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On the trail of the ancient betel nut palm: biogeographic, historical and ethnobotanical perspectives

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Abstract
In most of the world, some parts of plants are used for psychoactive purposes; coffee, tobacco and cannabis are three examples of plants that are used very widely to produce an altered state of consciousness. In South Asia, Southeast Asia, Near Oceania and part of Remote Oceania (e.g., western Micronesia), one of the most common plant species that has long provided traditionally significant, stimulating psychoactive substances is the betel nut palm, *Areca catechu* L. The customary and more recent very wide spread recreational uses of this "keystone" cultural species are described in some detail in this essay, with special attention to botanical, ethnobotanical, archaeological and historical evidence of its origins as a species, with additional attention focused on ancient more sacred uses versus more modern mundane or profane indulgence for mind-altering, stimulating effects.

Key words: Betel nut palm; *Areca catechu*; Trail; Biogeography; History; Ethnobotanical Perspectives

Introduction

The betel nut palm (*Areca catechu* L.) and betel pepper vine (*Piper betle* L.) have typically, but not always, been cultivated together and parts of them combined with slaked lime in the psychoactive, stimulating "betel nut quid." Some regard the name "betel nut palm" for A. catechu to be a misnomer, and instead prefer "areca nut palm" or "areca nut" (see Bavappa et al. 1982; Uhl & Dransfield 1988); however, we will continue to refer to this tree as the betel nut palm because of the widespread use of this English appellation.

Some years ago, Thomas Zumbroich (2008) published a sweeping review article focused on the identifying the origins and ancient dispersal of betel chewing across Southeast Asia, South Asia and the Pacific Islands. Zumbroich (l.c.) provided a wide-ranging perspective on the early spread of the betel chewing habit, noting that the limited biogeographical data available concerning the betel nut palm and betel pepper vine were consistent with a limited natural distribution which was followed by a wide diffusion via human agency. Zumbroich's critical survey of available archaeobotanical reports from South India to Papua New Guinea and beyond challenged the validity of a number of published radiocarbon dates supposedly indicating early betel chewing. Zumbroich (l.c.) combined evidence from "archaeology, historical linguistics and textual analysis" to demonstrate that the biogeographical origins, development, motivations and prehistoric spread of betel chewing "is far more complex than had previously been suggested." Zumbroich (l.c.) concluded that "no single model of dispersal, such as the migration of Austronesian speakers, fully explains the transmission of A. catechu and P. betle across Asia." On the other hand, he argued that a series of biological and cultural influences "can be identified that have facilitated the dynamic expansion of betel chewing across a wide geographic area up to the present." Zumbroich (l.c.) noted the lack of any comprehensive academic monograph on history of relationships between people and A. catechu, and consequently he made a valuable effort to produce an insightful critique of the literature dealing with the origin and diffusion of the betel chewing; his research pervades this discussion in many ways, and is (the present author hopes) enhanced by updated evidence and perspectives regarding where the betel nut palm and its resources were initially used, and then variously utilized by people as a significant resource for psychic, physiological, medicinal, recreational, and ritualistic aspects of many cultures in the tropical regions of the Old World.

Domesticated species as components of the transported landscape

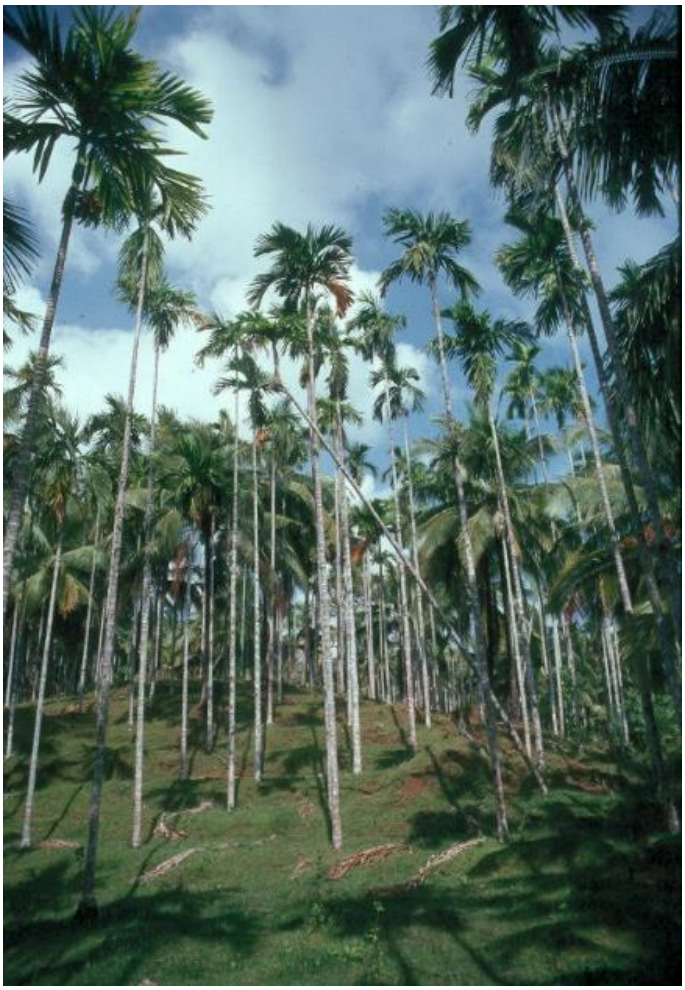

Figure 1. *Areca catechu* palm plantation on South Andaman Island, India.

