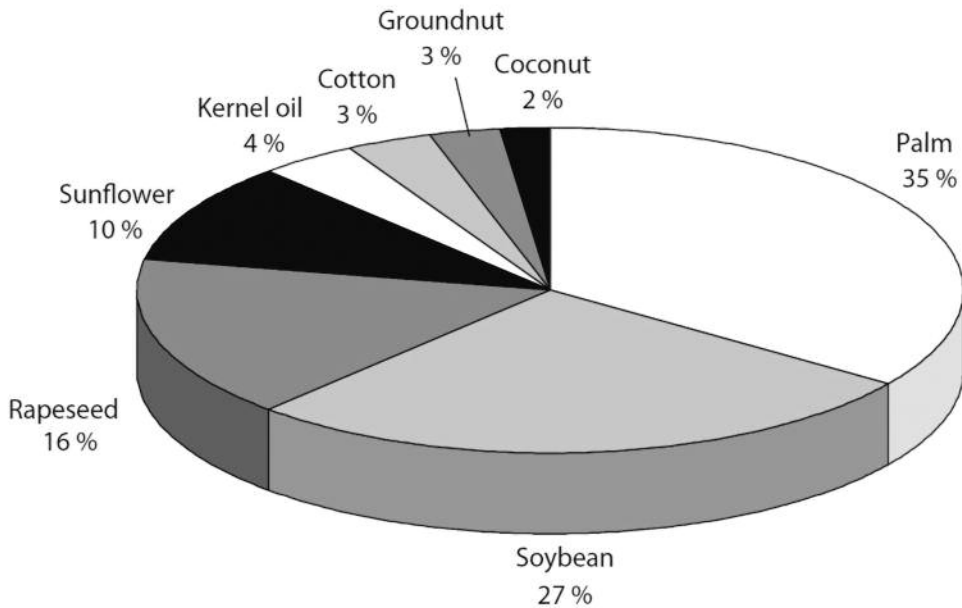
An exploited agronomic flexibility

Nearly 18 million hectares of land in tropical areas have been planted with oil palm.

Although it has been genetically improved since the 1940s (Cochard et al. 2005), oil palm remains a very hardy plant and is able to adapt to a very wide range of cultivation systems. These systems of cultivation range from family plots of a few hectares (or even less) to agrom-industrial estates covering several tens of thousands of hectares. Oil palm is a very resilient crop adapted to various agronomic contexts: oil yields vary according to the density of plantation and systems for irrigation, fertilization and intercropping. The stem (trunk) of the palm tree plays a vital part in this flexibility, enabling it to accumulate significant organic (carbohydrate) and mineral reserves (Legros et al. 2009). Thanks to such physiological plasticity, oil palms can survive an extended dry season, several years without fertilizer and competition from other oil palms or crops planted in proximity, such as maize, cassava or legumes. Almost 40% of the palm oil produced today comes from small farms. Globally, around 3 million smallholders are involved in the sector. In Indonesia alone it is

4. Comparative oil yields between major oil crops.





5. Share of palm oil in the global market (statistics from 2013).

estimated that 25 million people are now making a living – directly or indirectly – from oil palm cultivation (WWF 2011).

A versatile product

The fatty acid composition of palm oil gives it specific physiochemical properties that explain its successful adoption by processing companies in the North. In these countries its consistency at room temperature gives it a natural “melt in the mouth” characteristic, which means it can be used as a substitute for butter in many agri-food processing industries (patisserie, confectionery, savory snacks, ready-made dishes and frozen food). These technical and organoleptic properties can be obtained from oils extracted from temperate oil crops (rapeseed, soybean or sunflower), but such oils have to be artificially hydrogenated, which risks producing trans fatty acids (trans fats), which are legally banned or at least recognized as harmful. Palm oil responds well to the challenge to find alternative forms of fat with little or no trans fatty acids (FFAS 2012), which explains its success in the food industry.

Palm oil can replace most other vegetable oils and has a very wide range of uses in:

1. the agri-food industry (80% of palm oil usage): table oil, frying oil, margarines, fat for bakery products, patisserie and all types of food preparation, etc.

2. oleochemicals (19% of usage): cosmetics, soap production, lubricants and greases, candles, pharmaceutical products, leather, surfactants, agrochemicals, paint and lacquer, electronics, etc.

3. biodiesel (1% of usage).

The fragile coexistence with tropical forests

The biological requirements of oil palm limit its distribution to the wet tropics, where plantations must coexist with some of the planet's last biodiversity hotspots, namely the Congo Basin, the Amazon and Borneo (Fig. 6). Other major oil crops also have to coexist with fragile environments. Indeed, the cultivation of soybean (75% genetically modified), for example, has to overcome significant environmental constraints, particularly in Brazil where the area under cultivation has increased from 1.7 million to 21.7 million hectares within 40 years.

Oil palm and deforestation

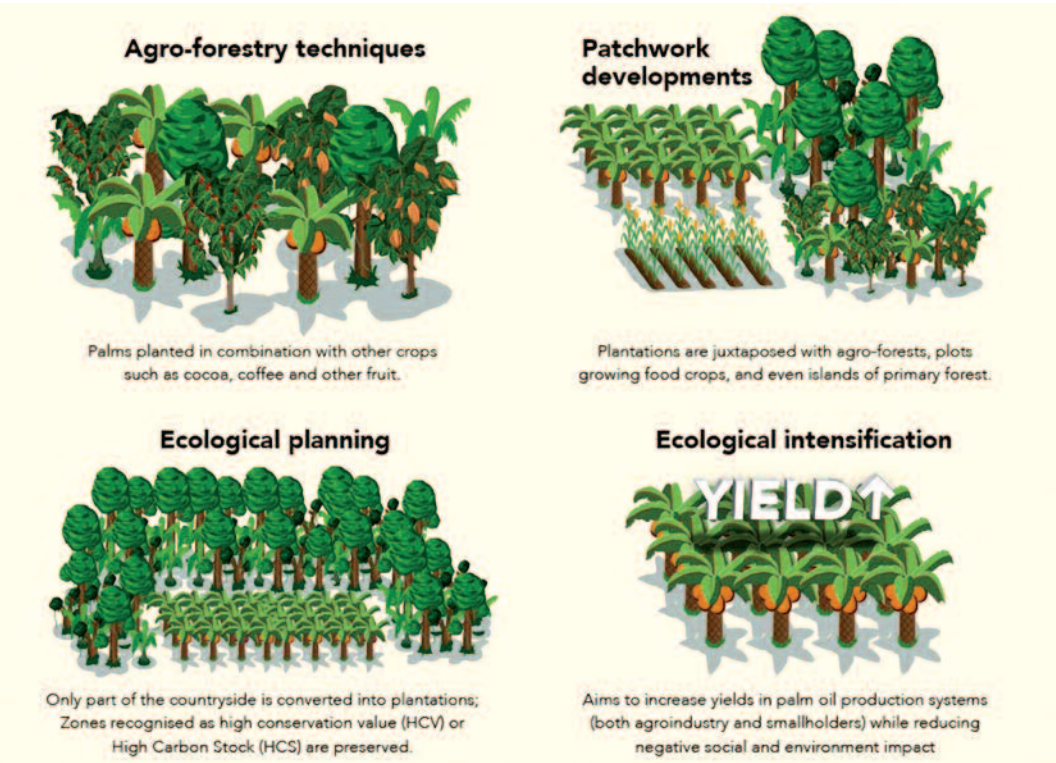
The relationship between palm plantations and deforestation is neither direct nor automatic. Concessions are granted by public authorities, often at local level, to forestry companies who extract timber. Degraded forests can become fallow land, savannah or farmed land, depending on what people do. Only a portion of deforested land is converted into palm plantations. Out of 21 million



