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Sweet Sap from Palms, a Source of Beverages, Alcohol, Vinegar, Syrup, and Sugar

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“For no civilization that is confined to city curbs can long appeal to the imagination of each coming generation. Some association with plants is necessary.”

David FAIRCHILD (ca. 1933)
*Through the West Indies for Plants**

RESUMEN: El uso de las palmeras como fuente de savia dulce es antiguo y amplio en regiones de Africa, Asia y el Nuevo Mundo donde las mismas se cultivan. La savia dulce se consume fresca, procesada como miel o azúcar o fermentada para producir bebidas alcohólicas o vinagre. Se revisa este uso en 40 especies de palmeras y los métodos para extraer su savia. Estos pueden ser destructivos o no destructivos. La explotación no destructiva, como sucede con *Phoenix canariensis*, puede proporcionar un aprovechamiento sostenible para la supervivencia de las palmeras.

Palabras Claves: Botánica económica; etnobotánica, Arnoldo Santos-Guerra; Arecaceae; agricultura tradicional; Macaronesia; islas tropicales; agricultura sostenible.

ABSTRACT: The use of palms as a source of sweet sap is ancient and widespread throughout the palm-growing regions of Africa, Asia and the Americas. Sweet sap is consumed fresh, processed into syrup or sugar, or fermented into alcohol or vinegar. We review 40 species of palms and their tapping

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methods, which may be either destructive or nondestructive. Nondestructive exploitation, as with *Phoenix canariensis*, can provide a sustainable harvest for the life of the palm.

Key Words: Economic botany; ethnobotany; Arnaldo Santos-Guerra; Arecaceae; traditional agriculture; Macaronesia; tropical islands; sustainable agriculture.

INTRODUCTION

The Canary Islands have a rich flora with over 600 species restricted to the archipelago (Reyes Betancort *et al.*, 2008; Francisco-Ortega *et al.*, 2009). Many of these endemic species have been used locally by both the pre-Hispanic and the European-descent populations (Morales Mateos, 2003), mostly as sources of forage (Pérez de Paz *et al.*, 1986; Fernández Galvan & Méndez, 1989; Méndez Pérez *et al.*, 1991) and medicines (Pérez de Paz & Hernández Padrón, 1999). Among the Canarian endemic plants, few have reached the economic and ethnobotanical importance of the Canary Island Date Palm, *Phoenix canariensis*. The official plant symbol of the islands, this palm has been the subject of several popular articles that highlight its relevance as part of the Canary Islands identity (Montesinos Barrera, 1979; Oliva Tacoronte, 1985; Santos-Guerra, 1994; Morici, 1998).

Worldwide, this palm is one of the most popular ornamental species for tropical, subtropical, and Mediterranean gardens and landscapes (Zona, 2008), but within the Canary Islands, the palm is also an important food crop. Its sap (locally known as “guarapo”) is extracted and processed into a syrup called “miel de palma” (= literally, “honey from palm”) (Quintero Lima, 1985). The harvesting of sap of this species on La Gomera is one of the most important cases of sustainable use of the native flora. It provides one of to be the best known examples of ethnobotany in the Canaries and is not only an important local farming activity but also a major tourist attraction for visitors. We believe that these sustainable tapping procedures have been relevant for La Gomera to preserve the healthiest and largest palm stands of the archipelago (Morici, 1998). Interestingly, many of these palms can be considered to be in a semi-cultivated status in which sap harvesting has become part of the life-cycle of the species on this island.

The exact origin of the practice of tapping *Phoenix canariensis* for its sugary sap is lost to the fog of history, but the practice is surely ancient. There is archeological evidence showing *P. canariensis* to be one of the most important plants used by the pre-Hispanic population as food [dates, also known with the name of “támaras”, see Wölfel (1965) for a linguistic discussion pertinent to this name], fibre, building material, and ceremonial offerings (Galván Santos, 1980; Rodríguez Rodríguez, 1999; Rodríguez Santana, 2002; Del Arco Aguilar, 1993; Morales Mateos & Rodríguez Rodríguez, 2007; Morales *et al.*, 2011). So far, no archeological remains have been found showing the use of palm sap by the pre-Hispanic inhabitants, but historical accounts paint a picture of a long history of use. Pliny the Elder (AD 23–79), in his *Naturalis Historia*, related an account by King Juba II of Mauretania (*ca.* 25 BC–AD *ca.* 23), who noted that the islands contained ‘palm-groves full of dates ... in addition to this there is a large supply of honey’ (Rackham, 1947, Santana Santana *et al.*,

2002; García García, 2008). Juba's mention of 'honey' may be the earliest mention of the syrup produced from *P. canariensis* (Zona, 2008); however, we cannot rule out that may refer to bee honey, as suggested by Santana Santana *et al.* (2002). Later writings suggested that *P. canariensis* was tapped to produce wine even before the islands were invaded by Europeans in the 15th century (Del Castillo, 1848; Frutuoso, 1964; Morales Padrón, 1978; Hernández, 2000). The earliest of these accounts is from the first quarter of the 16th century (ca. 1500–1525), just a few years after the last island of the archipelago (Tenerife) was annexed to the kingdom of Castilla in 1496 (Morales Padrón, 1978). Between the 18th and 19th centuries, the Canary Island naturalist Viera y Clavijo (1731–1813) also referred to palms from the archipelago as a source of honey and fermentable sap; however, he did not explain any procedures to obtain these products (Viera y Clavijo, 1982). It is worth mentioning that *Phoenix* flowers produce little if any nectar (Uhl & Moore, 1977) and are not regarded as nectar resources for honey production. Therefore we believe that the "honey" mentioned by Viera y Clavijo is the syrup, "miel de palma."

The objective of this study is not to provide a full account of the ethnobotany of "miel de palma" in La Gomera, an extensive and excellent review of which can be found in Quintero Lima (1985), but to draw attention to the diversity of palms used throughout the world as a source of sweet sap. *Phoenix canariensis* is but one of at least forty palms used for sap (see Table 1), and as we shall demonstrate, there are both similarities and differences in the way it is used in comparison to other palms.

