

A REVISION OF *TRIADICA* LOUR. (EUPHORBIACEAE)

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Abstract. A revision of the Asian genus *Triadica* is presented, with three species accepted, *T. cochinchinensis*, *T. sebifera*, and *T. rotundifolia*. For the latter species a new combination is proposed. One new synonym is included, as well as a key to and complete synonymy of all taxa, and a note on the validity of the name *Croton macrocarpus*.

Keywords: Euphorbiaceae, Hippomaneae, *Sapium*, taxonomy, *Triadica*.

Triadica Lour. is a small genus of Euphorbiaceae, subfamily Euphorbioideae, tribe Hippomaneae, and is endemic to E. and SE. Asia. It was described by Loureiro (1790). Because the flowers are similar to those of several other genera of the tribe, various authors united *Triadica* as a distinct section with other genera of the Hippomaneae, such as *Stillingia* Garden ex L. (Baillon, 1858), *Excoecaria* L. (Müller, 1866), or *Sapium* Jacq. (Pax and Hoffmann, 1912). The species are still often treated under *Sapium*, although Webster (1994) expressed serious doubts about the identity of both. This history was reviewed in more detail by Esser (1999).

The genus is, however, well circumscribed and very probably monophyletic (Kruijt, 1996; Esser et al., 1998). Therefore, it was accepted as a distinct genus in recent years (Hurusawa, 1954; Esser, 1994, 1999, 2001; Kruijt, 1996; Govaerts et al., 2000).

Important diagnostic (and very probably apomorphic) characters are leaves with adaxial glands on the petiole apex and with the lowermost lateral veins forming the basal margin of the blade, and fruits with an early caducous pericarp, exposing seeds with a whitish sarcotesta. Additionally, the petioles are unusually long within Hippomaneae (Esser et al., 1998).

The variation patterns within *Triadica* are quite unusual. Whereas flowers and fruits show only minor morphological variation between species, the species are separated largely by characters of the leaves: shape, apex, and glands.

The whitish sarcotesta is unique in Euphorbiaceae. It yields oils and waxes in *T. sebifera* (L.) Small, which are used for a wide range of purposes and make this species an

important economic crop species in East Asia ("Chinese Tallow Tree"). The sarcotesta of the other species is thinner and less rich in palmitic acid; these species are therefore economically not important.

Triadica was always accepted as either a genus or section. The opinions about limits and species concepts however changed through time. Therefore the number of included species ranged from one (Hurusawa, 1954; Kruijt, 1996), two (Loureiro, 1790; Baillon, 1858; Govaerts et al., 2000, but including several new synonyms) to six (Pax and Hoffmann, 1912; Tseng, 1997). The present study follows largely the opinions of Govaerts et al. (2000), with a third species added, for which a new combination is proposed. Some species are now considered as synonyms, but two species included by former authors are accepted in separate genera (Esser, 1999; Govaerts et al., 2000): *Stillingia japonica* Siebold & Zucc. (now in *Neoshirakia* Esser), and *Sapium baccatum* Roxb. (now in *Balakata* Esser).

Illustrations and distribution maps of all species are already available in previous publications (cited under the relevant species below).

TRIADICA

Triadica Lour., Fl. Cochinch. ed. 1, 2: 598, 610. 1790. *Stillingia* sect. *Triadica* (Lour.) Baill., Étude Euphorb.: 511. 1858. *Sapium* sect. *Triadica* (Lour.) Müll. Arg., Linnaea 32: 121. 1863. *Excoecaria* sect. *Triadica* (Lour.) Müll. Arg. in DC., Prodr. 15(2): 1210. 1866. TYPE: *Triadica sinensis* Lour. [= *Triadica sebifera* (L.) Small], lectotype designated by Webster (1994).

Stillingfleetia Bojer, Hortus Maurit.: 284. 1837, nomen.

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Seborium Raf., Sylva Tellur.: 63. 1838.

TYPE: *Seborium chinense* Raf. [= *Triadica sebifera* (L.) Small].