Ancient farming people who migrated far and wide across much of Eurasia and eventually further to the east into Oceania, consciously brought their "portmanteau biota" of numerous domesticated plants and animals along with a variety of organisms introduced unwittingly. Generally, the most important traditional tropical plant food sources of the Eastern Hemisphere included key domesticated starch-rich or caloric energy species such as Asian rice (Oryza sativa L.), true or sweet taro [Colocasia esculenta (L.) Schott], swamp taro [Cyrtosperma merkusii (Hassk.) Schott], yams (Dioscoria spp.), breadfruit [Artocarpus altilis (Park.) Fosberg], coconut (Cocos nucifera L.), bananas (Musa x paradisiaca L.) and several others. These key food plants were part of the successful human-related dispersals of early farmers who spread their ethnobiologically important (domesticated plant and animal) species as integrated communities of "transported landscapes." These transformed environments were created by sweeping ecological alteration that converted largely wild wet and seasonally dry forests to open cultivated lands (see Anderson 1952, Crosby 1986, Kirch 1982, Lebot 1999).

Many archaeologists, culture archaeologists, historians and ethnobotanists would like to know when the key domesticated nutritional species of farming societies were first introduced to diverse regions such as those in the vast Eurasian continent and subcontinent of South Asia, as well as the multitude of small to very large islands of Southeast Asia and Oceania. More specifically, many historians and scientists have long been interested in what has been the relative significance of these key species in local subsistence strategies - what were their roles in the adaptation and social organization of prehistoric settlers (see Yen 1993, Bellwood 2004, Larson et al. 2014, Stantis et al. 2015, Denham 2017, 2018). However, less attention has been directed toward those plants that were brought in for non-subsistence purpose, but rather for their economic and social importance (for some exceptions, see Lebot et al. 1992; Matthews 1996; Whistler 1991, 2009).

Figure 2. *Areca catechu* palms in front of a house in Siem Reap, Cambodia.

Indeed, the betel nut palm (*A. catechu*) and the betel leaf vine (P. betle) are often grown in tandem, at least in historic times, and were a significant part of the "transported landscape" of ancient farmers. These cultivators of the betel nut palm and vine have stretched geographically from some areas of eastern tropical Africa, across South Asia, Southeast Asia, and Oceania. Although these plants are, more or less, strictly non-nutritive from a

dietary perspective, in their respective traditional areas of psychoactive use, they have also been valued for a variety of invigorating, spiritually imbued, medicinally valuable, and culturally significant purposes.

Figure 3. Ripe fruits on an *Areca catechu* palm cultivated in the Regional Station of the Central Plantation Crops Institute, Vittal, India; this station maintains a germplasm collection of *A. catechu* and related species from within India as well as from Sri Lanka, southern China, Thailand, Malaysia, Singapore, Indonesia, the Philippines, Fiji, the Solomon Islands, and Mauritius.

One particularly intriguing traditional use of betel chewing involves its ability to subdue hunger and how this effect could have been integrated into its role in ancient dispersal and settlement of people throughout its terrestrial and especially its insular biogeographical distribution in Oceania (see Fitzpatrick 2003:61-62). Zumbroich (2008:126-127) summed up this putative use by ancient and contemporary traditional voyagers:

> "Similarly, the physiological responses betel chewing evokes could have been of importance in its diffusion. The ability of areca nut to suppress appetite and to combat fatigue has remained an incentive to this date to take a supply on long-distance travel as is shown by current use amongst the Nuaulu of South-central Ceram (Maluku). This [practice] could have played a particular role for the dispersal via transoceanic voyages in the Indo-Malaysian archipelago and across the Pacific" (see Strickland 2002; Ellen 1991:109; Fitzpatrick et al. 2003:59).

Figure 4. *Piper betle* vine growing on *Areca catechu* palms in a plantation in the Regional Station of the Central Plantation Crops Institute, Vittal, India.

Authoritarian cultural restrictions and preferences for betel nut, whatever their full extent of social prohibition may have been, have dissipated to varying degrees in modern times. This can be explained by increased human population mobility (geographically and socially), as well as the introduction and widespread use of a variety of "new" psychoactive substances, such as tobacco, alcohol and cannabis. Nevertheless, traditional use, symbolic meanings, and the social importance of the betel quid and its components, remain significant in a number of areas of tropical Asia and the Pacific. In this essay, striking differences, as well as age old similarities, of provenance

and relative cultural status are referred to in light of the more modern cultural changes in the psychoactive use of betel nut from the sacred to the profane.

Figure 5. Betel nut quid unwrapped, including leaf of *Piper betle* holding fruits of *Areca catechu* and a lump of slaked lime; photo taken in Banaue, Luzon, the Philippines.

An example, of the shifting relationships between betel chewing and people in modern times, especially among peoples belonging to "non-industrial" communities, can be found in an essay by Hirsch (2007:95) who presented a modern "view from Papua New Guinea" in which he suggested that "betel nut is as much 'bisnis' [pidgin for business] as it is cosmology" (also see the movie Betelnut Bisnis: Directed by Chris Owen, available on YouTube, which focuses on a "grass roots family" which makes a precarious living by trading in betel nut in the Highlands of Papua New Guinea). More detail pertaining to the contrasting decline in use among more urban societies as opposed to the soaring use and assumed health dangers in more rural or relatively poor urban areas will be addressed later in this essay.

Cultural keystone species

A major contention of this paper is that psychoactive use of betel nut has become secularized to varying degrees. However, as suggested above, in some areas, betel chewing retains intense relevance in terms of its psychoactive, therapeutic and ritualistic use, especially in the more traditionally-oriented cultures. According to Auluck et al. (2009), four factors contribute to the popularity of betel nut and betel quid: social acceptability, religious beliefs, perceived health benefits, and addiction. It is assumed here that these four cultural and psychological factors have applied generally in the past as well as the present to betel nut use in areas where betel nut has lengthy customary relationships with traditional or tribal cultures (also see Khalid 2015).

