



# Revision of the Malesian species of *Dimorphocalyx* (*Euphorbiaceae*)

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## Key words

*Dimorphocalyx*  
*Euphorbiaceae*  
Malesia  
*Ostodes*  
*Paracroton*  
*Trigonostemon*

**Abstract** *Dimorphocalyx*, a small genus ranging from Sri Lanka to Indomalesia to Australia, has eight species in Malesia, of which one is here raised from variety to species level and another, endemic in the N Moluccas, is newly described. *Dimorphocalyx murinus* and – tentatively – *D. loheri* are synonymised with *D. denticulatus*, and *D. luzoniensis* is synonymised with *D. malayanus*. *Dimorphocalyx cumingii* is regarded as a species of *Trigonostemon*. The differences between *Dimorphocalyx*, *Ostodes*, *Paracroton* (formerly *Fahrenheitia*), and *Trigonostemon* are discussed.

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## INTRODUCTION

*Dimorphocalyx* was established by Thwaites in 1861 based on his Sri Lankan *Trigonostemon glabellus*. *Di-morpho-calyx* means two forms of the calyx and the name was chosen because the calyx enlarges during fruit set. The genus ranges from Sri Lanka via Indomalesia to Australia. *Dimorphocalyx* contains c. 13 species of which 8 are found in Malesia (one name, *D. angustifolius* (Merr.) Airy Shaw, could not be interpreted). Characteristic for *Dimorphocalyx* are dioecy (seldom monoecy), penninerved leaves (at most obscurely triplinerved), white petals, and generally more than 10 (7–20) stamens of which the outer ones are usually free or only at the very base of the filaments adnate to the androphore formed by the partly united inner stamens (Airy Shaw 1972b). The exception is *D. muricatus* (Hook.f.) Airy Shaw, which has completely free stamens, a reason why it was first described as a species of *Ostodes* Blume.

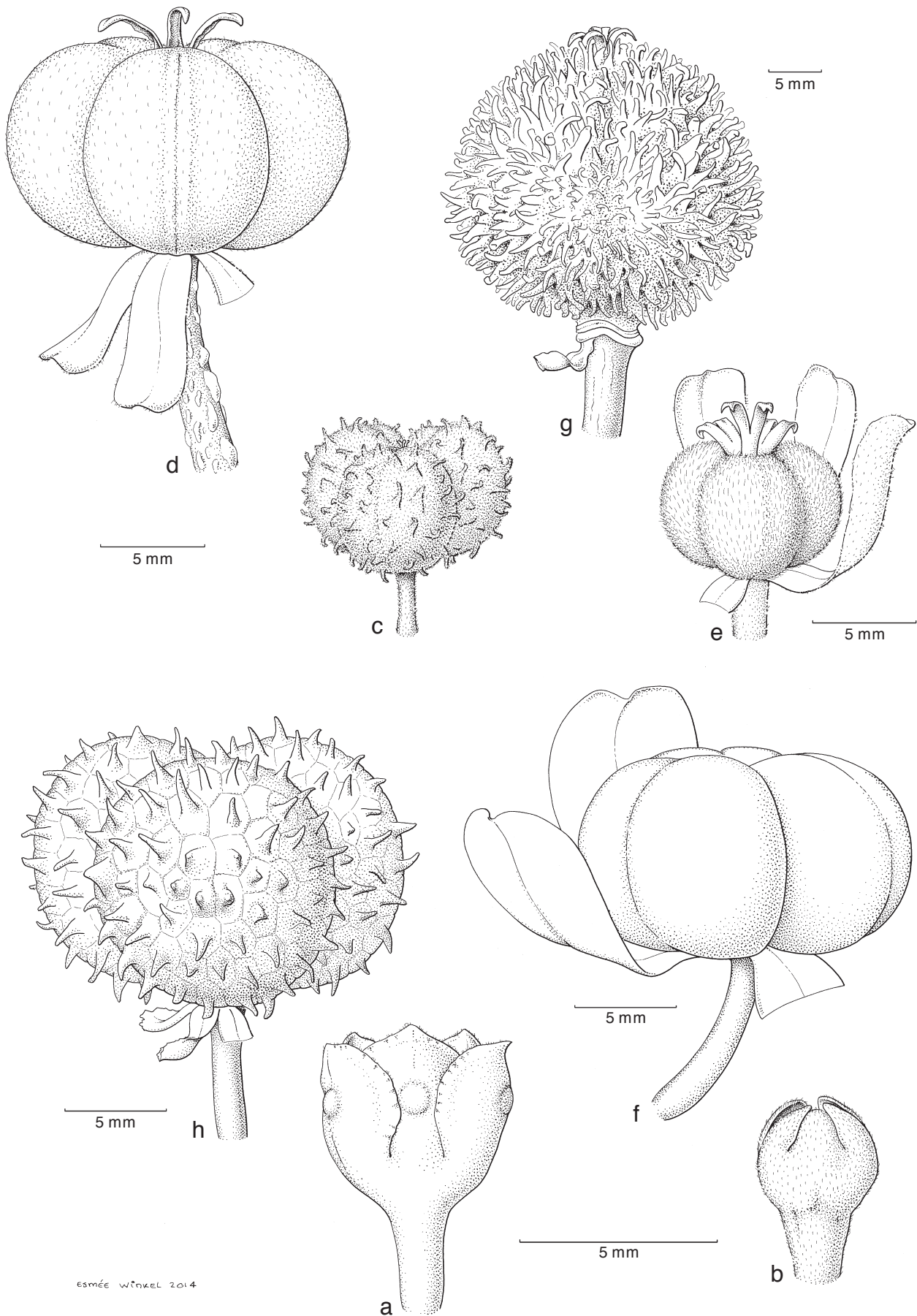
*Dimorphocalyx* is classified in subfamily *Crotonoideae*, tribe *Codiaeae* (Webster 1994, 2014, Radcliffe-Smith 2001). *Dimorphocalyx* was not included in the molecular phylogeny of Wurdack et al. (2005), but, if the classification of Webster (1994, 2014) and Radcliffe-Smith (2001) is correct, then *Dimorphocalyx* might have ended close to *Trigonostemon verrucosus* J.J.Sm. in their clade C2. Airy Shaw (1967) described the differences between *Ostodes*, *Dimorphocalyx*, and *Fahrenheitia* Rchb.f. & Zoll. (the latter is nowadays *Paracroton* Miq.), because they are easily confused. According to Airy Shaw *Paracroton* is distinct by its stellate hairs (the other genera have only simple hairs). *Ostodes* has distinctly triplinerved leaves with long petioles and a conspicuously glandular-denticulate margin, inflorescences that are often borne below terminal tufts of leaves, free filaments that are pilose below and a non-acrescent calyx; whereas the leaves of *Dimorphocalyx* are penninerved to at most obscurely triplinerved, with long to very short petioles and a glandular-denticulate to entire margin, the inflorescences are always axillary and much shorter, the filaments are glabrous with the inner ones (partly) united into a column; and the calyx is often

accrescent in fruit. Additionally, *Ostodes* has two large glands adaxially between petiole and leaf blade, which are absent in *Dimorphocalyx*, and while the petals in *Ostodes* are larger than those of *Dimorphocalyx* and stick together after drying (not loosening anymore after rehydration), while the petals of *Dimorphocalyx* are smaller and separate after rehydrating dried flowers. It is also difficult to separate *Dimorphocalyx* from the genus *Trigonostemon* Blume. It is unknown why Airy Shaw (1967) did not include this genus in his discussion too, because both genera are generally confused. It is also surprising that Webster (1994, 2014) and Radcliffe-Smith (2001) classify *Trigonostemon* even in a separate tribe (*Trigonostemoneae*), though Radcliffe-Smith indicates that *Trigonostemon* may have to be included in the *Codiaeae* as well. On the other hand Müller Argoviensis (1866: 1105) already united both genera and treated *Dimorphocalyx* as a section within *Trigonostemon* (*D. cumingii* (Müll.Arg.) Airy Shaw was placed by him in section *Anisotaxis* Müll.Arg.; p. 1107). Airy Shaw (1969) rectified his earlier omission and discussed the differences between both genera, but none of the characters discussed is typical for all species, there is always overlap. *Trigonostemon* is always monoecious (*Dimorphocalyx* dioecious, seldom monoecious), the leaves are often triplinerved (penninerved in *Dimorphocalyx*), the petals come in various colours, including white (white only in *Dimorphocalyx*), the staminate disc varies between circular, cupular and glandular (glandular in *Dimorphocalyx*), stamens generally 5(–13) (usually more than 10 in *Dimorphocalyx*). The cymose inflorescences in *Dimorphocalyx* appear generally as short cymes, umbels or thyrsoid racemes, in *Trigonostemon* they can be up to large panicles. Unlike *Dimorphocalyx*, the pistillate calyx is usually not accrescent in *Trigonostemon*.

A revision of the Malesian species of *Dimorphocalyx* was never made, only island/country treatments (Backer & Bakhuizen van den Brink Jr 1963: Java; Whitmore 1973: Malay Peninsula; Airy Shaw 1972a: Thailand; 1975: Borneo, 1980a: New Guinea, 1981: Sumatra) or checklists were prepared (Airy Shaw 1982: Sulawesi, Moluccas, Lesser Sunda Islands; 1983: Philippines). Most of the treatments lack descriptions or only describe a small part of the variation per species. Identification is even a bigger problem, because only local keys exist based on relatively few specimens.

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**Fig. 1** Flower buds and fruits of *Dimorphocalyx* Thwaites. — Flower buds: a. Staminate flower bud of *D. pauciflorus* (Merr.) Airy Shaw showing glabrous sepals with subapical, round, glandular regions; b. staminate bud of *D. denticulatus* Merr. showing hairy sepals without glands. — Fruits: c. *D. australiensis* C.T.White; d. *D. denticulatus* Merr., glabrous exception; e. *D. denticulatus* Merr., typical hairy form; f. *D. malayanus* Hook.f.; g. *D. muricatus* (Hook.f.) Airy Shaw; h. *D. pauciflorus* (Merr.) Airy Shaw (a: S (Rosli) 3361; b: S (Tinggi) 29250; c: Anonymous s.n., barcode L.2211857; d: SAN (Chai) 21646; e: S (Paie) 50176; f: BS (Ramos & Edaño) 29134; g: Nangkat 180; h: S (Ilias & Bernard) 37966; all L). — Drawing by Esmée Winkel, 2014.