USES OF SAP

The sap tapped from palms comprises an aqueous solution of photosynthates and hydrolyzed starch reserves from the trunk (Dalibard, 1999); the tapping process intercepts the flow of these sugars en route to the inflorescence and/or crown. Sap from palms may contain to 10–20% sugar, depending mostly on the species, time of year, and extraction method (Dalibard, 1999). Once collected, the sap can have any of five uses, depending on local needs (and the availability of alternatives), traditions and markets. Fresh, unfermented sap is boiled down to produce a syrup or molasses (sometimes called honey) or further refined into sugar. Alternatively, sap can be consumed fresh (e.g., "the guarapo" of *P. canariensis*) or lightly fermented (sweet toddy), or it can be fermented into palm wine (also called arak, toddy, or tuba). Palm wine, in turn, can be distilled to produce spirits. Finally, fermented sap can also be used to produce vinegar through fermentation by acetic acid bacteria. In tropical environmental conditions, with the use of non-sterile implements and without refrigeration, fermentation can scarcely be avoided. In order to minimize fermentation, sap is usually collected two or more times per day, and anti-microbial agents are added to the collecting vessel. These agents may be lime or the bark or wood of certain trees and/or crushed dried leaves (Dransfield, 1976b; Theivendirarajah & Jeyaseelan, 1977; de Zoysa, 1992; Siebert, 1999). In addition, vessels are cleaned regularly and sometimes treated with lime or smoke (Theivendirarajah & Jeyaseelan, 1977).

Fresh sap quickly spoils without filtration and refrigeration. Because refrigeration is costly and because maintaining fresh sap at the optimum temperature during transport and

marketing is impractical, fresh sap is essentially a product confined to local markets. Sugar, syrup and vinegar are relatively stable at ambient temperatures and enter local, regional, and sometimes even international markets. A sixth product, a natural source of yeast for leavening bread, is also attributed to fermented palm sap (Brady & McGrath, 2010), but this is a highly local use. The use of fermented palm sap as a source of baker's yeast is seldom documented in ethnobotanical literature, and our review will not discuss this use any further.

The use of palm sap has responded to market forces throughout the world. Sugar cane has supplanted palms as a source of sugar in some parts of the tropics. As cultures change, some palm products fall into disuse. For example, there are historical records of *Phoenix canariensis* sap being processed into wine (see above), but nowadays, its only use is for syrup or as a non-alcoholic fresh drink ("guarapo"). Likewise, *Sabal bermudana*, once tapped for its sugary sap in Bermuda, is no longer exploited (Hodge, 1960), and *Mauritia flexuosa* (synonym: *M. vinifera*) is no longer or only rarely used for beverage and alcohol production (Schomburgk, 1923; Lévi-Strauss, 1952), although it produces a valuable and much used fruit crop in the Amazon Basin (Padoch, 1988). In the latter two cases, alternative sugar and alcohol sources have supplanted palm sap in the local economies.

GEOGRAPHIC RANGE OF PALM SAP USE

The use of *Phoenix canariensis* in the Canary Islands is the only instance of palms being tapped for sap in a European country, but Europe has very few native palms. Throughout much of the world, palms are or have been tapped for their sweet sap almost everywhere in which palms grow (Tab. 1). The factors that determine whether palm resources are used for sap include abundance of palms, their productivity as a sap resource, local knowledge and skills, and alternative sugar sources.

In the Americas, several genera have been used for sweet sap since pre-Columbian times. The earliest depiction of an American palm used for wine comes from the Drake Manuscript (Pierpont Morgan Library, 1996). The drawing, which shows a pinnate-leaf palm with leaf-bases retained on the trunk (Fig. 1), may represent either *Acrocomia aculeata* or a species of *Attalea*. The artist has fancifully shown the tapping at the base of the trunk, although the text makes it clear that terminal bud ("heart") was tapped. The full text reads: "Tree from which the Indians draw wine having the taste of perry [fermented pear juice]; they cut the trees nearby giving shade so that the sun can give its warmth more intensively, for the stronger the sun the more wine has the tree. They also pierce said tree to its heart in order to make the wine gush out and even make a big fire to keep away the poisonous beasts." There is no indication of where the practice was observed; it could have been anywhere in the Caribbean Basin from Colombia or Panama to Veracruz (Mexico) and the Antilles, all places visited by Sir Francis Drake during the 16th century (Dudley, 2003). Nevertheless, the illustration makes clear that during this period tapping of palms was practiced in the New World by the Amerindians.

In Chile, the endemic Chilean Palm (*Jubaea chilensis*) was most famously mentioned by none other than Charles Darwin. After visiting Chile on 16 August 1834, Darwin (1845)

wrote of the palms, "They are excessively numerous in some parts of Chile, and valuable on account of a sort of treacle made from the sap." The English common name, Chilean Wine Palm, is a misnomer, as the palm sap is not fermented into wine. Elsewhere in Central and South America, *Acrocomia aculeata* and at least three species of *Attalea* are tapped for sap (for references, see Tab. 1). In the Dominican Republic, both *Pseudophoenix vinifera* and *P. ekmanii* are used for sap. Schomburgk (1923) published observations on the use of *Mauritia flexuosa*, a very widespread palm in South America. A published report (Haynes & McLaughlin, 2000) that three species of *Bactris* (*B. guineensis*, *B. major*, *B. maraja*), two species of *Parajubaea* (*P. cocoides*, *P. torallyi*), and two of *Oenocarpus* (*O. bataua*, *O. distichus*) are exploited for sap appears to be in error or to represent very minor usage (or perhaps, potential use), as we have been unable to locate any primary literature on their use for sugary sap.

Africa and Madagascar are home to several sap-producing palms (see Tab. 1), the best-known of which are the African Oil Palm (*Elaeis guineensis*), better known as a source of edible oil, several species of *Raphia*, including *R. vinifera*, *R. farinifera*, *R. sudanica*, *R. africana* and *R. hookeri*, and the Date Palm (*Phoenix dactylifera*). The Senegal Date (*Phoenix reclinata*) is also used for sap. Another important sap source is the genus *Borassus*, two species of which occur in Africa and are tapped: *Borassus aethiopum* and *B. akeassii*. A fifth genus, *Hyphaene*, is sometimes tapped. Three of its species are known to be used for sap: *H. coriacea*, *H. petersiana*, and *H. thebaica*. In Madagascar, the following species are known to have been used for sap: *Beccariophoenix madagascariensis*, *Borassus madagascariensis*, *Hyphaene coriacea*, *Raphia farinifera*, and *Dypsis nodifera*, although some of these palms are now so rare that they are no longer tapped for sap (Dransfield & Beentje, 1995).

In Asia, Malesia, and the Pacific Islands, the most important sap-producing palms are *Phoenix sylvestris*, the coconut (*Cocos nucifera*), the sugar palm (*Arenga pinnata*), *Caryota urens* and *C. cumingii*, *Corypha utan* and *C. umbraculifera*, *Nypa fruticans*, and *Borassus flabellifer* (see Tab. 1). These species are widely used across a large area from India to Polynesia. These species may owe their broad geographic distribution in part to their utility as sources of sweet sap. Other species of *Arenga* and *Hydriastele microcarpa* are also sometimes used. The Betel-nut Palm (*Areca catechu*) as a source of sweet sap was mentioned by Dalibard (1999), who erroneously attributed the information to Johnson (1988), but no such information was given by Johnson (1988). Likewise, a report (Haynes & McLaughlin, 2000) that *Rhopalostylis sapida* of New Zealand is tapped for sap appears to be erroneous as a review of the economic botany of this island makes no mention of it (Brooker *et al.*, 1989). In Vanuatu, the use of *Calamus vitiensis* (as *C. vanuatuensis*) for sap was mentioned in error (Johnson, 1998); the stems of this lianoid palm are cut for their xylem liquid, which is a reliable and readily obtainable source of drinking water.

