Disentangling a complex genus: systematics, biogeography and bioactivity of the genus Phyllanthus L. and related genera of tribe Phyllantheae (Phyllanthaceae)

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CHAPTER 5

LECTOTYPIFICATION AND AMENDED DESCRIPTION OF PHYLLANTHUS (PHYLLANTHACEAE) SPECIES DESCRIBED BY KOORDERS FROM SULAWESI, INDONESIA

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Chapter 5

LECTOTYPIFICATION AND AMENDED DESCRIPTION OF PHYLLANTHUS (PHYLLANTHACEAE) SPECIES DESCRIBED BY KOORDERS FROM SULAWESI, INDONESIA

Short title: On *Phyllanthus* (Phyllanthaceae) from Sulawesi

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ABSTRACT
Two species of *Phyllanthus* collected and described by Koorders during his travels on the island of Sulawesi (Indonesia) are lectotypified, descriptions amended and their taxonomic affinity is discussed. *Phyllanthus mindorensis* was found to be too similar to *P. celebicus* and is placed in the synonymy of the latter. A key is provided to the species of *Phyllanthus* on Sulawesi.

Keywords: Celebes, *Eriococcus*, Koorders, Euphorbiaceae s.l., Phyllantheae, *Phyllanthus*, Sulawesi, Taxonomy

Introduction
The flora of Sulawesi represents an interesting biodiversity hotspot that borders several biogeographical zones, with the Sunda shelf to the west, the Sahul shelf to the east and the Philippines to the north (Stelbrink et al. 2012). It is the largest island of Wallacea, a biogeographic region that also includes the Moluccas, the Lesser Sunda Islands (Dickerson 1928), and botanically usually also the Philippines (van Welzen et al. 2011). While this island has become better explored recently, the flora remains understudied and many taxa did not receive any taxonomic treatment for some time. The enumeration of Euphorbiaceae for Central Malesia by Airy Shaw (1982) lists ten species of *Phyllanthus* L. for Sulawesi (table 1), but this was only based on a limited number of collections. Airy Shaw (1982) made no redescription of the species and did not treat the Wallacean islands extensively like he did for Borneo (Airy Shaw 1975) and Papua New Guinea (Airy Shaw 1980). Several species are probably still undiscovered and it is important that an adequate comparison can be made between those previously described from the island. Koorders (1898) reported two new species of *Phylllanthus* (*P. celebicus* Koord. and *P. minahassae* Koord.) in his travel account of the island, but only included a brief description of their habit with no mention of flower morphology. During the preparations for

Table 5-1. Species of *Phyllanthus* in Sulawesi, compiled from Robinson (1909), Airy Shaw (1982) and supplemented by records from the L herbarium. Species are listed by subgenus following Bouman et al. (2018). *Phyllanthus mindorensis* was listed by Airy Shaw (1982) and is treated here as synonym.

Subgenus	**Species**
Eriococcus (Hassk.) Croizat & Metcalf	*Phyllanthus buxifolius* (Blume) Müll.Arg.
	Phyllanthus celebicus Koord.
	Phyllanthus lamprophyllus Müll.Arg.
	Phyllanthus minahassae Koord.
	Phyllanthus trichosporus Adelb.
Macraea (Wight) Jean F.Brunel	*Phyllanthus lancifolius* Merr.
	Phyllanthus samarensis Müll.Arg.
	Phyllanthus virgatus G.Forst.
Gomphidium (Baill.) G.L.Webster	*Phyllanthus tenuirhachis* J.J.Sm.
Kirganelia (A.Juss.) Kurz	*Phyllanthus reticulatus* Poir.
Emblica (Gaertn.) Kurz	*Phyllanthus urinaria* L.
Swartziani (G.L.Webster) Ralim. & Petra Hoffm.	*Phyllanthus amarus* Schumach. & Thonn.
Afroswartziani Ralim. & Petra Hoffm.	*Phyllanthus debilis* Klein ex. Willd.

a new classification of the genus *Phyllanthus* several taxonomic problems were identified, often concerning rare species (Bouman et al. 2018). This included the species of Koorders (1898), which could not yet be placed in any subgeneric group of *Phyllanthus* (Bouman et al. 2018).