The aim of this study is to revise all Malesian species of *Dimorphocalyx* (species circumscription, descriptions, nomenclature, literature, identification key, distributions, uses, and vernacular names).

## CHARACTERS

### Indumentum

The hairs are simple, usually yellowish, sometimes ferrugineous (*D. australiensis*), but in most species they are generally only very locally present. Only *D. denticulatus* and *D. trichocarpus* (new combination, see below) have mainly hairy parts (leaf blades excepted), but all species are glabrescent.

### Leaf morphology

The petiole of *D. muricatus* is generally longer than 3 cm, whereas the petiole of the other species is usually less than 3 cm long (*D. trichocarpus* 25–36 mm). The petioles are completely pulvinate when short to slightly pulvinate apically and basally when longer. Adaxially the petiole is sharply grooved (to flattened in large leaves). The shape of the blades is generally elliptic, with the largest width  $\pm$  in the middle except for *D. ixoroides*, which is ovate and widest almost basally. Typical for the genus is the presence of laxly distributed glands at the lower surface along the margin, usually present in the teeth of the serrae, and visible as a serrate to serrulate leaf margin (only *D. malayanus* has a more or less entire margin).

### Inflorescences

The inflorescences are generally short (up to 12 cm long), axillary (to terminal) and cymose in origin. The staminate ones are thyrsoid to narrowly paniculate (= the side branches are short) with groups of flowers per node. The pistillate inflorescences are more thyrsoid racemose with single flowers per node or a single flower or fruit per inflorescence.

### Staminate and pistillate flowers

The flowers are 5-merous. The sepals are basally to halfway connate into a calyx. The calyx lobes can have glands. Round, subapical glands (Fig. 1a) are present in *D. muricatus* and *D. pauciflorus*, though in the former they can be quite obscure. The pistillate sepals of *D. malayanus* have a different type of gland, much smaller and more convex with a slightly raised margin in the emarginate apex at the outside. The staminate sepals are white, the pistillate ones greenish white. The petals are usually longer than the calyx, but in some species the pistillate calyx lobes enlarge very fast and then the petals seem to be shorter. The petals are caducous, usually glabrous, and always white. The staminate flowers have disc glands, which are often arranged around the stamens, the disc in the pistillate flowers is annular. The number of stamens varies between 7 and 20, the outer stamens are free or basally adnate to the central androphore. Along the androphore often two whorls of stamens split off. The anthers are 2-thecate, dorsifixed and open introrse via lengthwise splits. The ovary is generally ovoid and can be densely hairy; the style is generally lacking and the three stigmas split in the upper 2/3rd part.

### Fruits and seeds

The fruits can be smooth or muricate, glabrous or hairy. Muricate fruits are present in *D. australiensis* (Fig. 1c), *D. muricatus* (Fig. 1g) and *D. pauciflorus* (Fig. 1h), all other species have smooth fruits or the fruits are unknown (*D. moluccensis*, newly described below). *Dimorphocalyx australiensis*, *D. denticulatus* and *D. trichocarpus* have hairy fruits.

The seeds are dry, ellipsoid to obovoid and usually flattened at one side, they lack a caruncle and the small micropyle is often very distinctly extended.

## TAXONOMIC TREATMENT

### *Dimorphocalyx* Thwaites

*Dimorphocalyx* Thwaites (1861) 278; Benth. (1880) 301; Hook.f. (1887) 403; Trimen (1898) 54, pl. 84; Brandis (1906) 581; Pax & K.Hoffm. (1911) 31; Ridl. (1924) 266; Gagnep. (1925) 295; Pax & K.Hoffm. (1931) 158; Airy Shaw (1967) 412; (1969) 123; (1972a) 251; (1972b) 92; Whitmore (1973) 86; Airy Shaw (1974) 328; (1975) 95; (1980a) 73; (1980b) 237; (1980c) 624; (1981) 286; (1982) 16; (1983) 20; Chakrab. & N.P.Balakr. (1990) 286; G.L.Webster (1994) 106; Philcox (1997) 107; Raddl.-Sm. (2001) 300; Phattar. & Chayam. (2005) 229. — *Trigonostemon* sect. *Dimorphocalyx* (Thwaites) Müll.Arg. (1865) 212; (1866) 1105. — Type: *Dimorphocalyx glabellus* Thwaites.

Treelets to trees, dioecious (seldom monoecious). *Indumentum* of simple hairs, usually on young parts only. *Stipules* small, triangular, caducous. *Leaves* simple, alternate, petiolate, symmetric, margin entire to serrulate to serrate, with glands abaxially in the teeth or near the margin when entire; venation pinnate, slightly raised (to slightly sunken) above, raised below, secondary veins looped and joined near the margin, tertiary veins reticulate (or scalariform), veinlets reticulate. *Inflorescences* axillary or terminal, short, cymose, thyrsoid or narrowly paniculate when staminate, more or less racemose when pistillate, staminate flowers few together in cymose groups, pistillate flowers usually single per node or per inflorescence; bracts triangular to leaf-like. *Flowers* regular, 5-merous; calyx cup-shaped, (4–)5(–6)-lobed, lobes imbricate; petals 5, longer than calyx, imbricate, white. *Staminate flowers*: disc glands 5, free or zig-zagging around free stamens; stamens (7–)10–15(–c. 20), in 3 whorls, outer free, inner 2 with filaments connate into an androphore, anthers ellipsoid, dorsifixed, opening introrse via a lengthwise slit, thecae 2, parallel; pistillode absent. *Pistillate flowers*: petiole slightly broadening towards apex; disc annular; ovary ovoid, 3-locular, ovules 1 per locule, style generally absent, stigmas apically split. *Fruits* 3-lobed capsules, subglobose, dehiscing septicidally and (partly) loculicidally into separate or 2-valved cocci; pedicels elongating; sepals enlarging and enclosing fruit; wall thinly woody, exocarp often detaching; columella persistent, T-shaped. *Seeds* dry, obovoid, ecarunculate.

Distribution — A genus of c. 13 species, in SE Asia from Sri Lanka to Hainan to Australia. Eight species are recognised for Malaysia.

## KEY TO THE SPECIES

- 1 Leaf blade narrowly ovate, widest near the base, base emarginate to cordate . . . . . 3. *D. ixoroides*
1. Leaf blade ovate to elliptic to obovate, widest in  $\pm$  middle, base rounded to obtuse to cuneate to attenuate . . . . . 2
2. Staminate flowers present . . . . . 3
2. Pistillate flowers or fruits present . . . . . 9
3. Petals with a nail and basal margins thickened and hairy outside, rest glabrous; stamens 7–8. — Lesser Sunda Islands, New Guinea, Australia. . . . . 1. *D. australiensis*
3. Petals without nail and thickened basal margins, either completely glabrous or at least hairy outside; stamens 10 or more. — SE Asia, W Malaysia, Moluccas . . . . . 4
4. Disc lobes hairy . . . . . 5
4. Disc lobes glabrous (unknown for *D. trichocarpus*, but probably glabrous, just as pistillate flowers) . . . . . 6
5. Petioles 2–10 mm long. Staminate flowers 10–13 mm diam. — W Malaysia . . . . . 2. *D. denticulatus*



5. Petioles 8–20 mm long. Staminate flowers c. 8 mm diam. — Moluccas ..... 5. *D. moluccensis*
6. Petioles 2.5–7 mm long; margin serrulate. — Borneo (Brunei, Sarawak) ..... 7. *D. pauciflorus*
6. Petioles 7–140 mm long, if less than 11 mm long then margin entire. — W Malesia ..... 7
7. Leaf blades 2.9–19 cm long; margin entire, seldom serrulate (glandular parts extending due to revolute margin) ..... 4. *D. malayanus*
7. Leaf blades 6.8–42 cm long; margin serrulate to serrate 8
8. Apex of leaf blades acuminate to usually cuspidate; blades 6.8–42 by 2.6–13.2 cm, 1.9–3.7 times as long as wide; margin serrate (to serrulate). Calyx glabrous inside. — SE Asia, W Malesia (incl. Borneo) ..... 6. *D. muricatus*
8. Apex of leaf blades acuminate; blades 22–33 by 9.4–14.3 cm, c. 2.3 times as long as wide; margin laxly serrulate. Calyx lobes probably hairy inside. — Borneo (Sarawak). ..... 8. *D. trichocarpus*
9. Pistillate flowers and fruits unknown. — Moluccas ..... 5. *D. moluccensis*
9. Pistillate flowers and fruits present. — Outside Moluccas ..... 10
10. Ovaries and fruits echinate ..... 11
10. Ovaries and fruits smooth ..... 13
11. Fruits hairy. — Lesser Sunda Islands, New Guinea, Australia ..... 1. *D. australiensis*
11. Fruits glabrous. — SE Asia, W Malesia ..... 12
12. Petioles (11–)30–140 mm long, (0.8–)1–4 mm diam; blades 6.8–42 cm long. Ovaries and fruits with spines often united into short, stump ledges. — SE Asia, W Malesia ..... 6. *D. muricatus*
12. Petioles 2.5–7 mm long, 0.8–1.7 mm diam; blades 12.3–21.4 cm long. Ovaries and fruits with slender spines, not united. — Borneo (Sarawak) ..... 7. *D. pauciflorus*
13. Ovaries and fruits glabrous. Blade margins entire (to serrulate). Disc glabrous. Sepals with apical gland outside ..... 4. *D. malayanus*
13. Ovaries and fruits hairy (to glabrous); if glabrous then blade margins serrulate to serrate and disc hairy. Sepals without apical gland ..... 14

14. Discs hairy. Leaf blades 7.9–30 cm long; petioles 2–10 mm long ..... 2. *D. denticulatus*
14. Discs glabrous. Leaf blades 22–33 cm long; petioles 25–36 mm long. .... 8. *D. trichocarpus*