Australia, despite having a rich palm flora, has no indigenous palm-tapping culture. Sweet sap from other tree sources was collected by Aboriginal people, along with flower nectar and honey (Isaacs, 1987; Latz, 1995).

METHODS OF TAPPING

Palms, unlike most trees, typically have unbranched stems. Moreover, as monocotyledons, they have scattered vascular bundles in their stems, rather than the concentric rings of vascular tissue found in other trees. These two aspects of palm morphology impose strict limits on how palms can be tapped for sap. Some palms are clustering and produce multiple stems via basal branching. Species of *Hyphaene* are unusual in that they are clustering and their aerial stems naturally branch dichotomously. In clustering palms, the presence of multiple stems allows for tapping different stems over time. Palm stems are tapped in ways that are either destructive to the stem (and to the individual palm, in the case of single-stemmed palms) or non-destructive.

Most palms produce axillary inflorescences, and a mature palm produces an inflorescence at every leaf axil. Methods of tapping that exploit the inflorescence do no harm to the palm and can be practiced over the life of the palm. A few sugar-producing palms have unusual life histories: they are hapaxanthic, meaning that the stem producing the inflorescence(s) dies after flowering and subsequent fruiting. In the case of clustering, hapaxanthic species, individual stems die, but other stems live and continue to grow. Individuals of solitary-stemmed, hapaxanthic palms die after flowering and fruiting. *Caryota*, *Arenga*, and *Raphia* are hapaxanthic palms with both solitary-stemmed and clustering species. The flowering process in these genera is prolonged, in which many new inflorescences are produced over a period of several months or even years, thus prolonging the tapping life of an individual. In the hapaxanthic genus *Corypha*, which has a solitary stem that produces a single, massive, terminal inflorescence, the palm is truly monocarpic. Tapping the inflorescence will neither hasten nor delay the eventual death of the palm.

Destructive Tapping of the Stem

In the Americas, the palms in the genera *Acrocomia*, *Attalea*, and *Pseudophoenix* are tapped in a destructive way. The process is relatively simple: The selected palm is felled by cutting the trunk at or near ground level. The stem is placed horizontally, and the leaves are removed. Using a knife or axe, a person cuts a box-shaped cavity or trough into the bud of the palm just above the apical meristem (Fig. 2). The cavity is cleaned of debris and covered with leaves, plastic, or cloth. Over a period of ca. 24 hrs., the cavity fills with sap, which is scooped out with a ladle or cup. Sap production and collection proceed over many weeks, until the palm stem is exhausted. A similar method was described by Schomburgk (1923) for *Mauritia flexuosa*, with the addition of burning a fire under the length of the trunk in order to hasten sap flow. Workers extract sap from *Pseudophoenix ekmanii*, a relatively small palm, without felling the stem (Fig. 3). A rectangular hollow or trough is cut away, and the flow of sap is collected in a bottle or vessel attached to the stem below the trough. Standing palms occasionally survive such rough treatment, and one can find living trees bearing the scars of sap extraction.

In parts of tropical Africa and Madagascar, *Elaeis guineensis* is destructively harvested for sap. The procedure is much the same as used in the Americas: the palm is felled or left standing, the apical bud is partially scooped out, and the sap is allowed to accumulate (Onuche *et al.*, 2012). A similar method is used to tap *Borassus aethiopum*, but the

palm is left standing during the procedure. The method involves cutting through the leaf bases, into the terminal bud. A spout (often made of bamboo) is inserted into the cut area, and sap is directed into a vessel affixed to the palm (Sambou *et al.*, 2002). If the incisions are not too deep, the palm may survive, but usually the palm dies after 35–45 days of tapping (Sambou *et al.* 2002). Tuley (1964) described a similar process for *Raphia hookeri* in Nigeria, but with the addition of inserting a small bundle of smoldering kindling into the incision to “stimulate” the flow of sap.

In Chile, the Chilean Palm (*Jubaea chilensis*) has been used for centuries, and vast numbers of the palms have been destroyed in pursuit of its sweet sap (Gonzalez *et al.*, 2009). The palm is uprooted and the stem is placed horizontally. The apex of the crown is removed, cutting down into the terminal bud (Fig 4). Sap flowing off the cut surface is funnelled into collecting vessels for later processing into syrup. An identical method is employed for tapping *Raphia hookeri* in tropical West Africa (Russell, 1963).

Clustering palms, such as *Phoenix reclinata*, *Hyphaene coriacea*, and *H. thebaica*, are exploited for sap in Africa in ways that are destructive to individual stems, but non-destructive to the entire plant. In all cases, single stems are selected, leaves are trimmed or burned, and the stem is tapped while standing or the stem is felled. The apical bud is tapped by boring or cutting into the bud and collecting the sap as it exudes (Blanc-Parmard, 1980) or by decapitating the palm just above the apical meristem and cutting a channel to one side of the stump to direct sap flow into a collection vessel. Sometimes a spout is added, and the cut surface and vessel are protected from the sun and dust with a plaited leaf of *H. coriacea* (Cunningham, 1990). Occasionally, the stem survives this procedure if the daily cuts never progress as deep as the apical meristem.

Non-Destructive Tapping of the Stem

A skilled tapper can cut into the apex of the stem without destroying the apical meristem. A palm tapped in this way survives the process and can be tapped again. There are two methods of tapping the stem in a non-destructive way: cutting from the top of the palm or cutting from the side of the leaf crown. The former method is has been used for centuries to tap *Phoenix canariensis* in the Canary Islands and *P. dactylifera* in parts of North Africa. The tapper climbs into the crown of the palm and removes the youngest leaves, leaving the older leaves to support the palm. In the Canary Islands, with *P. canariensis*, the apex of the leaf bud is scooped out – taking care not to go too deep and injure the meristem – to form a bowl-shaped hollow at the apex of the stem in which palm sap accumulates (Fig. 5). With *P. dactylifera*, the apical bud is trimmed to a cone-shaped structure, from which the sap exudes and trickles to the base of the cone, collects in a trough cut into the stem, and is directed via a spout into collecting vessels (Barreveld, 1993). In both methods, the sap-exuding surface must be periodically re-cut to encourage adequate flow of sap.

In *Borassus akeassii*, the new leaves in the terminal bud are tapped by boring a hole into the crown. The sap flowing from the bore-hole is collected in a vessel, and the hole is re-drilled daily to ensure sap flow (Yaméogo *et al.*, 2008).

