The LINNEAN SOCIETY of London BOTANICAL Journal of the Linnean Society

Botanical Journal of the Linnean Society, 2012, **168**, 147–173. With 7 figures

A monograph of the betel nut palms (*Areca*: Arecaceae) of East Malesia

CHARLIE D. HEATUBUN FLS[1,2]*, JOHN DRANSFIELD FLS[2], THOMAS FLYNN[3], SRI S. TJITROSOEDIRDJO[4], JOHANIS P. MOGEA[5] and WILLIAM J. BAKER FLS[2]

[1]*Faculty of Forestry, Universitas Negeri Papua, Jl. Gunung Salju, Amban, Manokwari 98314, Papua Barat, Indonesia*
[2]*Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AE, UK*
[3]*Department of Plant Sciences, University of Oxford, South Parks Road, Oxford, OX1 3RB, UK*
[4]*Biology Department, Sekolah Pascasarjana Institut Pertanian Bogor, Darmaga, Bogor 16680, Jawa Barat, Indonesia*
[5]*Herbarium Bogoriense, Puslitbang Biologi LIPI, Jl. Ir. H. Juanda no. 22, Bogor, Jawa Barat, Indonesia*

Received 30 June 2011; revised 22 August 2011; accepted for publication 10 October 2011

The palm genus *Areca* is widespread in tropical Asia and includes the economically important betel nut palm, *A. catechu*. The genus has three centres of high species diversity: the Sunda Region, the Philippines and East Malesia (to the east of Wallace's line). The taxonomy of the genus in East Malesia has been neglected. Prior to this study, 19 species were accepted for this area, all but one endemic, but their limits and differences were not understood. Here, we provide a taxonomic monograph of East Malesian *Areca* spp., based on an extensive study of the genus in herbaria and in the field. We recognize six species of *Areca* in East Malesia, including the widespread cultivated *A. catechu*. Five wild species are accepted, namely *A. macrocalyx*, *A. mandacanii*, *A. novohibernica*, *A. oxycarpa* and *A. vestiaria*. We place 12 of the previously accepted species into synonymy, and provide additional new synonymy in *A. catechu*. *Botanical Journal of the Linnean Society*, 2012, **168**, 147–173.

ADDITIONAL KEYWORDS: conservation – *Palmae* – species – taxonomy.

INTRODUCTION

Areca, described by Linnaeus (1753), is the type genus of the palm family Arecaceae (Moore & Dransfield, 1979; Dransfield *et al*., 2008). It is perhaps best known as the source of betel nut (primarily derived from *Areca catechu* L.), a stimulant that is regarded as the fourth most widely used addictive substance after caffeine, nicotine and alcohol (Norton, 1998). In the recent phylogenetic classification of the palm family, *Areca* was placed together with *Nenga* H.Wendl. & Drude and *Pinanga* Blume in subtribe Arecinae (Areceae; Arecoideae; Dransfield *et al*., 2005, 2008). This classification is supported strongly by the results of recent phylogenetic studies (Loo *et al*., 2006; Norup *et al*., 2006; Baker *et al*., 2009, 2011), which indicate that the three genera are monophyletic and that *Areca* is sister to a clade of *Pinanga* and *Nenga*.

The genera of Arecinae are found in the Asian tropics and are generally small to moderate, unarmed tree palms possessing tubular leaf sheaths that form a well-defined crownshaft, infrafoliar inflorescences, fruit with apical stigmatic remains and seed with a basal embryo. They are unusual among members of Areceae in bearing only one well-developed inflorescence bract (the prophyll), whereas other Areceae typically carry both a well-developed prophyll and peduncular bract. Like the majority of Arecoideae, genera of Arecinae bear unisexual flowers in groups of

*Corresponding author.
E-mail: charlie_deheatboen@yahoo.com

three (triads) comprising a central pistillate flower flanked by a pair of staminate flowers (Dransfield, 1984; Dransfield *et al*., 2008). *Areca* is readily distinguished from the other genera because it has complete triads only at the base of each rachilla with pairs or solitary staminate flowers throughout the remainder of the rachilla, whereas *Nenga* bears numerous complete triads up to three-quarters of the length of the rachilla and *Pinanga* bears complete triads throughout each rachilla.

The last infrageneric classification of the genus *Areca* was proposed by Furtado (1933) and comprises two subgenera and five sections: subgenus *Blumeoareca* Furtado (sections *Arecella* H.Wendl. & Drude, *Oeotheanthe* (Scheff.) Furtado and *Axonianthe* Scheff.) and subgenus *Beccarioareca* Furtado (sections *Microareca* Furtado and *Mischophloeus* (Scheff.) Becc.). However, relationships within the genus were based on morphological affinities alone (Furtado, 1933; Dransfield, 1984; Harley & Dransfield, 2003), and it has been suggested that they need to be reassessed using modern methods (Dransfield, 1984). A reappraisal of the infrageneric classification of *Areca* is in progress (C. D. Heatubun *et al*., unpubl. data).

The centre of diversity of *Areca* is in Malesia and, within this area, there are three regional hotspots for the genus that also reflect palm diversity in general in South-East Asia (Dransfield, 1987; Baker *et al*., 1998; Baker & Couvreur, in press). In West Malesia (west of Wallace's line), the Sunda Region is the primary centre of diversity for the genus with 26 species (Govaerts & Dransfield, 2005; Heatubun, 2011). The second centre is East Malesia, the region east of Wallace's line as far as the Solomon Islands, with 18 species. The third centre is the Philippines with 11 species (Govaerts & Dransfield, 2005). The genus extends further west into mainland tropical Asia as far as China, India and Sri Lanka. Recent studies have suggested that the genus contains 48 (Dransfield *et al*., 2008) or 50 (Henderson, 2009) species in total, although, in the light of recent taxonomic research (Heatubun, 2011; C. D. Heatubun *et al*., unpubl. data), the current total is closer to 42 species. However, a thorough revision of the entire genus *Areca* is needed. As a step towards this goal, we present here an account of the genus in East Malesia, the area in which the genus is least well known and most poorly understood. The monograph presented here covers all *Areca* spp. from Sulawesi, Maluku, New Guinea and the Solomon Islands (Fig. 1).

The early taxonomic history of *Areca* is closely connected to East Malesia because the first species recognized for the genus was described from the region. Linnaeus erected the genus *Areca* and the first species, *A. catechu*, in his *Species Plantarum* in 1753 based on plate IV of Rumphius' (1741)

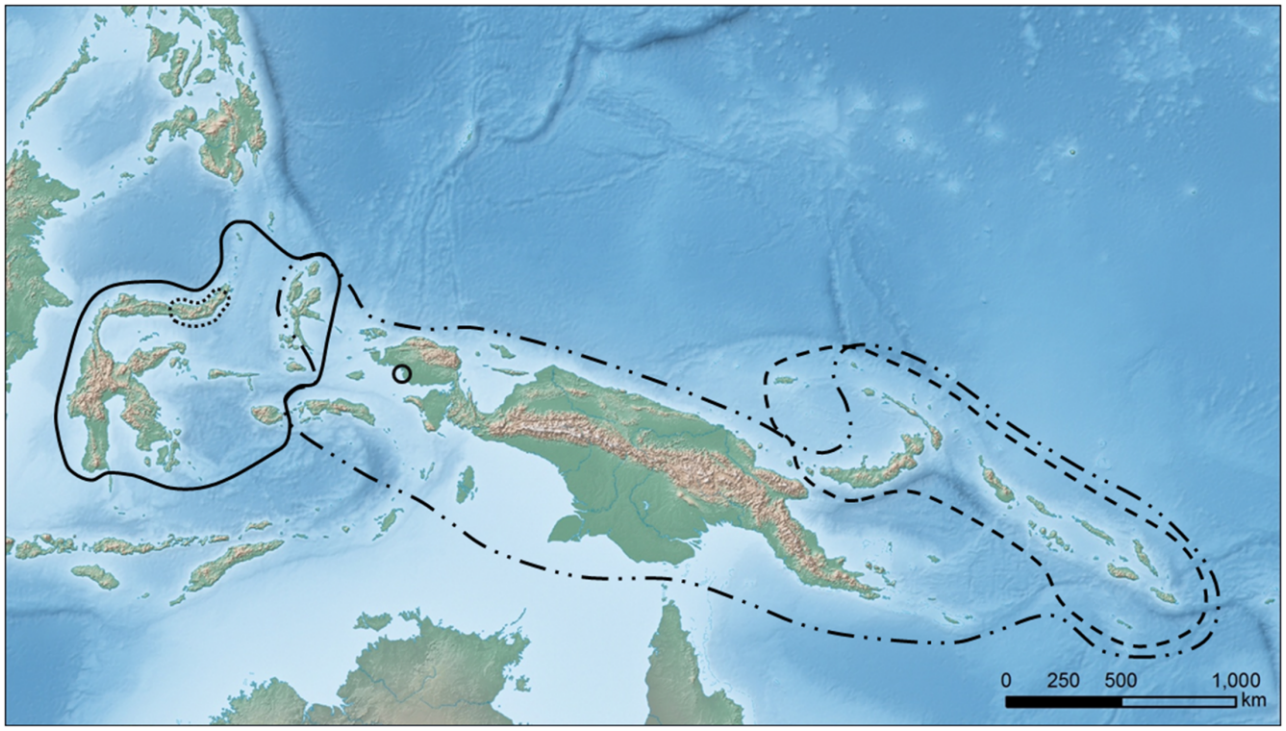

Figure 1. Distribution map of *Areca* spp. native to East Malesia. *Areca mandacanii* (circle), *A. macrocalyx* (–· ·–), *A. novohibernica* (– – –), *A. oxycarpa* (···) and *A. vestiaria* (full line).

Ambonese herbal, *Herbarium Amboinense*; this plate was subsequently selected by Moore & Dransfield (1979) as the lectotype for *A. catechu*. Similarly, the second species described from the region, *A. vestiaria* Giseke (1792), was also based on Rumphius (Dransfield, 1974). A further 17 species from East Malesia were described, primarily during the 19th and early 20th centuries and more recently: *A. macrocalyx* Zipp. ex Blume (Blume, 1838–1839); *A. oxycarpa* Miq. (Miquel, 1868); *A. jobiensis* Becc. (Beccari, 1877); *A. rechingeriana* Becc. (Beccari, 1910); *A. nigasolu* Becc., *A. guppyana* Becc., *A. torulo* Becc. (Beccari, 1914a); *A. warburgiana* Becc., *A. novohibernica* (Lauterb.) Becc. (Beccari, 1914b); *A. congesta* Becc., *A. ledermanniana* Becc. (Beccari, 1923); *A. nannospadix* Burret (Burret, 1931); *A. celebica* Burret (Burret, 1933); *A. rostrata* Burret (Burret, 1935); *A. multifida* Burret, *A. salomonensis* (Burret) Burret ex A.W. Hill & E.Salisb. (Burret, 1936; Hill & Salisbury, 1947); *A. mandacanii* Heatubun (Heatubun, 2008). *Areca* spp. from East Malesia fall into Furtado's (1933) sections *Axonianthe*, *Oetheanthe* and *Mischophloeus*.

Flynn (2004) reassessed the delimitation of species in *Areca* in New Guinea and the Solomon Islands using a morphometric approach, proposing a reduction of seven species into *A. macrocalyx* and two species into *A. guppyana*, although the taxonomic changes were never formally made.

MATERIAL AND METHODS

An extensive study of specimens (dried and spirit-preserved materials) deposited at international herbaria [A, AAU, B, BH, BO, BRI, BZF, CANB, E, FI, FTG, K, KEP, L, LAE, MAN, PNH, SAN, SAR, SING; herbarium acronyms following Holmgren, Holmgren & Barnett, 1990, except for BPKM, the newly established small herbarium in *Balai Penelitian Kehutanan* (Forestry Research Institute – BPKM) in Manokwari, West Papua, Indonesia] underpins this study. In addition, the authors have conducted extensive fieldwork across the region, notably between 1998 and 2011, concentrating on New Guinea and North Sulawesi. Specimens were made in the field using standard preparation guidelines for palms (Dransfield, 1986; Baker & Dransfield, 2006).

Measurements were taken from spirit-preserved material, dried herbarium specimens and living palms. Floral parts were measured from spirit-preserved material or dried specimens rehydrated by boiling. Morphological characters relating to habit, stem, leaves, inflorescence, staminate flower, pistillate flower, fruit, seed and their details were used to delimit and describe taxa. The conservation status of each species of *Areca* in East Malesia was assessed based on the International Union for the Conservation of Nature (IUCN) red list categories and criteria, version 3.1 (IUCN, 2001).

TAXONOMY

In total, 258 distinct herbarium collections (not counting duplicate specimens) were studied. We accept six species in East Malesia, in contrast with the 19 species accepted prior to this study (Govaerts & Dransfield, 2005; Heatubun, 2008). The accepted species are *A. catechu*, *A. macrocalyx*, *A. mandacanii*, *A. novohibernica*, *A. oxycarpa* and *A. vestiaria* (see Taxonomic treatment for details). These species names are used in the remainder of this paper.

MORPHOLOGY

HABIT

The habit of *Areca* spp. can be variable, from acaulescent undergrowth palmlets to moderately robust tree palms, and from solitary to clustering (Dransfield, 1984; Uhl & Dransfield, 1987; Dransfield *et al*., 2008). All species in East Malesia are solitary, except for *A. vestiaria* (although some populations of *A. vestiaria* are single-stemmed). No East Malesian species is acaulescent, unlike several species in West Malesia (Dransfield, 1980, 1984; Heatubun, 2011). Two *Areca* spp. in the region have stilt roots, namely *A. novohibernica* and *A. vestiaria*. Although the ecological significance of stilt roots has been debated, they are thought to be related to swampy habitats, light environments or stabilization in rocky habitats (see Dransfield *et al*., 2008). These roots are essential for mechanical support and vascular function (Frangi & Ponce, 1985; Tomlinson, 1990), but not for 'walking', as erroneously proposed by Leopold (2000) (but see Bodley & Benson, 1980). According to Tomlinson (1990), stilt roots usually occur in solitary palms (such as *A. novohibernica*), providing support for the trunk, but some populations of *A. vestiaria* can be clustering with stilt roots.

STEMS

The stem size varies from slender (1.0–1.5 cm in diameter) in *A. oxycarpa* and *A. macrocalyx* to moderately large (15–20 cm in diameter) in *A. catechu* and *A. macrocalyx*. The leaf scars are prominent. The internode length is variable, and is likely to be related to the conditions in which an individual palm grows. The stems are shiny green (or yellowish-green) near the stem apex and become

brown to whitish near the base. Shiny black stems have been observed in populations of *A. macrocalyx* from heath forest in the central mountains of Japen Island, New Guinea.

Leaves

All *Areca* spp. in East Malesia have pinnately divided leaves, contrasting strongly with the simple bifid leaves of several *Areca* spp. in West Malesia (Dransfield, 1980, 1984; Heatubun, 2011). The number of leaves in the crown of almost all species in this region varies from five to 11. The petiole ranges from lacking or short (up to 5 cm long) to long (to 50 cm long). The arrangement of leaflets is varied in *Areca* but, in most species in East Malesia, the leaflets are irregularly arranged (regular in some specimens) and arrayed in the same plane, except for *A. mandacanii* (Heatubun, 2008). This species has unique plumose leaves, with single-fold leaflets arranged irregularly in different planes. This plumose leaf is unknown in other *Areca* spp. and other members of Arecinae.

The number of leaflets on each side of the rachis varies from five to 75 in East Malesian *Areca*, with the smallest numbers being found in *A. novohibernica* and *A. oxycarpa*, and the highest in *A. macrocalyx*. The number of leaflets is variable in the genus in this region and shows a high degree of plasticity. Sometimes the variation is continuous within species and is inversely related to the number of folds per leaflet, as in *A. macrocalyx*, which can have a small number of broad leaflets to many single-folded leaflets. However, *A. mandacanii* always has single-folded leaflets.

The crownshaft, which is typical of Arecinae and many other arecoid palms, is variable in colour. It is dark brown to black only in *A. oxycarpa*, yellow to orange in *A. vestiaria* (sometimes reddish and rarely pale green or greenish-yellow) and green in all other species. A form of *A. macrocalyx* with a red crownshaft has been reported from the Finschhafen area of Papua New Guinea (Baker & Dransfield, 2006; specimen: *Banka et al. 2001*) and from Wosimi in West Papua (specimen: *Heatubun et al. 776*). The leaf sheath varies from thin in the smaller taxa to thick in emergent tree palms, and sometimes has disintegrating fibres at the margins just below the petiole.

Indumentum

The indumentum can occur on the leaf sheaths, leaves, inflorescences and staminate flowers, although it is relatively unimportant to the taxonomy of *Areca* in this region, with the exception of *A. novohibernica*. Fine purple scales, filamentous brown scales and thick black scales can be found on the leaf sheaths and petioles. Dense white, greyish and brown scales can occur on the leaf rachis. Inflorescences of *A. mandacanii*, especially the peduncle and rachillae, may carry minute red to brown dots and a thick light brown to chocolate brown indumentum. A velvet indumentum on the staminate flowers is one of the important characters separating *A. novohibernica* from *A. vestiaria*.

Inflorescences

The inflorescences of all *Areca* spp. in East Malesia are infrafoliar, although interfoliar inflorescences are found in several *Areca* spp. in West Malesia (Beccari, 1877; Dransfield, 1984). Three species are usually branched to one order (*A. macrocalyx*, *A. novohibernica* and *A. oxycarpa*), *A. vestiaria* is always branched to two orders and *A. catechu* and *A. mandacanii* are branched to two or three orders. Occasionally, those species branched to one order will have a branched, basal-most rachilla. Most species in this region have erect inflorescences in the early stages of development that become pendulous when the fruits develop, although *A. oxycarpa* always has erect inflorescences even when bearing ripe fruits (Fig. 3C, D). Generally, the inflorescence of *A. macrocalyx* is erect in the early stages of development and becomes pendulous later. However, in some populations, inflorescences are always erect, whereas, in others, they are always pendulous; in some instances, combinations may be observed (Fig. 2A–F).

The prophyll, which encloses the inflorescence in bud, is thin, membranous and quickly splits and falls at anthesis. As in all other Arecinae, no further well-developed major bract occurs on the peduncle (Dransfield *et al*., 2008). The prophyll is generally similar to the crownshaft or leaf sheath in colour. For example, in the red crownshaft form of *A. macrocalyx*, the prophyll is also red. The peduncle is shorter than the rachis in all species in this region. The rachillae are glabrous, bearing minute rachilla bracts.