6. Worldwide distribution of oil palm cultivation.

hectares of primary forest that disappeared in Indonesia between 1990 and 2005, no more than 3 million were developed as palm plantations. However, there are growing signs of a direct link in new frontier areas, such as Borneo, where nearly 30% of the primary forests felled have been planted with oil palm (Carlson et al. 2012). On average new plantations are responsible for 10% of the deforestation that has taken place in Indonesia and Malaysia (FAO 2010). These figures do not take into account the indirect causes of deforestation linked to activities that spring up following the introduction of plantations at the edge of forests; these activities are difficult to estimate but are far from negligible.

7. Schematic representation of oil palm production systems.



and degradation) in major producing countries such as Malaysia and Indonesia, the big Asian companies are tempted to diversify their production zones, and they now invest strongly in Africa (Hoyle & Levang 2012). Indonesia anticipates doubling its production between now and 2020, while West Africa and the Congo basin offer a new frontier: 650,000 hectares were at the planning stage in Liberia alone, although these figures are now revised downwards.

A recognized role in poverty eradication

From the beginning, oil palm is always viewed by local people as the best way out of underdevelopment and of gaining a toehold in the modern way of life. In isolated forest areas of Sumatra or Kalimantan in Indonesia, local people dream first and foremost about paved roads, electricity, water supply, mobile phone networks, schools and dispensaries, even international airports. Living in harmony with nature by hunting and gathering forest products, far removed from the stress of the modern commercial world is the dream of the affluent urban westerner and not that of the "noble savage." When the companies' door-to-door salesmen turn up, offering a high and regular source of income, salaried jobs and modern infrastructure, they are not forcing anyone's hand but are meeting a real demand. The terms of exchange may sometimes be unequal, but it should not be forgotten that land is abundant and cheap on the forest margins of the Indonesian archipelago. Loans, labor, selected seeds and agricultural inputs are, however, rare and expensive. If the forest people have any lingering doubts, the local government representatives and their village leaders can easily dispel them. Planting palm trees is a national project, and the few doubters are accused of being behind the times, of holding up progress or of being antisocial. If enough of them resist and if they know how to stay grouped, their lands will be excluded from the deal and treated as enclaves. Part of the land granted to the company will be handed over to transmigrants from Java or Bali, and these settlers will provide the labor that is lacking locally.

Once the deal has been struck the dream may take some time to come true. The work takes longer than expected. Between clearing and the official handing over of plantations years go by, and the cash made from giving up the land is just a distant memory. In the worst case scenario, the vision of a new life of luxury

just around the corner leads peasants to neglect preparation of their food crop plots. The early stage of production of the plantations is disappointing, yields are low and do not meet the family's needs. Often finding themselves in debt, these families have no choice but to sell off their plots of palms at a low price to their better-off neighbors or to migrants.

A few years later, when the palm trees enter into full production, the sellers have nothing left but the clothes they stand in. Their land capital has disappeared and their only option is to seek jobs as laborers at the company in order to survive. For those who know how to wait or have the means to do so the situation is different. Seven years after being planted, the oil palm enters the mature phase of production. Despite the 30% cut in price to repay the loan, the owners benefit from a steady source of income and have the security to allow themselves to contemplate the future with more serenity, put money aside to educate their children or even expand their land holding. When the start of the mature phase of the plantation coincides with high palm oil prices, as in 2008, some planters choose to accelerate the reimbursement of their debt, paying it off in as little as 6–8 years (Feintrenie et al. 2010).

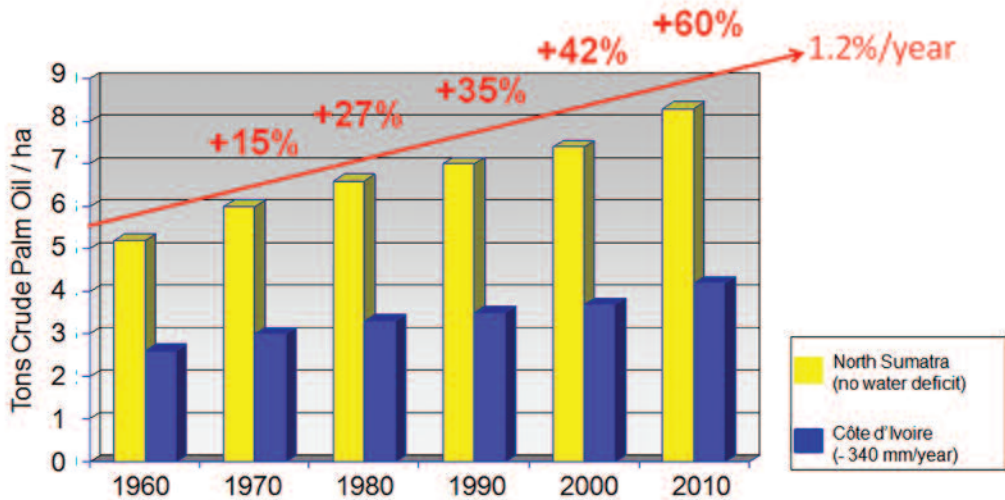
Oil palm is an opportunity for development offered to the local population as a whole but is something only a proportion of them will be able to take advantage of. The same would have applied to any other cash crop or new opportunity such as fish-farming or mining.