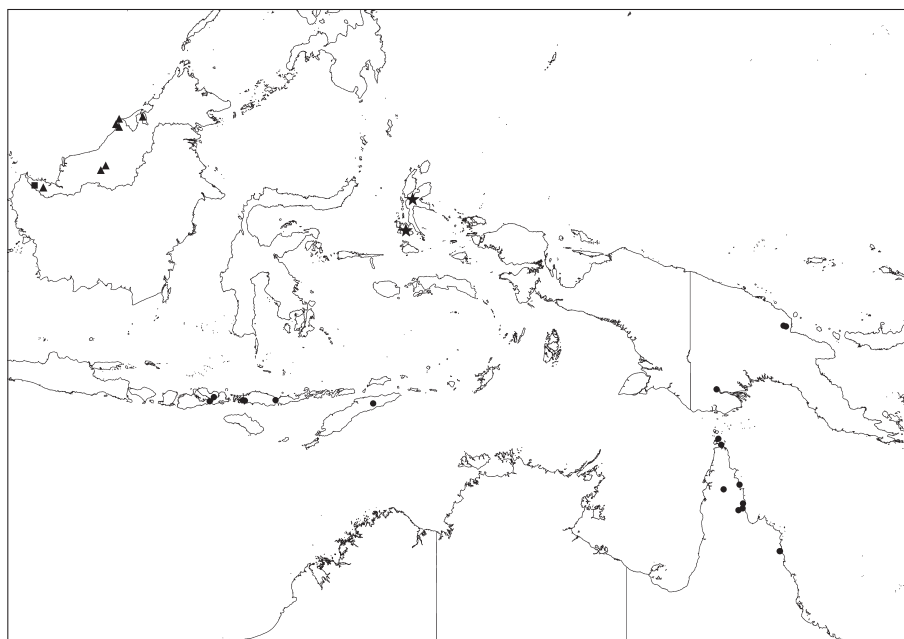
# 1. *Dimorphocalyx australiensis* C.T.White — Fig. 1c, Map 1

*Dimorphocalyx australiensis* C.T.White (1936) 80; Airy Shaw (1969) 125; (1974) 328; (1980a) 74; (1980b) 237; (1980c) 624; (1982) 16. — Type: *Brass* 2019 (holo BRI; iso A, K, 2 sheets, US), Australia, Queensland, Mowbray River.

[*Croton muricatus* Zipp. ex Span. (1841) 348, nom. nud. — Based on: *Zippelius s.n.* (L, 3 sheets, barcodes: L0245271, L0245278, L0245277), [Indonesia, Lesser Sunda Islands.] Timor.]

*Tritaxis australiensis* S.Moore (1920) 218. — Type: *Damel s.n.* (holo K; iso BM, not seen, BRI, K), Australia, Queensland, Cape York, Cook pastoral district.

Shrubs to small trees, to 10 m high, dbh to 20 cm; flowering branches 1–2 mm thick, round to somewhat angular, yellow to brown, mainly slightly hairy at nodes, usually striate. *Indumentum* of ferruginous hairs, most parts mainly glabrous. *Outer bark* (greenish) brown to grey, rough, sometimes flaky, c. 0.5 mm thick; under bark red; inner bark orange-brown to reddish brown to light brown, c. 7 mm thick; sapwood cream to pale brown. *Stipules* triangular, c. 5 by 1.5 mm, outside hairy, very early caducous, usually absent. *Leaves*: petiole 0.4–2.7 cm long, 0.7–1.5 mm diam, glabrous to slightly hairy, often transversely cracked when dry, basically and apically pulvinate; blade (ovate to) elliptic (to obovate), widest in  $\pm$  middle, 2.3–14.3 by 1.5–6.5 cm, 1.3–2.2 times as long as wide, papyraceous, base obtuse to round to cuneate to attenuate, margin  $\pm$  entire to serrulate, revolute, apex (rounded) to acuminate (to cuspidate), upper surface dark green, lower surface lighter green, venation slightly raised above, raised below, secondary veins (6–)8–12 pairs, tertiary nerves reticulate. *Inflorescences* axillary to mainly terminal, very short, dichasial, to 6 cm long, branches round to angular, partly to completely densely sericeous; bracts and 2 bracteoles forming tight cups, 1.1–1.9 by 1.1–2.2 mm, hairy outside, coriaceous, midrib thickened, apex mucronulate. *Staminate flowers* c. 15 mm diam, white, buds green; pedicel 3.5–7 mm long above abscission zone, round, hairy; calyx connate at base, lobes ovate to obovate, 1.7–2.5 by 2–2.5 mm, apex round, outside hairy except margin, inside glabrous,



**Map 1** Distribution of *Dimorphocalyx australiensis* C.T.White (●), *D. moluccensis* Welzen & Oostrum (★), *D. pauciflorus* (Merr.) Airy Shaw (▲), and *D. trichocarpus* (Airy Shaw) Welzen & Oostrum (■).

without subapical glands outside; petals oblong to obovate, 6.5–8.3 by 3.2–5.3 mm, basally with a nail of c. 0.7 mm, apex round, nail and basal margins thickened and hairy outside, rest glabrous; disc 5 lobes thick, short lobes, 0.6–1 by 0.5–0.6 mm, glabrous; stamens 7–8, in 2 whorls, all filaments partly united, glabrous, basal part of androphore of outer 4–5 stamens c. 3.5 mm long, free part of filaments c. 1.3 mm, inner part of androphore of inner 3 stamens c. 5.2 mm long, free part of filaments c. 0.5 mm, anthers 0.5–1 by 0.5–0.9 mm, dorsifixed. *Pistillate flowers* 6–7 mm diam, white; pedicel 5–8 mm long above abscission zone, round to flattened, hairy, glabrescent; calyx (4–)5-lobed, lobes, ovate, 2.3–3.5 by 2–3 mm, outside and inside sericeous, without subapical glands outside; petals very early caducous; disc a thin ring, glabrous; ovary ovoid, 2.5–3 by 2–3 mm, densely set with slender, pointed spines, hairy, style absent to 0.7 mm long, stigmas 1.3–2 mm long, upper 0.3–1 mm split. *Fruits* 9–10 by 6–6.5 mm, echinate, hairy, green to dark brown; pedicel 6–10 mm long; sepals enlarging to 4 by 2 mm; wall c. 0.8 mm thick, woody, exocarp not splitting off; columella 4–4.5 mm long. *Seeds* ellipsoid to obovoid, c. 5.3 by 4 by 4 mm, slightly marbled.

**Distribution** — Lesser Sunda Islands (Sumbawa, Flores, Timor), New Guinea, Australia (Queensland) (Airy Shaw 1980b).

**Habitat & Ecology** — In monsoon forest to complex notophyll vine forest to the substage of primary rain forest, but also in scrubs; often in wetter areas, but also dry slopes; found on metamorphic rocks (tuff breccia) to soils derived from basalt. Altitude: 10–800 m. Flowering: whole year through; fruiting: January, October, December (probably also whole year through).

**Vernacular name** — Lesser Sunda Islands: Flores: Anak watu.

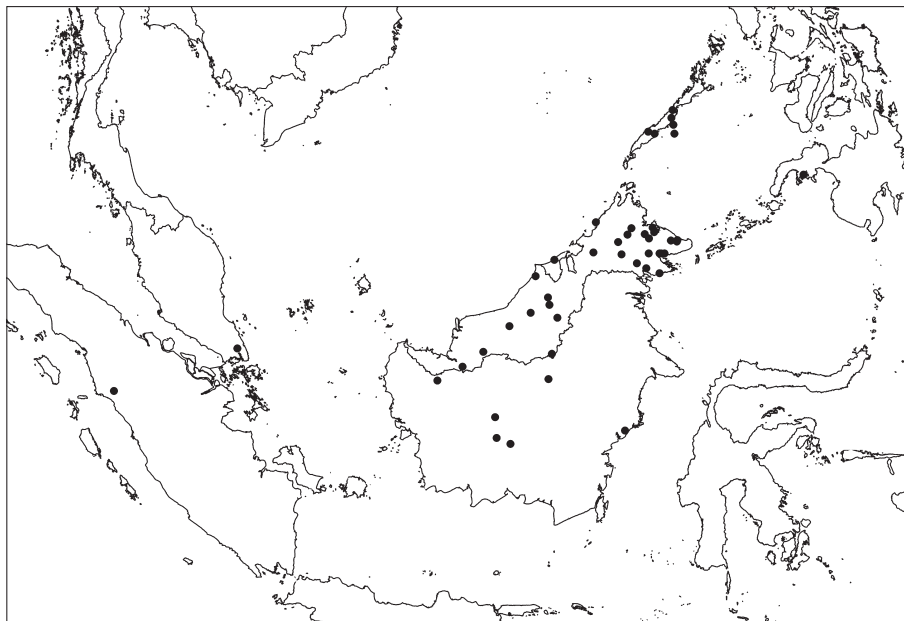
## 2. *Dimorphocalyx denticulatus* Merr. — Fig. 1b, d, e; Map 2

*Dimorphocalyx denticulatus* Merr. (1909) 278; Pax & K.Hoffm. (1912) 285; Merr. (1923) 455; Airy Shaw (1975) 96; (1983) 20. — Type: *FB* (Whitford & Hutchinson) 9033 (holo PNH†; iso K, US), Philippines, Mindanao, District of Zamboanga, Port Banga.

*Dimorphocalyx murinus* Elmer (1911) 1285 ('*murina*'); Pax & K.Hoffm. (1914) 404; Merr. (1923) 455; Whitmore (1973) 87; Airy Shaw (1975) 97; (1983) 21. — Lectotype (designated here): *Elmer 12844* (holo L; iso BM, HBG, K, L, NY, P, U under *D. lawianus*, US), Philippines, Palawan, Puerto Princesa (Mt Pulgar).

*Dimorphocalyx loheri* Merr. (1925a) 30; (1925b) 252; Airy Shaw (1920) 413; (1983) 20. — Lectotype (designated here): *Loher 12467* (holo UC; iso A), Philippines, Luzon, Rizal Prov., Montalban.