Flowers

As explained previously, in *Areca*, complete floral triads are confined to the proximal part of the rachillae, these reducing to paired or solitary staminate flowers distally. The distribution of triads in the rachilla is important taxonomically in *Areca*, especially in East Malesia. Complete triads occur up to halfway along the rachillae of *A. novohibernica* and *A. vestiaria*, whereas triads occur on the lower third of the rachilla of *A. oxycarpa*. Only one triad is found at the base of each rachilla in *A. catechu* and *A. mandacanii*. In the remarkable inflorescence of *A. macro-*

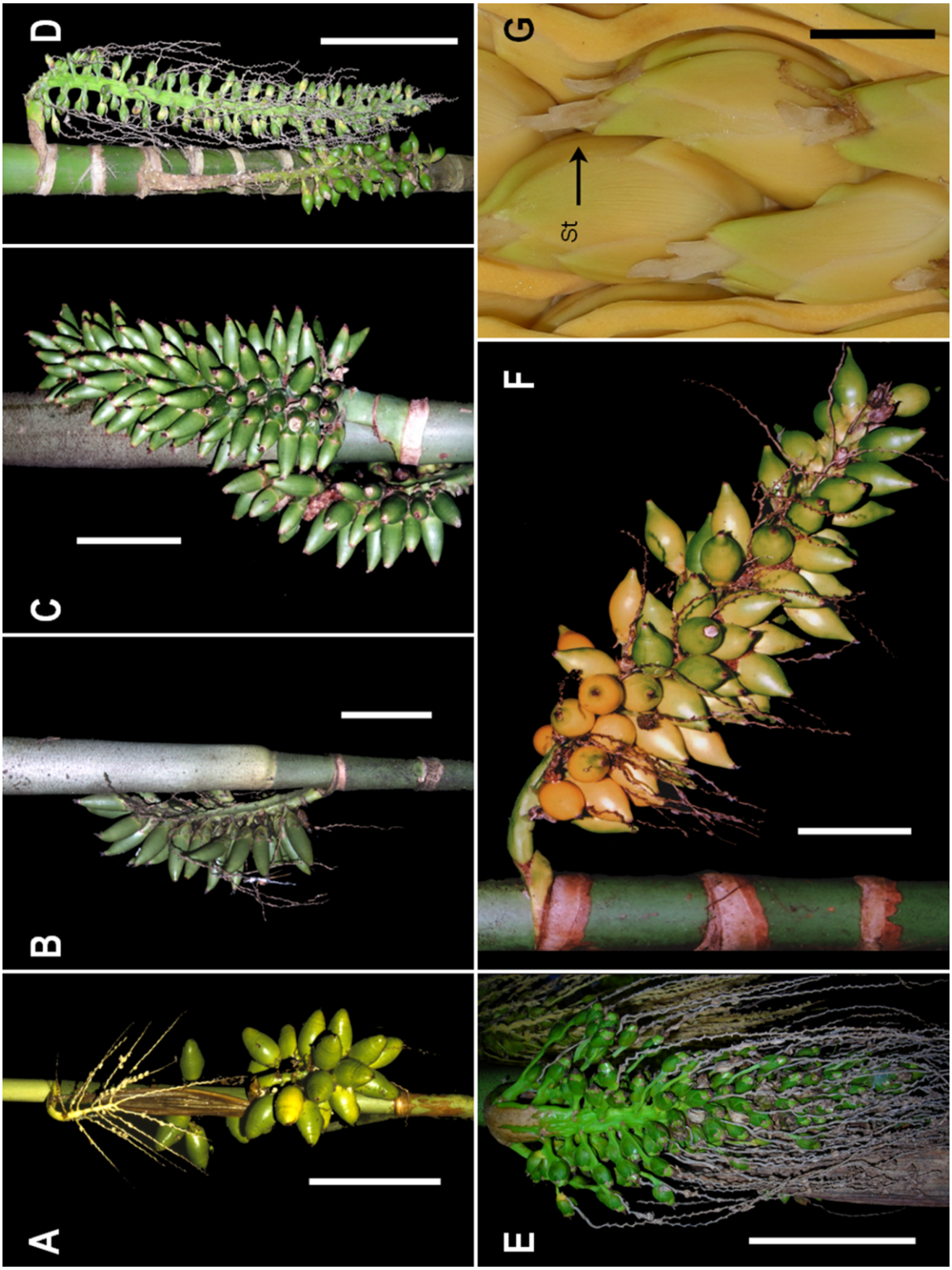

Figure 2. The inflorescence (infructescence) and pistillate flower morphology of *Areca macrocalyx*: A, lax, pendulous inflorescence; B, C, crowded, erect inflorescence; D, long pendulous, lax inflorescence with paired fruits; E, pendulous inflorescence with more than one triad on basal-most rachillae; F, turning from erect to pendulous; G, pistillate flowers at anthesis, stigmas congenitally exposed (St). Scale bars: A, 10 cm; B, C, F, 5 cm; D, 20 cm; E, 25 cm; G, 1 cm. Photographs: A, William J. Baker; B, John Dransfield; C–G, Charlie D. Heatubun.

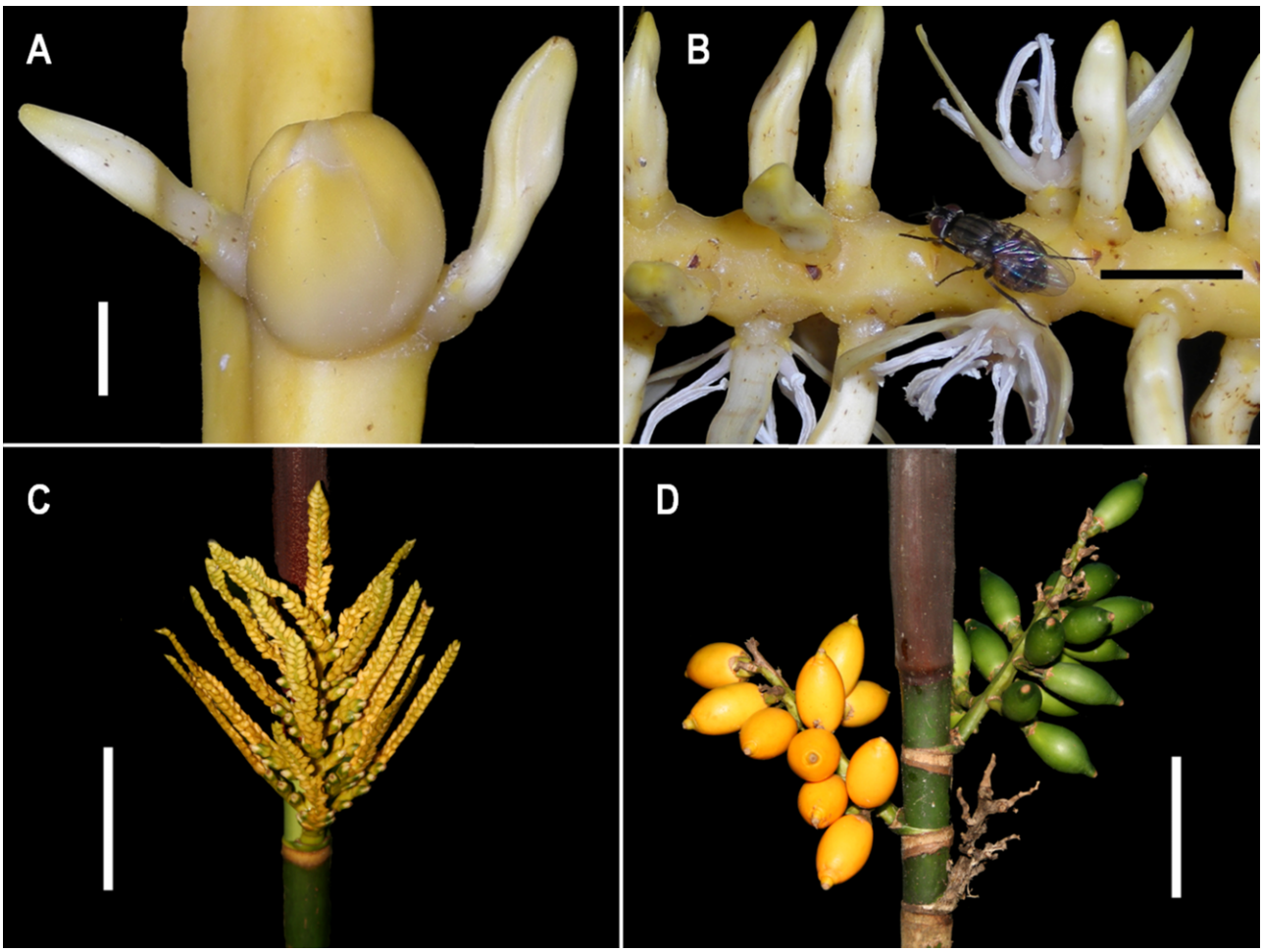

Figure 3. Reproductive organs of *Areca vestiaria* and *A. oxycarpa*: A, triad in *A. vestiaria*, comprising two lateral staminate flowers and a central pistillate flower; B, different stage at anthesis of the staminate flowers of *A. vestiaria*, with flesh fly (Sarcophagidae) visiting the flowers; C, inflorescence of *A. oxycarpa*, slightly congested and protogynous; D, ripe and young fruits of *A. oxycarpa*. A, B, from *Heatubun et al. 885*; C, from *Heatubun et al. 883*; D, from *Heatubun et al. 877*. Scale bars: A, 2 mm; B, 10 mm; C, D, 7 cm. Photographs by Charlie D. Heatubun.

calyx, one to five complete triads including pistillate flowers occur at the very base of each rachilla. The remaining purely staminate portion of the rachilla is slender and dries and falls after anthesis, the remaining part of the inflorescence then resembling a spike and becoming congested and maize-like in fruit (Fig. 2A–F).

As in many palms, the flowers in *Areca* are sexually dimorphic. The staminate flowers are smaller than the pistillate flowers. In East Malesian species, the staminate flowers are cream coloured in bud and white to yellowish-white at anthesis. The pistillate flowers are cream coloured to white or greenish-white with green at the tip in bud, and cream coloured to greenish-cream coloured near the tip at anthesis.

The staminate flowers have three distinct, slightly imbricate, triangular sepals or a cupular calyx with or without three triangular lobes. The corolla comprises three triangular to elongate triangular or slightly spathulate, valvate petals much longer than the sepals. All species in East Malesia have six free stamens, except *A. novohibernica* with epipetalous stamens. The filaments are short to elongate with linear to sinuous anthers, sometimes irregular. A pistillode may be present, sometimes minute and inconspicuous, other times in the form of a conspicuous, trifid column as long as the stamens.

Two distinct groups can be separated easily based on the nature of the staminate flowers among *Areca* spp. in East Malesia. The first has staminate flowers with a cupular calyx and three elongate triangular to slightly spathulate petals [*A. novohibernica* and *A. vestiaria* (Fig. 3A, B); i.e. section *Mischopleous* (Furtado, 1933)], and the second has the calyx with three, slightly imbricate, triangular sepals and three

triangular petals (including *A. catechu*, *A. macrocalyx*, *A. mandacanii* and *A. oxycarpa*).

The pistillate flowers are sessile, globular to triangular and much larger than the staminate flowers. The three sepals are distinct and imbricate (and/or united near the base in *A. novohibernica* and *A. vestiaria*). Petals are similar to the sepals, sometimes valvate at the very tip, otherwise imbricate. Four to six staminodes may be present. They can be triangular or ovate, or form a membranous to fleshy ring with four to six teeth. The gynoecium is unilocular, uniovulate, globose to ovoid, with three stigmas that are reflexed at anthesis.

Fruits and seeds

The fruits of East Malesian *Areca* are small to rather large for the genus (to 70 mm × 45 mm), and vary widely in shape. The epicarp is thin and smooth with a mesocarp that can be thin to moderately thick and fibrous or fleshy and juicy. A fibrous endocarp surrounds the solitary seed. The seeds are relatively large (up to 35 mm × 30 mm × 30 mm) with a basal hilum and anastomosing raphe branches. The size and shape of the fruits and seeds 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 distinguish Philippine *Areca* spp. and their varieties, and by Furtado (1933) in his infrageneric classification, we observed a high degree of plasticity in this character in this region.

TAXONOMIC TREATMENT

Areca L. Sp. Pl. 1189 (1753)

Type species: Areca catechu L., Sp. Pl. 1189 (1753).

Mischophloeus Scheff., Ann. Jard. Bot. Buitenzorg 1: 115, 134 (1876). Type: *Mischophloeus paniculatus* (Scheff.) Scheff. (*Areca paniculata* Scheff.) = (*Areca vestiaria* Giseke).

Gigliolia Becc., Malesia 1: 171 (1877) (non Barb. Rodr.). Lectotype: *Gigliolia insignis* Becc. (= *Areca insignis* (Becc.) J.Dransf.).

Pichisermollia H.C. Monteiro-Neto, Rodriguesia 28: 195 (1976). Type: *Pichisermollia insignis* (Becc.) H.C. Monteiro-Neto (*Gigliolia insignis* Becc.) (= *Areca insignis* [Becc.] J.Dransf.).

Distribution: India and south China, through Malesia to New Guinea and the Solomon Islands.

Number of species: 42 species in total, including six species in East Malesia.

1. *Areca catechu* L. (Fig. 4A–I)

Sp. Pl. 1189 (1753). *Areca faufel* Gaertn., Fruct. Sem. Pl. 1: 19 (1788), nom. superfl. *Areca hortensis* Lour., Fl. Cochinch. 568 (1790), nom. superfl. *Type: Pinanga* Rumphius, Herb. Amboin. 1: t. IV (1741) (Lectotype, designated by Moore & Dransfield, 1979).

Areca cathechu Burm.f., Fl. Indica: 241 (1768) (orthographic variant).

Areca catechu var. *nigra* Giseke, Prael. Ord. Nat. Pl. 73 (1792). *Type: Pinanga nigra* Rumphius, Herb. Amboin. 1: 29 (1741). (Lectotype, designated here). **Syn. nov.**

Areca catechu var. *alba* Blume, Rumphia 2: 68 (1839). *Type: Pinanga alba* Rumphius, Herb. Amboin. 1: 29 (1741). (Lectotype, designated here). **Syn. nov.**

Areca catechu var. *batanensis* Becc., Philipp. J. Sci. 3: 304 (1908). *Type:* Philippines, Batanes Island, 6.vi.1907, *Fenix 3834* (holotype: FI!). **Syn. nov.**

Areca macrocarpa Becc., Philipp. J. Sci. C4: 601 (1909). *Type:* Philippines, Mindanao, Zamboanga District, Port Banga, i.1908, *Whitford & Hutchinson 9103* (holotype: FI!). **Syn. nov.**

Areca catechu var. *longicarpa* Becc., Philipp. J. Sci. 6: 229 (1911). *Type:* Philippines, Polillo Island, 10.xi.1909, *McGregor 10470* (holotype: FI!). **Syn. nov.**

Areca catechu f. *communis* Becc., Philipp. J. Sci. 14: 304 (1919). *Type:* Philippine, Mindanao, Misamis Province, Katajan, Mt. Malindang, *Mearns & Hutchinson 4717* (holotype: FI!). **Syn. nov.**

Areca catechu var. *silvatica* Becc., Becc., Philipp. J. Sci. 14: 304 (1919). *Type:* Philippine, Palawan, Lake Manguao, iv.1913, *Merrill 9447* (holotype: FI!; isotypes: K!, L!). **Syn. nov.**

Invalid names: Areca himalayana Griff. ex H.Wendl. in O.C.E.de Kerchove de Denterghem, Palmiers: 231 (1878). Nom. nud.

Areca nigra Giseke ex H.Wendl. in O.C.E.de Kerchove de Denterghem, Palmiers: 231 (1878). Nom. nud.

Sublimia areca Comm. ex Mart., Hist. Nat. Palm. **3:** 169 (1838). Nom. inval.

Description: Moderate to large, solitary tree palm, 15–25(–30) m. Stem 15–25(–40) cm in diameter; internodes close to elongate (to 20 cm long). Leaves 8–12 in crown, crown shuttle-cock shaped to arching, 150–270 cm long (including petiole); sheath tubular, 50–130 cm long; crownshaft 100–175 cm long, 15–20 cm in diameter, light green to green; petiole almost lacking or short to 15 cm long, channelled adaxially, rounded abaxially; leaflets 20–35 on each side of the rachis, each comprising more than one fold, appearing more or less regular, distributed evenly along the rachis in one plane, basal leaflets *c.* 109 × 9 cm, middle leaflets *c.* 100 × 11 cm, apical leaflets *c.* 68 × 9.5 cm, briefly pointed and sometimes

KEY TO SPECIES OF *ARECA* IN EAST MALESIA

1. Palm with stilt roots; floral clusters spirally arranged on the rachillae; complete triads including pistillate flowers occurring from the base to half the length of each rachilla; sepals of the staminate flower united (calyx cupular), petals elongate and spathulate; fruits with fleshy and juicy mesocarp **2**
1. Palm without stilt roots; floral clusters uniseriate or distichously (or subdistichously) arranged on the rachillae; complete triads including pistillate flowers occurring only at the base and/or along the lower third of each rachilla; sepals of the staminate flower triangular, fused basally or free, petals triangular; fruits with fibrous mesocarp… **3**
2. Small palm with stem to 4(–5) m tall and to 5 cm in diameter; always solitary; crownshaft green; inflorescence branched to one order (rarely two orders); staminate flowers covered with velvet-like indumentum, stamens epipetalous, anthers irregular and sometimes twisted; Manus Island, the Bismarck Archipelago and the Solomon Islands..... **4. *A. novohibernica***
2. Moderate to large palm with stem to 10(–15) m tall and 7–15 cm in diameter; solitary or clustering; crownshaft brilliant orange, reddish to bright red (rarely pale green); inflorescence always branched to two orders; staminate flowers glabrous, stamens not epipetalous, anthers sagittate and elongate; Sulawesi to Maluku… **6. *A. vestiaria***
3. Small, undergrowth to robust, emergent tree palm; inflorescence somewhat compact and rachillae slightly congested along main axis, branched to one order (rarely two orders); protogynous..... **4**
3. Moderate to robust, emergent tree palm; inflorescence divaricate, branched from two or three orders; protandrous. **5**
4. Small, undergrowth to robust, emergent tree palm (to 25 m high); stem 3–20 cm in diameter; leaf sheath and crownshaft mostly green in colour (sometimes reddish to bright red); inflorescence club-like; rachillae numerous (up to 600), slender and sinuous to zigzag in appearance; complete triads including one to five pistillate flowers occurring at the very base of each rachilla, the remaining purely staminate portion slender, drying and falling after anthesis, giving the appearance of a spicate inflorescence, becoming congested and maize-like in fruit; Maluku through New Guinea to Solomon Islands ..... **2. *A. macrocalyx***
4. Small undergrowth palm (to 3 m high); stem 1–3 cm in diameter; leaf sheath and crownshaft always dark brown to black in colour; the inflorescence erect and divergent; rachillae few (up to 16), straight and rather stiff; the complete triads including pistillate flowers occurring along the lower third of all rachillae; endemic to North Sulawesi..... **5. *A. oxycarpa***
5. Leaflets multi-fold, all in the same plane; inflorescence divaricate, broad and crowded, mostly branched to three orders (rarely two); fruits with beaked or rounded with pointed apex; cultivated across the Old World tropics, commonly so in East Malesia ..... **1. *A. catechu***
5. Leaflets single-fold, held in different planes (plumose); inflorescence somewhat elongate and slender, mostly branched to two orders (rarely three); fruits with conspicuous woody discoid depression at the apex; native to Bird's Head Peninsula in western New Guinea..... **3. *A. mandacanii***

notched at apices, green, concolorous when dried. INFLORESCENCE infrafoliar, divaricate, 29–80 cm long, branched two or three orders; rachillae numerous; prophyll caducous, 65–78 × 15–17 cm, leathery; peduncle short, *c.* 6 cm long and *c.* 8 cm wide at the base; rachillae *c.* 10–40 cm long, rachilla bracts inconspicuous, calyces sometimes persistent on rachillae after fruits fallen. FLORAL CLUSTER distichous on rachilla with one to three complete triads including pistillate flowers occurring at the base of each rachilla. STAMINATE FLOWERS small, 4.0–7.5 × 2–5 mm, asymmetrical; sepals three, low, slightly connate near the base; petals three, 6–7 × 2.5–4.0 mm, triangular, cream coloured; stamens 12; filaments 1 mm long; anthers 1–2 × 0.5–0.7 mm; pistillode to 3 mm long, trifid. PISTILLATE FLOWERS larger than the staminate, 12–15 × 7–10 mm, triangular; sepals three, to 10 × 10 mm, imbricate, strongly keeled, cream to green at anthesis; petals three, 10–15 × 7–10 mm, cream; gynoecium *c.* 10 × 5 mm (including stigma 5 mm), stigma trifid; staminodes forming a membranous ring. FRUITS 5–7 × 2–4 cm, variously ovoid to ellipsoid, green and yellow to orange or reddish-orange when ripe; epicarp smooth and thin; mesocarp fibrous and thick; endocarp fibrous and thin. SEEDS 3.0–3.5 × 2.5–3.0 cm, variously subglobose to ovoid, more or less flat at the base.