During a recent visit to the Herbarium Bogoriense (BO) on Java by the first author, the types of the Koorders' species could be studied. Here, we place these species in *Phyllanthus* subgenus *Eriococcus* (Hassk.) Croizat & Metcalf section *Eriococcus* and expand the descriptions of both species. Affinities to, and differences with, other species are discussed and a provisional key to the known *Phyllanthus* species of Sulawesi is provided.

Taxonomic treatment

Both species discussed here are placed in *Phyllanthus* subgenus *Eriococcus* section *Eriococcus* based on the morphology of the staminate flowers. The staminate flowers in both species consist of four sepals in a cross shape with fimbriate margins, four disc glands and two connate stamens with horizontally dehiscing anthers. This is consistent with *Phyllanthus* subgenus *Eriococcus* section *Eriococcus* (see Müller 1866) and both species are classified here in this taxon. Subgenus *Eriococcus* section

Emblicastrum Müll.Arg., which is represented by *P. lamprophyllus* Müll.Arg. on Sulawesi, differs in the usually upright orientated sepals with entire margins, thicker leaves and the presence of a tubular style. No species of section *Eriococcus* is endemic to Papua New Guinea (Bouman et al. 2018) and the closest affinity of both species are similar *Phyllanthus* species of the Philippines. Roughly ten species of section *Eriococcus* occur on the Philippines and they are very similar in staminate flower and leaf morphology. Unfortunately many of these have been rarely collected. Differences for identification with the Philippine species are discussed below in the notes under the species, but they undoubtedly represent the closest relation to the species of Sulawesi within subgenus *Eriocccus*. A provisional key for *Phyllanthus* in Sulawesi is provided. Information for the key was derived from herbarium specimens, Luo et al. (2011a), Robinson (1909) and Verwijs et al. (2019). All acronyms for herbaria follow Thiers (2019, continuously updated).

Key to the *Phyllanthus* species of Sulawesi

1. Branching non-phyllanthoid (laminate leaves on main axes present, lateral branches subtended by leaves and not deciduous); stamens 3, filaments free; fruits capsules — subgenus *Macraea* 2
1. Branching phyllanthoid (leaves on main axes reduced to cataphylls, lateral branchlets bear laminate leaves and are deciduous); stamens 2, 3 or 5; filaments free or connate (or in whorls); fruits capsules or berries 4

2. Prostrate or erect herbs or subshrubs, up to 1 m high, axes glabrous; pistillate pedicel 3–9 mm long ..... *P. virgatus*
2. Erect shrubs to trees, up to 2 m high, axes mostly pubescent; pistillate pedicel 8–50 mm long 3

3. Leaf blades mostly ovate-elliptic, 9–79 mm long, apex acuminate; staminate sepals 1.1–1.4 × 0.5-0.8 mm; pistillate pedicel 8–50 mm long..... *P. lancifolius*
3. Leaf blades elliptic, 7–24 mm long, apex acute to obtuse or rounded to retuse; staminate sepals 1.2–1.6 × 0.6–0.8 mm; pistillate pedicel 8–10 mm long..... *P. samarensis*

4. Herbs (or only woody at the base) 5
4. Shrubs to trees 7

5. Pistillate inflorescences at basal part of lateral branchlets; ovary warted; seeds with transverse ridges— subgenus *Emblica* ..... *P. urinaria*
5. Pistillate inflorescences at distal part of lateral branchlets; ovary smooth; seeds smooth or with longitudinal striae 6

6. Leaf blades oblong, apex rounded, upper side green; inflorescences mostly

bisexual; staminate flowers with 5 sepals— subgenus *Swartziani* .....*P. amarus*

6. Leaf blades ovate, apex acute, upper side dark green; inflorescences unisexual; staminate flowers with 6 sepals— subgenus *Afroswartziani* .....*P. debilis*