Designing smarter production systems

There are several ways in which oil palm plantations can be developed without destroying vast stretches of tropical forests in the process. These include agrom-forestry techniques, patchwork developments, landscape planning and ecological intensification (Fig. 7).

Agrom-forestry

Many researchers, both agronomists and socio-economists, won over by the sustainable nature of agrom-forests, have tried to preempt what appears to be an unavoidable progression sweeping through most tropical parts of the world (Rival & Levang 2014). To improve the economic profitability of the agrom-forests, agronomists are trialing viable associations of several economically attractive species. Such studies are still underway, but promising results



8. Impact of genetic improvement and best management practices on palm oil yields.

have apparently been obtained for associations of oil palms and cocoa plants planted in conjunction with a few lines of fruit trees.

The main problem is the strong shade produced by palm fronds, which does not help in companion planting and makes it necessary to reduce significantly the density of palms. However, even if research manages to develop economically viable associations, the biodiversity of these systems remains very low in comparison to primary forest. There is always the danger that economically profitable systems, even of the agrom-forest type, will induce local people to make more agricultural land out of the adjacent forest.

Patchwork developments

Patchwork developments are in some ways a reflection of change in areas that were formerly mainly agrom-forests. Here, diversity is neither deliberate nor managed. It simply reflects the range of socio-economic situations of the households found within it. Monospecific plantations are juxtaposed with agrom-forests (which are dotted through forest clearings of various ages), plots growing food crops, shrubby fallow land and even islands of primary forest. The countryside is constantly changing as shrubby fallow land becomes a food plot, the latter is then set aside, agrom-forest is replaced by a monospecific plantation and old plantations are invaded by wild species.

The cycle of slash and burn follows the lifecycle of the heads of household. Young people take jobs as laborers or tenant farmers

working with older farmers. Once married, they create their own plantations and enjoy the fruit of their investments when they retire. The wild fauna also benefits from this diversity in the landscape. A varied range of niches exists, from intensively cultivated food crops to set-aside land and former fallow land, although the fauna in question mainly comprises rodents, birds and reptiles of all sorts. There is barely enough space for large mammals such as tigers, rhinos, elephants and large primates.

Landscape planning

This model follows the idea of a patchwork effect but is more tightly organized and controlled. Here, the objective is not to preserve the forest as a whole but rather to limit the worst effects of conversion. Following where possible the RSPO (Roundtable on Sustainable Palm Oil) Principles and Criteria (see Fig. 7), landscape planning aims at preventing those zones recognized as of high conservation value (HCV) or of High Carbon Stock (HCS) from being converted. The same applies to riparian areas, hilltops and very steep slopes. Sacred grounds, cemeteries and places of worship or cultural significance are also preserved. As a result, only part of the countryside is converted into plantations. Great care is taken to connect the different conservation zones. Where necessary, agrom-forest zones serve as buffers between conservation and plantation zones. This model was recently tested in Malaysia and Indonesia by a few companies that are keen to improve their environment-friendly image. There is an

underlying economic motive: being awarded certification implies respect of the highest environmental standards, and both shareholders and investors are increasingly concerned about their corporate social responsibility. Unfortunately, there is a range of factors that serve to hinder the spread of this system of ecological planning. First and foremost, implementation requires a degree of technical knowledge that is still rarely available on the ground. It also entails a substantial additional outlay that is by no means made up for by the premiums provided by certification, and the financial and legal incentives are still too low for most companies and smallholders' cooperatives. The market dominated by emerging countries is more interested in cheap oil than "green" oil and the weak governance in most of the countries where the major companies are active tends not to respect legislation (when this exists at all).

Ecological intensification

Areas already planted with oil palm often fall well short of producing the expected oil yields (3.7 tons per hectare as a global average while selected plant material used in trials produces more than 10 tons per hectare under optimum ecological conditions). It is, therefore, important to optimize the production system of existing palm plantations while keeping the impact on people and the environment to a minimum (Caliman 2011).

Ecological intensification of productivity means first and foremost ensuring all planters – both smallholders and agrom-industrial estates – have access to selected and certified seeds, so more people can benefit from the latest genetic breakthroughs made by research. The adoption of improved seeds adds value at all stages of oil production and primary processing. Investing US\$1 in an oil palm seed originating from the best hybrids will provide an average income of US\$1300 by the end of its 20 years of exploitation.

Improved planting material provides the planter with higher yields in terms of bunches and optimizes labor (through easier harvesting of shorter palms). It helps the factory owner by offering better extraction rates and the refiner by increasing olein content. By providing better resistance to disease and making it possible to use the same land for several generations, genetic selection and the availability of selected hybrid seeds help reduce pressure on land, particularly since yields also rise. Genetic progress for the oil palm has been

measured at 1–1.5% per year (similar to maize) which makes a significant contribution to ecological intensification (Fig. 8).

However, this alone is not enough to meet increased needs for vegetable oil (increasing 3–4% per year) and for palm oil in particular (increasing 5–6%). Best agricultural practices should also be adopted to contribute to this intensification, which is designed to meet global demand without expanding the area under cultivation.

Ecological intensification also relies on the implementation of well-planned fertilizer application, both for economic reasons (fertilizers account for over 60% of the running costs of a palm plantation) and out of respect for people and the environment. Fertilizers made from petrochemical products or non-renewable mineral sources have a limited future. The challenge is therefore to optimize the use of fertilizers (mineral and organic) to ensure they provide maximum benefit to the plant through staggered and well-planned applications that avoid any surplus leaching into ground or surface water. These needs are assessed from mineral analysis of soil and leaf samples taken in the plantations. Analysis provides thresholds for fertilizer use depending on climate, plant physiology, soil type and the genetic origin and age of plantation. This type of science-based management is not exactly a new concept. It has developed in recent years with the growing awareness of the need to combine high yields with environmental protection.

Major headway is being made in composting organic waste and recycling palm oil mill effluents. Almost all the biomass and by-products generated in plantations and oil mills can be recycled and used as organic fertilizers. This includes the pruned fronds as well as empty bunches and liquid effluents from mills. This practice is now integrated into fertilization management plans, mainly in industrial plantations; inputs from inorganic fertilizer can be cut by at least 15%. Some of the recycled products improve not only fertility but also the texture of the soil and both under- and above-ground biodiversity (Carron et al. 2015). The combination of inorganic and organic fertilizer (derived from recycling or composting) is managed differently from plantation to plantation, according to the specific needs of the plot of land, as the application of organic fertilizer alone is not always sufficient to maintain soil fertility.