Distribution and ecology: This is the most widely cultivated species in the genus and has been distributed by humans throughout the tropics. As a result of domestication, the country of origin is not known with certainty. However, several locations have been suggested based on the distributions of close wild relative species, including the Philippines, Malaysia, Celebes (Sulawesi) and New Guinea (Beccari, 1919; Furtado, 1933; Corner, 1966; Jones, 1995; Heatubun, 2008).

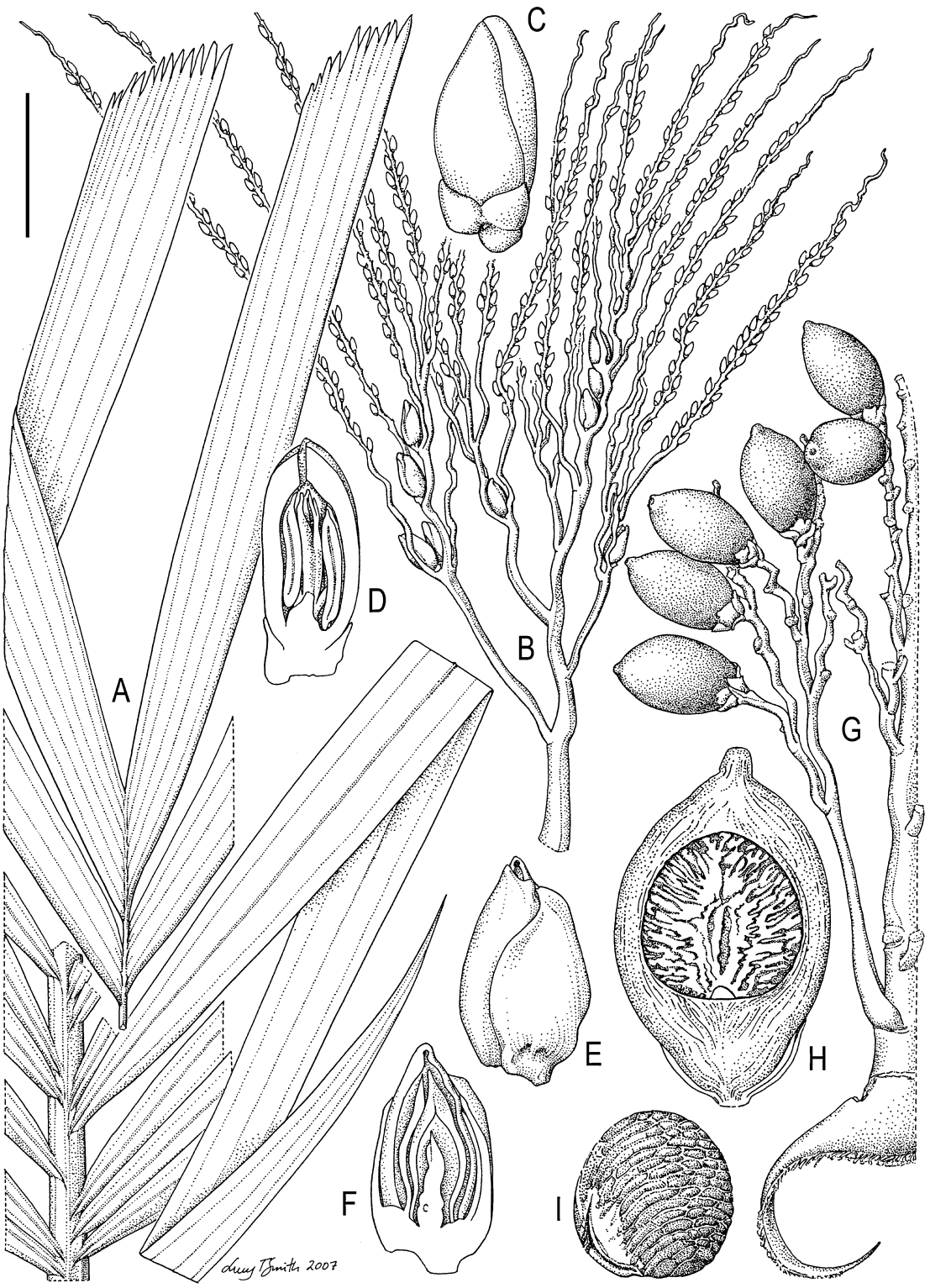

Figure 4. *Areca catechu* L.: A, apical and mid-portion of leaf; B, portion of inflorescence; C, staminate flower; D, staminate flower in section; E, pistillate flower; F, pistillate flower in section; G, portion of infructescence; H, fruit in section; I, seed. Scale bar: A, 8 cm; B, G, 6 cm; C, D, 3 mm; E, F, 1 cm; H, I, 2 cm. A–F, H, I, from *Noblick 5180*; G, from *de Vogel 3266*. Drawn by Lucy T. Smith.

Local names and uses: Many names have been recorded for this widely cultivated species of *Areca*; *angiro* (Solomon Islands: Kwar'ae), *adakka*, *gua*, *supari* (India), areca or areca-nut palm, betel nut (English), *arec cachou*, *arequier* (French), *betelnusspalme* (German), *bu* (Yap), *bua* (Palau), *buai* (Papua New Guinea Pidgin English), *buei* (New Ireland: Pala), *boa* (Bali), *boá*, *boñga*, *buá*, *buñga*, *lúyos*, *takobtob* (Philippines), *cau* (Vietnam), *cun pan*, *kunti* (Myanmar), *doma* (Bhutan), *inan'* (Biak), *jambe* (Javanese), *mark* (Thailand), *palma catechou* (Spanish), *pinang* (Indonesian), *pin lang* (China), *poc* (Pohnpei), *pu* (Chuuk), *puak* (Sri Lanka), *pugua* (Guam), *sawu* (Wandamen), *vua* (New Ireland: Lamekot).

The scale of betel nut palm use is enormous (Norton, 1998; Lee & Choi, 1999; Sullivan *et al*., 2000; Byun *et al*., 2001; Ray & Reddy, 2001; Staples & Bevacqua, 2006), and it has become one of the most important stimulant products in the world, used by around 200–400 million people (Norton, 1998; Gupta & Warnakulasuriya, 2002; Zumbroich, 2008). The origin and dispersal of the betel nut palm and the chewing habit have been discussed for many years, and the most comprehensive review was provided by Zumbroich (2008). Betel nut palm plantations have been shown to play an important role in maintaining biodiversity in the Western Ghats, India (*The Economist*, 8th November 2008: 100).

Conservation status: Least Concern – LC (IUCN, 2001). The widespread cultivation of this species means that it is not threatened. Nevertheless, the lack of evidence for the species in the wild suggests that its progenitors are unknown or may even be extinct.

Specimens cited: **UNITED KINGDOM**. Cultivated at Royal Botanic Gardens, no. x.1.776, *s.n.* (K!). **TANZANIA**. **Dar Es Salaam**, University Agriculture and Forestry campus, Morogoro, T6, 535 m, 11.xi.1976, *Wingfield 3708* (K!). **INDIA**. **Bengal**, Cari Bangar, Baharchara, 11.x.1943, *Sinclair 3272* (E!). **East Bengal**, 1863–1864, *Griffith s.n.* (K!). **Assam**, *Masters s.n.* (BO!). **Calcutta**, Botanic Garden, cultivated at Botanic Garden, *s.n.* (E!, L!). **SRI LANKA**. 1.iv.1860, *Dubuc 1869* (E!). **Peradinya**, Botanic Garden, lawn Q–306, 27.iii.1986, *Rutherford & Bandara 124* (K!); 23.ii.1909, *Baker 136* (BO!, K!). **Sinharaja**, *Barfod s.n.* (AAU photo!). **CHINA**. **Yunnan,** Yunnan Institute of Tropical Botany, 600 m, 2.vii.1978, *Chen 18806* (K!). **TAIWAN**. **Kagi Province**, Kagi, 24.ii.1918, *Wilson 9891* (K!); Orchid Island, Ten-tzu, 31.viii.1969, *Huang & Kao 5234* (L!). **Hainan**, 16.vii.1933, *Liang 62129* (K!); xi.1889, *Henry 8406* (K!); central eastern Hainan, between Kachek and Ling Mon, 5.vi.1922, *Canton Christian College 9808* (E!, K!); Taam Chau District, Na Lin Sham, 30.v.1928, *Tsang 146* (K!); Ngai District, Naam Shan Leng, 16.vi.1932, *Lau 266* (E!, K!). **THAILAND**. **Bangkok**, 4.vi.1920, *Graff 134* (K!). **Phangnga Province**, Laemson National Park, Kampuan Substation, Ton Lan, hill dipterocarp forest, 50–100 m, 22.ii.1994, *Barfod et al*. *45235* (AAU!, BKF, PSU). **SINGAPORE**. Botanic garden, iv.1920, *s.n.* (K!); lawn X, 19.vi.1929, *s.n.* (K!); lawn J, 26.vii.1929, *s.n.* (K!); National University Hospital, Kent Ridge wing, 13.vii.2001, *Ching & Tan TC 01* (K!). **THE PHILIPPINES**. **Luzon**, Manila, Isaac Peral Street, 1935, Bartlett 16226 (K!). **Rizal Province**, Antipolo, xi.1914, *Merrill Species Blancoanae 213* (BO!, K!, L!, PNH). **Laguna Province**, Los Banos, Mt. Makiling, vi–vii.1917, *Elmer 17468* (BO!). **Tayabas Province**, Lucban, v.1907, *Elmer 7795* (BO!, E!). **Isabela Province**, Jones, St. Domingo, 120 m, 22.iv.1987, *Fernando 665* (K!). **Bataan Province**, Mt. Mariveles, Lamao River, 3.xii.1903, *Williams 330* (K!); vii.1904, *Borden 20192 (Forestry Bureau 1272)* (K!). **Batanes Province**, Batan Island, Mt. Iraya, viii.1930, *Ramos (Bureau of Science) 80360* (K!). **Camarines Norte Province**, Labo, Bo Fondado, coconut grove, 14.vii.1985, *Fernando 546* (K!). **Visayas – Western Samar Province**, Mt. Malingon, Brgy Lokilokon, Paranas, 13.x.1992, *Reynoso et al*. *7363* (K!). **Mindanao**, Zamboanga Peninsula, La Paz, Camp Susana, 500 m, 4.vii.1986, *Fernando 600* (K!). **Mindoro**, Mt. Yagaw, SE slope, 5.viii.1953, *Conklin 18651* (L!); 300 m, 6.ii.1958, *Conklin 1055 (PNH 37593)* (L!). **MALAYSIA**. **Sarawak**, 1865–1868, *Beccari PB 3112* (FI!, K!); Triboh scheme, Serian, 14.iii.1988, *Othman & Munting S 61606* (K!, SAR!); Batu Bedanan, Ngarai Talong, Sungai Engkari, Batang Ai, Lubok Antu, 270 m, 31.vii.1994, *Lai S 68676* (K!, L!, SAR!, KEP); Kampung Melayu, Ulu Layar, Betong, 4.vii.1988, *Lee S 55696* (K!, L!, KEP, SAN, SAR!); Kapit, Upper Rejang River, 1929, *Clemens 21501* (K!). **Sabah**, Ranau District, Bundu Tuhan village, Siba, Himbaan village, 13.v.1994, *Soibeh 778* (K!); Poring village, at hill slopes, 31.x.1993, *Sambuling 8* (K!); 6.ii.1994, *Sambuling 76* (K!); Sandakan, mile 12, 10.iii.1949, *Acuadian 202* (K!); Lahad Datu, Masuri, Ulu Segama, 20.xi.1949, *Acuadian 254* (K!); Sorinsim village, Hutan muda, 13.iii.1993, *Sibil 153* (K!); Melangkap Tomis village, 10 m from village hall, 29.v.1995, *Lugas 442* (K!); Tongod District, 22 km logging road to upstream Milian River, 31.x.1984, *Mansus & Aban SAN 69388* (K!, L!); Kiaunuluh village, Nuluhon, 4.ii.1993, *Duaneh 255* (K!); Kota Marudu District, Serinsim village, 9.iii.1995, *Bakia 416* (K!). **INDONESIA**. **Riau Islands Province**, Bengkalis, Singoro, 4 m, 17.ix.1919, *Beguin 330* (BO!). **West Sumatera Province**, Siberut, 9.ix.1924, *Boden-Kloss 11440* (BO!); Mentawai Islands, Sipora

Island, 18.x.1924, *Iboet 440* (BO!). **Banten Province**, Panaitan Island, Ciharahas, upstream, 5.ix.1951, *Borssum-Waalkes 350* (BO!, K!); Peucang Island, Ujung Kulon, 4 m, 13.iv.1971, *Dransfield 1403* (BO!); track to Cibunar, 5 m, 17.iv.1971, *Dransfield 1467* (BO!); *Dransfield 1471* (BO!); Ujung Kulon National Park, *c.* 1 km NW of Cibunar security post, along the bank of Cibunar River, 40 m, 2.x.1998, *Noblick et al. 5180* (BO!, K!, MBC). **Jakarta Province**, Bidara Cina, xi.1863, *Edeling s.n.* (BO!). **West Java Province**, Bogor, Botanic Garden, ex cultivated, lawn II.F.9, *s.n.* (BO!); lawn VII.B.78, *s.n.* (BO!); lawn VII.B.79, *s.n.* (BO!, L!); lawn VII.B.80, *s.n.* (BO!); lawn VII.B.81, *s.n.* (BO!); lawn VII.B.84, *s.n.* (BO!, L!, G); lawn VII.B.85, *s.n.* (BO!, L!); lawn VII.B.87, *s.n.* (B, BO!, K!, L!); lawn VII.B.88, *s.n.* (BO!, L!); lawn VII.B.89, *s.n.* (BO!, L!); lawn VII.B.91, *s.n.* (BO!); lawn XI.B(XX)6, *s.n.* (BO!); lawn XIII.A.6, *s.n.* (BO!); Ciherang, 700 m, 8.i.1928, *van Steenis 212* (BO!); W of Bogor, Leuwiliang, Pasir Honje, 300 m, 5.vi.1927, *Bakhuizen van den Brink 6724* (BO!); *Bakhuizen van den Brink 6782* (BO!); *Bakhuizen van den Brink 6788* (BO!); *Bakhuizen van den Brink 6789* (BO!); 7.vi.1927, *Bakhuizen van den Brink 6807* (BO!, L!); 14.viii.1927, *Bakhuizen van den Brink 6866* (BO!); Tasikmalaya, Nusa Gede, Penjalu, 720 m, 30.vii.1917, *Koorders 396* (BO!). **Central Java Province**, Banyumas, Jagadanda River, 3 m, 10.v.1921, *Backer 31478* (BO!). **Gorontalo Province**, 250 km W of Gorontalo, 75 km inland from Papayuto, on tributary of Papayuto River, 150 m, 30.iii.1990, *Burley et al. 4215* (A, BO!, K!). **South Sulawesi Province**, *c.* halfway South road Soroaku–Wasupoda, 700 m, 1.vi.1979, *de Vogel et al. 6048* (BO!, L!). **North Sulawesi Province**, Bolaang Mongondow, Pindool District, Lolak, 50 m, 19.x.1973, *Dransfield & Mogea 3808* (BO!, L!). **Southeast Sulawesi Province**, Kolaka area, Mt. Watuwila foothills, above Sangguna, Mokuwu camp, 200 m, 30.x.1989, *Coode 6074* (BO!, K!). **East Nusa Tenggara Province**, Alor Island, Atimelang, 750 m, 24.i.1939, *Du Bois 24* (BO!); Timor Island, Baumata village, 50 m, 21.iii.1939, *Bloembergen 3555* (BO!); *Bloembergen 3556* (BO!). **North Maluku Province**, Halmahera Island, Ekor, near the village, 20 m, 1.x.1974, *de Vogel 3266* (BO!, K!, L!); Tidore, 17.v.1921, *Beguin 1613* (BO!, B); Bacan Island, NE Bacan, 2.ix.1985, *Sidiyasa et al. TCW 3580* (K!). **Maluku Province**, Seram Island, Masohi, Waipia, Jerili village, 10 m, 18.xi.1981, *Mogea 3140* (BO!). **West Papua Provinc**e, Raja Ampat Islands District, Gag Island, 10 m, 29.vii.2006, *Heatubun et al. 751* (BO!, K!, MAN!, BPKM!); *Heatubun et al. 752* (BPKM !); *Heatubun et al. 753* (BO!, K!, MAN!, BPKM!). **Papua Province**, Japen Island, Konti Nuai village, 100 m, 25.ii.2008, *Heatubun et al. 870* (BO!, K!, MAN!, BPKM!).

Notes: Areca catechu is the most widespread cultivated species in the genus and has long been the subject of selection by humans. It is planted throughout tropical regions and, although it is most often encountered in village gardens, it has also been developed in large-scale plantations in some areas, notably India. This palm is planted mainly for betel nut production, and thus fruits and seeds are the main target for selection, although cultivation for ornamental purposes has increased in recent years. Anthropogenic selection pressure makes this species variable in cultivation, especially the habit, fruits and seed size, shape, colour and even taste (Zumbroich, 2008).