Trees or shrubs, with white latex. Monoecious. Glabrous. Stipules ovate-triangular, 0.5–2 mm long, eglandular. Leaves alternate; petioles 1–7 cm long, glandular on the adaxial apex; blade simple, orbiculate, ovate or elliptic, margin entire, eglandular at base (the petiolar glands sometimes on the adaxial junction with the blade), abaxially often with few submarginal glands, papillate-glaucous abaxially; lateral veins eucamptodromous, the lowermost pair different and forming the basalmost part of the blade margin, veinlets reticulate. Inflorescences terminal or in few terminal leaf axils, not compound, yellowish-green, elongate; floral bracts 1–2 mm long, with a distinct pair of spheroidal-cylindrical glands; pistillate flowers at base, one per bract; staminate flowers numerous in apical part, (3–)5–8 per bract; bracteoles present, similar to bracts. Pistillate flowers with a short but

distinct pedicel 2–10 mm long; sepals 3, fused at base, sometimes divided and then appearingly more; disc and staminodes absent; ovary with 3 carpels, smooth; style present; stigmas 3, undivided, eglandular. Staminate flowers with distinct pedicel 1–3 mm long; sepals 3, nearly completely fused; stamens 2 or 3, the filaments short but distinct; disc or pistillode absent. Fruits with a short but distinct pedicel; schizocarp nearly circular in outline, 3-seeded, slightly to not sulcate, smooth, dry and woody, splitting along the septa and soon after loculicidally; the septa remaining at the central columella to a large part, the remaining columella triquetrous, apically distinctly alate. Seeds often remaining attached to the central columella after dehiscence of the fruits, with a whitish or greyish sarcotesta, without caruncle or aril.

A genus of three species, distributed from India to China, Celebes and the Philippines. Published illustrations are summarized in Esser (2001).

KEY TO THE SPECIES OF *TRIADICA*

- 1a. Leaves orbicular [index 0.9–1.1(–1.3)], with the base cordate to rounded (very rarely obtuse) and the apex emarginate to mucronate; adaxial petiole apex with a single gland *T. rotundifolia*
 1b. Leaves ovate to elliptic [index (0.8–)1.1–2.6], with the base cuneate to obtuse (very rarely rounded to cordate) and the apex acute to acuminate; adaxial petiole apex with a pair of glands 2
 2a. Leaves broad [index 0.8–1.4(–1.7)], apex distinctly acuminate; fruits 11–13 mm long;
 seeds 6–9 mm long, sarcotesta whitish, distinct *T. sebifera*
 2b. Leaves narrow (index 1.5–2.6), apex acute to subacuminate; fruits 7–9 mm long;
 seeds 3.5–5 mm long, sarcotesta greyish, thin *T. cochinchinensis*

1. *Triadica cochinchinensis* Lour., Fl. Cochinch.: 610. 1790. *Excoecaria loureiroana* Müll. Arg. in DC., Prodr. 15(2): 1217. 1866. *Sapium cochinchinense* (Lour.) Pax & K. Hoffm. in Engl., Pflanzenr. IV.147.v: 252. 1912, nom illeg. [non (Lour.) Kuntze, Revis. Gen. Pl. 3: 293. 1898, = *Excoecaria cochinchinensis* Lour.]. *Shirakia cochinchinensis* (Lour.) Hurus., J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot. 6: 318. 1954. TYPE: VIETNAM. “Cochinchina”, without date, *Loureiro s.n.* (Holotype: BM!; Isotype: BM!).

Stillingia discolor Champ. ex Benth., Hooker’s J. Bot. Kew Gard. Misc. 6: 1. 1854; Esser, Blumea 44: 198, 201. 1999, as *syn. nov.* *Sapium discolor* (Champ. ex Benth.) Müll.Arg., Linnaea 32: 121. 1863. *Excoecaria discolor* (Champ. ex Benth.) Müll.Arg. in DC., Prodr. 15(2): 1210. 1866. TYPE: CHINA. Hongkong: without date, *Champion s.n.* (Lectotype, designated by Esser, Blumea 44: 201. 1999: K!; Isolectotypes, GH!, K!).

Stillingia ? lanceolaria Miq., Fl. Ned. Ind., Erste Bijv.: 183, 461. 1861. *Excoecaria ? lanceolaria* (Miq.) Müll.Arg. in DC., Prodr. 15(2): 1221. 1866. TYPE: INDONESIA. Sumatra: Padang, Paloe Pisang, without date, *Teijsmann HB 549* (Holotype: U!; Isotype: CAL).