Lagoons for the decanting of liquid effluents produce methane – a gas with a strong greenhouse effect – and are now used to produce biogas around oil extraction plants. This is a way of harnessing the considerable energy potential of organic palm oil by-products (12 m³ of methane per ton of fruits extracted, 15 m³ of methane per m³ of liquid effluents). Each 1 m³ of biogas generated saves the equivalent of 0.56 liters of diesel. This practice is spreading rapidly in a large number of plantations, and new installations are now equipped at the time of construction for biodigestion of effluents and biogas capture. The transportation of this excess energy remains problematic because plantations and oil mills are often geographically very isolated from the distribution networks. Ironically, some plantations have to settle for burning their surplus biogas in flares. In Indonesia alone, at the level of 2012 palm oil production, the biodigestion of palm oil mill effluents can produce approx. 3.3 million MWh per year. This can reduce the use of diesel oil by 1.3 million kiloliter per year, which is around 4% of the annual diesel import volume, and thus can save US\$1–1.3 billion of foreign exchange reserves per annum.

The use of pesticides in oil palm cultivation is restricted to limited applications of herbicides in young plantations to control the growth of cover plants and to create paths for harvesting. In some areas, particularly in Southeast Asia, use of rat poison is common, although this is increasingly being replaced by the introduction of barn owls (*Tyto alba*), their natural predators.

The ecological intensification of oil palm cultivation comes up against the biological constraints of the plant, which make production difficult to mechanize. Palm oil has to be extracted promptly from the fruit to avoid losing its physical and chemical properties. This requires an efficient harvesting network, maintained infrastructure and reliable organization of the harvesting areas.

The transfer of innovation to smallholders remains one of the main challenges facing ecological intensification. If these planters can be organized into national projects or public and private sector associations, the transfer of innovation (selected seeds and best agricultural practices) is relatively easy and swift; the organizational structure offers the necessary credit facilities and technical and financial support. Independent planters who are not

The eight principles of RSPO certification

- 1. Commitment to transparency
- 2. Compliance with applicable laws and regulations
- 3. Commitment to long term economic and financial viability
- 4. Use of appropriate best practices by growers and millers
- 5. Environmental responsibility and conservation of natural resources and biodiversity
- 6. Responsible consideration of employees, and of individuals and communities affected by growers and mills
- 7. Responsible development of new plantings
- 8. Commitment to continuous improvement in key areas of activity

9. RSPO Principles and Criteria.

grouped together in cooperatives remain harder to reach, and therefore convince, in spite of the enormous gains in yield to be achieved.

Choosing a model for development

Smallholders or agrom-industries?

The choice of development model is therefore not a technical decision but a societal choice. There is no doubt that agrom-industries are often more efficient than family farming in terms of fruit and oil yield. Transaction costs are lower, and State involvement may be limited to granting easy terms to investors. In addition, in terms of duties and taxation, monitoring compliance with environmental rules (such as the Roundtable on Sustainable Palm Oil certification or pollution control) or social standards (workers' rights), it is always easier to deal with a small number of big estates than thousands of unorganized or poorly organized smallholders. But, in terms of social justice, job creation and reduction of poverty, there is also no doubt that family farming has proved itself.

The association of agrom-industrial estates and smallholders, following the model that has contributed to the success of the oil palm in Southeast Asia, would be beneficial in economic, social and environmental terms. Economically speaking, the involvement of a large number of smallholders creates more

jobs, both direct and indirect, and triggers an economic snowball effect that has a major impact on the reduction of rural poverty. The additional cost of involving smallholders (mainly transaction costs) is partly made up for by requiring smallholders to pay the cost of development through credit. On the social level, shared goals and development aid, rather than competition and the exclusion of smallholders, will boost social cohesion. Finally, on the environmental level, the development of plantations on land that has already been cleared by smallholders near villages and roads, means the equivalent area of primary forest is spared (Hoyle & Levang 2012).

Certifying sustainability

The Roundtable on Sustainable Palm Oil (RSPO) initiative

When it was launched in 2004, RSPO was a business-to-business initiative bringing together about 10 members, both private actors in the industry (such as Unilever) and NGOs (such as WWF). It was designed as an international, multi-stakeholder platform to certify and promote sustainable palm oil. In November 2005, eight principles and 39 criteria for certification were approved (Fig. 9), leading to certification of the first plantations in 2008. The first batch of Certified Sustainable Palm Oil (CSPO) was sold at the end of 2008.

Today, the Roundtable has reached 1800 members, divided into seven categories: growers, processors and traders, manufacturers, banks and investors, retailers, environmental/nature conservation NGOs and social/developmental NGOs. The Roundtable has various working groups through which it carries out, diversifies and enhances its activities. National or regional interpretation groups are responsible for integrating the certification principles and criteria into national legislation. There is still some way to go before they are adapted to the specific constraints of family farmers; the cost of certification and corrective action, estimated at US\$20–40 per hectare is often prohibitive for smallholders who are barely, if at all, organized into cooperative arrangements (WWF 2012a). Today, 3.1 million hectares of plantations are RSPO certified, that is about 18% of the global surface area planted (as compared to 106,000 hectares in 2008) and 11.2 million tons of certified sustainable palm oil as were produced in 2013 (620,000 tons in 2008).