In this treatment, we apply a broad species concept to *A. catechu* and do not recognize any infraspecific taxa as proposed by earlier authors (Giseke, 1792; Blume, 1838–1839; Beccari, 1908, 1911, 1919). In our view, the morphological features highlighted in these entities are simply part of the spectrum of variation in this variable species. Moreover, distinct individuals, populations or groups found within the morphological range of *A. catechu* are better treated as cultivars, being the product of human selection. Merrill collected a specimen (*Merrill 9447*) in primeval forest in Palawan, Philippines, but he noted in a letter to Beccari (Beccari, 1919) that the trees he collected originated from seeds accidentally left there by native people. The two varieties, var. *nigra* (Giseke, 1792) and var. *alba* (Blume, 1838–1839), are based on interpretation of Rumphius' '*Pinanga nigra* or pinang itam' and '*Pinanga alba* or pinang poëtih' in *Herbarium Amboinense* (Rumphius, 1741: 29), varieties erected on the basis of different colours in the plant and reproductive organs, including fruits. Beccari (1919) keyed out three varieties and one form of *A. catechu* in the Philippines, var. *batanensis* (Beccari, 1908), var. *longicarpa* (Beccari, 1911), var. *silvatica* (Beccari, 1919) and forma *communis*, based on stem, inflorescence, fruit and seed characters. Finally, we follow Merrill (1923: 26) in treating *A. macrocarpa* Becc. as a synonym of *A. catechu*.

2. *Areca macrocalyx* Zipp. ex Blume (Figs 2A–G, 5A–K)

Rumphia 2: 75 (1839). *Areca macrocalyx* var. *zippelliana* Becc., Malesia 1: 19 (1877). *Type:* New Guinea, SW coast, *Zippel s.n.* (holotype: L!).

Areca jobiensis Becc., Malesia 1: 21 (1877). *Type:* New Guinea, Geelvink Bay, Japen Island, Ansus, iv.1875, *Beccari s.n.* (holotype: FI!; isotype: K!). **Syn. nov.**

Areca macrocalyx var. *aruensis* Becc., Malesia 1: 20 (1877). *Type:* Aru Islands, Vokan (Wokam), iii.1875, *Beccari s.n.* (holotype: FI!; isotype: K!). **Syn. nov.**

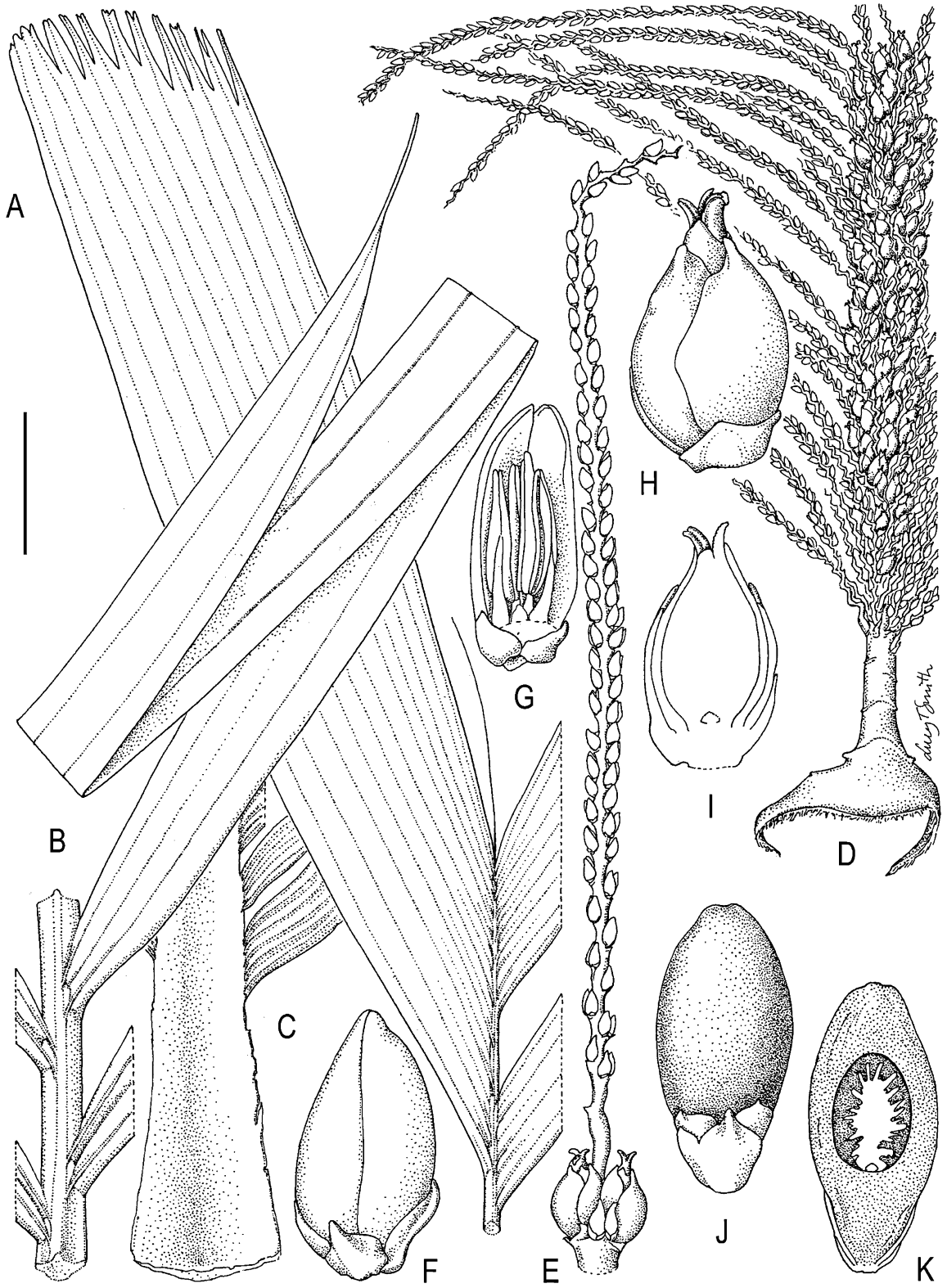

Figure 5. *Areca macrocalyx* Zipp. ex Blume: A, apical portion of leaf; B, middle portion of leaf; C, petiole; D, inflorescence; E, portion of rachilla with staminate and pistillate flowers; F, G, staminate flower whole and in section; H, I, pistillate flower whole and in section; J, K, fruit whole and in section. Scale bar: A–C, 8 cm; D, E, 6 cm; F–I, 7 mm; J, K, 1.5 cm. All from *Baker 1100*. Drawn by Lucy T. Smith.

Areca macrocalyx var. *conophyla* Becc., Malesia 1: 20 (1877). *Type:* New Guinea, NW coast, Ramoi and Amberbaken, 1872, *Beccari s.n.* (holotype: FI!; isotype: K!). **Syn. nov.**
Areca macrocalyx var. *waigheuensis* Becc., Malesia 1 : 20 (1877). *Type:* New Guinea, Waigeo Island, Wakkere (Wakre), iii.1875, *Beccari s.n.* (holotype: FI!; isotype: K!). **Syn. nov.**
Areca rechingeriana Becc., Webbia 3: 163 (1910). *Type:* Papua New Guinea, Bougainville Island, Kieta, *Rechinger 3992* (holotype: B†; isotype: FI!). **Syn. nov.**
Areca macrocalyx var. *intermedia* Becc., in R. Rechinger, V. Teil. Denkschr. Kaiserl. Akad. Wiss. Wien Math.-Naturwiss. Kl. 89: 506 (1913). *Type:* Papua New Guinea, Bougainville Island, Kieta, *Rechinger 4182* (holotype: B†, isotype: FI!). **Syn. nov.**
Areca nigasolu Becc., Webbia 4: 256 (1914). *Type:* Solomon Islands, Treasury Island, *Guppy 95* (holotype: K!, photograph FI!). **Syn. nov.**
Areca torulo Becc., Webbia 4: 253 (1914). *Type:* Solomon Islands, Treasury Island, *Guppy 94* (holotype: K!). **Syn. nov.**
Areca warburgiana Becc., Bot. Jarhrb. Syst. 52: 24 (1914). *Type:* New Guinea, Sigar, *Warburg 20* (holotype: B†, photograph FI!; isotype: FI!). **Syn. nov.**
Areca nannospadix Burret, J. Arnold Arbor. 12: 265 (1931). *Type:* Papua New Guinea, Ihu, Vailala River, rain forest, 9.ii.1926, *Brass 921* (holotype: A!). **Syn. nov.**
Areca rostrata Burret, Notizbl. Bot. Gart. Berlin-Dahlem 12: 322 (1935). *Type:* Papua New Guinea, Diemi, Onange road, Central Division, 6.v.1933, *Brass 3971* (holotype: A!). **Syn. nov.**
Areca multifida Burret, Notizbl. Bot. Gart. Berlin-Dahlem 13: 331 (1936). *Type:* New Guinea, Papua New Guinea, Veiya, 11.iii.1935, *Carr 11661* (holotype: B†, isotypes: A!, K!). **Syn. nov.**

Invalid names: Areca glandiformis Lam., Encycl. 1: 241 (1783). Nom. nud.
Areca macrocalyx var. *keyensis* Becc. in Martelli, Nov. Giornale Bot. Italiano 42: 24 (1935). Nom. nud.

Description: Solitary, slender to robust palm, height to 1.5–25.0 m. STEM 2.5–25.0 cm in diameter; internodes close to elongate, 2–20 cm long, light brown to whitish with conspicuous leaf scars, and shiny green near the crown. LEAVES 6–10 in crown, lamina glabrous, to 250 cm long (including petiole); sheath tubular, to 92 cm long; crownshaft to 150 cm long, green to dark green (reddish-green to bright red in some populations) with numerous black dot-like scales; petiole almost lacking or to 10 cm long, channelled adaxially, rounded abaxially; 6–75 leaflets on each side of rachis, regularly to irregularly arranged, papery, including broad leaflets with several main folds to single folded leaflet, basal-most leaflets slightly sigmoid with oblique-acuminate tips, terminal leaflets slightly flabellate to linear with notched tips, green, discolorous when dried. INFLORESCENCE infrafoliar, protogynous, erect to pendulous, elongate and compact, 10–65 cm long and to 16 cm wide, branched to one order (sometimes basal-most rachillae branched again), the branches spirally arranged and more congested distally; prophyll to 60×16 cm, cream to reddish; peduncle to 10 cm long and to 7 cm at the base, elongate; rachis much more robust than rachillae, up to 30 times wider than rachillae, solid; rachillae numerous (12–600), to 41 cm long, to 3 mm wide, cream to green, slender, elongate, sinuous to zigzag in appearance, somewhat congested along main axis of inflorescence, sometimes perianth persistent on rachillae after fruits fall; rachilla bracts triangular, up to 5 cm long and 1 cm wide at the base, caducous. FLORAL CLUSTER distichously arranged on the rachillae, one to five complete triads including pistillate flowers at the very base of each rachilla, sometimes two triads seated opposite or distichously almost at the same level on the rachilla and appearing paired, the remaining purely staminate portion very slender, and drying and falling after anthesis, giving the appearance of spike-like inflorescence, becoming congested and club- or maize-like in fruit. STAMINATE FLOWERS numerous, triangular, *c.* 14×7 mm, asymmetrical, cream; sepals three, united at the base, low, three-lobed, *c.* 7×4 mm; petals three, thick and fleshy, *c.* 12×4 mm, triangular, striate; stamens six, 7–9 mm long; filaments *c.* 3–4 mm long; anthers 6–7 mm long; pistillode minute. PISTILLATE FLOWERS larger than staminate flowers, triangular, to 20×15 mm; sepals three, imbricate, $10–17.5 \times 5–10$ mm; petals three, imbricate, $10–20 \times 7.5–10.0$ mm; gynoecium 10.0×17.5 mm (including stigma 5 mm); staminodes circular, membranous. FRUITS typically obovoid, but somewhat variable from conical to spindle shaped to almost globose, to 5×3 cm, with beak 1.0–14.5 mm long, green to bright yellow or orange or even red when ripe. SEEDS to 3×2 cm, ovoid, rounded apically and flatted basally.

Distribution and ecology: This is the most widespread species of *Areca* in East Malesia, distributed from the Maluku through New Guinea to the Solomon Islands in the east (Fig. 1). It occupies a wide ecological spectrum, growing from sea level to the highlands up to 1500 m.

Local names and uses: Several local names have been recorded for this species within its area of distribution; *are* (Sayal), *ariki* (Onate), *aupmo* (Keroom), *kasmai* (Waigeo), *monbat* (Matbat), *muncu sirbi*

(Arfak), *owee* (Yamur), *rigi* (Kotte), *sias* (Karon), *sunggeri piawan* (Wandamen), *pinang hutan* (Indonesia) and *wauneb* (Amungkal).

Areca macrocalyx is often used as a substitute for betel chewing when *A. catechu* is unavailable. There is some limited use of *A. macrocalyx* in New Guinea, e.g. stems and leaves are used for building materials (flooring and thatching for huts or temporary houses) and fruits are used for medicine.

Conservation status: Least Concern – LC (IUCN, 2001). This is a widespread species in East Malesia that is locally common. Nevertheless, anthropogenic forest degradation is likely to reduce the extent and abundance of this species.

Specimens cited: **INDONESIA**. **Maluku Province**, Seram Island, Masohi, Waipia, Jerili village, 10 m, 19.xi.1981, *Mogea 3139* (BO!, K!); Aru Islands, Kobroor Island, 10 m, 6.xi.1994, *van Balgooy 6864* (L!, BO!). **West Papua Province**, Kepulauan Raja Ampat District, Misool Island, Motlol, 10 m, 22.i.2002, *Heatubun et al. 360* (K!, MAN!); *c.* 10 km SW of Limalas village, around Wavari camp, 5 m, 20.i.2002, *Wanggai et al. 03* (AAU!, BO!, K!, LAE!); Gag Island, Kaplebet River, 10 m, 28.vii.2006, *Heatubun et al. 747* (BO!, K!, MAN!, BPKM!); Waigeo Island, Omrab, 21.viii.1956, *Manuputty BW 958* (BO!, CANB!, L!, MAN!); Sorong District, road between Bayangkate village to Makbon, 72 m, 9.iii.2008, *Heatubun et al. 876* (BO!, K!, MAN, BPKM!); Manokwari District, Manokwari subdistrict, Amban, Pantai Anggori, 5 m, 9.viii.1995, *Dransfield et al. JD 7533* (BO!, K!, MAN!); Mupi, *c.* 40 km S of Manokwari, along coast of Arfak Nature Reserve, 50 m, 11.iv.1994, *Mogea 6204* (BO!, K!, MAN!); Ransiki subdistrict, Siwi village, 28.i.1999, *Heatubun 292* (AAU!, BO!, FTG!, MAN!); Mountains S of the Arfak Plains, step ridge between the Arfak Plains and Mt. Itsiwei, 900 m, 27.iv.1994, *Sands et al. 6365* (BO!, K!); Teluk Bintuni District (before as Bintuni subdistrict of Manokwari District), near Saengga village, 10 m, *Maturbongs et al. 728* (BO!, K!); Kaimana District (before as Kaimana subdistrict of Fakfak District), Arguny Bay, subdistrict Arguni Bawah, Manggera village, Wasesu Forest, 22 m, 6.x.2010, *Heatubun et al. 1095* (K!, MAN!); Etna bay, Urie Base camp, km-36 road of PT. Kaltim Hutama, 70 m, 1.ii.2001, *Heatubun et al. 331* (AAU!, K!, MAN!). **Papua Province**, Japen Island, Ambaidiru village, 800 m, 23.xi.1998, *Maturbongs et al. 605* (BO!, K!, MAN!); Mamberamo Raya District, Idenburg River, 4 km SW of Bernhard Camp, 850 m, iii.1939, *Brass 13437* (A!, L!); *Brass 13437A* (A!, L!); *Versteeg 1592* (BO!, L!); Bivak Eiland, 6.x.1907, *Versteeg 1782* (L!); Jayapura District, North Cyclops Mts., 100–200 m, 30.i.2001, *Desianto 04* (AAU!, K!, MAN!); Keerom District, Tami River, 91 m, 16.ii.2008, *Heatubun et al. 796* (BO!, K!, MAN!, BPKM!); *Heatubun et al. 798* (BO!, K!, MAN!, BPKM!); *Heatubun et al. 799* (BO!, K!, MAN!, BPKM!); Arso, Tami River, Yawu, 80–110 m, 16.iii.2002, *Gusbager et al. 20* (K!, MAN!). **PAPUA NEW GUINEA**. **Sandaun Province**, Bewani District, N of Bewani Patrol Post, 150 m, 28.viii.1985, *Karenga LAE 55423* (L!, LAE!); Bewani, 0 m, 19–20.iii.2000, *Barfod et al. 488* (AAU!, BRI!, CANB!, K!, LAE!); Round house village, 200–250 m, 27.xi.1996, *Barfod 416* (AAU!, K!); Vanimo, Warastron Forestry Station, 1–2 m, 9.ix.1982, *Karenga LAE 56441* (L!, LAE!); Sepik District, Aitape subdistrict, near Sumo village, Rhainbrum River, 15 m, 7.vii.1961, *Darbyshire & Hoogland 8089* (CANB!, L!, LAE!); Telefomin District, Mt. Entaldam, immediately S of Busilmin airstrip, 1500 m, 28.iii.1975, *Vinas LAE 67031* (L!, LAE!); Hak valley, head of Bal Creek, tributary of Sek River, Donner Mts., S of airstrip, 1050 m, 15.x.1993, *Morren 3049* (K!). **Western Province**, Palmer River, 2 miles below junction, Black River, 100 m, vi.1936, *Brass 7001* (A!, L!); vii.1936, *Brass 7170* (A!); *Brass 7188* (A!); *Brass 7386* (A!); lower Fly River, Sturt Island, x.1936, *Brass 8189* (A!, A photo!); near Ingembit village, 144 m, 16.vi.1967, *Henty et al. NGF 33055* (LAE!); *Henty et al. NGF 33057* (L!, LAE); Oriomo River, 2–7.vii.1968, *Reeve 899* (CANB!); upper Fly River, near N'glei village, *c.* 10 miles N of Kiunga, 60 m, 10.vii.1967, *Pullen 7299* (CANB!); Kiunga, 25 m, 12.ix.1972, *Streimann & Lelean NGF 18311* (LAE!); *Streimann & Lelean NGF 34118* (BRI, L!, LAE); Lake Daviumbu, middle Fly River, ix.1936, *Brass 7901* (A!, L!). **East Sepik Province**, Wewak-Anggoram area, *c.* 5 miles N of Timbunke on Kwoiwut track, right hand side of Minjim River, 30 m, 12.ix.1959, *Pullen 1712* (CANB!, L!, LAE!); Sepik District, Ambunti, eastern ridge of Sumset (Mt. Hunstein), 1140 m, 18.viii.1966, *Hoogland & Craven 11081* (CANB!, K!, L!, LAE); Sepik River, vicinity of Langu village, 40 m, 18.viii.1994, *Takeuchi 10075* (A!, LAE). **Southern Highlands Province**, Mt. Bosavi, northern side, 1250–1350 m, 25.ix.1973, *Jacobs 8761* (L!); 700–800 m, 4.x.1973, *Jacobs 9002* (L!); 900–1000 m, 26.x.1973, *Jacobs s.n.* (L!); near Bosavi mission, Dudessa or Ludessa village, 750 m, 5.ii.1996, *Baker et al. 631* (K!, LAE); Tari, Mt. Bosavi, head of Kuru Creek, 1300 m, 24.viii.1986, *Gideon LAE 57404* (L!, LAE!); E of Mendi, upper Agimo River, Mt. Gilure, southern slopes, 2017.5 (?) m, 27.vi.1961, *Pullen 2638* (CANB!). **Madang Province**, Bogia, mouth of Ramu River, Bogia–Bosmun road, near to Bosmun 2 village, 50 m, 20.i.1996, *Baker & Utteridge 591* (K!, LAE); Josephstaal FMA area, near Kumamdeber, along streambed flowing to SW of Expedition camp 1, 160 m,

