THAI FOREST BULL., BOT. 50(1): 20–39. 2022.
DOI https://doi.org/10.20531/tfb.2022.50.1.03

Additional knowledge on the genus *Mitragyna* (Rubiaceae) in Thailand

CHATCHAI NGERNSAENGSARUAY[1,5], NISA LEKSUNGNOEN[2,5,*], WEEREESA BOONTHASAK[1]
SUWIMON UTHAIRATSAMEE[2,5], PHRUET RACHARAK[2,5], KANTINAN LEETANASAKSKUL[3]
PORNKANOK PONGAMORN[4] & ATCHARAPHAN SAENGBUAPUEAN[1]

ABSTRACT

A revision of the genus *Mitragyna* (Rubiaceae) in Thailand is reported. Four species, i.e. *M. diversifolia*, *M. hirsuta*, *M. rotundifolia*, and *M. speciosa* are described in this taxonomic treatment. A summary of taxonomic history, detailed morphological descriptions, distributions, ecology, phenology, vernacular names, uses, IUCN conservation status, specimens examined, photographs and a key to the species are proposed. Two names are lectotypified: *M. rotundifolia* and *M. speciosa*.

KEYWORDS: krathom, lectotypification, Mitragyninae, mitriform stigma, Naucleeae

Accepted for publication: 28 December 2021. Published online: 7 March 2022

INTRODUCTION

The genus *Mitragyna* Korth. belongs to the subtribe Mitragyninae of the tribe Naucleeae, the subfamily Cinchonoideae, and the family Rubiaceae (Bremer *et al.*, 1995; Razafimandimbison & Bremer, 2002; Löfstrand *et al.*, 2014; Puff *et al.*, 2021). The generic name *Mitragyna* from the Greek *mitra*, *mitro*, headband, headdress, and *gyne*, *gyno*, woman, female, referring to the mitriform stigma (Wong, 1989; Stearn, 1992; Radcliffe-Smith, 1998; Gledhill, 2002). This genus contains 10 species native to tropical Africa and Asia to South China: four species in Africa, i.e. *Mitragyna inermis* (Willd.) Kuntze, *M. ledermannii* (K.Krause) Ridsdale, *M. rubrostipulata* (K.Schum.) Havil., and *M. stipulosa* (DC.) Kuntze, and six species in Asia, i.e. *M. diversifolia* (Wall. ex G.Don) Havil., *M. hirsuta* Havil., *M. parvifolia* (Roxb.) Korth., *M. rotundifolia* (Roxb.) Kuntze, *M. speciosa* (Korth.) Havil., and *M. tubulosa* (Arn.) Kuntze (Ridsdale, 1978; POWO, 2019; WCSP, 2021).

In Thailand, a taxonomic revision of the genus *Mitragyna* was just recently published by Puff *et al.* (2021) and four species were recognized, *M. diversifolia*, *M. hirsuta*, *M. rotundifolia*, and *M. speciosa.* In this paper, we provide further knowledge on the genus *Mitragyna* in Thailand obtained from our research project entitled "Biological extracts from species in genus *Mitragyna* (Rubiaceae)" and the research subproject entitled, "Morphology, distribution, ecology, and ecophysiology of the genus *Mitragyna* (Rubiaceae) in Thailand". In these projects, we undertook extensive field surveys throughout Thailand and examined specimens in various herbaria including digital herbarium database in the foreign countries. As a result, we here update morphological variation, vernacular names and distribution in Thailand, and also provide illustrations, uses, IUCN conservation status, distribution maps and specimens examined in Thailand for each species. In addition, during our study, we noted that the two species, *M. rotundifolia* and *M. speciosa* are lectotypified.

[1] Department of Botany, Faculty of Science, Kasetsart University, Chatuchak, Bangkok 10900 Thailand.

[2] Department of Forest Biology, Faculty of Forestry, Kasetsart University, Chatuchak, Bangkok 10900 Thailand.