A well-illustrated account of the non-destructive method of tapping *Phoenix sylvestris* was given by Davis (1972). The palm is tapped by exposing the stem on one side of the palm, at or just below the stem’s apical meristem. The face of the wound exudes sap, which

is channelled to a spout at the base of the wound and directed into a collecting vessel. Repeated tapping, on opposite sides of the stem, results in a zigzag pattern of scars on the trunk (Fig. 6).

Non-Destructive Tapping of the Inflorescence

The male inflorescence of *Borassus flabellifer* is specifically chosen for tapping. An excellent, step-by-step account of the tapping procedure used in Java was given by Dransfield (1976b). The inflorescence is squeezed or bruised for several days prior to the actual tapping. This process is said to encourage sap flow. When the inflorescence is ready, the tapper excises distal portions of the branches, and attaches a collecting vessel. The vessel is emptied twice daily, and the ends of the branches recut to ensure unobstructed sap flow. A very similar process is described for *Arenga pinnata* (Miller, 1964; Siebert, 1999) and *Nypa fruticans* (Davis, 1988; Hamilton & Murphy, 1988).

The process of tapping *Caryota urens* in Sri Lanka was described in detail by de Zoysa (1992). While similar to that of *Borassus* and *Arenga*, the tapping process has some additional steps. The process begins when the palm, a solitary, hapaxanthic species, begins to initiate inflorescences. The inflorescence selected for tapping is subjected to “stimulation” by removing the enclosing bracts and bruising the inflorescence with a stone or the handle of the tapper’s knife. Next, the bruised area is treated with a paste made from ground leaves, slaked lime, lamp black, and others additives, such as salt, mustard, and garlic. The inflorescence is bound along its length with a rope and allowed to rest for 48 hrs, after which time, the tip is sliced off and a vessel attached to collect the flow of sap. Often, a forked branch is attached to the palm to support the inflorescence and collecting vessel.

The tapping of coconut (*Cocos nucifera*) inflorescences is similar to those described above. The process, as practiced in coastal Kenya, was described by Kadere *et al.* (2004). The process begins when the tappers force the emerging inflorescence into a pendant position. This is accomplished by notching the woody bract that surrounds the inflorescence and tying the inflorescence into position with rope. When the inflorescence has reached its full size, the tip is cut off, then the branches, bound together in a bundle, are allowed to exude sap into a collection vessel. The vessel is emptied two or three times a day, and the cut end of the inflorescence is shaved daily to insure unobstructed sap flow. There is no beating or bruising of the inflorescence prior to tapping.

The terminal inflorescences of monocarpic *Corypha* species have been reported as a source of sap in the SE Asia (see Tab. 1). The massive inflorescence must be a tremendous physiological sink for the sugar reserves of the palm, but surprisingly, this genus is not often mentioned as a sap source in the region (Davis, 1988). The use of this genus for sap has received scant attention in the literature.

In parts of Africa, the inflorescences of *Elaeis guineensis* and various species of *Raphia* are tapped for sap (Onuche *et al.*, 2012). The process, at its most basic level, simply involves cutting the inflorescence, sometimes back to the peduncle, and attaching a vessel to collect the exudate (Fig 7).

SUSTAINABILITY

The tapping of inflorescences of *Cocos nucifera*, *Nypa fruticans*, *Arenga pinnata*, *Borassus flabellifer* and *Caryota urens* is highly sustainable, causing no permanent damage to the palms. Provided that some inflorescences are allowed to mature and produce seeds for population regeneration, there is no reason to believe that palms could not be tapped indefinitely. Likewise, the careful tapping of *Phoenix canariensis* and *P. sylvestris* is remarkable for its sustainability. Indeed, the many tapping scars evident of some very old palms (e.g., Fig. 6) show that tapping can occur throughout the life of the palm, with obvious economic benefits to the tapper.

Destructive harvesting of palms, which are large, long-lived perennials, is known to be unsustainable at current levels of exploitation in some areas (Cunningham, 1990; Mollet *et al.*, 2000), although with stringent limits to the number of individuals cut, along with reforestation programs, some species (e.g., *Jubaea chilensis*) can be sustainably harvested (González *et al.*, 2009). There are, however, areas in sub-Saharan Africa where palm populations are being depleted (Sambou *et al.*, 1992, 2002). The rate of harvesting will likely rise as human populations grow. In Madagascar, *Beccariophoenix madagascariensis* is now so rare near human population centres (Dransfield & Beentje, 1995) that the practice of tapping the palms for sap has all but died out.

There are no apparent physiological or anatomical differences among palms whose stems are tapped versus those whose inflorescence are tapped, so there is no reason why inflorescence-tapping could not be substituted for destructive stem-tapping. In fact, *Elaeis guineensis* is exploited both ways by different communities of tappers in different regions of Africa (Onuche *et al.*, 2012). *Borassus aethiopum* is morphologically very similar to *B. flabellifer*, and yet the former is destructively tapped in western Africa while the latter is sustainably exploited in Asia. These palms illustrate that sustainable practices could, in theory, supplant unsustainable practices through a process of training and outreach to palm tappers.

As demonstrated by the centuries-long use of *Phoenix canariensis* in the Canary Islands, the sustainable and rational use of palms can insure that traditional sources of sustenance and economic benefit last for generations to come.

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REFERENCES

- ABRENILLA, C. G., N. R. PABLO, & M. A. POLINAG (1988). Buri plantation: toward a sustainable industry. *Canopy International* 14: 9-11.
- BALICK, M. J. (1990). Production of coyol wine from *Acrocomia mexicana* (Arecaceae) in Honduras. *Economic Botany* 44: 84-93.
- BARREVELD, W. H. (1993). Date palm products. *FAO Agricultural Services Bulletin* 101: 1-262
- BASU, S. K. (1991). India: Palm utilization and conservation. Pp. 13-35. In: D. Johnson (ed.). *Palms for human needs in Asia*. Rotterdam: A. A. Balkema.
- BAYTON, R. P., A. OUÉDRAOGO, & S. GUINKO (2006). The genus *Borassus* (Arecaceae) in West Africa, with a description of a new species from Burkina Faso. *Botanical Journal of the Linnean Society* 150: 419-427
- BERNAL, R., G. GALEANO, N. GARCÍA, I. L. OLIVARES, & C. COCOMÁ (2010). Uses and commercial prospects for the wine palm, *Attalea butyracea*, in Colombia. *Ethnobotany Research and Applications* 8: 255-268.
- BLANC-PAMARD, C. (1980). De l'utilisation de trois espèces de palmiers dans le sud du "V Baoulé" (Côte d'Ivoire). *Cahiers ORSTOM, série Sciences Humaines* 17: 247-255.
- BRADY, M. & V. MCGRATH (2010). Making *tuba* in the Torres Straits Islands. *Journal of Pacific History* 45: 315-330.
- BROOKER, S. G., R. C. CAMBIE & R. C. COOPER (1989). Economic native plants of New Zealand. *Economic Botany* 43: 7-106.
- CHOWDHURY, M. S. H., M. A. HALIM, N. MUHAMMED, F. HAQUE, & M. KOIKE (2008). Traditional utilization of wild date palm (*Phoenix sylvestris*) in rural Bangladesh: an approach to sustainable biodiversity management. *Journal of Forestry Research* 19: 245-251.
- CUNNINGHAM, A. B. (1990). Income, sap yield and effects of sap tapping on palms in south-eastern Africa. *South African Journal of Botany* 56: 137-144.
- DALIBARD, C. (1999). Overall view on the tradition of tapping palm trees and prospects for animal production. *Livestock Research for Rural Development* 11 (1). Retrieved January 9, 2013, from <http://lrrd.cipav.org.co/lrrd11/1/dali111.htm>.
- DARWIN, C. R. (1845). *Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world, under the command of Capt. Fitz Roy, R.N.* 2nd edition. Corrected with additions. London: John Murray. 519 pp.
- DAVIS, T. A. (1972). Tapping the wild date. *Principes* 16: 12-15.
- DAVIS, T. A. (1988). Uses of semi-wild palms in Indonesia and elsewhere in South and Southeast Asia. *Advances in Economic Botany* 6: 98-118.