Like a large number of multi-stakeholders initiatives devoted to the promotion and standardization of a sustainable product (Forest Stewardship Council, Marine Stewardship Council, Round Table on Responsible Soybean, BonSucro), the RSPO receives considerable criticism. It is based on the voluntary acceptance, by consensus of all members, of its principles and criteria and is therefore considered not rigorous enough and lacking in power (Laurance et al. 2010). The fact that RSPO certification is unable to protect the rights of indigenous people in terms of land rights, compensation for land annexation and respect for customary law has also been highlighted. As happened in the case of Forest Stewardship Council (FSC) certification for timber, the RSPO principles and criteria, which were designed to be consensual and universal, have become very difficult to apply and therefore of limited use in complex local contexts, such as in Indonesia, where land ownership conflicts are not settled by the Central Government but at the district level. This means that on one side we have a set of directives based on the logical approach of the North and on the other we have a local authority which may have little awareness of questions of sustainability, feels the pressure of development and is therefore in a precarious position. Negotiations are necessarily unbalanced, and the process of certification does not succeed in protecting the rights of indigenous people. This puts the credibility of the whole process of certification at stake and clearly raises question about the role of governments (McCarthy 2012). Ruyschaert and Salles (2014) recently questioned how effective RSPO is in attaining its claimed conservation goals, especially regarding orangutans. Their study described five shortcomings explaining the poor outcomes regarding the protection of the forest area, and especially the orangutan habitat: financial compensation too small, too much room for interpretation in the guidance document, postponement on contentious issues, non-integration of RSPO within the socio-political-legal Indonesian context and the lack of effective external control system. As these shortcomings complement each other, the authors found that effectiveness of the RSPO scheme was dramatically reduced for biodiversity conservation and that it was negligible for species such as Sumatran orangutan, which needs large areas of forested habitat.

Strengths and weaknesses of a voluntary international standard

Its detractors criticize the RSPO for the lack of participation by governments from the moment the Roundtable was set up. Ironically, it is the public authorities in each country that have the task of translating the RSPO Principles and Criteria into legislation in conformity with their respective constitutions. They are also responsible for applying these laws effectively in the field and of enforcing sanctions against offenders. It is all well and good to draft a highway code, but it is not worth the paper it is written on if there are no incorruptible policemen at the side of the road, responsible for ensuring that it is respected!

Finally, the market share of certified crops remains limited even if, as in the case of oil palm, it is growing rapidly. To date no more than 2.5% of world cane sugar is BonSucro certified, as compared to 16% of palm oil sold under the CSPO (Certified Sustainable Palm Oil) label. In the case of palm oil, the paradox lies in the fact that many processors and distributors in the North only committed themselves to using 100% CSPO certified oil by 2015, when they could have been doing it long before this virtual deadline because about half (48%) of the certified oil available on the market is not being bought up. The goodwill expressed by consumers is taking its time to bring about change in the supply chain of processors and distributors in the North.

There is no denying that the supply network is extremely complex. The first positive impact of certification has been to map and identify the networks of suppliers and intermediaries. There are many lessons to be learned from the recent work carried out by Nestlé and The Forest Trust in this area. In 2010, a campaign by Greenpeace which was very persuasive and visually violent compared a Kit-Kat chocolate bar with the bloody fingers of an orangutan, accusing Nestlé of destroying tropical forests and their biodiversity. Nestlé then entered into a partnership with a specialized NGO, The Forest Trust, which was to help it develop a completely sustainable supply chain. The partnership led to guidelines for sustainability (Responsible Sourcing Guidelines), which are specific to palm oil and establish the principle of traceability back to the plantation. A considerable amount of work has been done to map suppliers and intermediaries. The strategy is based on assessing the performance of suppliers in order to exclude those who

participate in deforestation, and on providing technical support to suppliers who wish to implement the sustainability guidelines. In February 2011, in collaboration with The Forest Trust, the Indonesian group Golden AgriResources, one of the main Nestlé suppliers and a target of Greenpeace, set up a forest conservation program designed to protect high conservation value forests and peat bogs.

In addition, some RSPO members make much of the confusion between the concept of affiliation, which is a form of voluntary adherence to the general principles of the Roundtable, and certification, which follows from a process that is standardized and validated by an independent certifying body and alone confers the right to use the registered trademark RSPO.

RSPO constantly revises its Principles and Criteria, which had become necessary to adapt to the specific constraints of smallholders. It became pressing to do more to involve stakeholders who were still under-represented, such as governments, importers and processors from the South (China, India, Pakistan), smallholders, universities and national and international research centers. An improved system of certification should also ensure that governments are given an important role. Because, when all is said and done, it is they who are in charge of legislating and applying the laws that convey the criteria of sustainability in each country (forest moratoria, compulsory standards, land concessions and community rights).

The recent emergence of national standards (Indonesian Sustainable Palm Oil and Malaysian Sustainable Palm Oil) is a sign of the successful appropriation of the idea of certification but also of the need to move on to compulsory national rules backed by an enforceable legal system instead of voluntary international ones.

The request for a credible certification system comes also from major investors such as the World Bank (Teoh 2010; WWF 2012b) or major banking groups, which are increasingly aware of the importance of ethical investments.

Beyond voluntary certification

Going further on the sustainability track

The Palm Oil Innovation Group (POIG) aims to demonstrate innovation in sustainable palm oil production through developing new models and paradigms for best practices in the

sector. The POIG currently consists of international NGOs along with several palm oil producing companies recognized as innovative leaders in socio-environmental issues. Current members include Agropalma, Daabon Organic, Forest Peoples Programme, GAR Agribusiness and Food, Greenpeace, New Britain Palm Oil Limited, Rainforest Action network and WWF. The group was initiated after the 2013 review of the RSPO Principles and Criteria, which POIG members believed could have been more innovative, especially on the issues of deforestation, carbon stocks, biodiversity and social relations. All of the POIG members are committed to improving the RSPO Principles and Criteria.

The Manifesto

Launched in July 2014, The Sustainable Palm Oil Manifesto is a commitment to achieve common objectives held by a group of growers, traders, processors and end-users who are key stakeholders in the palm oil industry, to ensure sustainability in the entire chain from cultivation to consumption. Signatories to the Manifesto are among the largest players in the palm oil industry, which include Asian Agri, IOI Corporation Berhad, Kuala Lumpur Kepong Berhad, Musim Mas Group, and Sime Darby Plantation, who together produce about 9% of the world's palm oil. Other signatories include global palm oil trader Apical and global agribusiness group Cargill. The Manifesto aims to build upon the signatories' existing sustainability commitments to the Roundtable on Sustainable Palm Oil's principles and criteria with three specific objectives:

1. To build traceable and transparent supply chains;
2. To accelerate the journey to no deforestation through the conservation of high carbon stock forests and the protection of peat areas regardless of depth; and
3. To increase the focus on driving beneficial economic change and to ensure a positive social impact on people and communities.

A key commitment in the Manifesto is the funding of a study to define further what constitutes High Carbon Stock (HCS) forests, and to establish HCS thresholds that take into account environmental, socio-economic and political factors, as well as other practical considerations in developing and emerging economies where oil palm is cultivated. The study is expected to take 12 months.