(Under)shrubs to trees, to 20 m high, dbh to 20 cm; flowering branches 1–2.5 mm thick, round, slightly striate, often strongly lenticellate, hairy when young, persistent at nodes. *Indumentum* of light yellow hairs, present on most parts. *Outer bark* green to pale white to greyish to grey-brown to light brown, smooth to deeply fissured to scaly, thin to 4 mm thick, soft (to hard); inner bark 0.3–0.5 cm, pale yellowish to pink to red to red-brown to (pale) brown, fibrous, (soft to) hard; exudate red; sapwood creamy white and dull ochre, c. 2 cm thick; heartwood light red-brown. *Stipules* ovate, 3–5 by 2.2–3.8 mm, outside (glabrous to) hairy, glabrescent, inside glabrous. *Leaves*: petiole 2–10 mm long (see note 2), 1–3.1 mm diam, completely pulvinate, usually slightly hairy; blade elliptic, widest in ± middle, 7.9–30 by 3.3–12 cm, 1.8–3.2 times as long as wide, rather coriaceous, base rounded to cuneate, margin serrulate to serrate, revolute, apex (acuminate to) cuspidate to caudate, upper surface seldom with few hairs, dull dark green, lower surface often with few hairs, light green to glaucous, venation slightly raised to slightly sunken above, raised below, secondary veins 8–17 pairs, intercalary veins present, tertiary nerves and veinlets reticulate. *Inflorescences* axillary, cymose to thyrsoid, usually short, to 5 cm long, round to flattened and angular, (sparsely) hairy; staminate flowers in groups per node, pistillate flowers single per node and often single per inflorescence; bracts in various shapes, very broad and short to long, narrow and sharply folded to leaf-like, triangular to ovate to elliptic, 1.8–8 by 1.3–4 mm, margins thinner, with lighter colour when dry, outside (very) hairy, inside glabrous. *Staminate flowers* 10–13 mm diam, white; pedicel to 10 mm long above basal abscission zone, round, (slightly) hairy; calyx lobes often unequal, 4.3–5 mm deep, lobes ovate, 2.4–3 by 1.9–2.6, apex slightly emarginate to rounded, outside (glabrous to) hairy, inside glabrous (to basally slightly hairy); petals oblong to obovate, 5.3–7.3 by 2.6–3.6 mm, usually outside slightly hairy, apex rounded; disc glands rather thick, zig-zagging around stamens, hairy; stamens 16–18, the outer ones with (nearly) free filaments of c. 2 mm long, the inner ones diverging in two layers from an up to 2 mm long androphore, free part of filaments c. 1.5 mm long, anthers c. 0.7 by 0.7 mm. *Pistillate flowers* 12–22 mm diam; pedicel c. 9 mm long, round, hairy; sepals connate at base, lobes enlarging directly after opening (see note 3), obovate, c. 8.2 by 4.2 mm, green, outside hairy, inside glabrous, apex rounded; petals elliptic to oblong, 4.8–9 by 3–6 mm, usually shorter than calyx lobes, white, hairy outside, glabrous inside, apex rounded; disc



**Map 2** Distribution of *Dimorphocalyx denticulatus* Merr.

a flat ring, hairy, cream; ovary 2.5–4 by 2–4 mm, hairy (to perhaps seldom glabrous), glabrescent, green, stigmas 3–7 mm long of which upper 0.9–5 mm split, thick, broad, hairy below, green to yellow. *Fruits* 1.3–1.7 by 1–1.3 cm, smooth, hairy, glabrescent, green to slightly brownish green to greenish blue to purple, also cream mentioned; wall woody, 1–1.2 mm thick, exocarp often separating; pedicel elongating up to 25 mm; sepals enlarged to 12.8 by 5 mm (see note 3); columella 7–12 mm long. *Seeds* 8–12 by 6.5–10.5 by 5.5–9 mm.

**Distribution** — Malay Peninsula (Johore), W and Central Borneo, Philippines.

**Habitat & Ecology** — Mixed dipterocarp lowland forest to logged over areas on hillsides, ridges and along rivers; soil blackish sand to sandy clay to loam to sandstone shale; bed-rock igneous intrusive. Altitude: sea level to 700 m. Flowering: March to November; fruiting: February, March, May to August, October to December.

**Vernacular names** — Borneo: Kalimantan Barat: Buronte girek; Sabah: Alag alag, putat putat (Tidong); Binsuon, Parumpong (Dusun Kinabatangan). Philippines: Dagongdong, Pagangdong (Tagbanua).

**Notes** — 1. The type of *D. denticulatus* resembles the specimens of *D. pauciflorus* of Borneo. However, *D. pauciflorus* has echinate fruits, and the presence of spines on the ovary of *D. denticulatus* was not described by Merrill (1909). In habit the type of *D. denticulatus* resembles other Philippines specimens identified as *D. murinus* Elmer (serrulate leaf margin, short petioles). Therefore, the latter, younger name is synonymised with *D. denticulatus*.

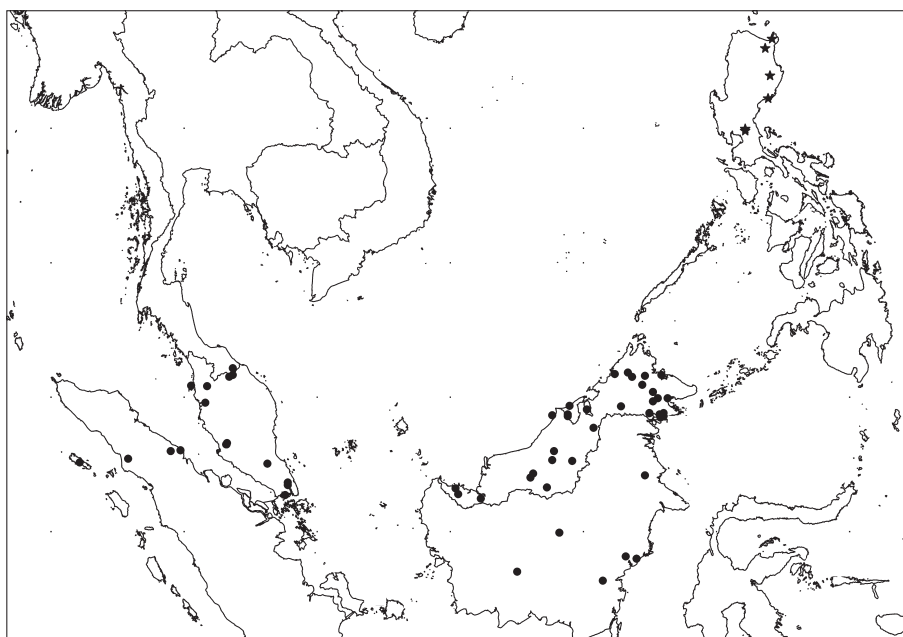
2. *Dimorphocalyx loheri* is tentatively placed in the synonymy here. Airy Shaw (1983) suggested “Genus uncertain, probably not *Dimorphocalyx*, but available material insufficient”. However, according to the description by Merrill (1925; “unfortunately flowering isotypes are absent and the holotype is lost”) this species is more like *D. murinus*, because of the hairy floral parts, than *D. denticulatus*; names which are here considered as conspecific.

3. *SFN (Corner)* 37248 from Johore, Malay Peninsula, has pistillate sepals that do not directly enlarge when the flower opens, similar to a specimen with unknown collector and origin (L, barcode L0158646). The latter also has exceptionally long petioles (up to 16 mm long), but still has the typical *D. murinus* hairy disc.

### 3. *Dimorphocalyx ixoroides* (C.B.Rob.) Airy Shaw — Map 3

*Dimorphocalyx ixoroides* (C.B.Rob.) Airy Shaw (1967) 412; (1983) 20. — *Ostodes ixoroides* C.B.Rob. (1911) 332; Pax & K.Hoffm. (1914) 403; Merr. (1923) 454. — Type: *FB (Klemme)* 13426 (holo PNHT; iso US), Philippines, Luzon, Province of Ilocos Norte, Bangui.

Small trees, to 6 m high, dbh to 18 cm; flowering branches 1–3 mm thick, round to somewhat angled, brownish, striate. *Indumentum* mainly absent. *Outer bark* brownish or greyish, striate, c. 0.5 mm thick; inner bark light brownish; sapwood c. 0.5 mm thick; heartwood c. 1 cm thick. *Stipules* triangular, 1.7–3 by 1–1.2 mm, glabrous to slightly hairy outside, late caducous. *Leaves*: petiole 2–8 mm long, 1.2–3.2 mm diam, round, completely pulvinate, glabrous; blade narrowly ovate, widest near the base, 8.5–26 by 2–8.7 cm, 3–6 times as long as wide, base emarginate to cordate, margin serrulate, flat, with glands abaxially in the teeth, apex gradually, indistinctly cuspidate, venation slightly raised on both sides, secondary veins 15–20 pairs, with intercalary nerves present, tertiary and higher order nerves reticulate. *Staminate inflorescences* thyrsoid, to 15 cm long, slightly paniculate with few, short side-branches, round, glabrous, green; staminate flowers in cymose groups along side branches, pistillate inflorescences racemose, up to 11.5 cm long with a single flower per node; bracts varying between broad and ovate, c. 0.8 by 1 mm, to narrow and elliptic, c. 0.9 by 0.4 mm, hairy outside, especially the margin. *Staminate flowers* seen in bud, 3.2–7 mm diam; bud of 3.2 mm diam described: pedicel c. 2 mm long above abscission zone, round, glabrous; calyx c. 3.2 mm high, glabrous to slightly hairy, especially the margin, lobes ovate, c. 2 by 1.8 mm, margin membranous, apices round, without subapical glands outside; petals free, broadly obovate, c. 2.7 by 1.8 mm (Robinson 1911: c. 6 mm long), glabrous, apex round; disc glands triangular, 0.3–0.6 by c. 0.5 mm, glabrous; stamens c. 10, filaments strap-like, apically narrowed, outer ones 4, free, c. 1 mm long, inner 6 partly united in a c. 1 mm high androphore, free part c. 0.8 mm long, anthers to 1 mm long. *Pistillate flowers* c. 4 mm diam, pedicel c. 3 mm long above abscission zone, round, glabrous; sepals connate at base, lobes elliptic, c. 4.5 by 3 mm, glabrous, without subapical glands outside; petals ovate, c. 5 by 2 mm, glabrous; disc a flat ring, glabrous; ovary c. 2.5 by 2 mm, glabrous, stigmas c. 0.25 mm long. *Fruits* 1.6–1.8 by 1.3–1.5 cm, smooth, glabrous; sepals enlarged to 1 by 0.5 cm; pedicel c. 9



**Map 3** Distribution of *Dimorphocalyx ixoroides* (C.B.Rob.) Airy Shaw (★) and *D. muricatus* (Hook.f.) Airy Shaw (●).



mm long; wall woody, c. 0.5 mm thick; columella c. 8 mm long. *Seeds* c. 8 by 6 mm.

**Distribution** — Philippines (endemic on Luzon).

**Habitat & Ecology** — On slopes in forest. Altitude: c. 435 m. Flowering: January, February, May, June, October, November; fruiting: January to March, May, June, December.