7. Staminate flowers with 5 sepals, stamens 5, fused in 2 whorls; stigmas entire; fruits berries— subgenus *Kirganelia*.....*P. reticulatus*

7. Staminate flowers with 4 or 6 sepals, stamens 2 or 3, filaments free or connate in one whorl; stigmas bifid or entire (not seen in *P. minahassae*); fruits capsules.....8

8. Leaves usually symmetric, blade elongated eliptic-ovate, longer than 5 cm; sepals 6 in both flowers of both sexes; stamens 3, filaments free, anthers dehiscing vertically — subgenus *Gomphidium* .....*P. tenuirhachis*

8. Leaves usually basally asymmetric, blade elliptic or ovate; shorter than 4.5 cm; sepals in staminate flowers 4, pistillate flowers with 5 or 6 sepals; stamens 2, filaments connate, anthers dehiscing horizontally— subgenus *Eriococcus*.9

9. Leaves coriaceous; staminate sepals erect, tubular, margins entire 10

9. Leaves membranous to slightly coriaceous; staminate sepals spreading, margins fimbriate, dentate or laciniate..... 11

10. Leaf blades up to 4 cm long; filaments of stamens thickened at apex; ovary 4–8-locular; style absent, stigma almost entire with only a bilobed fold at apex .....*P. buxifolius*

10. Leaf blades up to 1.2 cm long; filaments of stamens slender; ovary 3-locular; style present, tube of c. 2.2 mm, stigmas entire.....*P. lamprophyllus*

11. Branchlets 8–10 cm long, glabrous; capsules glabrous, smooth; seeds c. 1.8 mm high .....*P. trichosporus*

11. Branchlets 17–40 cm long, pubescent; capsules verrucate or smooth and puberulous; seeds c. 2–4.8 mm high..... 12

12. Leaf blades shorter than 22 mm; sepals red to brown; pistillate sepals not enlarged in fruit, shorter than 4 mm; fruit pedicel up to 3.5 cm long.....1. *P. celebicus*

12. Leaf blades longer than 25 mm; sepals pale green; pistillate sepals enlarged in fruit, up to 16 mm long; fruit pedicel 3–4 cm long.....2. *P. minahassae*

Note

Phyllanthus subgenus *Kirganelia* is represented by *P. reticulatus* Poir. on Sulawesi, though there is some discussion on how to differentiate it from *P. microcarpus* (Benth.) Müll.Arg. In the flora of Thailand (Chantaranothai 2007), they are distinguished based on the presence or absence of indumentum while Luo et al.

(2011a) distinguish them based on habit and floral characters. Specimens from Sulawesi seen for this study were characterized by emergent styles and sometimes bisexual inflorescences while there were both pubescent and glabrous forms present. This conforms to the definition Luo et al. (2011a) for *P. reticulatus* and it is treated as such here.

Species descriptions of *P. celebicus* and *P. minahassae*

1. Phyllanthus celebicus Koord.,
Phyllanthus celebicus Koord., Meded. Lands Plantentuin 19: 588, 627 (Koorders 1898). —
Lectotype (designated here): Indonesia, Sulawesi, Minahasa province (Menado), near Pinomorongan, near Kajoewatoe, *H.S. Koorders 16949* (fieldnumber 1917) (lecto BO (BO129623); isolecto L (L.2246433, L.2246434).
Phyllanthus mindorensis C.B.Rob., Philipp. J. Sci., C 4: 82 (Robinson 1909). — Type: *L.M. Merritt 5370* (not traced); paratype: Philippines, Mindoro, *L.M. Merritt 8789* (K (K001056684)); paratype *L.M. Merritt 8606* (not traced). **Syn. nov.**