[3] Functional Ingredients and Food Innovation Research Group, National Center for Genetic Engineering and Biotechnology, National Science and Technology Development Agency, Klong Luang, Pathum Thani 12120 Thailand.

[4] National Omics Center, National Science and Technology Development Agency, Klong Luang, Pathum Thani 12120 Thailand.

[5] Center for Advanced Studies in Tropical Natural Resources (CASTNaR), National Research University-Kasetsart University (NRU-KU), Chatuchak, Bangkok 10900 Thailand.

* Corresponding author: ffornsl@ku.ac.th

MATERIALS AND METHODS

The specimens were examined by consulting taxonomic literature, and by comparing with herbarium specimens deposited in BKF, including digital herbarium databases of BM, E, HUH (including A), K, L and P. The morphological characters, distributions, ecology, and phenology are described from specimens examined and from the observations during our field works in 2020–2021. The vernacular names were compiled from specimens examined and the literature (Royal Institute, 2003; Pooma & Suddee, 2014; Poopath *et al.*, 2018; Puff *et al.*, 2021). The conservation status assessments follow the IUCN Red List Categories and Criteria (IUCN, 2019).

KEY TO THE SPECIES

1. Flowering heads 1.5–2.5 cm in diam.; peduncle densely pubescent; interfloral bracteoles 1.7–3.5 mm long; calyx tube 1–1.5 mm wide; corolla tube 2.7–4 × 0.5–1.5 mm
 2. Calyx subtruncate (not lobed), sometimes unevenly and very shallowly (3–)5-lobed; flowering heads 1.5–2 cm in diam.; fruits usually 2.5–3 mm long; leaves typically smaller, 5–14 × 2–9 cm; petiole pubescent or glabrescent; widest spacing of the secondary veins up to 1 cm **1. M. diversifolia**
 2. Calyx shallowly or deeply 5-lobed; flowering heads 2–2.5 cm in diam.; fruits usually 4–5.5 mm long; leaves typically larger, 15–36.5 × 10–29.5 cm; petiole densely pubescent; widest spacing of the secondary veins up to 3 cm
  3. Calyx deeply 5-lobed, spathulate-oblong or oblong, more than 1 mm long, apex acute **2. M. hirsuta**
  3. Calyx shallowly 5-lobed, triangular or semiorbicular, less than 1 mm long, apex obtuse or rounded **3. M. rotundifolia**
1. Flowering heads 3–4 cm in diam.; peduncle glabrous; interfloral bracteoles 5–6 mm long; calyx tube 2.5–3 mm wide; corolla tube 5–6 × 2–3 mm **4. M. speciosa**

1. Mitragyna diversifolia (Wall. ex G.Don) Havil., J. Linn. Soc., Bot. 33: 71. 1897.— *Nauclea diversifolia* Wall. [Numer. List no. 6096. 208. 1831–1832, **nom. nud.**] ex G.Don, Gen. Hist. 3: 467. 1834.— *Stephegyne diversifolia* (Wall. ex G.Don) Brandis, Forest Fl. N.W. India: 263. 1874. Type: Myanmar, Irrawaddy river, Prome, Ava, 1826, *Wallich Cat. 6096C* (lectotype **K-W** [K001123024 digital image!] selected by Ridsdale (1978)). Figs. 1 & 2.

— *Mamboga capitata* Blanco, Fl. Filip.: 140. 1837. Type: not known.

— *Nauclea adina* Blanco, Fl. Filip. ed. 2: 102. 1845, **nom. illeg.**

— *Stephegyne tubulosa* Fern.-Vill. in F.M.Blanco, Fl. Filip. ed. 3, 4(13A): 104. 1880, **nom. illeg.**

— *S. parvifolia* S.Vidal, Sin. Gen. Pl. Leños. Filip.: t. 56, f. A. 1883. Type: not known.

— *Mitragyna javanica* Koord. & Valeton, Meded. Lands Plantentuin 59: 38. 1902; Backer & Bakh.f., Fl. Java 2: 299. 1965. Type: Indonesia, Java, Krawang, n.d., *Korthals s.n.* (lectotype **L** [L0000739] selected by Ridsdale (1978)).