31.vii.1999, *Takeuchi et al. 13638* (A!, LAE). **Eastern Highlands Province**, Kainantu District, between Ayura and Akuna, 1800 m, 12.x.1957, *Pullen 725* (CANB!, L!, LAE). **Gulf Province**, Kikori District, Victory junction (confluence of Sirebi River and Kuru River), 34 km N of Kikori, 50 m, 20.xi.2000, *Baker et al. 1098* (AAU!, K!, LAE, NY); Kopi–Kikori road, 10 km NW of Kikori, 40 m, 21.xi.2000, *Baker et al. 1100* (AAU!, BRI, K!, LAE, NY); Panini Creek, 13.xi.1959, *White NGF 10716* (LAE!); Baimuru, Purari River, 240 m, 27.iii.1974, *Croft et al. LAE 61183* (BRI, L!, LAE). **Morobe Province,** Finschhafen District, Jivewaneng village, 14 km NW of Finschhafen, 500 m, 5.xii.2000, *Banka et al. 2001* (AAU!, K!, LAE, NY); Wantot (Wantoat), *c.* 1170 m, 11.iv.1940, *Clemens 11351* (K!); Lae, Eriku, cultivated in Bulae International Primary School, 20.iii.1996, *Gideon s.n.* (K!); Houn Peninsula, Masba Creek, 3 miles S of Pindiu, 600 m, 22.v.1964, *Hoogland 9026* (CANB!, LAE, NY); NW of Waria River, along the streambed Wara Eya, near Yai village, 150–200 m, 15.vi.1999, *Takeuchi et al. 13374* (A!, LAE). **Central Province**, Gulf District, Kikori River, 13.ii.1959, *White NGF 10715* (K!, LAE); Karuku District, 2 miles N of Maipa village, 97.5 m, 10.ix.1962, *Darbyshire 921* (CANB!); Abau District, Cape Rodney, Mori River, 60 m, 19.vi.1968, *Henty NGF 38541* (L!, LAE); Dieni, Ononge road, 500 m, iv–v.1933, *Brass 3971* (A!, NY); Nunumai, *c.* 12 km N of Amazon bay, 30 m, 19.vi.1969. *Pullen 7641* (CANB!, LAE). **Milne Bay Province**, Alotau District, 2 km NE of Kapurika village, 200 m, 11.v.1978, *Essig & Young LAE 74091* (LAE!); SE of Kaporika village, road to Baraga and Cumuni villages, 70 m, 24.xi.1975, *Larivita & Katik LAE 70501* (LAE!); Sagarai, Pini Range, southern slopes, 200 m, 2.iii.1984, *Gideon LAE 76950* (CANB, K!, L!, LAE, USF); *Gideon LAE 76951* (L!, LAE); Raba-Raba District, junction Ugat and Mayu River, near Mayu I, 350 m, 29.vi.1972, *Streimann & Katik NGF 28593* (LAE!); 1100 m, 19.vii.1972, *Streimann & Katik NGF 28994* (L!, LAE); Gwariu River, Biniguni camp, 200 m, iii–iv.1938, *Brass 23977* (A!). **West New Britain Province**, West Wakanau, near cape Hoskins, Glilo village, 3.viii.1954, *Floyd 6422* (A!, LAE); Gasmata, 40–50 m, 29.v.1987, *Karenga & Obedi LAE 62315* (L!, LAE, USF). **East New Britain Province**, Pomio District, Aiwit River, E of Fulleborn harbour, 50 m, 11.v.1973, *Croft & Katik NGF 14984* (L!, LAE); Gaselle Peninsula, Warangoi valley, 60 m, ix.1955, *Kazakoff NGF 7057* (A!, LAE). **New Ireland Province**, Feni group, Ambitle Island, E side of Nanum Caldera, 50 m, 13.xi.2003, *Takeuchi 16771* (A!, LAE). **North Solomon Province**, Bougainville Island, 1932–1933, *Waterhouse s.n.* (K!); vicinity of Aku village, *c.* 10 miles W of Buin Station, 30 m, 14.ix.1964, *Schodde & Craven 4029* (A!, BRI, CANB!, K!, LAE). **SOLOMON ISLANDS**. *Eastern District*, Santa Cruz Island, Towuto Noi Island, Ngambwani area, 4.iv.1972, *Powell BSIP 19467* (CANB!, BSIP); St. Ysabel Island, Bogutu Peninsula, Longuhutu River, SE corner of Tanegoba harbour, 0–30 m, 21.iii.1964, *Moore & Whitemore 9303 (BSIP 4051)* (BSIP, K!); Guadacanal, Honiara, behind Lengakiki ridge, 2.xii.1963, *Whitmore BSIP 1268* (K!, BSIP); New Georgia, 15.vii.1929, *Waterhouse 185* (K!); San Cristobal, Wairaha River, 5 miles from North Coast, 300 m, 11.v.1964, *Whitmore BSIP 4273* (K!). **CULTIVATED**. **Sri Lanka**, Paradineya Botanic Garden, Q-451, 23.vii.1986, *Rutherford & Bandara 154* (K!). **Thailand**, Bangkok, *Sumawong s.n.* (K!). **Singapore**, Botanic Gardens Singapore, Lawn X, 9.x.1929, *Furtado s.n.* (K!, SING).

Notes: Areca macrocalyx is easy to distinguish from other *Areca* spp. in East Malesia by the congested, club-like infructescence. The staminate-only portions of the rachillae are thin compared with the basal parts bearing complete triads including pistillate flowers. The staminate portion dries after anthesis and falls off as the fruits mature leaving a spike-like infructescence.

We have observed this species extensively in the wild. Flynn (2004) analysed *Areca* in New Guinea and the Solomon Islands using a morphometric approach, and, despite problems with missing data, concluded that seven species (*A. congesta*, *A. jobiensis*, *A. ledermanniana*, *A. multifida*, *A. nannospadix*, *A. rostrata* and *A. warburgiana*) should be included within *A. macrocalyx*. Based on our experience in the field and herbarium, we concur with this decision.

The morphology of *A. macrocalyx* is quite complex, perhaps as a response to different types of habitat and distribution. This species occupies a wide range of ecological conditions from littoral and swampy areas in lowlands to heath forest in lower montane vegetation, from evergreen rain forest to drier areas in savannah lands, and from the main island of New Guinea to small offshore islands, Maluku and the Solomon Islands. Adaptation to various habitats is reflected in the variable appearance. If two specimens from different localities are compared in isolation, the impression is readily gained that more than one taxon exists. However, with careful examination of the type specimens and protologues of the species listed in the synonymy above and a large number of other herbarium specimens, we found that morphological variation is continuous and overlapping, as Flynn discovered. No disjunctions in variation occur that would allow the consistent separation of species in this complex as proposed by previous authors. The narrow species concept used in the past reflects limited information obtained from single collections.

Although our treatment is aligned with that of Flynn (2004), we have included three species (*A. rechingeriana*, *A. nigasolu* and *A. torulo*) and five varieties of *A. macrocalyx* that were not covered by him, and consider two other species (*A. ledermanniana* and *A. congesta*) as doubtful taxa rather than as synonyms of *A. macrocalyx*. *Areca nigasolu* and *A. torulo* were described by Beccari (1914a) from Guppy collections in the Solomon Islands. The material is inadequate and consists of a fragment of leaf and a few fruits, but the fruits are typical of *A. macrocalyx*. *Areca macrocalyx* vars. *zippeliana*, *aruensis*, *conophylla, waigheuensis* and *intermedia* were described by Beccari (1877, 1913) based on different fruit characters and collection localities.

The types of *A. rechingeriana* and *A. warburgiana* and several specimens from recent collections (e.g. *Heatubun et al*. *796*, *798*, *799*, Tami River, Keerom, Indonesian Province of Papua) possess inflorescences that are elongate and slender with a thin rachis and laxly arranged pistillate flowers. The arrangement of two pistillate flowers in triads seated close to each other at the base of the rachilla and the 'stalk' formed by the rachilla give the distinct impression as the fruits develop of fruit borne in pairs. However, the typical inflorescences of *A. macrocalyx* with crowded pistillate flowers and/or fruits have also been observed in this population.

Two specimens in the Florence Herbarium (*Jaheri n. 245 ex Bogor* and *n. 279 culta in Bogor Botanic Garden, lawn V. K15. 1915*) are annotated by Beccari with his handwriting as *A. macrocalyx* var. *keyensis*, but this name was never published. In the synonym list of tribe Areceae provided by Martelli (1935), this variety was cited as having been published in Malesia (1: 20). This is not the case and the name is in fact a *nomen nudum*. Similarly, *A. glandiformis* (Lamarck, 1783) was published without a proper description.

Several different collections of *A. macrocalyx* from the main island of New Guinea have distinctive appearances, e.g. with thick-brown indumentum on the leaf sheaths, or the bright red crownshaft form from the Finschhafen area, Papua New Guinea and Wosimi, Indonesian Province of West Papua. Nevertheless, these striking forms fall within the general variation of *A. macrocalyx*, although they may represent unusual ecotypes.

We treat *A. congesta* and *A. ledermanniana* as doubtful taxa in this monograph because the type specimens of *A. congesta* (*Ledermann 12331 & 7250*) and *A. ledermanniana* (*Ledermann 9766*) were destroyed during the Second World War in Berlin, and we have been unable to locate other duplicates. Beccari's descriptions (Beccari, 1923) indicate that these taxa could fit within the range of variation of *A. macrocalyx*, but, in the absence of authentic material, it is not possible to synonymize these two species names formally.

The morphological plasticity in the size of the whole plant, leaf plication, inflorescence size and shape, and fruit size, shape and colour that occurs in *A. macrocalyx* displays gradual and often overlapping variation, and this has influenced the broad species concept used in this revision.

3. *ARECA MANDACANII* HEATUBUN (FIG. 6A–I)

Palms 52: 199 (2008). *Type:* Indonesia, West Papua Province, Sorong Selatan, Teminabuan, Sayal, Maampou Forest, 21.ii.2003, *Heatubun et al*. *423* (holotype: BO!; isotypes: K!, MAN!).

Description: Solitary, moderate tree palm. STEM up to 15 m tall, 8–10 cm in diameter; internodes 13–30 cm long, dark green, shiny, nodal scars conspicuous, white. LEAVES eight in crown, pinnate, appearing plumose, 200–250 cm long (including petiole); sheath tubular, *c.* 92 cm long, smooth, light green; crownshaft well defined, up to 152 cm long and up to 15 cm in diameter; petiole short to 6 cm long, channelled adaxially, rounded abaxially; rachis somewhat arching, with adaxial longitudinal ridge, rounded abaxially; blade with irregularly arranged leaflets, divided into 13–15 groups, in several planes, *c.* 60 leaflets on each side of the rachis, smaller near petiole and gradually becoming larger distally, terminal leaflets regularly arranged (*c.* 13–14 leaflets); leaflets somewhat arching, single-fold, linear, 4 cm long and 4 mm wide at the very base near petiole, tips pointed, 55–60 cm long and 2 cm wide in the middle leaflets, tip acuminate, notched, split to 3 cm depth, papery, green adaxially and lighter green abaxially. INFLORESCENCE infrafoliar, *c.* 60 cm long at anthesis, protandrous, mostly branching to two (rarely three) orders; peduncle 5 cm long, green with numerous minute red–brown dots; prophyll 64×6 cm, borne about one-third way up the peduncle, lanceolate, two-keeled, papery, cream to light brown, entirely enclosing the inflorescence, then splitting longitudinally and falling before staminate anthesis; first order branch elongate, slender, laxly branched; rachis green to whitish-green; rachillae numerous, 37 cm long, covered by thick light brown to chocolate-brown indument, highly contrasting with the rachis, first branching rachillae *c.* 50 cm long, elongate. FLORAL CLUSTER distichously arranged on the rachillae, only one complete triad including a pistillate flower occurring at very base of each rachilla. STAMINATE FLOWERS triangular, 4.5×2.5 mm, asymmetric; sepals three, low, about 2×1 mm; petals three, strongly keeled, valvate, 4.5 mm long, *c.* 1.25 mm wide at base; pistillode 2.5×0.5 mm, trifid, dark brown; stamens six,

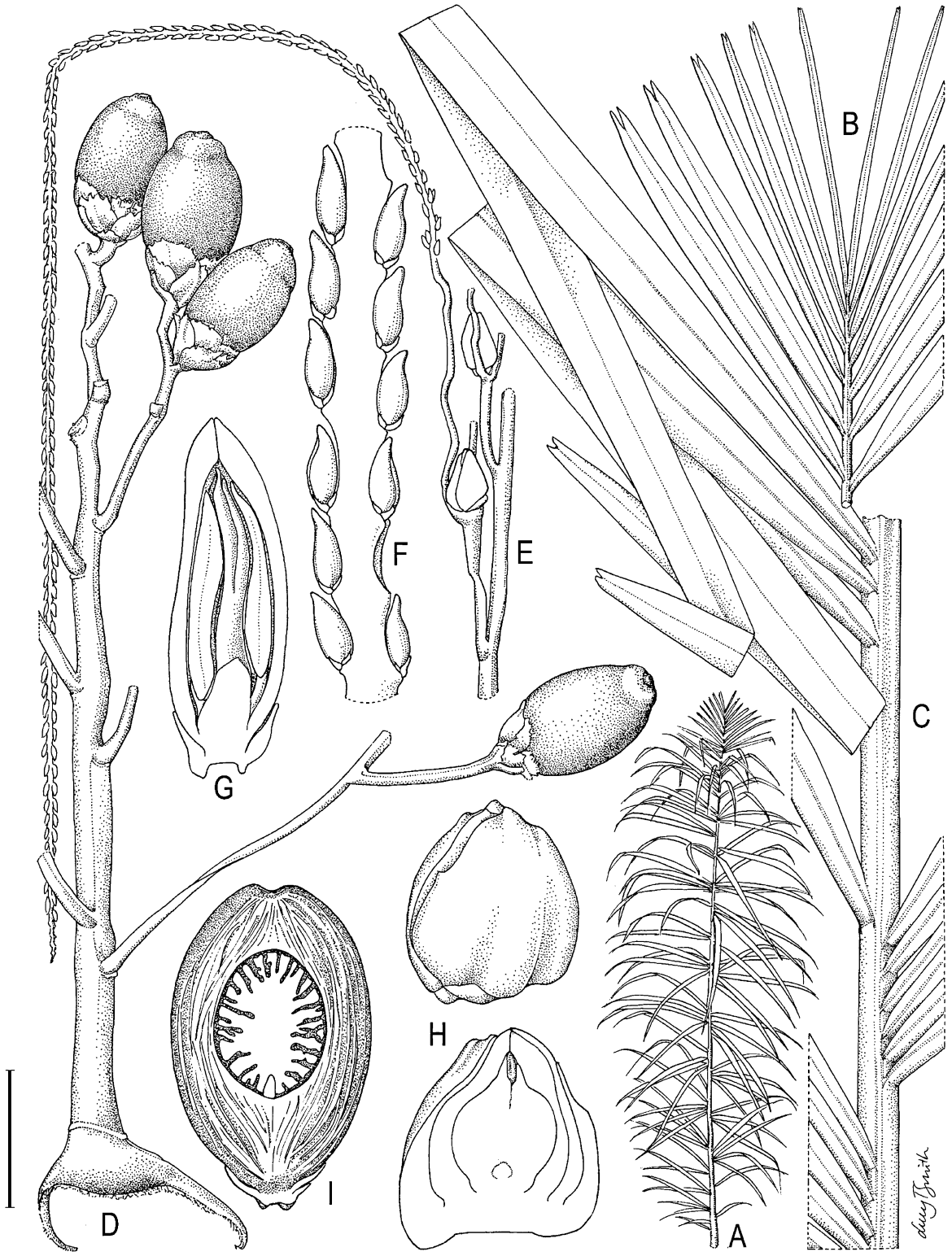

Figure 6. *Areca mandacanii* Heatubun: A, leaf; B, apical portion of leaf; C, mid-portion of leaf; D, infructescence with immature fruits; E, portion of rachilla showing position of staminate and pistillate flowers; F, staminate flowers on rachilla; G, staminate flower in section; H, pistillate flower whole and in section; I, fruit in section. Scale bar: A, 62.5 cm; B–D, 4 cm; E, I, 3 cm; F, 7 cm; G, 1.6 mm; H, 1 cm. A, from photograph taken by Charlie D. Heatubun; B–E, H, from *Heatubun 423*; F, G, I, from *Heatubun 413*. Drawn by Lucy T. Smith.

1.5 mm long; anthers 1.5 mm long, sagittate, cream, longer than the filaments, twisted basally; filaments 0.5 mm long, dark brown. PISTILLATE FLOWERS larger than the staminate, triangular, 10–13 mm in diameter; sepals three, imbricate, triangular, 10–13 mm long, 10–12 mm wide, 1–3 mm thick, asymmetrical, thicker at base, cream to light green; petals three, imbricate, triangular, 13 × 10 mm, 0.5 mm thick, cream; staminodes ovate, 10 mm high, 9 mm wide, pointed, brown at the tip, fleshy. FRUITS ellipsoid, 65–70 × 42–45 mm, with conspicuous woody shallow disc-shaped depression at apex, 10–12 cm in diameter, stigmatic remains persistent in centre of depression, perianth persistent; epicarp smooth, shiny, *c.* 0.5 mm thick, dark green when young, turning to golden yellow or light orange when mature; mesocarp fibrous, *c.* 10 mm thick, but much thicker at the base of fruit (below the seed), where *c.* 20 mm thick; endocarp thin, adhering closely to seed. SEEDS *c.* 28 × 25 mm, subglobose; embryo basal.

Distribution and ecology: Endemic to Maampou Forest, Sayal, in Sorong Selatan District in Bird's Head Peninsula of Western New Guinea (Fig. 1). This palm grows in the transition between swamp forest and lowland rain forest, where the soils are temporarily inundated by water.