#### 4. *Dimorphocalyx malayanus* Hook.f. — Fig. 1f, Map 4

*Dimorphocalyx malayanus* Hook.f. (1887) 404; Pax & K.Hoffm. (1911) 33; Merr. (1921) 346; Ridl. (1924) 266; W.L.Stern (1967) 668; Whitmore (1973) 86; Airy Shaw (1975) 96; Phattar. & Chayam. (2005) 229, f. 50. — Lectotype (designated here): Griffith KD 4785 (holo K; iso A, P), [Malaysia,] Malacca. *Dimorphocalyx kunstleri* King ex Hook.f. (1887) 405; Pax & K.Hoffm. (1911) 32; Ridl. (1924) 266. — Type: King's collector 1455 (holo K), [Malaysia,] Penang.

*Dimorphocalyx luzoniensis* Merr. (1910) 192; Pax & K.Hoffm. (1912) 284; Merr. (1923) 455; Whitmore (1973) 87; Airy Shaw (1975) 96; (1983) 21. — Lectotype (designated here): FB (Tamesis) 11907 (holo K; iso US), Philippines, Luzon, Prov. of Laguna, Los Baños.

*Dimorphocalyx beccarii* Gagnep. (1924) 621. — Lectotype (designated here): Beccari PB 2215 (holo P; iso A, K), Borneo, Sarawak.

*Trigonostemon bulusanensis* Elmer (1939) 3735; Airy Shaw (1967) 413. — *Dimorphocalyx bulusanensis* (Elmer) Airy Shaw (1972b) 92; (1983) 20. — Type: Elmer 17296 (holo PNH<sup>+</sup>; iso HBG, K, L, MO, NY, S, U), Philippines, Luzon, Prov. of Sorsogon, Irosin (Mt Bulusan).

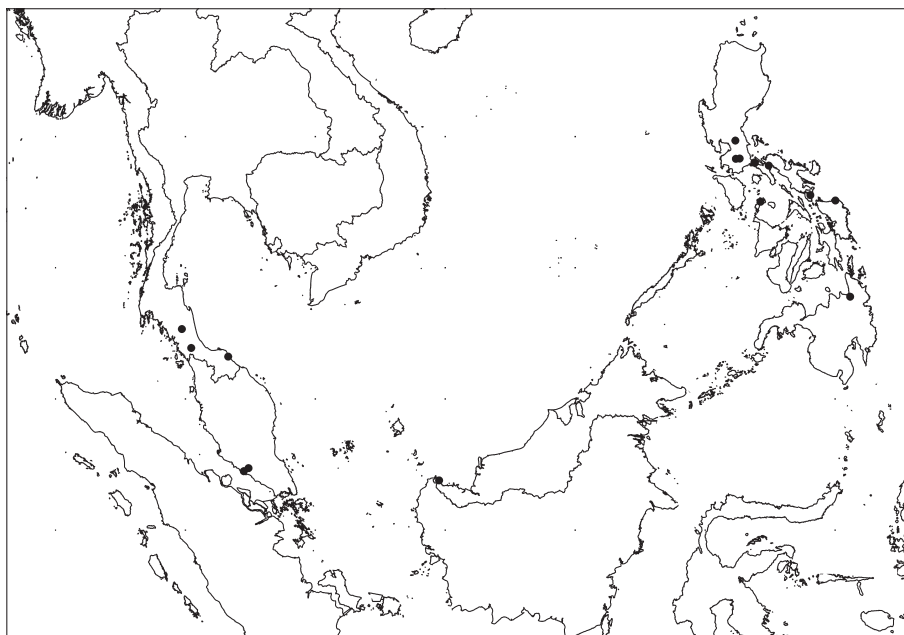
Shrubs to trees to 15 m high, dbh to 18 cm; flowering branches 2–3 mm diam, greyish brown, yellowish when dry, at most slightly striate. *Indumentum* mainly absent, hairs light yellow. *Outer bark* grey, thin, slightly roughened, not detaching; under bark usually indistinct, if distinct dark red; inner bark cream to paler red than under bark, fibrous; wood white. *Stipules* triangular to ovate, 1–3 by 1–3 mm, stiff, with dark brown centre and thinner, lighter brown margins, glabrous. *Leaves*: petiole 7–35 mm long, 0.8–1.8 mm diam, deeply furrowed above, not to slightly pulvinate basally and apically, glabrous, light green to green; blade ovate to elliptic, widest in  $\pm$  middle, 2.9–19 by 0.8–10.3 cm, 1.8–3.6 times as long as wide, papyraceous (to pergamentaceous), base obtuse to cuneate to attenuate, margin entire, seldom serrulate (glandular parts extending due to revolute margin), flat to revolute, apex (acuminate to) cuspidate (to caudate), dark green above, pale green below, venation slightly raised above, raised below, secondary veins 9–17 pairs, tertiary nerves reticulate. *Inflorescences* axillary, short and dichasial (especially pistillate ones) to longer and thyrsoid (to

slightly paniculate; especially staminate ones), staminate ones to 10 cm long, pistillate to 7 cm long, branches often flattened, glabrous, lower bracts often leaf-like, higher ones triangular to ovate, 0.7–6 by 0.3–1.5 mm, with a few hairs on the midrib outside and along the margin. *Staminate flowers* 6.5–13 mm diam, white; pedicel 3.7–6.5 mm long above abscission zone, round, glabrous, abscission zone basally (Philippines, Borneo) to generally higher (SE Asia); calyx 2–5.5 mm deep, lobes triangular and indistinct in SE Asia (c. 1 by 2.5 mm) with acute to erose apices, sometimes with a subapical gland outside, ovate and distinct in Borneo and the Philippines (1.3–3.5 by 1.3–3.3 mm) with round apices without glands outside; petals elliptic to oblong, 5–7.5 by 1.8–3.8 mm, apex rounded, glabrous; disc glands obtrapezoid, 0.3–0.9 by 0.6–0.8 mm, thin, glabrous; stamens 10–12, filaments white, outer 5 (or 8) free (to seldom basally connate for c. 1 mm with androphore), filaments 2.5–5 mm long, inner 4–7 often in two layers, androphore 2.3–6 mm long, free part 1–2 mm long, anthers ellipsoid, 0.8–1.1 by 0.8–1.5 mm, tan. *Pistillate flowers* 20–21.5 mm diam; pedicel 5–12 mm long above abscission zone, round, glabrous; calyx basally united, lobes ovate to oblong to obovate, 8–13 by 5–7.5 mm, apex rounded to emarginate, glabrous, usually with a gland outside just beneath apex, green to yellow; petals elliptic to obovate, c. 9.5 by 4.5 mm, apex rounded, white, glabrous; disc up to 0.4 mm high, glabrous; ovary ovoid, 2–2.2 by 1.7–2.2 mm, glabrous, smooth, bright yellow with local green tinges, style 0.8–1 mm long, cream or very pale green, stigma 2–5 mm long, basal 1–1.3 not split. *Fruits* 1.2–1.6 by 0.9–1 cm, smooth, glabrous, green, ripe brown; pedicel 8–19 mm long; sepals enlarging to 25 by 16 mm; wall c. 1 mm thick, exocarp detaching; columella c. 8.5 mm long. *Seeds* ellipsoid, 7.5–8 by 6.5–7.5 by 6–6.8 mm.

**Distribution** — Thailand (Peninsular), Malay Peninsula, Borneo, Philippines.

**Habitat & Ecology** — In primary and lowland evergreen to deciduous forest, on slopes, sandstone cliffs, among limestone outcrops. Altitude: 100–500 m. Flowering: January to May, September; fruiting: February to June.

**Note** — *Dimorphocalyx luzoniensis* and *D. bulusanensis* do not differ in any characters from each other and both are also very similar to *D. malayanus* and, therefore, synonymised with the latter. There are some geographical differences: leaf



Map 4 Distribution of *Dimorphocalyx malayanus* Hook.f.

blades are generally larger in Borneo and the Philippines ('*D. luzoniensis*', '*D. bulusanensis*') than in S Thailand and Malay Peninsula (typical *D. malayanus*), staminate flowers of typical *D. malayanus* generally have a visible abscission zone, not basal, and they are smaller with acute, very short calyx lobes (basal abscission zone and larger, with bigger, rounded calyx lobes in typical '*D. luzoniensis*/'*bulusanensis*'), the pistillate sepals in S Thailand and Malay Peninsula are generally more rounded/acute and always have a subapical extrafloral nectary at the outside, while on Borneo and in the Philippines the pistillate sepals are emarginate and often lack the glands, the style and disc are more distinct in S Thailand and Malay Peninsula than in the Philippines.

**5. *Dimorphocalyx moluccensis* Welzen & Oostrum, sp. nov.**  
— Map 1

*Dimorphocalyx* cf. *muricatus* auct. non (Hook.f.) Airy Shaw: Airy Shaw, Kew Bull. 37 (1982) 16.

Resembles *D. denticulatus* most closely in the hairy disc and petals and *D. muricatus* in the long inflorescences, but differs from both in having leaves larger, with relatively long petiole and at most an acuminate apex; and staminate flowers smaller. — Type: *De Vogel* 3134 (holo L), Indonesia, N Moluccas, Halmahera, Ekor, side of Gunung Panjang.

Trees to 12 m high, dbh to 28 cm, one specimen fluted, flutes c. 4 m high, c. 2 m out and c. 5 cm wide; flowering branches 2.5–3 mm thick, round, glabrous. *Indumentum* of light yellow hairs, most parts glabrous. *Outer bark* brownish grey, not fissured, c. 0.2 mm thick; inner bark red, c. 3 mm thick, without exudate; sapwood pale yellow tinged violet, gradually passing into the darker yellow heartwood. *Stipules* triangular, 4–4.5 by c. 3.5 mm, thick, margins thinner, outside glabrous to hairy, inside glabrous, caducous. *Leaves*: petiole 0.8–2 cm long, 1.5–3 mm diam, above flat to furrowed, glabrous to few hairs, completely pulvinate; lamina elliptic to oblong, widest in ± middle, 10.5–24.5 by 5.8–12.8 cm, 1.8–1.9 times as long as wide, (rather) coriaceous, base rounded to attenuate, margin laxly serrulate, with glands in the teeth abaxially, recurved, apex acute to acuminate, mainly glabrous, venation slightly raised above and beneath, secondary veins 13–15 pairs, higher order veins reticulate. *Staminate inflorescences* terminal and axillary on apical nodes, several close together, thyrsoid to slightly paniculate with short side branches, to 11.3 cm long, angular to flattened, hairy, quickly glabrescent; bracts ovate, 2.7–4 by 1.7–3 mm to elliptic, c. 5 by 1 mm, outside usually hairy, inside glabrous. *Staminate flowers* c. 8 mm diam, white, unpleasant smell; pedicel 4.5–5.5 mm long above abscission zone, round to slightly flattened, with few hairs, abscission zone well-visible, not hidden by bracts; calyx 3–3.3 mm high, lobes ovate, 1.7–2.3 by 2–2.5 mm, thickest in middle, thinnest at margins, margin and often base outside hairy, apex emarginate to rounded; petals ovate to obovate, 4.2–5.5 by 3.3–6 mm, apex rounded, few hairs outside; disc glands rectangular (not zig-zagging around stamens), 0.3–1 by 0.3–0.8 mm, thick, apex hairy; stamens 11–12, 5 outer free or base adnate to androphore, filaments c. 4.5 mm long, central 6–7 partly united in an androphore of c. 4 mm long, free part of filaments c. 1.5 mm, anther elliptic, 0.6–1 by 0.8–1 mm. *Pistillate flowers, fruits and seeds* unknown.