- DAVIS, T. A. & D. V. JOHNSON (1987). Current utilization and further development of the palmyra palm (*Borassus flabellifer* L., Arecaceae) in Tamil Nadu state, India. *Economic Botany* 41: 247-266.
- DE ZOYSA, N. (1992). Tapping patterns of the Kitul Palm (*Caryota urens*) in the Sinharaja Area, Sri Lanka. *Principes* 36: 28-33.
- DECARY, R. (1964). Les utilisations des palmiers à Madagascar. *Journal d'Agriculture Tropicale et de Botanique Appliquée* 11: 259-266.
- DEL ARCO AGUILAR, M. DEL C. (1993). *Recursos vegetales en la prehistoria de Canarias*. Santa Cruz de Tenerife: Museo Arqueológico, Cabildo de Tenerife. 134 pp.
- DEL CASTILLO, A. (1848). *Descripción histórica y geográfica de las Islas Canarias*. Santa Cruz de Tenerife: Imprenta Isleña. 376 pp.
- DRANSFIELD, J. (1976a). Palms in the everyday life of West Indonesia. *Principes* 20: 39-47.
- DRANSFIELD, J. (1976b). Palm sugar in East Madura. *Principes* 20: 83-90.
- DRANSFIELD, J. & H. BEENTJE (1995). *The palms of Madagascar*. Kew: Royal Botanic Gardens. 475 pp.
- DUDLEY, W. G. (2003). *Drake. for God, Queen, and plunder*. Washington, DC: Brassey's Inc. 97 pp.
- FERNÁNDEZ GALVÁN, M. & P. MÉNDEZ (1989). La vinagrera (*Rumex lunaria* L.). Forraje para zonas cálidas áridas y semiáridas. *Investigación Agraria. Producción y Protección Vegetales* 4: 87-96.
- FOX, J. J. (1977). *Harvest of the palm: Ecological change in Eastern Indonesia*. Cambridge (Massachusetts): Harvard University Press. 220 pp.
- FRANCISCO-ORTEGA, J., A. SANTOS-GUERRA, & J. J. BACALLADO (2009). Canary Islands, Biology. Pp. 127-133. In: R. G. Gillespie & D. A. Clague (eds.). *Encyclopedia of islands*. Berkeley: University of California Press.
- FRUTUOSO, G. (1964). Las Islas Canarias (de *Saudades da Terra*). *Fontes Rerum Canariarum. Colección de Textos y Documentos para la Historia de Canarias* 12: 1-194. [Original manuscript from 1590, edited and translated by E. Serra, J Régulo & S. Pestana. La Laguna: Instituto de Estudios Canarios].
- GALVÁN SANTOS, B (1980). El trabajo del junco y la palma entre los canarios prehistóricos. *Revista de Historia* 37: 43-81.
- GARCÍA GARCÍA, A. M. (2008). El informe de Juba II sobre las *Fortunatae Insulae* (Plinio el Viejo, HN, VI, 202-205). *Tabona* 17: 141-164.
- GIFRI, A. & S. A. GABALI (1991). Notes on the distribution of shrubs and trees in Aden (Republic of Yemen). *Fragmenta Floristica et Geobotanica* 35: 89-95.
- GONZÁLEZ, L. A., R. O. BUSTAMANTE, R. M. NAVARRO C., M. A. HERRERA M., & M. TORAL IBAÑEZ (2009). Ecology and management of the Chilean palm (*Jubaea chilensis*): history, current situation and perspectives. *Palms* 53: 68-74.
- HAMILTON, L. S. & D. H. MURPHY (1988). Use and management of Nipa palm (*Nypa fruticans*, Arecaceae): a review. *Economic Botany* 42: 206-213.
- HAYNES, J. & J. MCLAUGHLIN (2000). *Edible palms and their uses*. UF/Miami-Dade County Extension Fact Sheet MDCE-00-50. Retrieved January 9, 2013, from