Deciduous tree, 5–20 m tall, up to 150 cm girth; bark scaly, grey to greyish brown; inner bark pinkish to pinkish brown. *Leaves* opposite, decussate; laminas variable in shape, elliptic-oblong, oblong, oblong-obovate, obovate, pentagonal-like-obovate, elliptic, broadly elliptic, oblanceolate-obovate or suborbicular, (3.5–)5–14 × 2–9 cm; apex rounded, obtuse or acute; base rounded, obtuse, cuneate, subcordate, cordate, oblique or truncate; margin entire, proximally ciliate; chartaceous to subcoriaceous, glabrescent or pubescent above, pubescent along veins or pubescent on the laminas below; midrib raised below; secondary veins 6–10(–12) pairs, 0.3–1 cm apart, departing from the midrib at an angle of 15°–50°, curving and connected in loops near the margin, raised below; tertiary veins scalariform; veinlets reticulate; petioles red, greenish red or pale green, (0.5–)1–2(–3) cm long, 0.7–2 mm in diam., shallowly grooved above, pubescent or glabrescent; leaves turning yellow and falling off. *Domatia* present, densely hairy in the axil of secondary veins. *Stipules* interpetiolar, red, greenish red, reddish green or green, keeled, lanceolate-ovate or ovate, 0.7–1.5 × 0.3–1 cm; apex obtuse, rounded or acute; margin entire, densely hairy along ridge (a central keel); inside with dense colleters interspaced with hairs at the base, colleters lanceolate or oblong. *Inflorescences* consisting of globose, many-flowered flowering heads, terminal on main and lateral branches, arrangement like simple or compound dichasia; flowering heads 1.5–2 cm in diam.; peduncle 0.2–1 cm long, densely pubescent; common receptacle densely long hairy. *Bracts* one pair, small, leaf-like, subtending flowering heads, oblanceolate-obovate,

Figure 1. *Mitragyna diversifolia* (Wall. ex G.Don) Havil.: A. habitat and habit; B. bark; C. leafy branches; D. interpetiolar stipules, keeled; E. flowering branches; E. fruiting head. Photographed by Chatchai Ngernsaengsaruay.

Figure 2. *Mitragyna diversifolia* (Wall. ex G.Don) Havil.: A. calyces; B. flowers showing corollas, stamens, styles and stigmas; C. interfloral bracteoles; D. fruits with persistent calyx lobes; E. seeds (include wings). Photographed by Weereesa Boonthasak.

obovate, oblanceolate, elliptic-oblong or elliptic, 1.3–4.5 × 0.4–1.8 cm; apex rounded, obtuse or acute; base cuneate; margin entire, proximally ciliate; petioles 2–7 mm long. *Interfloral bracteoles* keeled, spathulate or linear-spathulate, 1.7–2.5 × 0.2–1 mm, apical part ciliate. *Flowers* fragrant. *Calyx* pale green, tubular, 1.4–1.8 × 1–1.5 mm, glabrous or glabrescent outside, glabrous inside, subtruncate, sometimes unevenly and very shallowly (3–)5-lobed, lobes semiorbicular, 0.2–0.5 × 0.5–1 mm; apex obtuse; margin ciliate. *Corolla* creamy white to pale yellow, turning dark yellow to orangish yellow with age, hypocrateriform, 3–3.7 × 0.8–1.3 mm, glabrous outside, densely long hairy inside, hairs protruding from the corolla throat, 5-lobed, lobes narrowly elliptic or narrowly elliptic-oblong, 2–2.8 × 0.4–1 mm; apical part involute and fused like toe box, glabrous outside, hairy inside, with a median vein. *Stamens* 5; filaments 0.4–1 mm long; anthers 0.8–1.2 mm long, protruding from the corolla throat. *Ovary* obovoid, 0.8–1.2 × 0.4–0.8 mm; style slender, 6–7 mm long, glabrous; stigma mitriform or clavate, 1.5–1.8 × 0.5–0.7 mm; apical part of style and stigma protruding from the corolla throat. *Fruiting heads* 0.8–1.5 cm in diam.; stalks 0.2–1 cm long, densely pubescent. *Fruits* obovoid or turbinate, 2.5–3(–5) × 1.3–2.5 mm, dark green, turning brown or blackish brown when dry, long hairy becoming glabrescent or glabrous with age, with persistent calyx. *Seeds* numerous, brown or blackish brown, flattened, narrowly elliptic, 1.3–2 × 0.2–0.5 mm (include wings), winged at both ends, acuminate at both ends or lower wing bifid.