Betel nut chewing has dissipated in many more modernized areas where it was customarily used for hundreds, even thousands of years, especially in more urbanized areas, to a large extent because darkened teeth resulting from habitual betel chewing is now longer held in high esteem. In some regions, betel nut use has been adapted into modern products such as dried parts of the A. catechu kernel sold in sealed packages throughout much of India to be chewed after eating a meal to freshen the breath and aid in digestion.

Figure 6. Green, unripe *Areca catechu* fruits for sale by street vendor in Hanoi, Viet Nam

However, there can be little doubt that the betel nut palm (*A. catechu*) has been and remains as very special plant species in the cultural traditions of several ancient and contemporary societies. Again in reference to India, where the palm is among the significant commercial crops of South India, Konkan, the Andaman and Nicobar archipelagos, and in the North Eastern region, it is cultivated mainly for its masticatory kernels. Indeed through much of India today, where it is popularly known as "areca nut," "supari," or various other local names, betel nut maintains its conspicuous role in the religious, social, cultural and economic life of the people. Generally among people living on the Indian subcontinent, the betel nut palm, at least to some extent, can be viewed as a traditional "cultural keystone species."

> "The concept of 'keystone species' has been widely used in biology and ecology to better understand

> certain biological dynamics at the ecosystem level of analysis. It illustrates the complexity of ecosystem interactions and the dependency of the entire web on certain species that are critical to its stability. While great effort has been put into studying those species that are central to the functioning of the natural ecosystem where they are embedded, not enough is known about the importance of certain plant and animal species for the cultural stability of human communities. Historically, some animal and plant species have been attributed tremendous spiritual or symbolic value by different cultures. Some of these species are so important that a cultural group may define them as critical elements in their relationship with and adaptation to the environment" (Cristancho & Vining 2004:153).

The cultural keystone species concept can be seen as valid for betel nut use, especially its importance in different circumstances of private and public life that focuses on enabling and organizing relationships. Betel nut has long had a significant role in many of the diverse cultures of tropical Asia, and is characterized by its spiritual, socio-economic and, medicinal importance. The insightful discussion by Ellen (1991:97) concerning the cultural status of betel nut use among the Nuaulu of Seram in the Maluku Islands of Indonesia stands out in this regard.

The Nuaulu are a small group of sago-extractors, swidden cultivators, and hunters which Ellen suggested are "widely representative of the region as a whole." In his essay on the ethnobotany and cultural importance of Nuaulu betel chewing, Ellen (l.c.) analyzed selected "meanings attached to betel in social practice: in connection with curing and ancestral contacts, in the way in which it structures interaction and ritual, and in its symbolization of sharing; and how these are related to whatever changes in somatic states take place." Furthermore, in his study of betel use among the Nuaulu, Ellen (1991) made special reference to what he considered a crucially important observation reported by Harold Conklin in his classic study of Hanunoó betel chewing on Mindaro Islands in the Philippines (Conklin 1958, 2007): "namely the self-evidently vital role of the [betel] quid in initiating and promoting interpersonal relationships (including relationships with the supernatural), and as a way of structuring interaction".

Conklin's classic ethnobotanical study concerning the significance of betel nut use among the Hanunoó is a remarkably insightful ethnography demonstrating "how a single plant can be imbricated in so much of human life, including matters historical, physiological, ethnobotanical, behavioral, economic, social, literate, religious, medicinal, and symbolic" (Dove & Kirch 2018:5; also see Frake 2007). Indeed, Conklin's assessment of the crucial cultural significance of the betel nut palm can be viewed as recognition of this palm as a "cultural keystone species."

As noted above, some of the plant species spread from their native territories were not brought along for nutritive or culinary purposes, but rather to satisfy the mind-altering patterns learned from their ancestors. These psychoactive plants and people were strongly associated culturally with their stimulating or relaxing effects, spiritual beliefs, ritual activities, medicinal use, and in the case of the betel nut palm, multiple other uses (described below). The cultural keystone species status implied herein for the betel palm and use of its fruits, in association with betel vine leaves and slaked lime, can be compared with the status of the coca plant (Erythroxylum spp.) and its use (e.g., coca leaves and slaked lime) among some New World peoples.

> "[The] particular conception of the coca plant as a mediator in their communication with the supernatural beings who control nature… [and therefore] the coca plant, becomes so indispensable that people from these communities are unable to conceive of their culture should they suffer from a shortage or a lack of this plant….Were the coca plants to disappear completely, their culture would face a major adaptation" (Cristancho & Vining 2004:155).

Burton-Bradley (1979) referred to "Arecaidinism, or betel-nut habituation," as having "existed since earliest recorded times." In sum, the betel nut palm can be regarded as culturally defined keystone species which are of special interest because they are considered to be, among other things, non-nutritive cultivated species traditionally associated with rites of passage, sociality, societal status, as well as spirituality (i.e., communication with ancestors or the spirit world).

Traditionally, the betel nut palm and the culturally associated betel leaf vine have been cultivated, and to some extent naturalized extensively in many island areas of the tropical Western Pacific (most of which is now referred to as Near Oceania; e.g., see Hirsch 2007 for an example in highland Papua New Guinea). The Pacific range of distribution of these two species has included parts of New Guinea and the Solomon Islands in Near Oceania, as well as in the western region of Remote Oceania, for example, in the Micronesian Islands of Palau, Yap, and the Marianas (see Rooney 1993, Fitzpatrick et al. 2003, Zumbroich 2008, Paulino et al. 2011). The traditional use of the betel nut was restricted in the western region of Micronesia to these islands, with Yap as putatively the furthest location eastward in the Pacific. However, it should be noted here that during the 20th century, and now in this century, betel nut use has been spreading to other parts of the Federated States of Micronesia such as Pohnpei, and even recently to the Marshall Islands, with serious concerns raised about its

soaring use, especially when tobacco is included in the betel chew (see below for more detail).