Sapium eugeniaefolium Buch.-Ham. ex Hook.f., Fl. Brit. India 5: 470. 1888; Chakrab. & M. Gangop., J. Econ. Tax. Bot. 14: 184. 1990 (under *Sapium discolor*). TYPE: INDIA. Assam: Goalpara, *Wallich (leg. Buchanan-Hamilton) 7970* (Holotype: K-WALL, microfiche!).

Sapium laui Croiz., J. Arnold Arbor. 21: 505. 1940; Y. C. Tseng, Fl. Reip. Pop. Sin. 44(3): 18–19. 1997 (under *Sapium discolor*). TYPE: CHINA. Hainan: Kan-en District, Chim Fung near Fong Ngau Po Village, 01–28 February 1935, *S. K. Lau 5498* (Holotype: A!).

Tree up to 25 m tall. Deciduous. Leaves withering red; petiole (1–)3–6 cm long, apically with a pair of adaxial glands, each of which 1–1.5 × 0.5–0.75 mm; blade narrowly elliptic to slightly ovate, (2.5–)6–12 × (1–)3–6 cm, index (1.5–)1.8–2.6, base cuneate to (rarely) obtuse, apex acute to acuminate, abaxially with 0–3 laminar glands on each side, lateral veins in 9–17 pairs. Inflorescences 4–12 cm long, basally with 0–13 pistillate flowers. Pistillate flowers: pedicel 2–4 mm long. Staminate flowers: pedicel 2–3 mm long; stamens with filaments 0.75–1 mm long. Fruits: pedicel 2.5–6 mm long; schizocarp 7–9 × 7–9 mm, base often clavate, pericarp 0.3–0.4 mm thick. Seeds 3.5–5 × 3.5–4.5 mm, sarcotesta greyish-pale but hardly white.

Illustrations were published by Ridley (Fl. Malay Penins. 3: 316, pl. 155. 1924) and Esser (1999: fig. 7).

Distribution and ecology: This is the most widespread species of the genus, distributed from India through Thailand and Indochina to China (up to Hubei and Zheijiang), Borneo, Celebes and the Philippines (for maps see Lee, 1956: map; Esser, 1999: map 7). It grows in various types of disturbed forests and thickets, also on dry places, often on acidic soils, in elevations of up to c. 1,000 m.

Sapium hookeri Hook.f., mentioned as synonym by Govaerts et al. (2000), was only mentioned as nomen pro syn., and was therefore not validly published.

2. *Triadica rotundifolia* (Hemsl.) Esser, *comb. nov.* *Sapium* ? *rotundifolium* Hemsl., J. Linn. Soc. 26: 445. 1891. TYPE: CHINA. Guangdong: without locality, Aug. 1887, C. Ford 169 (Holotype: K!).

Baccaurea esquirolii H. Lev., Fl. Kouy-Tchéou: 159. 1914–15. TYPE: CHINA. Guizhou: Lo-fou, 1908, *Cavalerie 3458* (Lectotype, designated by Haegens, Blumea Suppl. 12: 192. 2000: A!; Isolectotypes: E, K!, UC!).

Sapium rotundifolium var. *obcordatum* S. K. Lee, Acta Phytotax. Sin. 5: 121. 1956; Y. C. Tseng, Acta Phytotax. 20: 106. 1982 (under *Sapium rotundifolium*). TYPE: CHINA. Guangxi: Mao'er Mountain (Mou-I-Shan), May 1948, L. H. Chun 900105 (Holotype: IBSC?).

Tree to 10 m tall. Leaves: petiole 2.5–4.5(–6) cm long, apically with a single

adaxial gland 1.5–2 × 1.5–2.1 mm, rarely divided on single leaves; blade orbicular, 7–11 × 6–10 cm, index 0.9–1.1(–1.3), base rounded to slightly cordate to slightly obtuse, apex emarginate, rounded or mucronate, abaxially eglandular or with up to 6 glands per side, 0.3–0.6 mm in diam., lateral veins in 9–14 pairs. Inflorescence c. 4–5 cm long, basally with 1–8 pistillate flowers. Pistillate flowers: pedicel c. 1 mm long. Staminate flowers: pedicel 1.5–3 mm long; stamens not seen. Fruits: pedicel 2–3 mm long; schizocarp 11–12 × 14–15 mm, base not clavate; pericarp c. 1.5 mm thick. Seeds c. 5 × 3 mm, sarcotesta greyish-pale but hardly white.