Shrubs, 0.5–1 m high, monoecious, all axes puberulent to pubescent with dark brown short stiff hairs; branching phyllanthoid; branchlets terete, 17–26 cm long, bearing 32–56 leaves, internodes 2–3 mm long. *Cataphyllary stipules* triangular, c. 1.5 × 2 mm, membranous, caducous, base plane, tending to fuse with cataphyll, margin entire, apex acute. *Cataphylls* triangular, 1–1.5 × c. 1 mm, membranous, caducous, margin entire, apex acute. *Stipules* triangular, c. 1 × 0.5 mm, caducous, membranous, base plane, margin brittle, apex acute. *Leaves* distichous; sessile to petiole 0.5–1 mm long, glabrous; blade elliptic, asymmetric, 10–21 × 5–7.5 mm, 2–3.2 times longer than wide, membranous to slightly coriaceous, base cuneate, margin slightly thickened and slightly revolute, apex rounded, mucronate, mucro 0.1–0.2 mm long, glabrous except for some hairs on basal part of lower side, upper side darker green; venation pinnate, midrib prominent, flat on both sides, lateral veins 4–6 per side, indistinct. *Inflorescences* axillary fascicles, usually unisexual and originating from small brachyblasts, up to 4 staminate flowers together near basal part of branchlets, pistillate flowers solitary on distal part of branchlets. *Staminate flowers* c. 1.1 mm in diameter closed, 2.2–3.5 mm when open; pedicel 4.5–5 mm long, terete, glabrous, thin; sepals 4, ovate, 1–1.5 × 0.8–1.1 mm, spreading, red-brown, margin dentate to laciniate, apex acute, midrib indistinct; disc glands 4, alternating with sepals, obovate, 0.2–0.3 × 0.3–0.6 mm, indented from thecae; stamens 2, 0.4–0.5 mm long, filaments and connectives connate, filaments c. 0.2 mm high, anthers slightly stipitate resulting in cross-shaped connective, apically extended for c. 0.1 mm, thecae oblong, c. 0.3 × 0.2 mm, hanging above disc gland, dehiscing horizontally via slits. *Pistillate flowers*: pedicel c. 16 mm long, terete, pubescent, thin; sepals 5, ovate, c. 1.5 x 1.1 mm, red-brown, margin fimbriate to

laciniate, apex acute, midrib indistinct; disc annular, strongly star-shaped, c. 0.8 mm in diameter at shortest point, with large oblong lobes alternating with sepals, lobes 0.3–0.7 mm long and c. 0.2 mm wide, slightly thickened at the end; ovary globose, c. 1.3 mm wide, c. 1.1 mm high, puberulous; style absent; stigmas 3, bifid for entire length, c. 0.2 mm long, curved upwards. *Fruits* capsules, only dehisced remains left; pedicel terete, 1.8–3.5 cm long, greenish, puberulous, rarely glabrous, smooth; sepals not enlarged in fruit, columella triangular, c. 1.2 mm long. *Seeds* trigonous, c. 2 × 1 mm, covered with transverse striae that break up epidermis, striae radiating from hilum.

Distribution. Philippines (Luzon, Mindoro) and Sulawesi (Tenga, Utara, Minahassa, Pangkadyeu).

Habitat. This species was collected from fertile turf and dry riverbeds, but it is known only from few specimens in Sulawesi. In the Philippines it was collected also from coastal areas. Altitude: 10-600 m a.s.l. This species was found with flowers and fruits in February till June, but more specimens could expand on this as we saw now collections from later in the year than June.

Etymology. This species is named after the area where it was found as Celebes is the name formerly used for Sulawesi.

Notes

The collection *Koorders 16949* stored at Bogor herbarium (BO) is selected as lectotype, while additional specimens are stored in the Naturalis Biodiversity Center (L). The material at Bogor bears Koorders' handwriting and notes on comparisons with other species, making it likely that it was used in the first description by him (Koorders 1898). *Phyllanthus celebicus* agrees in almost all characters with *P. mindorensis* C.B.Rob., which was first described for the Philippines (Robinson 1909) and its distribution was expanded by Airy Shaw (1982) to include Sulawesi. Airy Shaw noted on material of *P. celebicus* that it was very similar to *P. mindorensis* and differences between the Koorders specimens and the description by Robinson (1909) only include minor qualitative differences. Pistillate flowers were dissected from specimens from the Philippines and Sulawesi previously assigned to *P. mindorensis* and these were found to have similarly lobed discs, but with slightly shorter lobes (c. 0.3 vs 0.6–0.7 mm). Taking into account the similarities in vegetative and floral characters and the variation shown by specimens from Sulawesi, we decided to synonymize *P. mindorensis* with *P. celebicus*.