The signatories are firmly committed to, and are fully supportive of the RSPO and its Principles and Criteria. Signatories will continue to ensure that the palm oil produced, traded, processed and consumed are in line with RSPO standards. The RSPO is currently the only sustainability standard available in the global edible oil industry, making palm oil the only edible oil produced on a large scale that adheres to stringent social and environmental standards.

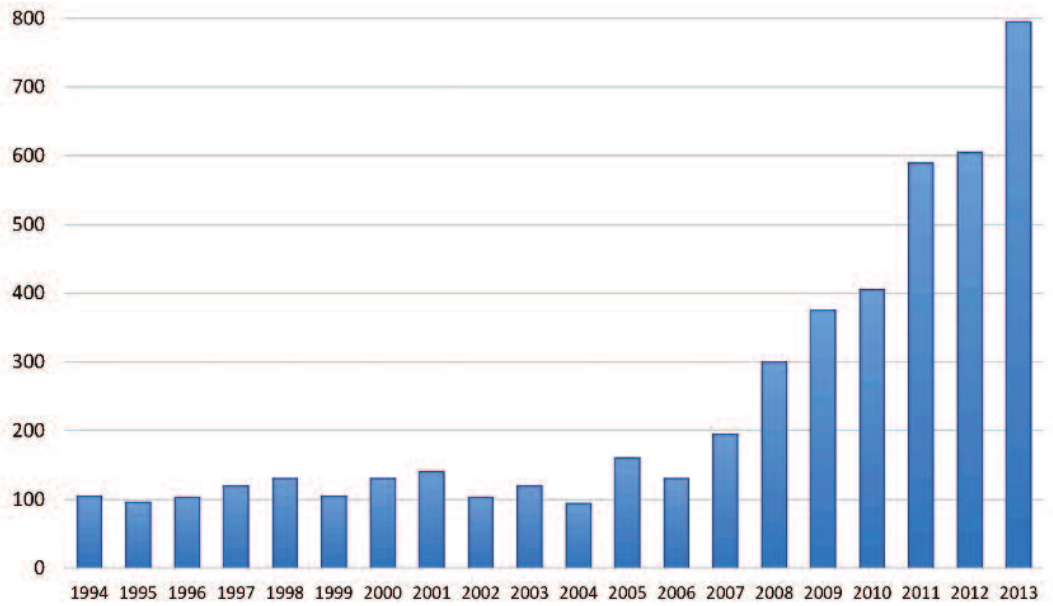
On the research agenda

Sayer et al. (2012) smartly defined the four oil palm truths: 1) the demand for palm oil will continue to increase in response to a growing and increasingly affluent global population; 2) oil palm is one of the most profitable land uses in the humid tropics; 3) oil palm plantations store more carbon than alternative agricultural land uses; 4) native biodiversity within oil palm plantations is far lower than the natural forests they often replace.

These four simple truths address multiple issues for researchers who are also in charge of providing a sound scientific basis for the legal certification schemes of sustainability that are under way. The public and the oil palm sector are both waiting for immediate, applicable, robust and credible results, and this creates unique opportunities for multidisciplinary and collaborative research initiatives. Over the last decade, several large-scale collaborative projects linking plantation companies, NGOs and academic institutions have finally got off the ground and started work on decoding the biological, agrom-ecological and social bases of sustainability in oil palm cultivation.

The High Carbon Stock (HCS) Study of the Sustainable Palm Oil Manifesto

This is a project linking Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) and the group of growers, traders, end users and key stakeholders in the palm oil industry committed to the Sustainable Palm Oil Manifesto. The study aims clearly to define what constitutes HCS forest, and establish HCS thresholds that take into account not only environmental concerns but also socio-economic and political factors in developing and emerging economies. The study aims to provide: 1) a definition of HCS forests that is based on potential greenhouse gas emissions from biomass and soils, as well as a practical method for identifying and delineating HCS



10. Changes in the number of published articles referring to oil palm (Web of Science).

forests on the ground; 2) suggested threshold values for greenhouse gas emissions from HCS forests, which take account of the regional socio-economic context in SE Asian and African countries where new oil palm developments are planned and 3) Guidance on how to accommodate the rights and livelihoods of local communities and indigenous peoples when implementing a future HCS approach to land use planning.

SENSOR (Socially and Environmentally Sustainable Oil Palm Research)

This project, coordinated in Southeast Asia by the Royal Society of London is aimed at developing a multidisciplinary approach to the validation and development of RSPO principles and criteria. The project brings together the European universities of York, Wageningen, Leeds, Lancaster and Swansea and tackles five major topics: water and soil, air quality and greenhouse gas, biodiversity, zones of high conservation value, and participatory rights and procedures and standard of living. Its main objectives are to build up confidence in CSPO palm oil amongst users, investors and the general public, guarantee that the efforts and investments put into sustainable practices are profitable and that these practices are recognized in the market and, finally, to protect the environment and society in the long term through rigorous evaluation and the development of practices capable of delivering proven results.

SAFE (Stability of Altered Forest Environment)

This project is being carried out on the island of Borneo over a period of 10 years (2010–2020), by the Royal Society of London and the Sime Darby Foundation, with a budget of €7.3 million. This is an ecological research project designed to quantify the impact of establishing oil palm plantations on the biodiversity of adjacent forests. It aims to identify situations that minimize impact on biodiversity and optimize ecosystem services. Research programs look at the diversity of flora and fauna, water and soil, the carbon cycle, nutrients and the microclimate in forest blocks of 1, 10 and 100 hectares, set aside within an oil palm plantation. The study zones are set up in new plantations, productive plantations, zones previously deforested and plots of primary forest.

BEFTA (Biodiversity and Ecosystem Function in Tropical Agriculture) Project

This aims at quantifying the effect of habitat complexity within oil palm plantations on biodiversity and experimentally test the role of this biodiversity in ecosystem functioning and productivity. Working in Indonesia with the oil palm industry (Sinar Mas Agrom Resources and Technology Corporation Research Institute – SMARTRI) and an international team of collaborative researchers led by the University of Cambridge, UK, the BEFTA project is experimentally manipulating the habitat

Useful Internet Sites

Biodiversity and Ecosystem Function in Tropical Agriculture (BEFTA) Project: <http://oilpalmbiodiversity.com/>

Forest Stewardship Council: www.fsc.org

Greenpalm: www.greenpalm.org

Manifesto High Carbon Stock Study: <http://www.carbonstockstudy.com/Home>

Palm Indicators Network PalmiNet: <http://community.plantnet-project.org/pg/groups/2879/palminet/>

Palm Oil Innovation Group: http://wwf.panda.org/what_we_do/footprint/agriculture/palm_oil/solutions/palm_oil_innovation_group/

Roundtable on Sustainable Palm Oil: www.rspo.org

Roundtable on Responsible Soy Association: www.responsiblesoy.org

Socially and Environmentally Sustainable Oil Palm Research Program (Sensor): www.searrp.org/sensor

Stability of Altered Forest Ecosystems Project: www.safeproject.net

Sustainable Development of Palm Oil Production (SPOP): <http://spop.cirad.fr/project/context/agrobiosphere-2011>

complexity of plantations to test its effect on a wide range of taxa and ecosystem processes. Through establishing the role of biodiversity within tropical agrom-ecosystems, the project will develop improved oil palm management and industry-compatible biodiversity surveys and guides.