- <http://miami-dade.ifas.ufl.edu/old/programs/urbanhort/publications/PDF/EdiblePalms.pdf>
- HERNÁNDEZ, J. (2000). Canarias en el *Liber de Arte Medendi* (1564) de Cristóbal de Vega (1510-1573). *Anuarios de Estudios Atlánticos* 46: 407-415.
- HODGE, W. H. (1960). Bermuda's palmetto. *Principes* 4: 90-100.
- HODGE, W. H. (1963). Toddy collection in Ceylon. *Principes* 7: 70-79.
- ISAACS, J. (1987). *Bush Food*. Willoughby (Australia): Weldon Publishers. 256 pp.
- JAYATISSA, P. M. (1983). Palm sap vinegar. *Vidyodaya Journal of Arts, Science and Letters* 11: 63-68.
- JOHNSON, D. (1972). The carnauba wax palm (*Copernicia prunifera*). IV. Economic uses. *Principes* 16: 128-131.
- JOHNSON, D. (1988). Palms as multipurpose cash and subsistence tree crops. Pp. 222-236. In: D. Withington, K. G. MacDicken, C. B. Sastry & N. R. Adams (eds.). *Multipurpose tree species for small-farm use*. Winrock International Institute for Agricultural Development & International Development Research Centre of Canada.
- JOHNSON, D. (1992). Palm utilization and management in Asia: Examples for the Neotropics. *Bulletin de l'Institut Français d'Études Andines* 21: 727-740.
- JOHNSON, D. (1998). *Non-wood forest products 10. Tropical palms*. Rome: Food and Agriculture Organization of the United Nations.
- KADERE, T. T., R. K. ONIANG'O, P. M. KUTIMA, & S. N. MUHOHO (2004). Traditional tapping and distillation methods of coconut wine (mnazi) as practised in the coastal region of Kenya. *African Journal of Food Agriculture Nutrition and Development* 14(1). Retrieved January 9, 2013, from <http://www.bioline.org.br/abstract?id=nd04007&lang=en>
- KAMALUDDIN, M., T. K. NATH, & M. JASHIMUDDIN (1998). Indigenous practice of Khejur palm (*Phoenix sylvestris*) husbandry in rural Bangladesh. *Journal of Tropical Forest Science* 10: 357-366.
- LATZ, P. K. (1995). *Bushfires and bushtucker: Aboriginal plant use in Central Australia*. Alice Springs: IAD Press. 400 pp.
- LÉVI-STRAUSS, C. (1952). The use of wild plants in tropical South America. *Economic Botany* 6: 252-270.
- MADULID, D. A. (1991). Utilization of Philippine palms. Pp. 245-253. In: D. Johnson (ed.), *Palms for human needs in Asia*. Rotterdam: A. A. Balkema.
- MARTIUS, C. F. VON (1824). *Historia naturalis palmarum*, vol 2. Lipsiae: T.O. Weigel. 152 pp.
- MAY, P. H., A. B. ANDERSON, M. J. BALICK, & J. M. F. FRAZÃO (1985). Subsistence benefits from the babassu palm (*Orbignya martiana*). *Economic Botany* 39: 113-129.
- MÉNDEZ, P., M. FERNÁNDEZ GALVÁN, & A. SANTOS-GUERRA (1991). Variedades de *Bituminaria bituminosa* (L.) Stirton (Leguminosae) en el archipiélago canario. *Pastos* 20: 157-166.
- MILLER, R. H. (1964). The versatile sugar palm. *Principes* 8: 115-147.
- MOGEA, J. P. (1991). Indonesia: Palm utilization and conservation. Pp. 37-73. In: D. Johnson (ed.). *Palms for human needs in Asia*. Rotterdam: A. A. Balkema.

- MOLLET, M., F. HERZOG, Y. E. N. BEHI, & Z. FARAH (2000). Sustainable exploitation of *Borassus aethiopum*, *Elaeis guineensis* and *Raphia hookeri* for the extraction of palm wine in Cote d'Ivoire. *Environment, Development and Sustainability* 2: 43-57.
- MONTESINOS BARRERA, J. (1979). La palmera canaria. Aspectos botánicos y culturales. *Aguayro* 111: 17-21.
- MORALES, J., J. F. NAVARRO-MEDEROS, & A. RODRÍGUEZ RODRÍGUEZ (2011). Plant offerings to the gods: seed remains from a pre-Hispanic sacrificial altar in La Gomera island (Canary Islands, Spain). *Reports in African Archeology* 3: 67-78.
- MORALES MATEOS, J. (2003). *De textos y semillas. Una aproximación etnobotánica a la prehistoria de Canarias*. Las Palmas de Gran Canaria: El Museo Canario. 249 pp.
- MORALES MATEOS, J. & A. C. RODRÍGUEZ RODRÍGUEZ (2007). El aprovechamiento de la palma (*Phoenix canariensis*) por los primeros habitantes del archipiélago canario: bueno para comer, bueno para trabajar. *El Pajar (II época)* 24: 4-9.
- MORALES PADRÓN, F. (1978). *Canarias. Crónicas de su conquista*. Las Palmas de Gran Canaria: Ayuntamiento de Las Palmas de Gran Canaria & El Museo Canario. 558 pp.
- MORICI, C. (1998). *Phoenix canariensis* in the wild. *Principes* 42: 85-89, 92, 93.
- NAMOFF, S., A. VELOZ, F. JIMÉNEZ, R. A. RODRÍGUEZ-PEÑA, B. PEGUERO, C. LEWIS, J. MOYNIHAN, M. ABDO, M. MAUNDER, E. VON WETTBERG, A. W. MEEROW, M. P. GRIFFITH, & J. FRANCISCO-ORTEGA (2011). Sweet drinks are made of this: Conservation genetics of an endemic palm species from the Dominican Republic. *Journal of Heredity* 102: 1-10.
- OGBAZGHI, W. & E. BEIN (2007). The contribution of non-wood forest products to food security in Gash-Barka. Pp. 29-40. In: B. Ghebru & T. Mehari (eds.). *Innovative agricultural approaches of promoting food security in Eritrea: Trends, challenges and opportunities for growth*. Bern: Geographica Bernensia.
- OLIVA TACORONTE, D. (1985). *La palmera*. Las Palmas de Gran Canarias: Centro de la Cultura Popular Canaria. 37 pp.
- ONUCHE, P., S. A. SHOMKEGH, & T. N. TEE (2012). Palm wine tapping methods among Idoma and Tiv ethnic groups of Benue state, Nigeria: Implications on conservation of palm trees (*Elaeis guineensis*). *Journal of Environmental Issues and Agriculture in Developing Countries* 4: 86-91.
- OTEDOH, M. O. (1982). A revision of the genus *Raphia* Beauv. (Palmae). *Journal of the Nigerian Institute for Oil Palm Research* 6: 145-189.
- PADOCH, C. (1988). Aguaje (*Mauritia flexuosa* L. f.) in the economy of Iquitos, Peru. *Advances in Economic Botany* 6: 214-224.
- PÉREZ DE PAZ, P. L., M. J. DEL ARCO AGUILAR, J. R. ACEBES GINOVÉS & W. WILDPRET DE LA TORRE (1986). *Leguminosas forrajeras de Canarias*. Santa Cruz de Tenerife: Museo Insular de Ciencias Naturales. 157 pp.
- PÉREZ DE PAZ, P. L. & C. E. HERNANDÉZ PADRÓN (1999). *Plantas medicinales o útiles de la flora canaria. Aplicaciones populares*. La Laguna: Francisco Lemus Editor. 386 pp.
- PIERPONT MORGAN LIBRARY. (1996). *Histoire naturelle des Indes: the Drake manuscript in the Pierpont Morgan Library*. Foreword by P. O'Brian; Introduction by V. Klinkenborg; translations by R. Kramer. New York: W.W. Norton & Co. 272 pp.