*Distribution* — Endemic in the N Moluccas (Bacan, Halmahera).

*Habitat & Ecology* — Rather dense primary forest to secondary forest on deep clayey soil. Altitude: sea level to 15 m. Flowering: August, September.

**6. *Dimorphocalyx muricatus* (Hook.f.) Airy Shaw — Fig. 1g, Map 3**

*Dimorphocalyx muricatus* (Hook.f.) Airy Shaw (1967) 412; (1972a) 252; Whitmore (1973) 87; Airy Shaw (1975) 97; (1981) 286; Phattar. & Chayam. (2005) 231, f. 51, pl. XIII: 1. — *Ostodes muricata* Hook.f. (1887) 401; Pax & K. Hoffm. (1911) 21; Ridl. (1924) 269. — *Ostodes muricata* Hook.f. var. *genuina* Pax (1911) 21, nom. inval. — Type: *King's collector* 3162 (holo K), [Malaysia,] Perak, Larut.

*Trigonostemon asahanensis* Croizat (1942) 54. — Type: *Rahmat si Boeea* 9872 (holo A; iso L), Sumatra, Asahan, vicinity of Tomoean Dolok.

*Dimorphocalyx* [?] sp.?, Merr. (1929) 163. — pro *Elmer* 21287 (L), British North Borneo [= Sabah], Elphinstone Prov., Tawao.

*Ostodes muricatus* Hook.f. var. ? *minor* Hook.f. (1887) 401. — *Dimorphocalyx muricatus* (Hook.f.) Airy Shaw var. *minor* (Hook.f.) Airy Shaw (1967) 412; Whitmore (1973) 87. — Lectotype (designated here): *Lobb* 304 (holo BM; iso E, GH, 2 sheets, K, L), Singapore.

Small shrubs to trees, to 10(–25) m high, dbh to 18 cm, evergreen but seemingly deciduous in S Thailand, young leaves when flowering; flowering branches 2–5.5 mm thick, ± angular, light grey (to brown) when dry, striate when dry, smooth to lenticellate, mainly glabrous. *Indumentum* variably present. *Outer bark* grey to brown, smooth (to scaly and hooped), soft, papery, c. 0.2 mm thick; inner bark yellow to orange-red to red, soft, (laminated, fibrous), c. 2 mm thick; exudate watery, red; sapwood creamy white to pale yellow. *Stipules* triangular, 5–8 by 3–4 mm, glabrous to hairy outside, early caducous. *Leaves*: petiole (1.1–)3–14 cm long, (0.8–)1–4 mm diam, deeply furrowed above, glabrous to hairy, basally and apically slightly pulvinate; blade (ovate to) elliptic to oblong (to obovate), widest in ± middle, 6.8–42 by 2.6–13.2 cm, 1.9–3.7 times as long as wide, papyraceous to pergamentaceous (to coriaceous), base round to obtuse to cuneate, margin serrate (to serrulate), flat to revolute, with glands abaxially in the teeth, apex acuminate to usually cuspidate, upper surface dark green, at most hairy on midrib, lower surface pale green to blue-green, sometimes a bit hairy on venation, latter flat to slightly raised above, raised below, secondary veins 12–15 pairs, intercalary nerves often present, tertiary nerves scalariform, higher orders reticulate. *Inflorescences* axillary thyrses, to c. 19 cm long, but usually less than 5 cm long, staminate ones more or less paniculate with a few side-branches, pistillate ones often almost umbellate or dichasial, glabrous to usually shortly sericeous; staminate flowers several per node, pistillate ones single; bracts ovate (to elliptic), 1.5–4 by 1.2–2 mm, usually hairy outside, glabrous inside. *Flowers*: calyx lobes mostly hairy outside except for lobe margins, glabrous inside, usually with a large, round gland outside, often indistinct. *Staminate flowers* 14–15 mm diam, white, scented; pedicel 15–17 mm long above abscission zone, roundish to flattened, usually hairy; calyx 5–5.5 mm high, lobes ovate to elliptic, 3–3.5 by 2–4 mm, apex round; petals oblong to obovate, 8–12 by 2.8–4.5 mm, reflexed, glabrous, apex round; disc glands often indistinct, winding around stamens, glabrous; stamens 10–16, not in distinct whorls, only inner c. 3 with connate filaments, latter 3.5–4 mm long, anthers dorsifixed, 1.2–1.4 by 1–1.3 mm, inner ones largest. *Pistillate flowers* c. 8 mm diam, not strongly scented; pedicel 6–13 mm long above abscission zone, round, hairy; sepals shortly connate, basally white, rest light green, lobes ovate to elliptic 3–6 by 3–4.5 mm, apex rounded; petals oblong to obovate, c. 8 by 6.2–7 mm, white, apex round; disc a thin ring, glabrous; ovary ovoid, 3.5–4.5 by 2–3 mm, densely beset with blunt spines, glabrous, style absent, stigmas 2–3.7 mm long, white to light green, completely split except for lower 0.5–1 mm, upper surface stigmatic. *Fruits* 1.8–3.5 by 1.5–2.7 cm, muricate with spines often united into short ledges, dark green to pink-yellow to brown, wall woody, c. 2 mm thick, exocarp and endocarp usually completely separating; pedicel elongated up to 24 mm; sepals slightly enlarged to 8 by 5 mm; columella 10.5–13 mm



long. *Seeds* sub-ellipsoid with usually abaxially a lengthwise ridge, 8–14 by 6–11 by 7–10.5 mm.

**Distribution** — Thailand (Peninsular: Narathiwat Prov.), Malay Peninsula, Sumatra, Borneo.

**Habitat & Ecology** — Evergreen forest, primary and (logged) secondary (Dipterocarp) forest, often on ridges and along rivers and swamps; soil varying from yellow clay to sandy clay to sandstone with clay to loam. Altitude: sea level up to 1000 m. Flowering: March to October; fruiting: whole year through.

**Vernacular names** — Sumatra: Batin batin delok alafai, Batin batin silafai; Kajoe si saram. Borneo: Brunei: Asah anak unyong; Kalimantan: Kupang parawa (Dayak); Sarawak: Bantas (Iban); Marok (Kayan)).

### 7. *Dimorphocalyx pauciflorus* (Merr.) Airy Shaw — Fig. 1a, h; Map 1

*Dimorphocalyx pauciflorus* (Merr.) Airy Shaw (1967) 413. — *Ostodes pauciflorus* Merr. (1916a) 72; (1921) 345. — Type: *Hose 244* (iso A, K, L, P), Malaysia, Sarawak, Baram District, Baram.

Shrubs to treelets, to 8 m high, dbh to 8 cm; young twigs greenish grey; flowering braches 1.5–2 mm thick, round, yellowish brown when dry, smooth. *Indumentum* of yellowish hairs most parts mainly glabrous. *Outer bark* grey to grey-brown, smooth. *Stipules* triangular, 1.8–3 by 1.8–2.5 mm, margin with few hairs, thick but margins thinner. *Leaves*: petiole 2.5–7 mm long, 0.8–1.7 mm diam, deeply grooved above, completely pulvinate, glabrous; blade slightly ovate to elliptic to slightly obovate, widest in  $\pm$  middle, 12.3–21.4 by 2.8–5.7 cm, 2.4–4 times as long as wide, pergamentaceous to slightly coriaceous, base cuneate, margin serrulate, with glands abaxially in the teeth, recurved, apex (acuminate to) cuspidate, lower surface bluish green, venation slightly raised above, raised below, secondary veins 10–14 pairs, intercalary nerves mainly absent, higher order nerves reticulate. *Inflorescences* axillary, cymose, less than 1 cm long, square, slightly hairy; staminate flowers with few together, pistillate ones single; bracts triangular to ovate, c. 1.5–2 by 1–1.8 mm, margin hairy to slightly hairy outside. *Staminate flowers* only seen in bud; pedicel c. 20.5 mm long above abscission zone, round, glabrous; calyx c. 4.8 mm deep, lobes ovate, outside and inside glabrous, on each lobe a round gland near apex outside; petals oblong; stamens c. 20, anthers dorsifixed, c. 1 by 1 mm. *Pistillate flowers* c. 9.5 mm diam; pedicel c. 13.5 mm long above abscission zone, round to ribbed, glabrous; calyx c. 4.7 mm deep, lobes ovate, c. 4.3 by 3.7 mm, glabrous, on each lobe a round gland near apex outside; petals not seen; ovary ovoid, c. 5 by 3.5 mm, echinate with stump, apically slightly thickened soft spines, glabrous, stigmas not seen. *Fruits* outside with soft non-confluent spines, glabrous, ripe purple or red; calyx lobes hardly enlarged, 4–5 by 3.8–4 mm; wall woody, c. 1.2 mm thick, exocarp detaching or not; columella 9–10 mm long. *Seeds* c. 9 by 8 by 7 mm.

**Distribution** — Endemic in W Borneo (Brunei, Sarawak).

**Habitat & Ecology** — Primary lowland dipterocarp forest to secondary forest, usually on hill slopes and ridges; soil: sandy clay to sandstone and shale. Altitude: 20–400 m. Flowering: April, May, August, September; fruiting: January, April, June, August to October.

**Uses** — Roots are boiled together with roots of *Psychotria* cf. *crassifolia* Miq. (*Rubiaceae*), mixture is drunk and known as the medicine 'Ubat sara'.