Local name and uses: Ngafa (Sayal). The fruits are chewed as a betel nut substitute and the stem is used for flooring.

Conservation status: Critically Endangered (CR B1ab, B2ab). *Areca mandacanii* is estimated to have an extent of occurrence of < 100 km^2 and an area of occupancy of < 10 km^2, being known from only a single location. Previously, the conservation status of *A. mandacanii* was given as Data Deficient (Heatubun, 2008), but the IUCN category of this endemic palm is updated here because no additional localities have been found in subsequent fieldwork, and we now recognize more potential threats to its area of distribution. Oil palm plantations and coal mining are planned in the vicinity of its occurrence. Moreover, the local people usually chop down the tree when they want to harvest the fruits or nuts for use as a betel nut substitute.

Specimens cited: **INDONESIA**. **West Papua Province**, Sorong Selatan District, Teminabuan subdistrict, Sayal village, Maampow forest, 10 m, 21.ii.2003, *Heatubun et al. 413* (K!, MAN!); *Heatubun et al. 424* (MAN!). **CULTIVATED**. **Indonesia**, West Papua Province, Manokwari District, Reremi, 75 m, 10.iv.2008, *Heatubun & Iwanggin 902* (MAN!).

Notes: The differences between *A. mandacanii* and the New Guinean *Areca*, including *A. catechu*, are discussed in detail by Heatubun (2008). The plumose leaves are unique in both *Areca* and Arecinae. It is most similar to *A. catechu*, but the inflorescence of *A. mandacanii* is more slender and laxly branched to two (rarely three) orders, as opposed to congested or crowded and branched mostly to three orders in *A. catechu*. Although fruits are varied in *A. catechu*, they have never been reported to have a conspicuous woody discoid depression at the apex, as in *A. mandacanii*.

Despite similarities to *A. catechu*, the known populations are certainly wild (as opposed to cultivated). Nevertheless, the discovery of *A. mandacanii*, apparently a close relative of *A. catechu*, in the wild in western New Guinea is important because it indicates that New Guinea should be considered alongside the Philippines (Beccari, 1919; Furtado, 1933), Malaysia (Corner, 1966; Jones, 1995) and Sulawesi (Corner, 1966) as a potential area of origin for *A. catechu*.

A specimen identified by Heatubun (2008) as *A. mandacanii* (*Maturbongs s.n.*, K) was cited in error. In fact, this is a duplicate of *Heatubun et al. 413* that was labelled incorrectly.

4. *ARECA NOVOHIBERNICA* (LAUTERB.) BECC. (FIG. 7A–J)

Bot. Jahrb. Syst. 52: 24 (1914). *Nenga novohibernica* Lauterb., Bot. Jarhb. Syst. 45: 357 (1911). *Type:* Papua New Guinea, Bismarck Archipelago, New Ireland, Nabumai, Urwald, *Peekel 110* (holotype: B!, photograph FI!; isotypes: FI!, K!).

Areca guppyana Becc., Webbia 4: 258 (1914). *Type:* Solomon Islands, Shorland Islands, Alu Island, 1 to 2 miles from coast, *Guppy 107* (holotype: K!). **Syn. nov.**

Areca novohibernica var. *salomonensis* Burret, Notizbl. Bot. Gart. Berlin-Dahlem 13: 69 (1936). *Areca salomonensis* (Burret) Burret ex A.W.Hill & E.Salisb., Index Kew. Suppl. 10: 19 (1947). *Type:* Papua New Guinea, Bougainville Island, Kugumaru, Buin District, 2.vii.1930, *Kajewski 1908* (holotype: B†; isotype: A!). **Syn. nov.**

Description: Solitary, small and slender, undergrowth palm, height 2–4(–5) m, with stilt roots. STEM 5–10 cm in diameter; internodes 3–4 cm long, light brown to whitish with conspicuous leaf scars (± 1 cm wide), and shiny green near the crown. LEAVES five to eight in crown, 120–150 cm long (including petiole); sheath tubular, 30–70 × 6.5–10.0 cm; crownshaft 60–90 cm long, light green to green; petiole 30–50 cm long, *c.* 1 cm wide at the base, channelled adaxially, rounded abaxially, covered by thick brown indumentum that continues on to the leaf rachis; leaflets more

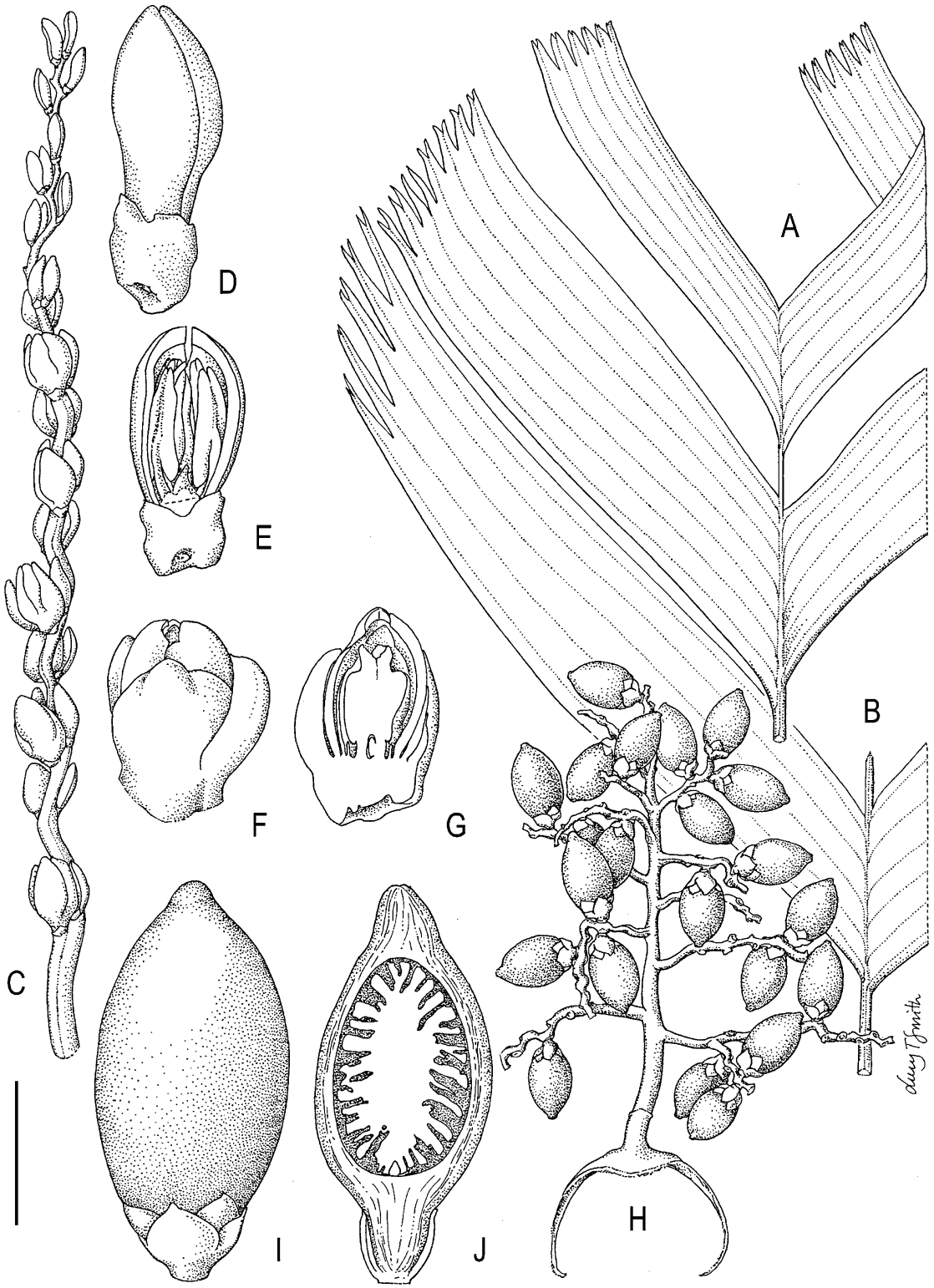

Figure 7. *Areca novohibernica* (Lauterb.) Becc.: A, apical portion of leaf; B, middle portion of leaf; C, portion of rachilla with staminate and pistillate flowers; D, E, staminate flower whole and in section; F, G, pistillate flower whole and in section; H, inflorescence; I, J, fruit whole and in section. Scale bar: A, B, 8 cm; C, I, J, 1.5 cm; D, E, 3 mm; F, G, 7 mm; H, 6 cm. A, B, from *Sands 726*; C–G, I–J, from *Sands 2124*; H, from *Takeuchi 16802*. Drawn by Lucy T. Smith.

or less regularly arranged, papery, *c.* five leaflets on each side of rachis, the basal-most leaflets 56.0–65.5 × 2.5–11.0 cm, three- to six-fold and slightly sigmoid with oblique-acuminate tip, the middle leaflets 54.0–73.5 × 9.5–12.5 cm, five- to seven-fold, slightly sigmoid with oblique, notched tip, splits between folds to 3–5 cm depth, terminal leaflets broader, 31–39 × 15–22 cm, with 9–15 folds, flabellate with truncate tips, green, slightly discolorous when dried, dark coloured adaxially, and paler abaxially. INFLORESCENCE infrafoliar, 15–36 × 14–30 cm, branched to one order (sometimes basal branched to two orders basally), erect at anthesis, pendulous in fruit; prophyll papery, 30–37 × 5–7 cm; peduncle 3–6 cm long and 1–2 cm wide at the base; rachilla 10–21, divaricate, 7–16 cm long and 2–4 mm wide, greenish-cream to green, sometimes perianth persistent on rachillae after fruits fall. FLORAL CLUSTER spirally arranged on the rachilla, complete triads including pistillate flowers occurring from the base up to half the length of the rachilla, and continuing with only pairs of staminate flowers to the tip. STAMINATE FLOWERS small, elongate, triangular, 5.25–6.50 × 2.50–2.75 mm, asymmetrical, white to greenish-cream, glaucous, covered with velvet-like indumentum; calyx copular, low, cup-shaped with marginal lobes, 2.0–2.5 × 1.75–1.80 mm; petals three, thick and fleshy, valvate, striate, 4.0–5.5 × 2.0 mm; stamens six, epipetalous, 3.50–3.75 mm long, fused with petals up half the height of the petal; filaments shorter than anthers, 0.50–0.75 mm long; anthers 2.8–3.0 mm long, sometimes twisted; pistillode low, about 0.5 mm high, variously shaped. PISTILLATE FLOWERS larger than staminate flowers, 8–9 × 7.0–7.5 mm; sepals three, imbricate, united 2–4 mm from the base, 7–9 × 6–7 mm, obovate, thick; petals three, imbricate, 6–8 × 5.5–6.2 mm; gynoecium 6–7 × 5 mm (including stigma 0.5–1.0 mm), stigma trifid; staminodes forming a membranous ring with four to six irregular teeth. FRUITS small, 3.2–4.0 × 1.6–2.0 × 1.5–2.0 cm, ellipsoid to slightly ovoid, ripening through yellow, orange to red; epicarp thin and smooth; mesocarp fleshy and juicy; endocarp fibrous. SEEDS 1.2–1.5 × 1.0–1.5 × 1.0–1.2 cm, slightly globose to ellipsoid, rounded apical and flattened basally, embryo basal.

Distribution and ecology: Areca novohibernica grows on volcanic and limestone soils at 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 (Fig. 1).

Local name and uses: tuva (Duke Island), *iburu bangara* (Roviana). The fruits are used as a betel nut substitute. The species has potential as an ornamental.

Conservation status: Endangered (EN B2b). The area of occupancy of this species is estimated to be < 500 km^2 on offshore islands on the north-eastern coast of New Guinea and the Solomon Islands. As an island species of palm, we infer that the populations of *A. novohibernica* are restricted and will potentially be affected by stochastic events or human activities. However, further population studies are still needed to assess more precisely the conservation status of this palm.

Specimens cited: **PAPUA NEW GUINEA**. **Manus Province**, Manus Island, Western Manus, South Coast, 1 km from Kabuli village, 25 m, 24.xi.1975, *Sands et al. 2756* (K!; LAE). **West New Britain Province**, Kapiura River, near Lavege village, 30 m, 16.iv.1968, *Henty & Lelean NGF 29417* (BRI, L!, LAE!); Hoskins District, near Dami, Kavui logging area, 15 m, 25.iv.1972, *Essig LAE 55210* (L!, LAE); Nuau, 210 m, 19.ii.1971, *Lelean & Stevens LAE 51221* (A!, BRI!, CANB!, K!, L!, LAE); Talasea, Mt. Tangis, ridge below rim of crater, 1350 m, 30.v.1966, *Frodin NGF 26882* (BRI!, L!, LAE); Kandrian District, Pulie River, 10 miles from the mouth, west side, 30 m, 14.iii.1966, *Henty NGF 27201* (BRI, L!, LAE). **East New Britain Province**, Rabaul District, Powell harbour, 30 m, 19.vi.1972, *Foreman LAE 52115* (LAE!); Awung village, 600 m, 23.iii.1968, *Ridsdale & Katik NGF 36757* (L!, LAE). **New Ireland Province**, Namatanai District, Hans Meyer Range, Danfu River valley, *c.* 8 km W and upstream of Danfu bridge, near Manga, upper terrace, behind base camp, to the north, 220 m, 27.i.1970, *Sands 726* (L!, LAE); close to Mindih Lake, east coast, 6 km W of NW Toron, 650 m, 6.x.1975, *Sands et al. 2124* (K!, LAE); Northern Hans Meyer Range, 70 km SE of Namatanai, 850 m, 31.x.1984, *Gideon LAE 77178* (L!, LAE); ridge adjacent to Weitin River, 1175 m, 27.i.1994, *Takeuchi & Wiakabu 9592* (A!, LAE); 31.i.1994, *Takeuchi & Wiakabu 9733* (A!, LAE); Feni group, Ambitle Island, Nanum caldera, thermal spring area, 125 m, 16.xi.2003, *Takeuchi 16802* (A!, LAE); New Hanover, west Lavongai, 2 km N of Matemulai village, 8.x.1974, *Croft & Lelean LAE 65521* (L!, LAE). **North Solomon Province**, Bougainville Island, 15 miles N of Buim, Lake Loloru Crater, lower south slopes, 750 m, *Craven & Schodde 202* (CANB!, L!). **SOLOMON ISLANDS**. Fauro Island, Kauriki village, ridge leading to peak, 24.iv.1964, *Whitmore BSIP 4132* (BSIP, K!, L!). Malaita, Mt. Alasa, 21.x.1965, *Corner RSS 223* (K!, BSIP). New Georgia Island, Duke Island, 15.viii.1929, *Waterhouse 248* (K!).

Notes: Areca novohibernica is similar to *A. vestiaria* in its stilt roots, the staminate flowers spirally arranged on the rachilla, the sepals united or calyx tubular, the

petals elongate and spathulate, the pistillate flowers also spirally arranged and distributed to half the length of the rachilla, and the fruits with fleshy and juicy mesocarps. However, it differs from the latter by its slender solitary habit (sometimes in *A. vestiaria*), the green crownshaft and inflorescence branched to one order (rarely two orders). It differs from all other East Malesian species in the presence of the velvet-like indumentum on the staminate flowers, epipetalous stamens, anthers irregular and sometimes twisted, and in its distribution at the very eastern limit of subtribe Arecinae.

On re-examining the type specimens of *A. guppyana* (*Guppy 107*), *A. novohibernica* (*Peekel 110*) and *A. novohibernica* var. *salomonensis* (*Kajewski 1908*) alongside more recent collections, we see no reason to maintain these distinct taxa. All three taxa (*A. guppyana*, *A. novohibernica* and *A. novohibernica* var. *solomonensis*) were described from inadequate material or single specimens, and thus a narrow species concept was applied by earlier authors. The fruit characters used by previous authors (Beccari, 1914a, b; Burret, 1936) to separate the taxa show particularly high plasticity within populations, individuals or even inflorescences.

In his description of *A. novohibernica* var. *salomonensis*, Burret (1936) mentions that, if he received more material and the differences from *A. guppyana* were to appear greater, the taxon should be called *A. salomonensis*. The name was not validly published by Burret, but was later validated in *Index Kewensis* (Hill & Salisbury, 1947).

5. *ARECA OXYCARPA* MIQ. (FIG. 3C, D)

Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk. 15: 1 (1868). *Type*: Celebes, Menado, Mt. Pisah, *Riedel s.n.* (holotype: L!).

Areca celebica Burret, Repert. Spec. Nov. Regni Veg. 32: 115 (1933). *Type:* Celebes, Tomohon, *Sarasin s.n.* (holotype: B!). **Syn. nov.**

Description: Solitary, slender undergrowth palm, height 1.5–3.0 m. STEM 1.0–2.5 cm in diameter; internodes 2.0–4.5 cm, light brown to whitish with conspicuous leaf scars, and shiny green near the crown. LEAVES 6–8 in crown, 80–150 cm long (including petiole), lamina glabrous; sheath tubular, 13–23 × 3–5 cm; crownshaft 25–40 cm long and 1.5–2.0 cm in diameter, dark brown to blackish-purple with numerous black punctiform scales; petiole 15–40 cm long, 4.0–6.5 mm wide and 4–6 mm thick at the base, channelled adaxially, rounded abaxially; leaflets irregularly arranged, four to eight leaflets on each side of rachis, basal-most leaflets 35–46 × 1.5–6.5 cm, two- to eight-folded, middle leaflets 42–49 × 5.9–9.0 cm, five- to seven-folded, sometimes with a single fold leaflet between two broad leaflets, slightly sigmoid, tips oblique-acuminate, terminal leaflets 23.0–31.5 × 4.6–8.5 cm, flabellate, seven- to eight-folded, tips truncate, green, slightly discolorous when dried. INFLORESCENCE infrafoliar, 8–15 cm long, branched to one order (sometimes branched to two orders basally), erect; prophyll caducous, not seen; peduncle 1–2 cm long and 5–7 mm wide at the base; rachillae 8–16, divergent, 5–8 cm long, greenish-cream to green, sometimes perianth persistent on rachillae after fruit fall. FLORAL CLUSTERS distichously arranged on rachillae, complete triads including pistillate flowers occurring along the lower third of all rachilla. STAMINATE FLOWERS 5–6 × 3.0–3.5 mm, triangular, asymmetrical, cream to greenish-yellow; calyx fused, low, cup-shaped with marginal lobes, *c.* 2.0 × 1.3 mm; petals three, thick and fleshy, *c.* 6 × 3 mm, triangular, striate; stamens six, 3.5–4.0 mm long; filaments *c.* 1.5–2.0 mm long; anthers *c.* 3 mm long; pistillode diminutive. PISTILLATE FLOWERS to 8 × 5 mm; calyx *c.* 7 × 5 mm, imbricate, greenish; petals three, *c.* 8 × 4 mm, imbricate, cream; gynoecium 8 × 3 mm (including stigma 1 mm), stigma trifid; staminodes forming a membranous ring. FRUITS 3.0–3.2 × 1.0–1.5 × 0.9–1.2 cm, elongate to ellipsoid, with 3–4 mm long beak, green to bright yellow or orange when ripe; epicarp smooth and thin; mesocarp fibrous; endocarp thin and fibrous. SEEDS small, 1.2–1.5 × 0.8–0.9 × 0.7–1.0 cm, ovoid, rounded apically and flattened basally, hard.