Illustrations were published by Tseng (1997: pl. 3 fig. 5–7).

Distribution and ecology: The distribution of this species is more limited than that of the other taxa. It is endemic to few provinces of China (Yunnan, Guangxi, Guizhou, Hunan, Guangdong; compare Lee 1956: map) and just reaches Vietnam, and is characteristic for subtropical evergreen broadleaf forest, collected in elevations up to c. 1,400 m.

3. *Triadica sebifera* (L.) Small, Florida Trees: 59. 1913. *Croton sebifer* L., Sp. Pl.: 1004. 1753 (as “*sebiferus*”). *Stillingia sebifera* (L.) Michx., Fl. Bor.-Amer. 2: 213. 1803. *Sapium sebiferum* (L.) Roxb., Fl. Ind. Ed. 1832, 3: 693. 1832. *Seborium chinense* Raf., Sylva Tellur.: 63. 1838, nomen superfl. *Excoecaria sebifera* (L.) Müll.Arg. in DC., Prodr. 15(2): 1210. 1866. *Carumbium sebiferum* (L.) Kurz, Forest Fl. Burma 2: 411, 412. 1877. *Seborium sebiferum* (L.) Hurus., Bot. Mag. (Tokyo) 61: 30. 1948. TYPE: CHINA. Canton: without date, *Osbeck s.n.* (Lectotype, designated by Radcliffe-Smith, Fl. Pakistan 172: 86. 1986: LINN 1140.9 !).

Triadica sinensis Lour., Fl. Cochinch.: 610. 1790. TYPE: CHINA. “Circa cantonem sinarum”, without date, *Loureiro s.n.* (Holotype: BM?).

Sapium chihsinianum S. K. Lee, Acta Phytotax. Sin. 5: 121, pl. 22. 1956; Govaerts et al., World Checkl. Euphorb.: 1562. 2000, as *syn. nov.* TYPE: CHINA. Guangxi: Lingui (“Hsien Lin-kwei”), Shan Yen, C. H. Chung 800257 (Holotype: IBG).

Sapium discolor var. *wenhsienensis* S. B. Ho, Fl. Tsingliensis 1(3): 451, fig. 155. 1981. *Syn. nov.* TYPE: CHINA. Gansu:

Wenxian County, Pi Kou, Fan-Pa, Miaokou, 01 Sep. 1959, *C. Y. Chang 10447* (Holotype: WUC).

Sapium pleiocarpum Y. C. Tseng, *Acta Phytotax. Sin.* 20: 105, fig. 1. 1982; Govaerts et al., *World Checkl. Euphorb.*: 1562. 2000, as *syn. nov.* TYPE: CHINA. Guizhou: Zheng'an, 06 November 1976, *Y. Zhang 1* [Holotype: GBG ('Herb. Guizhou Bot. Gard.').]

Sapium sebiferum var. *cordatum* S. Y. Wang, *Fl. Henan* 2: 480. 1988; Govaerts et al., *World Checkl. Euphorb.*: 1563. 2000, as *syn. nov.* TYPE: CHINA. Henan: October 1978, *S. Y. Wang s.n.* (Holotype: HEAC).

Sapium sebiferum var. *dabeshense* B. C. Ding & T. B. Chao, *Fl. Henan* 2: 481. 1988; Govaerts et al., *World Checkl. Euphorb.*: 1563. 2000, as *syn. nov.* TYPE: CHINA. Henan: *T. B. Zhao 78149* (Holotype: HEAC).

Sapium sebiferum var. *multiracemosum* B. C. Ding & T. B. Chao, *Fl. Henan* 2: 480, fig. 1394. 1988; Govaerts et al., *World Checkl. Euphorb.*: 1563. 2000, as *syn. nov.* TYPE: CHINA. Henan: October 1978, *S. Y. Wang s.n.* (Holotype: HEAC).

Sapium sebiferum var. *pendulum* B. C. Ding & T. B. Chao, *Fl. Henan* 2: 481. 1988; Govaerts et al., *World Checkl. Euphorb.*: 1563. 2000, as *syn. nov.* TYPE: CHINA. Henan, *T. B. Zhao 777104* (? 77104) (Holotype: HEAC).