**Note** — This species, formerly united with *D. denticulatus*, is here reinstated. It only occurs locally in NW Borneo and differs from the typical *D. denticulatus*. Typical are the echinate fruits and the sepals that are only slightly hairy along the margin and generally show a round glandular thickening on every sepal lobe.

### 8. *Dimorphocalyx trichocarpus* (Airy Shaw) Welzen & Oostum, *comb. nov.* — Map 1

*Dimorphocalyx luzoniensis* Merr. var. *trichocarpus* Airy Shaw (1975) 96. — Type: *S (Anderson) 20974* (holo K; iso L), Malaysia, Sarawak, First Division, Bidi, Bau.

Trees, dbh to 12 cm; flowering branches 3–4.5 mm diam, yellowish when dry, slightly lenticellate. *Indumentum* of light yellow hairs. *Outer bark* grey, smooth. *Stipules* caducous, base at least 4.5 mm wide, slightly hairy outside, especially in the thicker centre, stiff. *Leaves*: petiole 25–36 mm long, 1.2–3 mm diam, deeply furrowed to flattened above, slightly pulvinate basally and apically, glabrous; blade slightly ovate to slightly obovate, widest in  $\pm$  middle, 22–33 by 9.4–14.3 cm, c. 2.3 times as long as wide, papyraceous, base rounded, margin laxly serrulate, with glands abaxially in the teeth, recurved, apex acuminate, venation flat to slightly sunken above, raised below, secondary veins 13–16 pairs, higher order nerves reticulate. *Staminate inflorescences* and *flowers* not seen. *Pistillate inflorescences* axillary, short, racemose, one flower developing into fruit; flattened to angular, hairy; most bracts broken, one leaf-like, c. 12 by 7 mm, others ovate, c. 6 by 4 mm, outside hairy, inside glabrous. *Young fruits* smooth, densely hairy, green; pedicel c. 24 mm long above abscission zone, hairy; sepals enlarging, unequal, 14–17.5 by 11–15 mm, glandless, outside and inside hairy; petals caducous; disc glabrous; style c. 1 mm long, densely hairy, stigmas c. 5 mm long, basal 1.5 mm not split, hairy beneath. *Seeds* not seen.

**Distribution** — Borneo (endemic in Sarawak).

**Habitat & Ecology** — At base of limestone hill on limestone rocks with intervening igneous derived soil. Altitude: c. 100 m. Fruiting: April.

**Note** — Only known from the type, which is very distinct by its very large leaves, rather long petioles, hairy, enlarging sepals, hairy fruits and glabrous discs. Because of its distinctiveness this taxon is raised to species level.

### DUBIOUS NAMES

*Dimorphocalyx angustifolius* (Merr.) Airy Shaw (1967) 412; (1983) 20. — *Ostodes angustifolia* Merr. (1912) 403; Pax & K. Hoffm. (1914) 414; Merr. (1923) 454. — Type: *FB (Whitford & Hutchinson) 9343* (?), Philippines, Mindanao, district of Zamboanga, Port Banga.

**Note** — Typical for this taxon are the very long, linear-lanceolate leaves (18–27 by 1–1.5 cm). Unfortunately, the type was probably lost during the Second World War and the original description also contains no indication of characters typical for *Dimorphocalyx*.

### EXCLUDED TAXA

*Dimorphocalyx* (?) *borneensis* Merr. (1916a) 73; (1921) 345. — *Trigonostemon merrillianus* Airy Shaw (1971) 549, non *Trigonostemon borneensis* Merr. — Type: *Hose 420* (iso A, K, L), Malaysia, Sarawak, Baram District, Entoyut River = *Trigonostemon polyanthus* Merr. var. *polyanthus* (see Milne 1995: 30; K has an isotype and not the holotype as stated by Milne).

*Dimorphocalyx capillipes* Hook.f. (1887) 404; Pax & K. Hoffm. (1911) 33; Ridl. (1924) 266. — Type: *Lobb s.n.* (holo K), Singapore = *Trigonostemon capillipes* (Hook.f.) Airy Shaw (1967: 412).

*Dimorphocalyx cumingii* (Müll.Arg.) Airy Shaw (1969) 124; (1983) 20. — *Trigonostemon cumingii* Müll.Arg. (1865) 213; (1866) 1107. — *Tritaxis cumingii* (Müll.Arg.) Benth. (1878)

221; Pax (1910) 114; Merr. (1923) 449. — Type: *Cuming* 1693 (holo P-DC, n.v.; iso K, 2 sheets, L, 2 sheets), Philippines, Samar = *Trigonostemon cumingii* Müll.Arg.

Note — Airy Shaw transferred this species to *Dimorphocalyx*. Typical – and atypical for *Dimorphocalyx* – are the very condensed and contracted inflorescences. These are perhaps still young and might grow into larger inflorescences as only buds are present. However, the staminate buds contain few stamens, which is far more typical for *Trigonostemon*.

*Dimorphocalyx longipes* Merr. (1906) 82; Pax & K.Hoffm. (1911) 33. — Syntypes: *FB (Borden) 1801* (NY, US), *FB (Whitford) 1066* (NY, P, US), Philippines, Luzon, Bataan Prov., Lamao; *Merrill 2699* (US), Philippines, Luzon, Prov. of Rizal, Bosoboso = *Trigonostemon longipes* (Merr.) Merr. (1916b: 191).

*Dimorphocalyx ovalis* Ridl. (1911) 178; Pax & K.Hoffm. (1914) 404. — Syntypes: *Curtis s.n.* (not seen), Malaysia, Lan(g) kawi, Kwah/Coah; *Ridley 14890* (not seen), Malaysia, Perlis, Bukit Telor Jambu, Kanga/Kanya = *Actephila ovalis* (Ridl.) Gage (1922: 219).

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## REFERENCES

- Airy Shaw HK. 1967. Notes on Malaysian and other Asiatic Euphorbiaceae. LXXIX. Realignment in the Ostodes-Dimorphocalyx complex. *Kew Bulletin* 20: 409–413.
- Airy Shaw HK. 1969. Malesian and other Asiatic Euphorbiaceae. *Kew Bulletin* 23: 1–131.
- Airy Shaw HK. 1971. Notes on Malesian and other Asiatic Euphorbiaceae. *Kew Bulletin* 25: 473–553.
- Airy Shaw HK. 1972a. The Euphorbiaceae of Siam. *Kew Bulletin* 26: 101–363.
- Airy Shaw HK. 1972b. Notes on Malesian and other Asiatic Euphorbiaceae. *Kew Bulletin* 27: 92–93.
- Airy Shaw HK. 1974. Notes on Malesian and other Asiatic Euphorbiaceae. *Kew Bulletin* 29: 281–331.
- Airy Shaw HK. 1975. The Euphorbiaceae of Borneo. *Kew Bulletin, Additional Series* 4: 1–245.
- Airy Shaw HK. 1980a. The Euphorbiaceae of New Guinea. *Kew Bulletin, Additional Series* 8: 1–243.
- Airy Shaw HK. 1980b. New or noteworthy Australian Euphorbiaceae – II. *Muelleria* 4: 207–241.
- Airy Shaw HK. 1980c. A partial synopsis of the Euphorbiaceae-Platylobeae of Australia (excluding *Phyllanthus*, *Euphorbia* and *Calycopeplus*). *Kew Bulletin* 35: 577–700.
- Airy Shaw HK. 1981. The Euphorbiaceae of Sumatra. *Kew Bulletin* 36: 239–374.
- Airy Shaw HK. 1982. The Euphorbiaceae of Central Malesia (Celebes, Moluccas, Lesser Sunda Is.). *Kew Bulletin* 37: 1–40.
- Airy Shaw HK. 1983. An alphabetical enumeration of the Euphorbiaceae of the Philippine Islands. Royal Botanical Gardens, Kew.
- Backer CA, Bakhuizen van den Brink Jr RC. 1963. *Flora of Java* 1: 441–505. Noordhoff, Groningen.
- Bentham G. 1878. Notes on Euphorbiaceae. *The Journal of the Linnean Society, Botany* 17: 185–267.
- Bentham G. 1880. CLI. Euphorbiaceae. In: Bentham G, Hooker JD (eds), *Genera Plantarum* 3: 239–340. Reeve & Co., London.
- Brandis D. 1906. *Indian trees*. Archibald Constable & Co. Ltd., London.
- Chakrabarty T, Balakrishnan NP. 1990. Genus *Dimorphocalyx* Thw. (Euphorbiaceae) in India. *Proceedings: Plant Sciences* 100: 285–299.
- Croizat L. 1942. On certain Euphorbiaceae from the tropical Far East. *Journal of the Arnold Arboretum* 23: 29–54.
- Elmer ADE. 1911. Euphorbiaceae collected on Palawan Island. *Leaflets of Philippine Botany* 4: 1271–1306.
- Elmer ADE. 1939. Miscellaneous new species. *Leaflets of Philippine Botany* 10: 3673–3738.
- Gage AT. 1922. Euphorbiaceae novae e Peninsula Malayana. *Records of the Botanical Survey of India* 9: 219–249.
- Gagnepain F. 1924. Euphorbiacées nouvelles (Blachia, Dimorphocalyx et Erismanthes). *Bulletin de la Société Botanique de France* 71: 619–623.
- Gagnepain F. 1925. Euphorbiaceae. In: Lecomte MH (ed), *Flore Générale de l'Indo-Chine* 5: 229–673. Masson & Cie., Paris.
- Hooker JD. 1887. *The Flora of British India* 5. Reeve & Co., London.
- Merrill ED. 1906. The forest of the Lamao Forest Reserve. *The Philippine Journal of Science* 1, C. Botany, Supplement: 1–139.
- Merrill ED. 1909. New or noteworthy Philippine plants, VII. *The Philippine Journal of Science* 4, Botany: 247–330.
- Merrill ED. 1910. New and noteworthy Philippine plants, VIII. *The Philippine Journal of Science* 5, Botany: 167–257.
- Merrill ED. 1912. Notes on Philippine Euphorbiaceae. *The Philippine Journal of Science* 7, Botany: 379–410.
- Merrill ED. 1916a. Notes on the Flora of Borneo. *The Philippine Journal of Science* 11, Botany: 49–100.
- Merrill ED. 1916b. New plants of Samar. *The Philippine Journal of Science* 11, Botany: 175–206.
- Merrill ED. 1921. A bibliographic enumeration of Bornean plants. *Journal of the Straits Branch of the Royal Asiatic Society, Special Number*.
- Merrill ED. 1923. An enumeration of Philippine flowering plants 2. Bureau of Printing, Manila.
- Merrill ED. 1925a. New species of Philippine plants collected by A. Loher. *The Philippine Journal of Science* 27: 21–59.
- Merrill ED. 1925b. An enumeration of Philippine flowering plants 4. Bureau of Printing, Manila.
- Merrill ED. 1929. *Plantae Elmerianae Borneenses*. University of California Press, Berkeley.
- Milne RI. 1995. Notes on Bornean and other West Malesian *Trigonostemon* (Euphorbiaceae). *Kew Bulletin* 50: 25–49.
- Moore S. 1920. A contribution to the Flora of Australia. *The Journal of the Linnean Society (Botany)* 45: 159–220.
- Müller Argoviensis J. 1865. Euphorbiaceae. *Linnaea* 34: 1–224.
- Müller Argoviensis J. 1866. Euphorbiaceae excl. Euphorbieae. In: De Candolle A (ed), *Prodromus Systematis Naturalis Regni Vegetabilis* 15, 2: 189–1260. Masson & Fili, Paris.
- Pax F. 1910. Euphorbiaceae-Jatropeae. In: Engler A (ed), *Das Pflanzenreich* IV.147.i. Engelmann, Leipzig.
- Pax F. 1911. Euphorbiaceae-Cluytieae. In: Engler A (ed), *Das Pflanzenreich* IV.147.iii. Engelmann, Leipzig.
- Pax F, Hoffmann K. 1912. Euphorbiaceae-Gelonieae. In: Engler A (ed), *Das Pflanzenreich* IV.147.iv. Engelmann, Leipzig.
- Pax F, Hoffmann K. 1914. Euphorbiaceae-Acalypheae-Mercurialinae. In: Engler A (ed), *Das Pflanzenreich* IV.147.vii. Engelmann, Leipzig.
- Pax F, Hoffmann K. 1931. Euphorbiaceae. In: Engler A, Harms H (eds), *Die natürlichen Pflanzenfamilien* ed. 2, 19c: 11–233. Engelmann, Leipzig.
- Phattarahirankanok K, Chayamarit K. 2005. *Dimorphocalyx*. In: Chayamarit K, Van Welzen PC (eds), Euphorbiaceae. In: Santisuk T, Larsen K (eds), *Flora of Thailand* 8, 1: 229–231. The Forest Herbarium, Bangkok.
- Philcox D. 1997. Euphorbiaceae. In: Dassanayake MD (ed), *A revised handbook to the Flora of Ceylon* 10: 80–283. Balkema, Rotterdam.
- Radcliffe-Smith A. 2001. *Genera Euphorbiacearum*. Royal Botanic Gardens, Kew.
- Ridley HN. 1911. An account of a botanical expedition to Lower Siam. *Journal of the Straits Branch of the Royal Asiatic Society* 59: 27–234.
- Ridley HN. 1924. *The Flora of the Malay Peninsula* 3. Reeve & Co., Ashford.
- Robinson CB. 1911. *Alabastra Philippinensia*, III. *The Philippine Journal of Science* 6, Botany: 319–358.
- Spanoghe JB. 1841. *Prodromus Florae Timorensis*. *Linnaea* 15: 314–350.
- Stern WL. 1967. Kleinodendron and xylem anatomy of Cluytieae (Euphorbiaceae). *American Journal of Botany* 54: 663–676.
- Thwaites GHK. 1861. *Enumeratio Plantarum Zeylanicae* 4. Dulau & Co., London.
- Trimen H. 1898. *A hand-book to the flora of Ceylon* 4. Dulau & Co., London.
- Webster GL. 1994. Synopsis of the genera and suprageneric taxa of Euphorbiaceae. *Annals of the Missouri Botanical Garden* 81: 33–144.
- Webster GL. 2014. Euphorbiaceae. In: Kubitzki K (ed), *The families and genera of vascular plants* 11: 51–216. Springer, Heidelberg, New York, Dordrecht, London.
- White CT. 1936. Contributions to the Queensland Flora, no. 5. *Proceedings of the Royal Society of Queensland* 47: 51–84.
- Whitmore TC. 1973. *Tree Flora of Malaya* 2: 34–136. Longman, London.
- Wurdack KJ, Hoffmann P, Chase MW. 2009. Molecular phylogenetic analysis of uniovulate Euphorbiaceae (Euphorbiaceae sensu stricto) using plastid rbcL and trnL-F DNA sequences. *American Journal of Botany* 92: 1397–1420.