PalmiNet network

France's CIRAD (Centre de coopération internationale en recherche agronomique pour le développement) and INRA (National Institute for Agronomic Research), CENIPALMA (Corporación Centro de Investigación en Palma de Aceite in Colombia), PT Smart (an Indonesian plantation company) and NBPOL (New Britain Palm Oil Ltd, plantation company, Papua New Guinea) set up this network in order to develop shared indicators on the social and environmental impact of the oil palm crop. The idea is to promote the use of indicators by actors in the sector, share research efforts and feedback, facilitate the development of tools and

indicators, encourage new forms of collaboration and multidisciplinary research and disseminate results among a wide audience of potential users.

Sustainable Palm Oil Production (SPOP)

At the interface between agronomy and social sciences, this project, led by CIRAD and supported by the French Agence Nationale de la Recherche, aims to verify the sustainability of current smallholder-based systems or to propose new sustainable systems. It involves actors in the process through participatory methods such as multi-agent modelling.

Conclusions and research avenues

Improving sustainability requires multi-disciplinary and collaborative research

Large scale projects based on public/private partnerships are emerging or are presently underway, although some of them are facing funding problems to initiate or continue their activities. In order to provide robust, trustworthy and shared results, such projects need the successful integration of a large and diverse partnership and – above all – the involvement in the (very) long term of all contributors. Indeed, this is not an easy task; huge study areas are needed, and research conclusions and resulting statements are not immediate, as academic results need some time before being translated into reliable indicators and thresholds. This is far from comfortable lab research.

As an example, all stakeholders now agree on the need for establishing buffer zones between protected areas and plantations. This being said, research is crucially needed to determine the size and shape of such zones and developers are waiting for clear answers: inside or outside the plantation area? One single zone or a stepping stones design? Connecting protected zones with biodiversity corridors or not? Which percentage of the planted area to be protected: 10%, 20% or 40% as in Amazonia? The same applies for questions arising from the exploitation of peat soils, the controlled use of pesticides or the mitigation of greenhouse gas emissions.

Public awareness has pushed new approaches and new actors into the sector

Even if they were rarely science-based, quite caricatural and sometimes misleading, campaigns by NGOs played an important role in pushing all branches of the oil palm sector towards improved sustainability. RSPO is most

probably only the tip of the iceberg, as most estate companies are now addressing environmental and sustainability issues as they have embarked towards national and/or international certification. Most of the major plantation companies now publish a yearly sustainability report and have created their own sustainability department or task force. Interestingly, “revolving chairs” are at work as most of such departments are led by former environmental NGO executives. Of course, the risk of green-washing still exists (it is ironically branded “Talk and Log”), even if the sector is now permanently under scrutiny from NGOs and public agencies and – increasingly – from governments. A growing number of companies and their distributors cannot afford any more severe mistakes in their sourcing, traceability or social responsibility policies. NGOs and impact assessment bodies are now part of multidisciplinary research as they bring in new competencies and extended field-based expertise on both social and environmental areas. Such actors also bring in a recognized expertise in using mass media and especially the powerful, web-based social media.

Research results are more published and recognized

The “publish or perish” rule applies also to oil palm researchers. Sustainability issues cannot be solved easily without the help of basic science. As an example, soil science now includes metagenomics to describe and monitor life under and above ground. Remote sensing and precision agriculture are needed either to anticipate and mitigate climate changes such as El Niño, to map precisely planted and protected areas or to detect outbreaks of pests and diseases. Breeding strategies are now routinely integrating molecular markers (Rival et al. 2010) and genomics data derived from the recent sequencing of the oil palm genome (Singh et al. 2013). Scientific literature on oil palm research has boomed, reaching almost 800 journal articles (more than 7000 citations) in 2013 (Fig. 10).

There is a need for education and capacity building on sustainability

Before or during their professional life, plantation managers, cooperative leaders, researchers and planners must share the same corpus of basic knowledge about sustainability. A very recent initiative linking CIRAD with Universiti Putra Malaysia (UPM), the Roundtable on Sustainable Palm Oil (RSPO)

and Wild Asia, a specialized NGO with expertise in training Lead Auditors for RSPO, has also launched a course on Auditing Certification Schemes on Sustainability hosted in Malaysia by the Institute of Agricultural and Food Policy Studies. This is just a start; each company is still training its own executives following its own principles, and there is still huge room for improvement in sharing knowledge and methodology.

Scientists must be part of the public debate

Since developments such as the controversy in Europe over genetically modified crops, we scientists have become aware of the sensitivity of politicians and decision makers to public opinion, which more often retreats to entrenched positions. Some branches of science can be denied public funding once they have been publicly categorized as “sensitive.” Paradoxically, this has the opposite effect to that sought by early detractors. Indeed, by depriving a whole field of research of public funding the door is left open to scientific research supported exclusively by private money without any counterweight and therefore highly questionable. The public debate about the oil palm like in any other issue is generally triggered by the lack of sharing of scientific evidence obtained without conflict of interest by independent research teams. Thus scientist must not hesitate to show not only doubts and concerns but also promising research and development results and encouraging changes in the sector.