- QUINTERO LIMA, A. (1985). *Miel y palma*. Santa Cruz de Tenerife: Consejería de Agricultura y Pesca Gobierno Autónomo de Canarias. 67 pp.
- RACKHAM, H. (1947). *Pliny's natural history, vol. II: Books III-VII*. Cambridge: Harvard University Press. 672 pp.
- RANA, P., S. SOHEL, S. ISLAM, S. AKHTER, M. S. CHOWDHURY, M. ALAMGIR, & M. KOIKE (2009). Traditional practice of palm husbandry in the southeastern region of rural Bangladesh: status and potentials. *International Journal of Biodiversity Science and Management* 5: 155-161.
- RASCO, E. T., JR. (2010). Biology of nipa palm (*Nypa fruticans* Wurmb, Arecaceae) and its potential for alcohol production. *Asia Life Sciences* 19: 373-388.
- REYES BETANCORT, J. A., A. SANTOS-GUERRA, I. R. GUMA, C. J. HUMPHRIES & M. A. CARINE (2008). Diversity, rarity and the evolution and conservation of the Canary Islands endemic flora. *Anales del Jardín Botánico de Madrid* 65: 25-45.
- RODRÍGUEZ RODRÍGUEZ, A. C. (1999). Un ensayo de reconstrucción de la vestimenta de los aborígenes de las Islas Canarias. *El Pajar (II Época)* 5: 93-100.
- RODRÍGUEZ SANTANA, C. G. (2002). El trabajo de las fibras vegetales entre los antiguos canarios. *El Pajar (II Época)* 12: 4-10.
- RUSSELL, T. A. (1963). The *Raphia* palms of West Africa. *Kew Bulletin* 19: 173-196.
- SANTANA SANTANA, A., T. ARCOS PEREIRA, P. ATOCHE PEÑA & J. MARTÍN CULEBRAS (2002). El conocimiento geográfico de la costa noroccidental de África en Plinio: la posición de las Canarias. *Spudasmata* 88: 1-410.
- SANTOS-GUERRA, A. (1994). Distribution of *Phoenix canariensis* in the Canary Islands. *Acta Horticulturae* 360: 71, 72.
- SAMBOU, B., A. GOUDIABY, F. ERVIK, D. DIALLO, & M. C. CAMARA (2002). Palm wine harvesting by the Bassari threatens *Borassus aethiopicum* populations in north-western Guinea. *Biodiversity and Conservation* 11: 1149-1161.
- SAMBOU B., J. E. LAWESSON, & A. S. BARFOD (1992). *Borassus aethiopicum*, a threatened multiple purpose palm in Senegal. *Principes* 36: 148-155.
- SCHOMBURGK, R. (1923). *Travels in British Guiana during the years 1840-1844*, vol. 2., translated by W. E. Roth. Georgetown (British Guiana): Daily Chronicle Office. 443 pp.
- SIEBERT, S. F. (1999). Where there is no beer: *Arenga pinnata* and Sagueir in Sulawesi, Indonesia. *Palms* 43: 177-181.
- SULLIVAN, S., T. L. KONSTANT, & A. B. CUNNINGHAM (1995). The impact of utilization of palm products on the population structure of the vegetable ivory palm (*Hyphaene petersiana*) in north-central Namibia. *Economic Botany* 49: 357-370.
- SYLVESTER, O., G. AVALOS, & N. CHÁVEZ FERNÁNDEZ (2012). Notes on the ethnobotany of Costa Rica's palms. *Palms* 56: 190-201.
- THEIVENDIRARAJAH, K. & K. JEYASEELAN (1977). An evaluation of the methods employed in the preservation of kitul sap. *Ceylon Journal of Science (Biological Sciences)* 12(2): 150-155.
- TULEY, P. (1964). How to tap a *Raphia* palm. *Nigerian Field* 3: 120-132.
- UHL, N. W. & H. E. MOORE, JR. (1977). Correlations of inflorescence, flower structure, and floral anatomy with pollination in some palms. *Biotropica* 9: 170-190.

- VIERA Y CLAVIJO, J. (1982). *Diccionario de historia natural de las Islas Canarias*. Las Palmas de Gran Canaria: Mancomunidad de Cabildos de Las Palmas. [Original manuscript from late 18th – early 19th centuries (unknown date), edited by M. Alvar]. 472 pp.
- WÖLFEL, D. J. (1965). *Monumenta linguae Canariae: die kanarischen Sprachdenkmäler. Eine Studie zur Vor- und Frühgeschichte Weissafrikas*. Graz: Akademische Druck- u. Verlagsanstalt. 929 pp.
- YAMÉOGO, J., M. BELEM/OUÉDRAOGO, J. BAYALA, M. BERTIN OUÉDRAOGO, & S. GUINKO (2008). Uses and commercialization of *Borassus akeassii* Bayton, Ouédraogo, Guinko non-wood timber products in South-Western Burkina Faso, West Africa. *Biotechnologie, Agronomie, Société et Environnement* 12: 47-55.
- ZONA, S. (2002). A revision of *Pseudophoenix*. *Palms* 46: 19-38.
- ZONA, S. (2008). The horticultural history of the Canary Island Date Palm (*Phoenix canariensis*). *Garden History* 36: 301-308.

Table 1.- Palms tapped for sweet sap. Product: beverage (unfermented) = Be; alcohol = Al, sugar = Su; syrup = Sy; vinegar = Vi. *Indicates that the palm is no longer tapped for sap. Palm species names follow the nomenclature of Palmweb [Palmweb (2013). Palmweb: Palms of the World Online. Published on the internet <http://www.palmweb.org>. Accessed on 28 Jan 2013].