Trees to 13 m tall. Deciduous. Leaves: petiole 2–7 cm long, apically with a pair of adaxial glands, each 0.7–1 × 0.5–1 mm; blade broadly elliptic to slightly ovate or obovate, 3.5–10 × 3–9.5 cm, index 0.8–1.4(–1.7), base obtuse (very rarely rounded or even cordate), apex very distinctly acuminate, abaxially eglandular or with up to 5 glands per side, these 0.3–0.7 mm in diam., lateral veins in 7–11 pairs. Inflorescences 4–16 cm long, basally with 0–17 pistillate flowers. Pistillate flowers: pedicel 2–3 mm long; stylar column c. 2 mm long, stigmas 3–5 mm long. Staminate flowers: pedicel 2–3 mm long; stamens with filaments 0.4–0.7 mm long, anthers c. 0.4 mm long. Fruits: pedicel 4–13 mm long; schizocarp 11–13 × 13 mm, pericarp 0.8–1 mm thick. Seeds 6–9 × 4–7 mm, sarcotesta distinct, whitish.

Numerous illustrations were published, and particularly useful are those of Müller (in Mart., *Fl. Bras* 11.2: pl. 84. 1874), Pax and Hoffmann (1912: 238, pl. 44), Hurusawa (1954: fig. 45) and Lee (1956: pl. 22).

Distribution and ecology: The species is widespread in Taiwan and the southern parts of Japan and China (Yunnan and Hainan up to Gansu, Shandong and Henan; compare Lee, 1956: map; Jin and Huang, 1984). It grows in a wide ranges of forest types, on different soils, under dry or moist conditions, is even tolerant to short-term flooding, in elevations up to c. 1,700 m. It is frost hardy. It is cultivated around the earth, naturalizes easily where cultivated and became a problematic, invasive weed in the USA (Barrilleaux and Grace, 2000, and numerous other publications).

The species has a wide range of uses. The seed coat contains a solid fat ("Chinese Vegetable Tallow"), used for candles, soap etc. From the seeds a drying oil is extracted ("Stillingia Oil"). The plant is also used as source of a black dye, as timber tree, and as ornamental, among others. The history of cultivation in China resulted in a considerable range of variation (Jin et al., 1997).

Although the type collections of *Sapium chihsinianum* and *S. pleiocarpum* could not be studied, the synonymy proposed by Govaerts et al. (2000) is most probably correct. Differences in inflorescence length and the number of pistillate flowers and fruits (on which *S. pleiocarpum* was based) occur in most genera and species of Hippomaneae and do not distinguish species by themselves. It is known that species of Hippomaneae usually flower with purely staminate thyrses first, and in additional later flowering periods with bisexual or even pistillate thyrses, often of quite different size (Kruijt, 1996; various label data).

From *S. chihsinianum* a paratype (*Lau 28609*, A) was studied. The species differs from the majority of collections of *T. sebifera* in a shorter leaf apex and a thin seed coat. The seeds could not be compared, but a very similar, comparably short leaf apex is also found on the Linnean type of *T. sebifera*. The paired basal leaf glands distinguish it clearly from *T. rotundifolia*.

Sapium discolor var. *wenhsienensis*, however, clearly belongs here too (and not to *T. cochinchinensis*, as proposed by Govaerts et al., 2000); the leaf characters agree well, and the latter species has not been recorded for this province yet.

Croton macrocarpus Rchb. ex Müll.Arg., mentioned as synonym by Govaerts et al. (2000), was only cited as nomen pro syn., and was therefore not validly published. This also means that the name *Croton macrocarpus*

Ridl., Fl. Malay Penins. 5: 332. 1925, for a Malesian species, is valid and legitimate, and the replacement name *Croton grandifructus* Radcl.-Sm. & Govaerts, Kew Bull. 52: 187. 1997, is superfluous.

NOMEN EXCLUDENDUM

Triadica japonica (Siebold & Zucc.) Nakai = *Neoshirakia japonica* (Siebold & Zucc.) Esser (the combination under *Triadica* by Baillon,

1858, was not validly published, because the author accepted *Triadica* not as a genus but only as a section of *Stillingia*).

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