Distribution and ecology: This species is endemic to the northern part of Sulawesi in Tomohon, North Sulawesi Province and in Dumoga Nani Warta Bone National Park on the border between North Sulawesi and Gorontalo Provinces (Fig. 1). *Areca oxycarpa* grows at 200–450 m above sea level on volcanic soils in primary forest near streams on slopes.

Local name and uses: mamaan pita (Kotamobago). Fruits are used as a betel nut substitute, and the palm has ornamental potential.

Conservation status: Critically Endangered (CR B1ab, B2abc). *Areca oxycarpa* has a restricted area of distribution. The environmental pressures around its natural habitat are high and include land clearance, re-settlement, illegal gold mining and coconut, coffee, cocoa and rice farming. Moreover, based on direct observations in its natural habitat in Dumoga Nani Warta Bone National Park, the populations are sparse and there is limited regeneration in this species in the wild.

Specimens cited: **INDONESIA**. **North Sulawesi Province**, Bolaang Mongondow District, Dumoga Nani Warta Bone National Park, Tapak Kulintang, 280 m, 7.iii.1984, *Mogea 5070* (BO!, K!); Dumoga Nani Warta Bone National Park, West Dumoga subdistrict, Matayangan village, Tumokang–Kasinggolan forest, 225 m, 16.iii.2008, *Heatubun et al. 877* (BO!, K!, MAN!, BPKM!); 272 m, 16.iii.2008, *Asmarayani et al. 461* (BO!, MAN!, BPKM!); 284 m, 17.iii.2008, *Heatubun et al. 883* (BO!, K!, MAN!, BPKM!); Kasinggolan, 200 m, 28.ii.1994, *Mogea 4961* (BO!, K!); Gunung Mogogonipa, 300 m, 1.iv.1985, *de Vogel & Vermeulen 6950* (BO, L!, K!); Duloduo, 250 m, 16.ix.1984, *Whitmore & Sidiyasa 3407* (BO!, BZF, K!); Minahasa District, Tomohon subdistrict, 450 m, iv.1974, *Kaseger 210* (BO!, K!, L!). **CULTIVATED**. **USA**, Hawaii, Honolulu, the Harold L. Lyon Arboretum, accession no. L-94.0215, i.2008, *Bacon 115* (K!).

Notes: The inflorescence of *A. oxycarpa* is somewhat similar to that of *A. macrocalyx* in being compact and protogynous. However, they can be differentiated easily. *Areca oxycarpa* is always a small, slender undergrowth palm, with inflorescences that are somewhat divergent, erect with few rather straight, stiff rachillae. The pistillate flowers (in triads) are confined to the basal one-third of the rachilla. Moreover, *A. oxycarpa* has a dark brown to black leaf sheath.

Burret (1933) published *A. celebica* from inadequate material collected by Sarasin in Tomohon, North Sulawesi. He separated *A. celebica* from *A. oxycarpa* on the basis of fruit characters alone. However, the fruit characters in *Areca* are variable, and there is no justification for maintaining these taxa on these grounds. Furtado (1933) expressed his suspicions about *A. celebica* in his monograph, but made no formal transfer to *A. oxycarpa*. Our observations in the field and herbarium support the reduction to a single species.

6. *ARECA VESTIARIA* GISEKE (FIG. 3A, B)

Prael. Ord. Nat. Pl. 78 (1792). *Pinanga vestiaria* (Giseke) Blume, Rumphia 2: 77 (1839). *Seaforthia vestiaria* (Giseke) Mart., Hist. Nat. Palm. 3: 313 (1849). *Ptychosperma vestiarium* (Giseke) Miq., Fl. Ned. Ind. 3: 31 (1855). *Mischophloeus vestiarius* (Giseke) Merr., Interpr. Herb. Amboin. 121 (1917). *Type: Pinanga sylvestris e Buro Rumphius*, Herb. Amboin. 1: 41 (1741). (Lectotype, designated by Dransfield, 1974).

Ptychosperma paniculatum Miq., Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk. 11(5): 3 (1868). *Areca paniculata* (Miq.) Scheff., Tijdschr. Ned.-Indië 32: 179 (1873). *Mischophloeus paniculatus* (Miq.) Scheff., Ann. Jard. Buitenzorg 2: 152 (1876). *Type:* North Maluku, Bacan Island, *Teysmann & De Vriese* (holotype: L!).

Areca leptopetala Burret, Notizbl. Bot. Gart. Berlin-Dahlem 13: 199 (1936). *Type:* South Celebes, Porema, 10.ix.1929, *Kjellberg 2324* (holotype: B†; isotype: BO!).

Areca langloisiana Potztal, Willdenowia 2: 628 (1960). *Type: A. C. Langlois s.n.* (holotype: B!).

Description: Solitary or clustering, moderate palm, to 10(–15) m tall, with stilt roots. STEM 7–10 cm in diameter; internodes 10–20 cm long, greenish-yellow with conspicuous leaf scars. LEAVES about 11 in crown, 200–350 cm long (including petiole); sheath tubular, 60–70 × 20–30 cm; crownshaft 120–165 cm long and 20–30 cm in diameter, orange, reddish to bright red (rarely pale green) with numerous punctiform brown scales; petiole 4.5–45.0 cm long, 2–4 cm wide and 1–2 mm thick at the base, channelled adaxially, rounded abaxially, yellowish-green to orange (rarely pale green); leaflets somewhat irregularly arranged, papery to leathery, 11–16 leaflets on each side of the rachis, the basal-most leaflets 54–71 × 1.0–4.5 cm, two- to three-fold, lanceolate to sigmoid with oblique tips, the middle leaflets 95–117 × 7–16 cm, three- to four-fold, slightly sigmoid with oblique, notched tips, terminal leaflets 30–55 × 2–13 cm, flabellate, 4–11-fold, notched at tips with splits 5–11 cm deep between the folds, green, slightly discolorous when dried, with fine sparse ramenta on mid-vein in abaxial surface. INFLORESCENCE infrafoliar, 23–45 cm long and 16–30 cm wide, branched to two orders, erect to recurved and later pendulous in fruit; prophyll 20–55 × 6–11 cm, thin, papery, orange to reddish; peduncle 3–5 cm long and 1.5–3.0 cm wide at the base; rachillae numerous, up to 20 cm long, yellowish-cream, orange to red, sometimes perianth persistent on rachillae after fruit fall. FLORAL CLUSTERS spirally arranged on rachillae, complete triads including pistillate flowers occurring to half of the length of all rachillae. STAMINATE FLOWERS 7.00–9.75 × 3.00 mm at anthesis, triangular, asymmetrical, elongate, cream to yellowish-white; calyx cupular, low, 2 mm wide and 1.5–2.5 mm high, with shallow marginal lobes; petals three, thick and fleshly, 6.5–9.0 × 3.0 mm, elongate, ovate; stamens six, white to yellowish-cream, 6–7 × 1 mm; filaments shorter than anthers, 2–3 × 0.3–0.5 mm, white and becoming dark brown after anthesis; anthers 5.0–5.8 mm long, arrow-head shaped; pistillode low, various shapes. PISTILLATE FLOWERS 7–9 × 6.0–6.5 mm, triangular, asymmetrical; sepals three, 6–8 × 4.0–6.5 mm, triangular, strongly imbricate; petals three, similar to sepals, triangular, strongly imbricate; gynoecium 5.5 × 0.75–1.50 mm (including stigma), cylindrical; staminodes four to six, triangular (wedge-shaped),

low, membranous. FRUITS 2.0–3.0 × 1.0–1.5 × 1.0–1.5 cm, obovate to ellipsoid, yellowish-orange to red when ripe, costate when dried; epicarp thin and smooth; mesocarp fleshy and juicy; endocarp thin and fibrous. SEEDS 1.3–1.5 × 1.1–1.2 × 1.1–1.2 cm, ovoid, rounded apically and flattened basally.

Distribution and ecology: This species is relatively widely distributed in East Malesia, occurring throughout Sulawesi, north and central Maluku, except for Ambon, Kei, Aru and Tanimbar (Fig. 1). *Areca vestiaria* grows on volcanic soils from lowlands to highlands up to about 2000 m above sea level. Two collections (*Mogea 1303, 1305*) have been made on the summit of Mt. Maleno in Central Sulawesi, at an altitude of 2260 m above sea level, from a population with the tallest recorded individuals (to 30 m high), and these are quite exceptional for *A. vestiaria*.

Local names and uses: pinang yaki (Sulawesi and North Maluku). The fruits are used as a betel nut substitute, tonic and male contraceptive in North Sulawesi. This species is a popular ornamental.

Conservation status: Least Concern (LC). This species is widespread and also well established in ornamental horticulture as highlighted by Ellison & Ellison (2001).

Specimens cited: **INDONESIA**. **North Sulawesi Province**, Minahasa District, Mt. Soputan, Langoan, 900 m, 11.x.1973, *Dransfield & Mogea JD 3755* (BO!, K!, L!, BH); Tomohon subdistrict, Mt. Lokon, 950 m, 3.x.1973, *Dransfield & Mogea 3714* (BO!, K!, L! BH); 1000 m, 3.x.1973, *Dransfield & Mogea 3716* (BO!, L!); Bolaang Mongondow District, Dumoga Nani Warta Bone National Park, West Dumoga subdistrict, Matayangan/Kasinggolan village, 225 m, 17.iii.2008, *Heatubun et al. 879* (BO!, K!, MAN!, BPKM!); 257 m, 17.iii.2008, *Heatubun et al. 885* (BO!, K!, MAN!, BPKM!); Edwards camp, 750 m, 27.iii.1985, *de Vogel & Vermeulen 6768* (BO!, K!, L!); vicinity of Mt. Sinombayuga, 1750 m, 29.ix.1991, *Milliken & Bonde 1115* (BO!, K!); Dumoga Nani Warta Bone National Park, 250 m, 16.ix.1984, *Whitmore & Sidiyasa TCW 3411* (K!); Mt. Mogogonipa, 650 m, 10.iv.1985, *de Vogel & Vermeulen 7070* (BO!, K!, L!); 220 km W of Manado, 50 km inland from Pangi, on tributary of Ilanga River, 350–750 m, 13.iii.1990, *Burley et al. 3856* (A, BO!, K!). **Central Sulawesi Province**, Kulawi subdistrict, Moa, on the summit of Mt. Maleno, 2260 m, 17.x.1977, *Mogea 1303* (BO!, K!, L!); *Mogea 1305* (BO!, K!, L!); Luwuk area, inland from Batui and Saseba, on Batui River, at Totup camp 2, 2 hours upriver from Sinsing, Mt. Sohean, 170 m, 21.x.1989, *Coode 6045* (BO! K!); Palu, road Palu–Sopu valley, *c.* 40 km SSE of Palu, 600 m, 21.iv.1979, *de Vogel 5006* (BO!, K!, L!); Palu, Sopu valley, *c.* 80 km SSE of Palu, 1000 m, 27.v.1979, *de Vogel 5065* (BO!, K!, L!); Donggala District, Pangi-Binangga Nature Reserve, Puncak Beringin study area, 560 m, 14.x.1991, *Bynum 8201* (A, BO!, K!); Mt. Roroka, Timbu, west slopes, 2000 m, 1979, *van Balgooy 3267* (BO!, K!, L!); by the river S of Tongoa, 650 m, 3.iii.1981, *Johansson et al. 151* (BO!, K!, L!); 5.iii.1981, *Johansson et al. 179* (BO!, L!, K!); area of Mt. Nokilalaki, of lake Lindu to Sidaunta, 1000 m, 3.v.1975, *Meijer 9993* (A, BO!, L!, MO). **West Sulawesi Province**, Mamuju District, Kaluku subdistrict, Popangatalu village, Kona-Kona River, *c.* 200 m, 4.ii.1993, *Afriastini 2060* (BO!, K!). **North Maluku Province**, Bacan Island, Mt. Sibela, near Waiaua, 1050 m, 25.x.1974, *de Vogel 3655* (BO!, K!, L!); 250 m, 28.x.1974, *de Vogel 3725* (BO!, K!, L!); near Amasing River, 5 m, 6.xi.1974, *de Vogel 3926* (BO!, K!, L!); *de Vogel 3927* (BO!, K!, L!); *de Vogel 3929* (BO!, K!, L!); Halmahera, 20 km SE of Dodinga, Darco/Modul logging camp, Tapayo, 600 m, 9.ix.1985, *Sidiyasa et al. TCW 3611* (K!); 630 m, 13.ix.1985, *Sidiyasa et al. TCW 3651* (K!); Mt. Sahu, near Susupu, 500 m, 5.x.1974, *de Vogel 3272* (BO!, K!, L!); 6.x.1974, *de Vogel 3285* (BO!, K!, L!). **Maluku Province,** Buru Island, west Buru, Wae Nibe, wood industry base camp 2, 20 km, Wae Ili, 9.xi.1984, *Mogea & Ismail 5202* (K!, BO!). **CULTIVATED**. **Malaysia**, Malay Peninsula, Kepong, FRIM office, *Barfod s.n.* (AAU photo!). **Indonesia**, Bogor Botanic Garden, II. J. 14, iv–v.1936, *Furtado 155* (K!).

Notes: Areca vestiaria is a distinctive species with a unique combination of morphological characters: moderate, clustering or solitary habit with stilt roots, the almost always brilliant orange to bright red crownshaft, the inflorescence always branched to two orders, the staminate and pistillate flowers spirally arranged on the rachillae and the fruit with a fleshy, juicy mesocarp. For comparison with *A. novohibernica*, see notes under *A. novohibernica*.

The arrangement of staminate flowers was used by Scheffer (1876) as the basis for *Mischophloeus*, a genus distinct from *Areca*. Subsequently, Furtado (1933) synonymized with *Areca*, reducing it to a section under subgenus *Beccarioareca*. The morphological variation and wide distribution of this species have resulted in some taxonomic confusion and nomenclatural problems (Giseke, 1792; Martius, 1823–1850; Miquel, 1868; Scheffer, 1873, 1876; Merrill, 1917; Furtado, 1933; Burret, 1936; Potztal, 1960) since its first appearance in *Herbarium Amboinense* (Rumphius, 1741) until review by Dransfield (1974).

Doubtful or uncertain names

Areca congesta Becc., Engl. Bot. Jahrb. 58: 441 (1923). *Type:* Papua New Guinea, Sepik, *Ledermann 12331* (holotype: B†). See notes under *A. macrocalyx* for discussion.

Areca ledermanniana Becc., Engl. Bot. Jahrb. 58: 441 (1923). *Type:* Papua New Guinea, April River, *Ledermann 9766* (holotype: B†). See notes under *A. macrocalyx* for discussion.

ACKNOWLEDGEMENTS

Many individuals and institutions contributed to the completion of this work. We would like to thank the keepers and staff of herbaria A, AAU, B, BH, BO, BRI, BZF, CANB, E, FI, FTG, K, KEP, L, LAE, MAN, PNH, SAN, SAR, SING and BPKM for access to their specimens, databases and for providing loans in many cases. Maikel Simbiak, Herkilaus Rumaikewi, Lukas Manua, Krisma Lekitoo, Tobias Paiki and Herni Simbala are thanked for their help with fieldwork logistics. Many individuals assisted in a wide variety of ways: Piero Cuccuini, Chiara Nepi, Anders Barfod, Henrik Balslev, Jan Frits Velkamp, George Argent, Kate Armstrong, Christine Bacon, Raymond Baker, Edwino Fernando, Benito Tan, Serena Lee, Mien Rifai, Kuswata Kartawinata, Tim Utteridge, Eko Baroto Waluyo, Rugayah, Dedy Duryadi and Rani Asmarayani. Lucy T. Smith rendered the beautiful illustrations and Justin Moat for the base map used in this monograph.

This paper is part of CDH's PhD thesis which was researched at Institut Pertanian Bogor and the Royal Botanic Gardens, Kew, with funding from the Royal Botanic Gardens, Kew, the International Palm Society (IPS Endowment Fund 2007), the BAT Biodiversity Partnership, the Indonesian Ministry of Higher Education (*BPPS Dikti Diknas dan Beasiswa Unggulan Tahun 2007* # 0004.3/023-1.0/-/2007) and the Bentham–Moxon Trust for the 2011 postdoctoral visit during which the manuscript was finalized.

REFERENCES

Baker WJ, Asmussen CB, Chase MW, Dransfield J, Forest F, Harley MM, Savolainen V, Uhl NW, Wilkinson M. 2009. Complete generic level phylogenetic analyses of palms (Arecaceae) with comparisons of supertree and supermatrix approaches. *Systematic Biology* **58:** 240–256.

Baker WJ, Coode MJE, Dransfield J, Dransfield S, Harley MM, Hoffmann P, Johns RJ. 1998. Pattern of distribution of Malesian vascular plants. In: Hall R, Halloway JD, eds. *Biogeography and geological evolution of SE Asia*. Leiden: Backhuys, 243–258.

Baker WJ, Couvreur TLP. In press. Biogeography and distribution pattern of south-east Asia palms. In: Gower D, Johnson K, Richardson JE, Rosen B, Rüber L, Williams S, eds. *Biotic evolution and environmental change in southeast Asia*. Cambridge: Cambridge University Press.

Baker WJ, Dransfield J. 2006. *Field guide to the palms of New Guinea*. Kew: Royal Botanic Gardens.

Baker WJ, Norup MV, Clarkson JJ, Couvreur TLP, Dowe JL, Lewis CE, Pintaud JC, Savolainen V, Wilmot T, Chase MW. 2011. Phylogenetic relationships among arecoid palms (Arecaceae: Arecoideae). *Annals of Botany* **108:** 1–16. doi:10.1093/aob/mcr020.

Beccari O. 1877. Palmae della Nuova Guinea. *Malesia* **1:** 21–23, 171–174.

Beccari O. 1908. The palms of the Batanes and Babuyanes Islands. *Philippine Journal of Science, Botany* **3:** 339–342.

Beccari O. 1909. Notes on Philippine palms. II. *Philippine Journal of Science, Botany* **4:** 601–639.

Beccari O. 1910. Palme australasiche nuove o poco note. *Webbia* **3:** 131–165.

Beccari O. 1911. The palms of the island of Polillo. *Philippine Journal of Science, Botany* **6:** 229–230.

Beccari O. 1913. *Palmae*. In: Rechinger R. Botanische und zoologische Ergbnisse einer wissenschaftlichen Forschungsreise nach den Samoainseln, dem Neuguinea-Archipel und den Salomoninseln von Marz biz Dezember, 1905. *Teil. Denkschriften der Kaiserlichen Akademie der Wissenschaften, Wien Mathematischnaturwissenschaftliche Klasse* **89:** 502–509.