Specimens examined. Indonesia, Sulawesi *W.H. de Vries s.n.* (L). Indonesia, Sulawesi, Minahassa, Manembo-Nembo *A.H.G. Alston 16549* (L). Indonesia, Sulawesi, Road Palu - Donggala, near Loli *M.M.J. van Balgooy 2976* (BO, L).

Indonesia, Sulawesi, Minahasa province (Menado), near Pinomorongan, near Kajoewatoe, *H.S. Koorders 16949* (BO, L). Indonesia, Sulawesi, Tengah, Palu *G.J. de Joncheere 1024* (L). Indonesia, Sulawesi, Utara, Tondano *E.A.Forsten* (L). Philippines, Luzon, Batangas prov., Mt. Lobo, *PNH (M.D. Sulit)15718* (L). Philippines, Luzon, Mt Arayat, *FB (H.M. Curran) 19333* (L). Philippines, Mindoro, Mt. Yagaw, *PNH* (*H.C. Conklin) 18674* (L). Philippines, Rizal Prov., *BS (M. Ramos) 731* (L). Philippines, Luzon, *BS (M. Ramos) 8194* (L).

2. *Phyllanthus minahassae* Koord.
Phyllanthus minahassae Koord., Meded. Lands Plantentuin 19: 588, 627 (Koorders 1898). — Lectotype (designated here): Indonesia, Sulawesi, Minahasa province, near camp Totok, Rata Totok, *S.H.Koorders 16954* (fieldnumber 2595) (lecto BO (BO1310079); isolecto L (L.2059450).

Shrubs, 1–2 m high, monoecious?, all axes pubescent with dark brown short stiff hairs; branching phyllanthoid; branchlets terete, 20–40 cm long, bearing 30–52 leaves, internodes 2–3 mm long. *Cataphyllary stipules* and *cataphylls* caducous, not seen. *Stipules* triangular, c. 1.5 × 0.3 mm, persistent, membranous, pubescent, base plane, margin brittle, apex acute. *Leaves* distichous; petiole c. 1.8 mm long, pubescent; blade elliptic, asymmetric, 2.6–4.1 × 1–1.7 cm, 2.4–3.4 times longer than wide, membranous to slightly coriaceous, pubescent, base cuneate, margin slightly thickened and flat, pubescent, apex acute-rounded to obtuse, mucronate, mucro 0.1–0.2 mm long, puberulous at base on lower side, glabrous on upper side, upper side darker green than lower side; venation pinnate, midrib flat on either side, lateral veins 4–6, indistinct. *Inflorescences* axillary fascicles, usually unisexual, staminate flowers up to 6 together, at basal part of branchlets, pistillate flowers solitary on distal part of branchlets. *Staminate flowers* c. 1.5 mm in diameter when closed, 3.3–4 mm when open; pedicel 1.3–4 mm long, terete, pubescent, thin; sepals 4, ovate, 1.5–1.6 × c. 1 mm, spreading, outside covered in short hairs, pale green, margin fimbriate and brittle, apex acute to attenuate, midrib indistinct; disc glands 4, alternating with sepals, oblong, 0.2–0.4 × 0.4–0.6 mm, indented from thecae; stamens 2, c. 0.4–0.5 mm high, filaments and connectives connate, staminal column c. 0.2 mm high, anthers slightly stipitate resulting in cross shaped connective, apically extended for 0.1–0.2 mm, thecae oblong, c. 0.3 × 0.2 mm, hanging above disc gland, dehiscing horizontally via slits. *Pistillate flowers* not seen, information derived from fruit; sepals 6, elliptic, enlarged (only in fruit?) to 14–16 × 5–6 mm, outside covered in short hairs, pale green, margin entire, pubescent, apex acute to obtuse, midrib indistinct; disc, ovary and stigmas not seen. *Fruits* capsules (already dehisced, only fragments on type), estimated at c. 6 mm in diameter and c. 6 mm high, minutely verrucate; pedicel terete, 3–4 cm long, puberulous; columella triangular, 4.8–6 mm long. *Seeds* trigonous, 4.2–4.8 × c. 2.2 mm, covered with transverse striae that break up epidermis, striae radiating from hilum.