Betel chewing involves one absolutely essential component: the so-called "nut" (technically a ruminate endosperm, sometime referred to as the seed or kernel that is characterized by its uneven and enlarged surface). The "nut" is embedded within the husked-fruit of the A. catechu palm. Typically, a betel quid includes a sliced segment of a betel fruit including part of the nut is masticated alone, or with in a variable wrap of leaves, stems, or catkins (flowering spikes) of the pepper vine, P. betle; note: quid by definition refers to a portion of something, especially tobacco that is to be chewed but usually not swallowed. Slaked lime, often prepared from ground coral or seashells, is usually added to the segment of the betel palm fruit by itself, or included within the leaf-wrapped quid. Both the betel nut palm endosperm and the leaves of the betel vine "contain pharmacologically active alkaloids, and the lime is required to 'release' them in the chew" (Marshall 1994:1523; also see Fitzpatrick et al. 2003:58). Nine alkaloids form the active ingredients of the areca nut, with arecoline the most abundant and arecaidine also actively important. The alkaloids from the nut and an essential oil from the leaf of the betel vine produce the psychoactive effects of betel chewing. Such effects typically include a "suffused appearance, feeling of well-being, good humour and the undoubtedly increased capacity for activity" (Burton-Bradley 1979; for another point of view about the potential addictive aspects of betel chewing, see: Papke et al. 2015).

The Betel Nut Palm: Description, Adaptation and Putative Biological Origins

Areca catechu, the betel nut palm, belongs to the Arecaceae, the palm family (also still recognized by some botanists as Palmae). Arecaceae includes approximately 180 genera and 2,600 species (e.g., Christenhusz and Byng 2016). The number of species in genus Areca, the type genus of Arecaceae, has varied widely over the years according to systematic botanists; Heatubun et al. (2012:153) referred to 42 species, but there may be several more species in this genus (see Heatubun 2016). Of all the Areca species, A. catechu is the most widespread: a geographical distribution which is mostly, if not all today, the result of human dispersal. For millennia the betel nut palm has been artificially selected by farmers over an enormous terrestrial range coinciding with its diversity of human use as a stimulant source, as well as for many other purposes that are non-psychoactive (some of which are reviewed below).

Botanical description of *Areca catechu*

The betel nut palm is an attractive, well known woody species, with several recognized botanical varieties (see Heatubum 2012:153). A. catechu grows to heights of about 20 m (~65 ft) or more. The trunk is straight and relatively slender with a diameter that is about 15-20 cm (6-8 in) wide and dark gray ringed. The trunk bears a crown of pinnate leaves which are normally more than 1 m (3 ft) long with the lowest frond usually drooping. The leaf sheaths form a distinct cylinder at the top of the trunk, as in other palm species. Where trunk and sheaths join, a branched flower cluster develops. Each betel nut palm produces flowers of both sexes, with the small male flowers borne on the upper part of the flowering stalk, and the larger female flowers at the base. Pollination is reportedly dependent upon the wind to transport pollen from the male flowers, either from the inflorescence of the same palm or from a nearby palm, to the female flowers (Artero & Santos 2000:3). Fruits of A. catechu are produced in large clusters, with individual fruits generally 1.5-5 cm (1/2-2 in) in diameter. The endocarp or skin of the fruit changes from green to yellow or orange when it becomes fully mature. Fruits vary in size and shape greatly within individual palms as well as among populations, a trait that is especially pronounced in this common cultivated species. Each fruit holds a single nut (as noted above, technically an endosperm or seed kernel) which is typically grayish brown, 0.5-4 cm (1-1.5 in) wide and enclosed in a fibrous husk.

Ecological adaptations of *Areca catechu*

The betel nut palm generally prefers lowland tropical habitats on well-watered fertile soils. In open savanna areas dominated by grass or fern species betel nut palm is rarely found due to dry soil conditions. More specifically, A. catechu is typically an understory plant of tall, humid, tropical forest with more or less evenly distributed rainfall of about 1500–5000 mm (60–200 in), occurring from sea level to about 900 m (~3,000 ft) in elevation (see Staples & Bevacqua 2006). Although the betel nut palm can tolerate a variety of soil conditions, it is generally most productive growing in soils rich in organic matter. According to Staples and Bevacqua (2016:6), natural fertility is not as important a survival factor for A. catechu as the capacity of the soil in which it is grown to drain consistently and thoroughly during the raining season; while moisture retention within the plant must be sufficient, waterlogging must be avoided. It should also be noted that the betel nut palm is not salt tolerant and therefore large amounts of salt spray are to be avoided; consequently it is not common near ocean shore lines.

Fruiting in the life history of the *Areca catechu*

Under ideal growing conditions, the betel nut palm begins fruiting when it is about four or five years old, but more often starts when it is seven to eight years old. Maximum fruit production is reached at about 10-15 years or more. Fruits need 6-8 months from bloom to maturity. Betel nut trees in some tropical areas reportedly produce fruit even after 60 years of age, and others are even said to live and bear fruit when they are beyond 100 years of age. In sum, widespread artificial selection pressure on A. catechu over time has produced significant variability through

cultivation, especially in the form of the plant, including more specifically its fruits and seed size, shape, color and even taste (see Zumbroich 2008; Heatubun 2009, 2011, Heatubun et al. 2012:157).