Beccari O. 1914a. Manipolo di palme nuove polinesiane conservate nell' erbario di Kew. *Webbia* **4:** 253–291.

Beccari O. 1914b. Neue Palmen Papusiens. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* **52:** 28–29.

Beccari O. 1919. The palms of Philippines Islands. *Philippine Journal of Science* **14:** 295–362.

Beccari O. 1923. Neue Palmen Papusiens II. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* **58:** 450–451.

Blume CL. 1838–1839. *Rumphia*, Vol. 2. Leiden.

Bodley JH, Benson FC. 1980. Stilt-root walking by an iriartoid palm in the Peruvian Amazon. *Biotropica* **12:** 67–71.

Burman NL. 1768. *Flora Indica: cui accedit series zoophytorum Indicorum, nec non prodromus florae Capensis*. Amsterdam.

Burret M. 1931. Four new palms collected in the territory of Papua (British New Guinea) by L. J. Brass. *Journal of the Arnold Arboretum* **12:** 264–269.

Burret M. 1933. Palmae gerontogeae II. *Fedde's Repertorium Specierum Novarum Regni Vegetabilis* **32:** 115–117.

Burret M. 1935. Palmae gerontogeae 5. *Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem* **13:** 185–200.

Burret M. 1936. Neue Palmen aus Neuguinea IV. *Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem* **13:** 317–332.

Byun SJ, Kim HS, Jeon SM, Park YB, Choi SM. 2001. Supplementation of *Areca catechu* L. extract alters triglyc-

eride absorption and cholesterol metabolism in rats. *Annual Nutrition Metabolism* **45:** 279–284.

Corner EJH. 1966. *The natural history of palms*. London: Weidenfeld & Nicholson.

Dransfield J. 1974. New light on *Areca langloisiana*. *Principes* **18:** 51–57.

Dransfield J. 1980. Systematic notes on *Pinanga* (*Arecaceae*) in Borneo. *Kew Bulletin* **34:** 769–788.

Dransfield J. 1984. The genus *Areca* (*Palmae: Arecoideae*) in Borneo. *Kew Bulletin* **39:** 1–22.

Dransfield J. 1986. A guide to collecting palms. *Annals of the Missouri Botanical Garden* **73:** 166–176.

Dransfield J. 1987. Bicentric distribution in Malesia as exemplified by palms. *Oxford Monographs on Biogeography* **4:** 60–72.

Dransfield J, Uhl NW, Asmussen CB, Baker WJ, Harley MM, Lewis CE. 2005. A new phylogenetic classification of the palm family, Arecaceae. *Kew Bulletin* **60:** 559–569.

Dransfield J, Uhl NW, Asmussen CB, Baker WJ, Harley MM, Lewis CE. 2008. *Genera Palmarum: the evolution and classification of palms*. Kew: Royal Botanic Gardens, International Palm Society and L. H. Bailey Hortorium.

Ellison D, Ellison A. 2001. *Cultivated palms of the world*. Sydney: UNSW Press.

Flynn T. 2004. *Morphological variation and species limits in the genus* Areca *(Palmae) in New Guinea and the Solomon Islands*. MSc Thesis, University of Wales, Bangor.

Frangi JL, Ponce MM. 1985. The root system of *Prestoea montana* and its ecological significance. *Principes* **29:** 13–19.

Furtado CX. 1933. The limits of the genus *Areca* L. and its sections. *Fedde's Repertorium Specierum Novarum Regni Vegetabilis* **33:** 217–239.

Gaertner J. 1788. *De fructibus et seminibus plantarum*. Stuttgart: Typis Academiae Carolinae.

Giseke PD. 1792, ed. *Praelectiones in ordines naturales plantarum*. Hamburg: Impensis B.G. Hoffmanni.

Govaerts R, Dransfield J. 2005. *World checklist of palms*. Kew: Royal Botanic Gardens.

Gupta PC, Warnakulasuriya S. 2002. Global epidemiology of *Areca* nut usage. *Addictive Biology* **7:** 77–83.

Harley MM, Dransfield J. 2003. Triporate pollen in *Arecaceae*. *Grana* **42:** 3–19.

Heatubun CD. 2008. A new species of *Areca* from Western New Guinea. *Palms* **52:** 198–202.

Heatubun CD. 2011. Seven new species of *Areca* (Arecaceae). *Phytotaxa* **28:** 6–26.

Henderson A. 2009. *Field guide to the palms of southern Asia*. Princeton, NJ: Princeton University Press.

Hill AW, Salisbury E. 1947. *Index kewensis plantarum phanerogamarum, supplement 10*. Oxford: Clarendon Press.

Holmgren PK, Holmgren NH, Barnett LC. 1990. *Index herbariorum*, 8th edn. New York: New York Botanical Garden.

IUCN. 2001. *IUCN red list categories and criteria*. Version 3.1. Gland & Cambridge: IUCN.

Jones DL. 1995. *Palms throughout the world*. Sydney: Reed Books.

Kerchove O. 1878. *Les palmiers*. Paris: J. Rothschild.

Lamarck JBPAM. 1783. *Encyclopédie Méthodigue Botanique*. Paris: Panckoucke, Plomteux.

Lauterbach CAG. 1911. Beiträge zur Flora von Neu-Mecklenburg. *Botanische Jarhrburcher fur Systematik, Pflanzengeschichte und Pflanzengeographie* **45:** 354–365.

Lee KK, Choi JD. 1999. *Areca catechu* L. extract. I. Effect on elastase and aging. *Journal of Cosmetics Science* **49:** 285–297.

Leopold AC. 2000. Many modes of movement. *Science* **288:** 2131–2132.

Linnaeus C. 1753. *Species plantarum*, Vol. 2. Stockholm: Laurentius Salvius.

Loo AHB, Dransfield J, Chase MW, Baker WJ. 2006. Low copy nuclear DNA, phylogeny and the evolution of dichogamy in the betel nut palms and their relatives (Arecinae; Arecaceae). *Molecular Phylogenetics and Evolution* **39:** 598–618.

Loureiro J. 1790. *Flora cochinchinensis*. Lisbon: Typis et expensis academicis.

Martelli U. 1935. La sinonimia delle palme gerontogee della tribù delle Areceae. *Nuovo Giornale Botanico Italiano* **42:** 20–29.

Martius CFP von. 1823–1850. *Historia naturalis palmarum*, **3** Vols. Munich.

Merrill ED. 1917. *An interpretation of Rumphius's Herbarium Amboinense*. Manila: Bureau of Science.

Merrill ED. 1923. *An enumeration of Philippine flowering plants*, Vol. **1**. Manila: Bureau of Printing.

Miquel FAG. 1855. *Flora indiae batavae*, Vol. **3**. Amsterdam.

Miquel FAG. 1868. De palmis Archipelagi Indici observationes novae. *Verhandelingen der Koninklijke Nederlandsche Akademie van Wetenschappen, afdeeling Natuurkunde* **11:** 1–33.

Monteiro-Neto H. 1976. *Pichisermollia* Monteiro-Neto, um nome novo para *Gigliolia* Becc. *Rodriguesia* **28:** 195–198.

Moore HE Jr, Dransfield J. 1979. Typification of Linnean palms. *Taxon* **28:** 59–70.

Norton SA. 1998. Betel: consumption and consequences. *Journal of American Academy of Dermatology* **38:** 81–88.

Norup MV, Dransfield J, Chase MW, Barfod AS, Fernando ES, Baker WJ. 2006. Homoplasious character combinations and generic delimitation: a case study from Indo-Pacific arecoid palms (Arecaceae). *American Journal of Botany* **93:** 1065–1080.

Potztal E. 1960. Eine neue Palme von Celebes. *Willdenowia* **2:** 628–633.

Ray AK, Reddy DVS. 2001. Performance of *Areca*-based high density multi species cropping system under different level of fertilizer. *Tropical Agriculture* **78:** 152–155.

Rechinger R. 1913. Botanische und zoologische Ergebnisse einer wissenschaftlichen Forschungsreise nach den Samoainseln, dem Neuguinea-Archipel und den Salomoninseln von Marz biz Dezember, 1905. – *V. Teil. Denkschriften der Kaiserlichen Akademie der Wissenschaften, Wien Mathematischnaturwissenschaftliche Klasse* **89:** 502–509.

Rumphius GE. 1741. *Herbarium amboinense*, Vol. 1. Amsterdam.

Scheffer RHCC. 1873. Sur quelques palmiers du groupe des Arécinées 1. *Natuurkundig Tijdschrift voor Nederlandsch Indië* **32:** 149–193.

Scheffer RHCC. 1876. Sur quelques palmiers du groupe des Arécinées 2. *Annales du Jardin Botanique de Buitenzorg* **1:** 103–164.

Staples GW, Bevacqua RF. 2006. *Areca catechu* (betel nut palm), ver. 1.3. In: Elevitch CR, ed. *Species profiles for Pacific Island agroforestry*. Hōlualoa, Hawai'i: Permanent Agriculture Resources (PAR), 1–17. Available at: http://www.traditionaltree.org

Sullivan RJ, Allen JS, Otto C, Tiobech J, Nero K. 2000. Effects of chewing betel nut (*Areca catechu*) on the symptoms of people with schizophrenia in Palau, Micronesia. *British Journal of Psychiatry* **177:** 174–178.

Tomlinson PB. 1990. *The structural biology of palms*. Oxford: Clarendon Press.

Uhl NW, Dransfield J. 1987. *Genera palmarum*. Lawrence, KS: Allen Press.

Zumbroich TJ. 2008. The origin and diffusion of the betel chewing: a synthesis of evidence from South Asia, Southeast Asia and beyond. *Electronic Journal of Indian Medicine* **1:** 63–116.

APPENDIX

List of specimens examined and identified

Species numbers are given in bold in parentheses after the collection numbers. Key: (**1**) *A. catechu*; (**2**) *A. macrocalyx*; (**3**) *A. mandacanii*; (**4**) *A. novohibernica*; (**5**) *A. oxycarpa*; (**6**) *A. vestiaria*.

Afriastini: 2060 (**6**); Anonymous: (Cult. Kew) s.n. (**1**); (Cult. Calcutta) s.n. (**1**); (Cult. Singapore) s.n. (**1**); (Cult. Singapore, lawn X) s.n. (**1**); (Cult. Singapore, lawn J) s.n. (**1**); (Cult. Bogor, lawn II.F.9) s.n. (**1**); (Cult. Bogor, lawn VII.B.78) s.n. (**1**); (Cult. Bogor, lawn VII.B.79) s.n. (**1**); (Cult. Bogor, lawn VII.B.80) s.n. (**1**); (Cult. Bogor, lawn VII.B.81) s.n. (**1**); (Cult. Bogor, lawn VII.B.84) s.n. (**1**); (Cult. Bogor, lawn VII.B.85) s.n. (**1**); (Cult. Bogor, lawn VII.B.87) s.n. (**1**); (Cult. Bogor, lawn VII.B.88) s.n. (**1**); (Cult. Bogor, lawn VII.B.89) s.n. (**1**); (Cult. Bogor, lawn VII.B.91) s.n. (**1**); (Cult. Bogor, lawn XI.B. (XX)6) s.n. (**1**); (Cult. Bogor, lawn XIII.A.6) s.n. (**1**); Asmarayani *et al*. 461 (**5**).

Backer: 31478 (**1**); Bacon: 115 (5); Baker: 136 (**1**); Baker & Utteridge: 591 (**2**); Baker *et al*. 631 (**2**); 1098 (**2**); 1100 (**2**); Bakhuizen van den Brink: 6724 (**1**); 6782 (**1**); 6788 (**1**); 6789 (**1**); 6807 (1); 6866 (**1**); Bakia: 416 (**1**); Banka *et al*. 2001 (**2**); Barfod: s.n. (**1**); Barfod *et al*. 416 (**2**); 488 (**2**); 45235 (**1**); Bartlett: 16226 (**1**); Beccari: PB 3112 (**1**); s.n. (**2**); Beguin: 330 (**1**); 1613 (**1**); Bloembergen: 3555 (**1**); 3556 (**1**); Boden-Kloss: 11440 (**1**); Borden: 20192 (Forest Bureau 1272) (**1**); Borssum-Waalkes: 350 (**1**); Brass: 3971 (**2**); 7001 (**2**); 7170 (**2**); 7188 (**2**); 7386 (**2**); 7901 (**2**); 8189 (**2**); 13437 (**2**); 13437A (**2**); 23977 (**2**); Burley *et al*. 3856 (**6**); 4215 (**1**); Bynum: 8201 (**6**).

Canton Christian College: 9808 (**1**); Ching & Tan: TC 01 (**1**); Chen: 18806 (**1**); Clemens: 11351 (**2**); 21501 (**1**); Conklin: 1055 (**1**); 18651 (**1**); Coode: 6045 (**6**); 6074 (**1**); Corner: RSS 223 (**4**); Craven & Schodde: 202 (**4**); Croft & Katik: NGF 14984 (**2**); Croft & Lelean: LAE 65521 (**4**); Croft *et al*. LAE 61183 (**2**).

Darbyshire: 921 (**2**); Darbyshire & Hoogland 8089 (**2**); Desianto: 4 (**2**); de Vogel: 3266 (**1**); 3272 (**6**); 3285 (**6**); 3655 (**6**); 3725 (**6**); 3926 (**6**); 3927 (**6**); 3929 (**6**); 5006 (**6**); 5065 (**6**); de Vogel & Vermeulen: 6768 (**6**); 6950 (**5**); 7070 (**6**); de Vogel *et al*. 6048 (**1**); Dransfield: JD 1403 (**1**); JD 1467 (**1**); JD 1471 (**1**); Dransfield & Mogea: 3714 (**6**); 3716 (**6**); JD 3755 (**6**); JD 3808 (**1**); Dransfield *et al*. JD 7533 (**2**); Duaneh: 255 (**1**); Dubuc: 1869 (**1**); Du Bois: 24 (**1**).

Edeling: s.n. (**1**); Elmer: 7795(**1**); 17468 (**1**); Essig: LAE 55210 (**4**); Essig & Young: LAE 74091 (**2**).

Fernando: 546 (**1**); 600 (**1**); 665 (**1**); Floyd: 6422 (**2**); Foreman: LAE 52115 (**4**); Frodin: NGF 26882 (**4**); Furtado: 155 (**6**); s.n. (**2**).

Gideon: LAE 57404 (**2**); LAE 76950 (**2**); LAE 76951 (**2**); LAE 77178 (**4**); s.n. (**2**); Graff: 134 (**1**); Griffith: s.n. (**1**); Guppy: 107 (**4**); Gusbager *et al*. 20 (**2**).

Heatubun & Iwanggin: 902 (**3**); Heatubun *et al*. 292 (**2**); 331 (**2**); 360 (**2**); 413 (**3**); 423 (**3**); 424 (**3**); 747 (**2**); 751 (**1**); 752 (**1**); 753 (**1**); 796 (**2**); 798 (**2**); 799 (**2**); 870 (**1**); 876 (**2**); 877 (**5**); 879 (**6**); 883 (**5**); 885 (**6**); 1095 (**2**); Henry: 8406 (**1**); Henty: NGF 27201 (**4**); NGF 38541 (**2**); Henty & Lelean: NGF 29417 (**4**); Henty *et al*. NGF 33055 (**2**); NGF 33057 (**2**); Hoogland: 9026 (**2**); Hoogland & Craven: 11081 (**2**); Huang & Kao: 5234 (**1**).

Iboet: 440 (**1**).

Jacobs: 8761 (**2**); 9002 (**2**); s.n. (**2**); Johansson *et al*. 151 (**6**); 179 (**6**).

Kajewski: 1980 (**4**); Karenga: LAE 55423 (**2**); LAE 56441 (**2**); Karenga & Obedi: LAE 62315 (**2**); Kaseger 210 (**5**); Kazakoff: NGF 7057 (**2**); Koorders: 396 (**1**).

Lai: S 68676 (**1**); Larivita & Katik: LAE 70501 (**2**); Lau: 226 (**1**); Lee: S 55696 (**1**); Lelean & Stevens: LAE 51221 (**4**); Liang: 62129 (**1**); Lugas: 442 (**1**).

Mansus & Aban: SAN 69388 (**1**); Manuputty: BW 958 (**2**); Masters: s.n. (**1**); Maturbongs *et al*. 605 (**2**); 728 (**2**); s.n. (**3**); Meijer: 9993 (**6**); Merrill Species Blancoanae: 213 (**1**); Milliken & Bonde: 1115 (**6**); Mogea: 1303 (**6**); 1305 (**6**); 3139 (**2**); 3140 (**1**); 4961 (**5**); 5070 (**5**); 6204 (**2**); Mogea & Ismail: 5202 (**6**); Moore & Whitmore: 9303 (BSIP 4051) (**2**); Morren: 3049 (**2**).

Noblick *et al*. 5180 (**1**).

Othman & Munting: S 61606 (**1**).

Powell: BSIP 19467 (**2**); Pullen: 725 (**2**); 1712 (**2**); 2638 (**2**); 7299 (**2**); 7641 (**2**).

Ramos: Bureau of Science 80360 (**1**); Reeve: 889 (**2**); Reynoso *et al*. 7363 (**1**); Ridsdale & Katik: NGF 36757 (**4**); Rutherford & Bandara: 124 (**1**); 154 (**2**).

Sambuling: 8 (**1**); 76 (**1**); Sands: 726 (**4**); Sands *et al*. 2124 (**4**); 2756 (**4**); 6365 (**2**); Sarasin: s.n. (**5**); Schodde & Craven: 4029 (**2**); Sibil: 153 (**1**); Sidiyasa *et al*. TCW 3580 (**1**); TCW 3611 (**6**); TCW 3651 (**6**); Sinclair: 3272 (**1**); Soibeh: 778 (**1**); Streimann & Katik: NGF 28593 (**2**); NGF 28994 (**2**); Streimann & Lelean: NGF 18311 (**2**); NGF 34118 (**2**); Sumawong: s.n. (**2**).
Takeuchi: 10075 (**2**); 16771 (**2**); 16802 (**4**); Takeuchi & Wiakabu: 9592 (**4**); 9733 (**4**); Takeuchi *et al*. 13374 (**2**); 13638 (**2**); Tsang: 146 (**1**).
van Balgooy: 3267 (**6**); 6864 (**2**); van Steenis: 212 (**1**); Veersteg: 1592 (**2**); 1782 (**2**); Vinas: LAE 67031 (**2**).
Wanggai *et al*. 3 (**2**); Waterhouse: 185 (**2**); 248 (**4**); s.n. (**2**); White: NGF 10715 (**2**); NGF 10716 (**2**); Whitmore: BSIP 1268 (**2**); BSIP 4132 (**4**); BSIP 4273 (**2**); TCW 3411 (**6**); Whitmore & Sidiyasa: 3407 (**5**); Williams: 330 (**1**); Wilson: 9891 (**1**); Wingfield: 3708 (**1**).
Zippel: s.n. (**2**).