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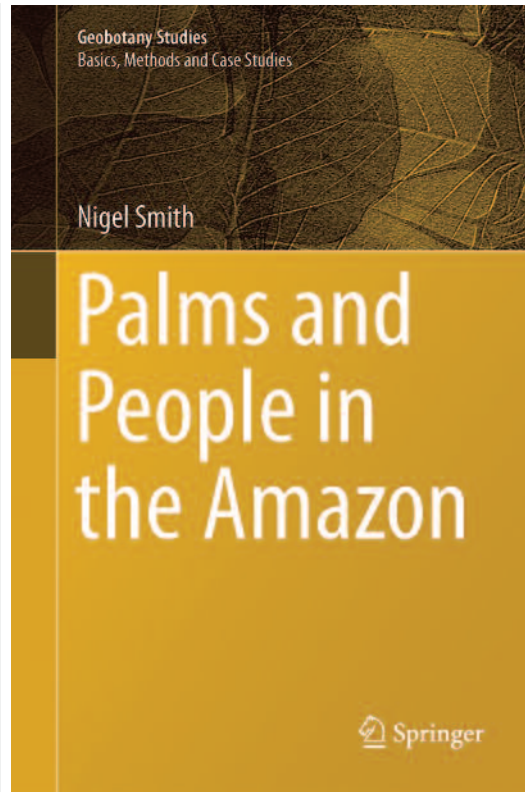
PALM LITERATURE

PALMS AND PEOPLE OF THE AMAZON – Nigel Smith. Springer International Publishing, Switzerland. 2014. ISBN-13: 9783319055084. Price: US\$156, £93.50, €107 Hardcover or e-book. 500 pages. Color illustrations throughout.

This profusely illustrated book on the most useful palms of the Amazon is a follow-up of Gouling and Smith's (2007) *Palms: Sentinels for Amazon Conservation*. The book starts with a short chapter on Palms and Cultural Landscapes, which discusses the long role humans have played in shaping palm distribution in Amazonia and the continuum existing between purely wild and truly domesticated species; although the author himself expressly avoids using the term "domesticated" and prefers "planted" instead.

Then comes the bulk of the work, wherein 56 of the most widespread, useful and/or appealing palms are alphabetically arranged (by their scientific name), and the relation of Amazonian people with them is discussed in detail. Information on uses is based both on the author's decade-long field work in the Amazon, and on an extensive literature review that covers over 600 references. The book presents the relation of palms and people in multiple ways, including some aboriginal myths involving palms, names of places alluding to the various palm species and, of course, the omnipresence of palms in everyday life. Photographs taken by the author richly illustrate uses, sometimes in excessive detail – a girl gnawing the pulp of one species, an old lady eating the fruits of another one, a boy gathering fruits of a third one from the ground, someone knocking down fruits with a slingshot, a man cracking palm endocarps and many others in every situation imaginable with palms. But, after all, that is what the book is all about, isn't it – palms and people? The book includes two appendices: a rather useless one citing the voucher specimens of seven of the species, and an interesting one with a list of some indigenous groups in Amazonia that use palms.

The taxonomy and nomenclature of the species treated is good, and I noticed only a few disputable cases. The *mararay* palm is treated under its former name, *Aiphanes aculeata*, as Finn Borchsenius and I did in our *Flora Neotropica* monograph of the genus, before the



older, darker name *Aiphanes horrida* was spotted and enthroned. The *murumuru* palm is treated under the broad concept of *Astrocaryum murumuru*, as accepted by Henderson in his *Palms of the Amazon* (1995). Current use recognizes several species in this complex. And, finally, the fiber-producing *chambira* palm, *Astrocaryum chambira*, appears to be confused in some citations with the fruit-producing *Astrocaryum aculeatum*, a 19th century confusion that lasted until 1934 and has reappeared now and then in the literature. (The name *Astrocaryum aculeatum* itself is still misapplied today, as it was originally given to what we call *Astrocaryum gynacanthum*; the right name for the *tucumá* palm is *Astrocaryum tucuma*, but this is a lawyers' case awaiting official approval at an International Botanical Congress).

In summary, this book is a nice and interesting addition to our understanding of the vital role that palms play in Amazonia. Through its human focus, it will introduce laypeople to this fascinating group of plants. A must.

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COMMENTARY

Plant scientists usually strive to develop classifications that reflect what we know of evolutionary history and relationships. As new sources of taxonomically valuable data such as DNA and new more objective methods of analysis have become available, novel insights have been gained into relationships, and these can be reflected in improved taxonomies. Such work continues, and since the publication of the second edition of *Genera Palmarum* (2008), there have been further generic-level changes. Two papers just published in *Phytotaxa* make yet more changes. Both papers focus on the subtribe Calaminae that includes many of the rattan palms, those classified in the genera *Calamus*, *Daemonorops*, *Ceratolobus*, *Retispatha* and *Pogonotium*. With practice there is absolutely no difficulty in identifying these genera – they are unambiguously defined. However, we have known, since 2000 (Baker et al., *Molecular Phylogenetics and Evolution* 14: 195–217. 2000.), that the classification of the subtribe was unsatisfactory and that *Retispatha*, *Daemonorops*, *Pogonotium* and *Ceratolobus* were embedded within the evolutionary line that includes the rest of *Calamus*. This problem was alluded to in the discussion in *Genera Palmarum* (2008), but the authors decided to take no action because molecular sampling within the group was so limited – better to wait for more data to see whether *Calamus* itself could be divided into further genera, or whether all should be subsumed within a huge genus *Calamus*. Henderson and Floda (*Phytotaxa* 192: 58–60. 2015), using Baker et al.'s published data and their own as yet unpublished data, subsumed *Retispatha* into *Calamus*. Baker (*Phytotaxa* 197:

139–152. 2015.) went further, using the data published in the 2002 paper to go the whole hog and to sink all the genera into a single genus *Calamus*, and made all the necessary nomenclatural changes. So we are now faced with a genus of almost 550 species, with no formal infrageneric classification that would allow easy navigation through the newly enlarged genus, with consequent loss of information. Some may applaud the changes as reflecting evolutionary relationships; some, especially those who never bothered to try to learn rattan genera, will continue to call any climbing palm in the Old World Tropics *Calamus*, and for the most part be right, while others will regret these premature taxonomic changes, based on limited sampling. Herbarium curators will be forgiven for continuing to maintain the old genera, as relabeling, resorting and rearranging the five genera into *Calamus* will be a nightmare. It may well be that once the Calaminae is more thoroughly sampled, it will prove to be impractical to divide the subtribe into separate genera. The case for inclusion of *Retispatha*, at least based on the already published data, seems sound. However, it is my belief that we do not have the evidence yet to make further changes, and in the meantime, recognition of the very genera included by Baker in *Calamus* provides a more useful method of reflecting morphological information and greater ease in species identification than if all taxa are included in a huge genus without formal structure.

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