Some aspects of the putative origins of *Areca catechu*

Before the observations and accounts of early European travelers to areas bordering the Indian and Pacific Oceans in the 16th century, the use of betel nut palm for psychoactive or other purposes was little known beyond its wide distribution in the Eastern Hemisphere. This historic distribution has been centered in South and Southeast Asia, but with outlier areas of traditional use that have reached westward to Madagascar and areas in tropical East Africa, as well as eastward to some islands in Near Oceania and western Micronesia. There is no doubt that the use of betel nut alone, or in a betel quid, and the leaves of the betel leaf vine (P. betle) have long been extensively significant in many cultural rites of passage such as birth, marriage and death, in multiple societies across South and Southeast Asia (see D'Souza, K. 2020; Zumbroich 2008). As important as betel nut has been in much of tropical and subtropical Asia, the antiquity of its use in this broad geographical realm is still uncertain.

As a result of its domestication and widespread cultivation, the origin of the A. catechu indeed remains unclear. However, several regions have been suggested based on the distributions of close wild relative species, including the Philippines, Malaysia, the Andaman and Nicobar Islands, Sulawesi and New Guinea (see Beccari 1919, Furtado 1933, Corner 1966, Balakrishnan & Nair 1975, Jones 1995, Heatubun 2008, Heatubun et al. 2012). Compounding the uncertainty has been the lack of evidence for truly wild populations of A. catechu beyond naturalized betel nut palms in association with previous or ongoing cultivation; this suggests that the progenitors of this palm tree are unknown or may even be extinct (Heatubun et al. 2012:154-156).

The most outstanding direct archaeobotanical discovery of "ancient betel nut" in Near Oceania, until it was re-evaluated and dismissed, was the remains of the fibrous husk of a fruit, identified as Areca catechu (see Yen & McEldowney 1991). This plant fragment was found at the Dongan site on the Sepik coastline of northern New Guinea, and its published radiocarbon date of ~5800 B.P. was based on associated wood charcoal. This "early" date challenged previous chronologies documenting the dispersal of arboreal crops from Southeast Asia to New Guinea. However, a re-examination of this mid-Holocene radiocarbon date and the husk itself (Fairbairn & Swadley 2005) confirmed earlier doubts about the antiquity; even the taxonomy of the "ancient" husk was determined to be nothing more than a "modern contaminant" which, despite its excellent preservation status, was not identifiable to the species level.

> "…the betelnut find prompted a great deal of interest. It is today a stimulant of global importance that is usually considered, on phytogeographical and linguistic grounds, to have spread from a center of domestication in Southeast Asia into Oceania (Lichtenberk 1998). Its pre-Lapita presence at Dongan hinted at different domestication and/or dispersal histories and has been interpreted as signifying pre-Lapita New Guinea-Asia connections" (see Yen 1993; Denham 2004).

Indeed, suspicions were raised about the antiquity of the betel nut husk noted in earlier published doubts about its age, which were largely based on its apparent freshness in original printed photographs of the fibrous husk (see Spriggs 1996:328). Although A. catechu has often been referred to as a species native to somewhere in Southeast Asia, its autochthonous area of origin could indeed be somewhere in Near Oceania, especially in an area of the very large island of New Guinea where traditional use is widespread and appears to have a lengthy ethnobotanical history. Recently, Heatubun (2016:175) and his associates have located and described three new species of Areca from New Guinea that are "closely related to the widespread, economically important species A. catechu, the cultivated betel nut palm." This supports the notion that the botanical origins of A. catechu may be located somewhere in New Guinea (presumably somewhere in lowland forest where its use on this very large island is assumed to be ancient); perhaps it proto-domestication occurred there as well. In their new review of the ethnobotany of palms in New Guinea, Dennehy and Cámara-Leret (2019:321) referred to the five most important palm species in island in Near Oceania; these include "Actinorhytis calapparia H.Wendl. & Drude, Adonidia maturbongsii W.J. Baker & Heatubun, Areca catechu, Areca macrocalyx Zipp. ex Blume, and Metroxylon sagu Rottb." Overall, Dennehy and Cámara-Leret argued that their investigation "highlights the importance of palms for fulfilling subsistence needs in New Guinea [and] indicates that palm ethnobotany is neglected in the world's most bioculturally diverse island, and gives directions for future research". It should be noted here that evidence from comparative linguistic could provide additional insight into the questions of betel nut origins, especially cultural origins and cultural diffusion of the palm and its uses; scholars and scientists are encouraged to review the rich linguistic research literature pertaining to the use of A. catechu, as well as that relating to the P. betle vine.

Betel nut palm substitutes in times of scarcity

The palm species or different plants that have provided kernels or other plant parts as substitutes for betel nut when A. catechu fruits have been inaccessible may offer

some clues that can help unravel botanical and cultural origins of the betel nut palm. Heatubun (2016) offered examples of psychoactive resource substitutes when A. catechu is unavailable; these include:

(1) *Areca macrocalyx* Zipp. ex Blume, which is distributed from the Maluku Islands through New Guinea to the Solomon Islands in the east and occupies a wide ecological spectrum, growing from sea level to the highlands, up to 1500 m above sea level;

(2) *Areca novohibernica* (Lauterb.) Becc., which is found on volcanic and limestone soils from 10-1350 m above sea level on the islands of Manus, New Britain and New Ireland in the Bismarck Archipelago, and in the Solomon Islands;

3) *Areca oxycarpa* Miq., which is found as an endemic to the northern part of Sulawesi in Tomohon, North Sulawesi Province, and in Bogani Nani Wartabone National Park, Indonesia, on the border between North Sulawesi and Gorontalo Provinces, growing at 200-450 m above sea level on volcanic soils in primary forest near streams on slopes;

(4) *Areca vestiaria* Giseke, which is found throughout Sulawesi, north and central Maluku, except for Ambon, Kei, Aru and Tanimbar, where it grows on volcanic soils from lowlands to highlands up to about 2000 m above sea level.