## IDENTIFICATION LIST

Specimens with a collector name and number can be identified by the following numbers after the semicolons:

1 = *Dimorphocalyx australiensis*  
2 = *Dimorphocalyx denticulatus*

3 = *Dimorphocalyx ixoroides*  
4 = *Dimorphocalyx malayanus*

5 = *Dimorphocalyx moluccensis*  
6 = *Dimorphocalyx muricatus*

7 = *Dimorphocalyx pauciflorus*  
8 = *Dimorphocalyx trichocarpus*

Achmad 727: 6; 1666: 6 – Ambriansyah & Arbainsyah Berau 593A: 6 – Ambriansyah & Arifin AA 6: 6; AA 11: 2; AA 273: 6; W 856: 6.  
Beccari PB 2214: 4; PB 2215: 4 – Brass 2019: 1; 8093: 1; 8237: 1; 18390: 1 – BRUN series 3051: 6; 15204: 6 – BS series 13901: 3; 20799: 4; 21176: 3; 24463: 4; 29134: 4; 34109: 3; 36920: 2; 36927: 2; 45402: 3; 45530: 3; 46866: 3; 47215: 3; 77649: 2; 77774: 2; 78452: 3; 78578: 3.  
Champion 570: 1 – Chew 679: 6 – Church, Mahyar & Afriastini 1819: 2; 1881: 2 – Clarkson 6101A: 1 – Coode & Fernando 5266: 4 – Curtis 806: 4; 811: 6; 1518: 4.  
De Jong 498: 2 – De Vogel 1737: 6; 1846: 6; 1850: 6; 3134: 5 – De Wilde & De Wilde-Duyfjes 20631: 6 – Dransfield 6855: 6.  
Elbert 3937: 1; 12773: 2; 12844: 2; 13156: 2; 17296: 4; 21287: 6 – Escritor 1260: 4.  
FB series 9033: 2; 11907: 4; 13426: 3; 20121: 4; 24867: 4; 25118: 4; 30725: 4; 30736: 4; 30760: 4 – Forman 906: 7 – Forster & Tucker 10487: 1.  
Gray 7859: 1 – Griffith KD 4785: 4.  
Hallier 2908: 2 – Hansen 600: 2; 1024: 6 – Hose 244: 7 – Hotta 12996: cf. 6 – Hyland 2550: 1; 2920: 1; 10218: 1; 12044: 1.  
Jacobs 5200: 6; 5270: 6 – Jaheri 474: 2 – Jessup 635: 1 – Johns 7473: 2.  
KEP series 77751: 6; 98254: 6; P 110220: 6 – KEP FRI series 5267: 6; 7820: 6; 7926: 6; 37335: 6 – King's collector 1349: 6; 1415: 4; 3162: 6; 6612: 6.  
LaFrankie 7084: 6; 7184: 7 – Larsen et al. 45588: 6 – Latupeirissa 94416: 6 – Laumonier 6557: 2 – Lobb 304: 6.  
Maidin 4572: 2; 4573: 2 – Maxwell 85-285: 4 – Mogeia & de Wilde 4247: 2; 4428: 2.  
Nangkat 180: 6 – NGF series 46605: 1.

Perumal & LaFrankie 78: 2; 715: 6 – Phusomsaeng 405: 6 – PNH series 9525: 4; 14151: 2; 23057: 2; 23059: 2; 33359: 4; 41828: 3; 42456: 4; 80814: 2; 91442: 2; 91544: 2 – Pooma et al. 4499: 6 – PPI series 22281: 4; 22473: 4; 22511: 4; 24613: 4 – Puasa & Enggoh 10684: 2.  
Rahmat si Boeea 9431: 6; 9567: 6; 9872: 6 – Ramlanto 905: 5 – Ramos 1936: 3 – Regalado Jr & Katik 1122: 1.  
S series 3361: 7; 3472: 6; 14376: 7; 14733: cf. 6; 20974: 8; 22422: 2; 22904: 2; 22952: 2; 23391: 2; 23666: 2; 25497: 7; 27057: 6; 29051: 6; 29250: 2; 29614: 6; 33320: 7; 36571: 7; 36685: 4; 37693: 7; 37966: 7; 41831: 4; 43126: 7; 43503: 6; 46433: 7; 46445: 2; 50156: 2; 50176: 2; 53721: 6; 66587: 6; 68752: 6 – Saakov 174: 1 – SAN series 16327: 6; 16850: 2; 19498: 6; 21381: 6; 21646: 2; 24516: 6; 24518: 6; 24582: 2; 26988: 2; 27300: 2; 28645: 2; 32534: 6; 34999: 2; 36904: 2; 36926: 2; 37547: 6; 38211: 2; 39166: 2; 57447: 2; 65482: 6; 75220: 2; 81767: 2; 84162: 2; 93822: 2; 96069: 6; 96179: 6; 96194: 2; 96709: 2; 97099: 6; 97623: 6; 97692: 2; 99910: 6; 108896: 6; 112328: 6; 120502: 2; 129662: 6; 130729: 6; 131112: 2; 133913: 6; 134610: 2; 136975: 6; 141190: 2 – B. Sangkhachand 152: 4 – P. Sangkhachand 1257: 6; 1275: 6; 1297: 6 – Schmutz 539: 1; 1892: 1; 4011: 1; 4120: 1 – SFN series 35333: 6; 37218: 4; 37219: 4; 37247: 2; 37248: 2 – Sidek bin Kiah 241: 4; 258: 6 – Sidisunthorn & Tippayasri ST 1640: 4 – Sidiyasa 497: 2; 686: 6; PBU 618: 6 – Slik IT73-3503: 6 – L.S. Smith 14357: 1 – Soejarto 16: 1 – Soejarto, Fernando & Majaducon 9222: 2 – Stocker 818: 1; 1178: 1.  
Teijsmann HB 10752: 1; HB 10756: 1.  
Van der Werff et al. 17417: 6.  
Wilkie & Latupeirissa 94343: 6.  
Zainudin 4605: 2.