SPECIES	LOCALE	PART TAPPED	Tapping non-/destructive	PRODUCT	REFERENCE(S)
<i>Acrocomia aculeata</i> (Jacq.) Lodd. ex Mart.	southern Mexico, Central America	terminal bud	destr.	Al	Balick, 1990; Sylvester <i>et al.</i> , 2012
<i>Arenga pinnata</i> (Wurmb) Merr.	Indonesia, Malaysia, SE Asia, Philippines	inflorescence	nondestr.	Al, Su, Vi	Miller, 1964; Dransfield, 1976a; Siebert, 1999
<i>Arenga tremula</i> (Blanco) Becc.	Philippines	inflorescence	nondestr.	Al	Madulid, 1991
<i>Arenga wightii</i> Griff.	India	inflorescence	nondestr.	Al	Basu, 1991
<i>Attalea butyracea</i> (Mutis ex L.f.) Wess. Boer	Colombia	terminal bud	destr	Al, Vi	Bernal <i>et al.</i> , 2010
<i>Attalea cohune</i> Mart.	Honduras, Mexico	terminal bud	destr.	Al	Balick, 1990
<i>Attalea speciosa</i> Mart.	Brazil	terminal bud	destr.		May <i>et al.</i> , 1985
<i>Beccariophoenix madagascariensis</i> Jum. & H.Perrier*	Madagascar	stem below terminal bud	?	Al	Decary, 1964
<i>Borassus aethiopum</i> Mart.	Tropical Africa	stem below terminal bud	destr.	Al	Sambou <i>et al.</i> , 2002
<i>Borassus akeassii</i> Bayton, Ouéd. & Guinko	West Africa	stem below terminal bud	nondestr.	Al	Bayton <i>et al.</i> , 2006; Yaméogo <i>et al.</i> , 2008
<i>Borassus flabellifer</i> L.	India, SE Asia; Indonesia	inflorescence	nondestr.	Be, Su, Vi	Dransfield, 1976b; Fox, 1977; Jayatissa, 1983; Davis & Johnson, 1987
<i>Borassus madagascariensis</i> (Jum. & H.Perrier) Bojer ex Jum. & H.Perrier	Madagascar	inflorescence	nondestr.	Al	Decary, 1964
<i>Caryota cumingii</i> Lodd. ex Mart. *	Philippines	inflorescence	nondestr.	?	Johnson, 1992
<i>Caryota mitis</i> Lour. *	Philippines	inflorescence	nondestr.	?	Johnson, 1992
<i>Caryota urens</i> L.	Sri Lanka, India	inflorescence	nondestr.	Al, Su, Sy, Vi	de Zoysa, 1992; Basu, 1991
<i>Cocos nucifera</i> L.	SE Asia, Africa	inflorescence	nondestr.	Al, Be, Su, Vi	Hodge, 1963; Jayatissa, 1983; Kadere <i>et al.</i> , 2004
<i>Copernicia prunifera</i> (Mill.) H.E.Moore*	Brazil	?	?	Be, Al	Johnson, 1972
<i>Corypha umbraculifera</i> L.	SE Asia	inflorescence	nondestr.	Be	Fox, 1977
<i>Corypha utan</i> Lam.	Indonesia	inflorescence	nondestr.	Al, Su, Vi	Abrenilla <i>et al.</i> , 1988; Moge, 1991
<i>Dypsis nodifera</i> Mart. *	Madagascar	?	?	Al	Decary, 1964

SPECIES	LOCALE	PART TAPPED	Tapping non-/destructive	PRODUCT	REFERENCE(S)
<i>Elaeis guineensis</i> Jacq.	Ghana, Ivory Coast, Nigeria, Madagascar	terminal bud	destr.	Al	Onuche <i>et al.</i> , 2012
	Nigeria, Senegal, Benin, Ivory Coast	inflorescence	nondestr.	Al	Onuche <i>et al.</i> , 2012
<i>Hydriastele microcarpa</i> (Scheff.) W.J.Baker & Loo	Indonesia	inflorescence	nondestr.	Be	Mogea, 1991
<i>Hyphaene coriacea</i> Gaertn.	Madagascar; SE Africa	terminal bud	destr.	Al	Decary, 1964; Cunningham, 1990
<i>Hyphaene petersiana</i> Klotzsch ex Mart.	Namibia	terminal bud	destr.	Al	Sullivan <i>et al.</i> 1995
<i>Hyphaene thebaica</i> (L.) Mart.	Eritrea, Yemen	?	?	Al, Sy, Vi	Gifri & Gabali, 1991; Ogbazghi & Bein 2007
<i>Jubaea chilensis</i> (Molina) Baill.	Chile	terminal bud	destr.	Sy	González <i>et al.</i> , 2009
<i>Mauritia flexuosa</i> L.f.*	Brazil	terminal bud	destr.	Be, Al	Martius, 1824; Schomburgk, 1923; Lévi-Strauss, 1952
<i>Nypa fruticans</i> Wurm	Bangladesh, Philippines; Indonesia, Papua New Guinea	inflorescence	nondestr.	Al, Su, Vi	Davis, 1988; Hamilton & Murphy, 1988; Rasco, 2010
<i>Phoenix canariensis</i> Chabaud	Canary Islands	terminal bud	nondestr.	Be, Sy	Quintero Lima, 1985
<i>Phoenix dactylifera</i> L.	North Africa	terminal bud	nondestr.	Al, Su	Barrevel, 1993
<i>Phoenix reclinata</i> Jacq.	SE Africa	terminal bud	destr.	Al	Cunningham, 1990
<i>Phoenix sylvestris</i> (L.) Roxb.	India, Bangladesh	stem below terminal bud	nondestr.	Al, Be, Su, Sy	Davis, 1972; Kamaluddin <i>et al.</i> , 1998; Chowdhury <i>et al.</i> , 2008; Rana <i>et al.</i> , 2009
<i>Pseudophoenix ekmanii</i> Burret	Dominican Republic	terminal bud	destr.	Be	Zona, 2002; Namoff <i>et al.</i> , 2011
<i>Pseudophoenix vinifera</i> (Mart.) Becc.	Haiti, Dominican Republic	terminal bud	destr.	Be	Zona, 2002; Namoff <i>et al.</i> , 2011
<i>Raphia africana</i> Otedoh	Nigeria	inflorescence	nondestr.	Al	Otedoh, 1982
<i>Raphia farinifera</i> (Gaertn.) Hyl.	Madagascar		destr.	Al	Decary, 1964
<i>Raphia hookeri</i> G.Mann & H.Wendl.	West Africa	terminal bud	destr.	Al, Vi	Russell, 1963; Tuley, 1964; Jayatissa, 1983
<i>Raphia sudanica</i> A. Chev.	West Africa	stem below terminal bud	destr.	Al	Russell, 1963
<i>Raphia vinifera</i> P. Beauv.	Nigeria	stem below terminal bud	destr.	Al	Russell, 1963
<i>Sabal bermudana</i> L.H. Bailey*	Bermuda	stem below terminal bud	nondestr.	Al?	Hodge, 1960



Figure 1.- An illustration of the tapping process from the 16th Century Drake Manuscript (Pierpont Morgan Library, 1996). Image courtesy of The Morgan Library, New York.



Figure 2.- The tapping process of *Acrocomia aculeata* involves cutting a trough into the terminal bud of a felled palm. The plastic sheet will keep rain and debris out of the trough as it fills with sap. Photograph by Michael J. Balick.



Figure 3.- An individual of *Pseudophoenix ekmanii* in the Dominican Republic recently tapped for sap. It is doubtful that this palm will survive. Photograph by Scott Zona.



Figure 4.- The stem of *Jubaea chilensis* is laid down, and the crown is removed. The black fabric protects the apical cut and the accumulating sap. Photography by Patricio González.



Figure 5.- The apical meristem of *Phoenix canariensis* regrows after tapping on La Gomera, Canary Islands. Powdered sulfur has been applied to the cut surface to protect against fungal growth, and the apex is shaded with fabric (removed for photography). Photograph by Scott Zona.



Figure 6.- Repeated tapping of *Phoenix sylvestris* in Bangladesh leaves zigzag scars on the trunks. Photograph by Mohammad Shaheed Hossain Chowdhury.



Figure 7.- *Elaeis guineensis* being tapped in Senegal. Photograph by Jan Michael Ihl.