Also see Zumbroich 2008 for reference to replacement use of other wild growing palm species such as *Pinanga dicksonii* (Roxb.) Blume and *Areca triandra* Roxb. ex Buch.-Ham. for their fruits in quid mastication.

According to Dennehy and Cámara-Leret (2019), the two Areca species listed as among the five most significant palms in New Guinea are the cultivated betel nut palm, *A. catechu*, and its close relative *A. macrocalyx*; the latter "is harvested from the wild for its seed, [and] is used as a substitute for betel nut (Areca catechu) and as a source of materials." Dennehy and Cámara-Leret (l.c.) also reported that *A. macrocalyx* "is often semi-cultivated for its fruit around the villages of highland New Guinea, and the fruits are sometimes sold in local markets." It seems likely that these two Areca palms (*A. catechu* and *A. macrocalyx*) have had a lengthy, perhaps very early history of artificial selection leading to semi-domesticaton or domestication in New Guinea?

Heatubun *et al.* (2012:154) described the distribution of A. catechu as "cultivated across the Old World tropics, commonly so in East Malesia" which is the region of Malesia that lies "east of Wallace's line as far as the Solomon Islands," with 18 native Areca species including A. macrocalyx, which as we noted above is closely related to *A. catechu*. For example, the stems of both A. catechu and *A. macrocalyx* are shiny green (or yellowish-green) near the stem apex and become brown to whitish near the base, and both species have prominent leaf scars; in addition, all Areca species in East Malesia have leaves that are pinnately divided, which differentiates them strongly with several Areca species in West Malesia which have the simple bifid leaves (leaves with two normally equal parts or are two-lobed from their apex; see Dransfield 1984, Heatubun 2011).

The commentary of Heatubun *et. al.* (2012:153) regarding the fruits and seeds produced by the East Malesian *Areca* spp. may be indicative of the region where "betel nut palms" and their use began? For example, fruits of East Malesian Areca spp. "are small to rather large for the genus…and vary widely in shape." Furthermore, the "epicarp [outer part of the fruit] is thin and smooth with a mesocarp that can be thin to moderately thick and fibrous or fleshy and juicy...with a fibrous endocarp [that] surrounds the solitary seed," and the seed kernels (containing the psychoactive alkaloids) of East Malesian Areca spp. are relatively large. These key plants traits appear to be reflective of lengthy selection by people; in other words, these fruit traits manifested in at least some of the East Malesian Areca species are "the size and shape of the fruits and seeds [that] vary greatly within individuals and populations, especially in the widespread native or cultivated species *A. catechu, A. macrocalyx* and *A. vestiaria*." Although fruit dimensions were used by Beccari (1919) as the main character to differentiate Philippine Areca spp. and their varieties in his infrageneric classification (also see Furtado 1933), Heatubun el al. (2012:153), also observed a high degree of plasticity in this character in the East Malesia region.

Not only are the biological origins of Areca catechu uncertain, indeed, the validity of archaeological and/or paleoecological evidence has been questioned with a kind of "chronological hygiene" approach applied to very early dates of human association with the betel nut palm and its fruit which have been cited often as putative direct and indirect archaeological evidence (see Zumbroich 2008).

Current distribution and use of betel nut

In recent times, some have estimated that about 10% of people living on earth are or were "betel chewers" (see Murphy & Herzog 2015). Although betel nut use appears to have decreased overall in modern times, the geographical range of its use as a stimulant today remains enormous and is regarded as the fourth most widely used "addictive substance" after caffeine, nicotine and alcohol (Boucher & Mannan 2002; Hirsch 2007).

In relation to the modern decreases of betel nut use in some regions, and increases in others, Zumbroich (2008:90) pointed out over a decade ago, that the "geographical

distribution of betel chewing has always been dynamic, e.g., more recently expanding through migratory movements of Asian populations into Europe or beginning to retreat from traditional betel chewing countries like Vietnam" (see Nguyên 2006, Nguyên & Reichart 2008). Even with a widespread decline in the overall geographic range of its use in the 20th century, due to social pressures and fashion preferences, it has been estimated that during the early part of the 21st century as many as 200-400 or many more millions of people were still chewing betel regularly (see Gupta & Warnakulasuriya 2002, Heatubun et al. 2012:147; Chen *et al.* 2017; note, Gupta *et al.* 2018 refer to 600 million betel chewers).

Betel nut palms can be found today cultivated widely throughout India, Sri Lanka, Indonesia, the Philippines, and Malaysia. In addition, A. catechu continues to be grown and used extensively in a number of islands of the tropical Pacific, traditionally, in the western Micronesian Islands of Palau, the Mariana Islands and Yap. More recently in other areas of Micronesia, largely as a result of increased intra-island travel among islanders for employments, educational and political administrative reasons, betel chewing has spread to some additional Micronesian Islands such as Chuuk, Pohnpei and the Marshall Islands, where it did not occur until modern times.

Uses of the Betel Nut Palm: Psychoactive Habits

Utilized today for mind-altering and other physiological purposes by hundreds of millions of people, mainly in Southeast and South Asia, betel mastication is used as a mild to strong stimulant by both men and women, and among various age groups and social classes. The scale of modern cultivation of the betel nut palm in South Asia alone is immense; for example, the Food and Agricultural Organization of the United Nations, reported that India, the largest producer of "areca nut" in the world had an "annual production of 809,000 tons in 2018 that covered an area of 495,000 hectares" (see Kamil *et al.* 2020; FAOSTAT 2018).