Distribution. Known from two collections by Koorders from the same area in Sulawesi, Minahassa province.

Habitat. The label information of the type showed it to be common in forests on fertile vulcanic sand. It was found at c. 200 m a.s.l. Flowering and fruiting is in March, but this is only based on the type specimen and one additional collection around the same time.

Etymology. Named after the province where it was found on Sulawesi.

Notes. The lectotype is here selected from two collections by Koorders, both bear his handwriting, but only the specimen designated here as lectotype possesses remains of fruits and seeds. The staminate flowers were described from the other collection (*Koorders 16954*; BO1310078), but this specimen is in poorer condition, has less information on the label and has only dehisced fruits without seeds. *Phyllanthus minahassae* is probably closely related to *P. celebicus*, but it has larger leaves and very distinct pistillate sepals (at least in fruit). Large pistillate sepals are also found in the Indian species, *P. macrocalyx* Müll.Arg. (also subgenus *Eriococcus*) and some species of subgenus *Gomphidium* (Baill.) G.L.Webster (Schmid 1991), but there they actually enclose the fruit in development (Naveen Kumar et al. 2015).

Specimens examined. Indonesia, Sulawesi, Minahasa province, near camp Totok, Rata Totok *H.S. Koorders 16924* (fieldnumber 2430) (BO, L). Indonesia, Sulawesi, Minahasa province, near camp Totok, Rata Totok *S.H.Koorders 16954* (fieldnumber 2595) (BO, L).

Discussion

With the rather brief description of *P. celebicus* and *P. minahassae* by Koorders (1898), these two species could not be confidently assigned to any subgroup within *Phyllanthus*. By examining material collected by Koorders including his notes on the labels, we were able to place both species in subgenus *Eriococcus*. This subgenus is distributed in Asia (and one species in Australia) and its 4-merous staminate flower is a consistent character that can be used to identify them (Bouman et al. 2018). However, while the staminate flower offers more information on subgeneric placement, the pistillate flower is often more useful for species identification as found here for *P. celebicus* and *P. minahassae*. Subgenus *Eriococcus* is mainly known from mainland Asia (see Bouman et al. 2018), but only includes few species from Western Malesia (e.g. *P. acutissimus* Miq., *P. kinabaluicus* Airy Shaw, *P. singalensis* (Miq.) Müll.Arg.), which often have symmetric leaves (pers. obs.). Therefore, the species treated here are most likely closely related to other species from the Philippines, which also have asymmetric leaves that appear quite similar. Some

species from the Philippines and Sulawesi of section *Eriococcus* seem to form a complex, all with usually pubescent axes, strongly asymmetric leaves and usually red flowers with fimbriate sepals (some exceptions occur). Other species that form this complex, aside from those already mentioned, include *P. laciniatus* C.B.Rob., *P. leytensis* Elmer, *P. sibuyanensis* Elmer, and perhaps *P. blancoanus* Müll.Arg. (see Robinson 1909). A thorough revision or phylogenetic study with sampling of these taxa might help to improve some of the species delimitations. This group of species could lend support to the inclusion of the Philippines in Wallacea (see van Welzen et al. 2011). While not many species of *Phyllanthus* occur on Sulawesi, the two species treated here already highlight the interesting flora found on the island and the need to study it further.

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