Traditionally, sharing and mastication of betel nut, is deeply ingrained in many sociocultural and religious activities in many cultures. Chewing or sucking on a "betel quid" has been a cultural tradition for undetermined thousands of years. There may be variety of reactions in the human body produced by betel nut mastication:

> "Betel chewing has been claimed to produce a sense of well-being, euphoria, heightened alertness, sweating, salivation, a hot sensation in the body and increased capacity to work. Betel chewing also may lead to habituation, addiction and withdrawal. However, the mechanisms underlying these effects remain poorly understood. Arecoline, the major alkaloid of Areca nut, has been extensively studied, and several effects of betel chewing are thought to be related to the actions of this parasympathomimetic constituent. However, betel chewing may produce complex reactions and interactions" (Chu 2001:229).

Although the complexity of physiological reactions related to betel nut chewing are still in need of further study, especially the neurological aspects of this activity, research has confirmed a number of effects claimed by betel quid users. These effects seem to be habit-related and dose-dependent, and even though the arecoline alkaloid "has been thought to be responsible for several effects of betel quid chewing, the present data suggest a role also played by sympathetic activation" (Chu 2002:111). However, more study is indeed needed to determine more precisely the respective roles played by central and autonomic nervous systems and the individual pharmacological effects of the components of the betel quid mixture (Chu 2002:114).

In a more recent review by the International Agency for Research on Cancer that evaluated "areca nut" and products made from the endosperm as being carcinogenic continued to underscore the "urgent need to identify best control policies and research gaps" (Gupta *et al.* 2018:1). Another review published in 2020, focused on the acute and chronic effects that betel nut chewing has on "brain functional connectivity." It is clear that the "active alkaloid" in betel nut is arecoline and its ingestion via chewing betel nut is associated with both acute and longer-term addictive effects. However, even with increasing evidence that chewing betel nut is associated with altered brain function and neural connectivity, "the neurobiology of this psychoactive substance in initial acute chewing, and long-term dependence, is [still] not clear" (Sariah et al. 2020:198).

The alleged dangerous effects associated with short and/or long term betel chewing, and the differential health threats associated with the inclusion of tobacco definitely needs more clarity. Nevertheless, it should be recognized that the psychoactive and other biological reactions connected to betel nut chewing depend upon a number of variables. These include the quality of the individual components of the betel quid (i.e., the seed/nut of *A. catechu*, slaked lime, leaf and sometimes inflorescence of *P. betle*, and now in many places tobacco); another variable strongly affecting the mind-altering and other effects is the quantity of the active components consumed. The amount ingested depends to a large extent on whether the liquid mix (but not the quid itself) is swallowed, or to what extent some of the liquid mix produced by mastication is allowed to be absorbed through the mucous membrane lining the inside of the mouth, while periodically spitting out most if not all of the remaining liquid and solid mix.

Besides the attraction to the stimulation and other effects associated with betel chewing, cultural factors affecting

motivations to indulge in this mastication activity, and expectations of resulting social implications need to be considered:

> "Beyond the individual biological responses, the betel quid carries deeply symbolic connotations and has long played a role in the social fabric of many Asian cultures [and a series of tropical Pacific Island cultures]. Its significance in different circumstances of private and public life centers around the theme of facilitating and structuring relationships. These aspects have previously been explored in varying depths from an ethnographic and literary perspective" (Zumbroich 2008:90; also see Strickland 2002; Murphy *et al.* 2019).

For example, recent research among the Chamorro and non-Chamorro living in the Mariana Islands indicates that "chewing betel nut is a learned behavior, embedded within the culture, and is viewed as an important cultural identifier [and thus it] would be considered rude and disrespectful to not chew." (Murphy & Herzog 2015; Murphy *et al.* 2019). On a much grander scale, similar cultural keystone species values have long been deeply associated with the use of betel nut in tropical Asia: "In India, areca nut and betel leaf are considered as sacred and no ceremonial function is complete without them" (See ICAR document: Areca nut and Human Health).

In addition to millions of people who cultivate the betel nut palm for non-commercial purposes, today the betel nut fruit is widely available commercially, and can be obtained in dried, cured, and fresh states, depending on cultural and personal preferences. The husk of fresh fruit is soft enough to be cut through with a sharp knife; however, as the fruit ripens and dries, the exterior of the fruit husk becomes yellow, orange or even somewhat reddish, while the interior hardens considerably and thus can only be sliced using a special scissors-like cutter. Although the chewing or sucking on the betel quid, or part of the palm fruit, is an ancient culture trait that remains very widespread, the consumption of the betel quid for stimulating purposes has been called into question in regards to short term and long term health issues, especially when more modern additives, such as tobacco, are integrated into the betel quid (see Paulino *et al.* 2011, 2017; Chen *et al.* 2017).

Additional Uses of the Betel Nut

Besides the psychoactive recreational and ritualistic uses of the betel nut, *A. catechu* has also been used by people for a multitude of other purposes. Examples of known utilitarian uses with probable ancient roots in more than one tropical society of the Eastern Hemisphere are referred to briefly below.

Edible parts: although the "palm heart" (comestible young terminal bud) has been referred to as the only food product produced by the betel nut palm, the fruit skin of this palm is reportedly edible, and the seed kernels (endosperms) are also reportedly eaten raw; in addition, young leaves, inflorescences and the sweet inner part of the shoots are purportedly cooked and eaten as vegetables (see Johnson 2011. Uphof 1959, Facciola 1998).

Medicinal applications: mastication of the seed kernel alone or as part of a betel quid can be motivated partially or purely for therapeutic purposes. Much recent discussion has directed attention to the potential deleterious aspects of chewing betel nut alone or in a quid, and the resultant absorption of the masticated fruit and associated liquid into the human body (albeit much of the danger, as noted previously, may be attributed to the combination of tobacco into the betel quid). Nevertheless, betel nut use is perceived traditionally in many countries as having beneficial health effects. For example, multiple parts of the betel nut palm are integrated into various therapeutic preparations, including the nuts (seeds), husks, young shoots, buds, leaves, and roots (Laurent & Tuquero 2019:3). In India, which has the world's largest output per country of "areca nut" (almost 50% according to FAO statistics in 2016), and where nearly 10 million people are estimated to depend on the betel nut industry for their livelihood, the fruits of A. catechu have long been used in traditional herbal medicine (see Peng *et al.* 2015; Jaiswal *et al.* 2011):

According to a recent internet site presentation ("Areca nut and Human Health") produced by the Indian Council of Agricultural Research (ICAR-Central Plantation Crops Research Institute), located in Kasaragod Kerala, there are many "health benefits" of chewing betel nut:

> "Since time immemorial, areca nut is being used for chewing as it is believed to have lots of medicinal properties. It has an important place in the ancient Indian system of medicine such as Ayurveda, Unani and Homeopathy. WHO has listed out as many as 25 different beneficial effects of areca nut on mankind. Chewing areca nut sweetens the breath, removes bad taste from the mouth, strengthens the gums and checks perspiration. It has potent antioxidant, anti-inflammatory and analgesic, antiulcer, hypolipidemic, antidiabetic and neuroprotective properties. It is also traditionally used in a number of ailments for its laxative, digestive, carminative, antidiarrhoeal, anthelmintic, antimalarial, antihypertension, diuretic, prohealing, antibacterial, hypoglycaemic, antiheartburn properties" (https://anantkumarhegde.com/site/assets/pdfs/Health-Benefits-of-arecanut_full.pdf; also see Keshava Bhat et al. 2017, 2018; Lee et al. 2016).

On a much smaller scale, in the Mariana Islands of western Micronesia, betel "nuts" are reportedly used as an

astringent, a mouth freshener after meals, a taste enhancer, a purgative, a remedy for impotence and gynecological problems, a remedy for parasitic intestinal infection, and a preventative of pregnancy-related morning sickness (Khalid 2015:1). In addition, betel seed kernels reputedly alleviate "anemia, vitiligo, leprosy, and obesity, as well as serving as an emetic and diuretic [that are] used in veterinary medicine, primarily to expel tapeworms" (see Fitzpatrick *et al.* 2003:58; Bown 1995; Blombery & Rodd 1992).

Other Uses: The betel nut palm is said to be a "great source of tannins" which are used for fabric dyeing, as adhesives in production of plywood, and other processes:

> "Long before the nature and properties of tannins were determined, the tannins in areca nut were being used for dyeing clothes, as adhesives in plywood manufacture, and for tanning leather for home use in southeast Asia and the Pacific Ocean countries. The tannins are obtained as a byproduct in preparing immature betel nuts for chewing" (Orwa *et al.* 2009:3).

In addition, the trunk of the betel nut palm tree has long been utilized widely for traditional building purposes. For example, the lengthy trunk of this palm is hollow inside but hard on the outside, and thus provides raw material for a number of traditional uses in tropical areas where A. catechu is cultivated. These include construction use for building houses, benches, pig pens, and a lot of other items (Balick & Kitalong 2020; also see Chao *et al.* 2020 for a discussion of "new uses" for Areca catechu).

More specifically, wood extracted from the betel palm, particularly the outside portion of betel palm trunk, is utilized in various kinds of construction in villages. Furthermore, the stem timber can also be used in making a variety of utility articles, and even for making "nails" that are used widely in contemporary furniture manufacturing (Orwa *et al.* 2009:3). In some regions, leaves of A. catechu are used traditionally for thatching, and its leaf sheath is made into cups, plates and bags, as well as skullcaps, small umbrellas and dishes (personal observations by M. Merlin in South and Southeast Asia; also see Blombery & Rodd 1992; Dodge 1897). In addition, sometimes the betel nut palm is employed as an ornamental plant such as in the Hawaiian Islands today, or in the traditional Palauan first birth ceremony (Fadiman *et. al.* 2018; for another overview of diverse betel nut palm usage see Staples & Bevacqua 2006).

Conclusions – a vast dynamic history with much still to be learned

The betel nut palm, Areca catechu, is a domesticated species that has been spread far and wide with a current cultivated range stretching across many areas in tropical Africa, Asia and Oceania. A. catechu is a cultural keystone species that has served many millions of humans as a multipurpose plant in great many ancient and contemporary societies. The geographical, historical and cultural origins of A. catechu are complex and still generally unclear. This relatively brief overview of previous evidence and hypotheses, along with selected new evidence, provides insight for further studies. We have reviewed aspects of the botany, ethnobotany and biogeographical history of A. catechu, which hopefully makes available more details about a multipurpose palm species used for millennia mainly for its stimulating and therapeutic effects. Immoderate indulgence in betel chewing and its alleged impact on human health notwithstanding, the betel nut palm, and its major botanical cohort in the betel nut quid, the *Piper betle* vine, are among those special plants whose history of plant-people relationships through the ages speaks to us in so many different languages, different cultures and different geographical areas. Much of their rich ethnobotanical associations with people remains to be revealed and understood.

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