Thailand.— NORTHERN: Chiang Mai [28 Aug. 1911, *Kerr 1966* (**L** [L2924917], **P** [P03984580]); Doi Suthep, 16 Dec. 1922, *Kerr s.n.* (**P** [P03984578])]; Chiang Rai [18 Dec. 1967, *Nimanong & Phusomsaeng 142* (**BKF**)]; Lamphun [Ban Lan, Mueang Lamphun, 1 Feb. 1979, *Bjørnland & Schumacher 644* (**BKF**)]; Lampang [Ngernsaengsaruay own observation]; Tak [Ngernsaengsaruay own observation], Sukhothai [Na Thung Subdistrict, Sawankhalok District, 19 Feb. 2021, *Ngernsaengsaruay et al. Md11-19022021* (**BKF**)]; Phitsanulok [27 July 1973, *Murata T-17205* (**BKF**); 25 Mar. 1985, *Santisuk s.n.* (**BKF** [120677])]; Kamphaeng Phet [50 km east of Kamphaeng Phet, 19 Jan. 1959, *Sørensen et al. 6638* (**BKF**, **L** [L2924907]); between Kamphaeng Phet and Sai Ngam, 29 July 1973, *Murata T-17265* (**BKF**); 28 Nov. 1977, *Phengklai et al. 3953* (**BKF**); Kosamphi Subdistrict, Kosamphi Nakhon District (cultivated in the parkway), 20 Feb. 2021, *Ngernsaengsaruay et al. Md13-20022021* (**BKF**); Paddy field, Ban Khlong Khayaeng, Tha Phutsa Subdistrict, Khlong Khlung District, 21 Feb. 2021, *Ngernsaengsaruay et al. Md14-21022021* (**BKF**); Ban Salok Bat, Salok Bat Subdistrict, Khanu Woralaksaburi District, 21 Feb. 2021, *Ngernsaengsaruay et al. Md15-21022021* (**BKF**)]; Nakhon Sawan [Pak Nam Pho, Mueang Nakhon Sawan, July 1920, *P.V. P 1028* (**BKF**)]; NORTH-EASTERN: Loei [reported by Puff *et al.* (2021)]; Maha Sarakham [Ngernsaengsaruay own observation]; EASTERN: Chaiyaphum [Tat Ton, 13 Aug. 1972, *Larsen et al. 31803* (**BKF**, **P** [P03984583]); Nong Bua Daeng, 15 Aug. 1972, *Larsen et al. 31911* (**BKF**, **P** [P03984584)]; Nakhon Ratchasima [Khao Yai NP, Pak Chong, 12 Dec. 1997, *Charoenchai 467* (**BKF**, **L** [L2924911]); Non Sung, 28 June 2003, *Chantaranothai et al. s.n.* (**BKF** [156728])]; Buri Ram [24 Nov. 1976, *Phengklai et al. 3377* (**BKF**)]; Ubon Ratchathani [Muang Sam Sip, 28 Sept. 2003, *Wongprasert 039-26* (**BKF**, **P** [P01037875, P01037876])]; SOUTH-WESTERN: Ratchaburi [reported by Puff *et al.* (2021)]; CENTRAL: Chai Nat [Ngernsaengsaruay own observation]; Sing Buri [Ngernsaengsaruay own observation]; Lop Buri [Ngernsaengsaruay own observation]; Phra Nakhon Si Ayutthaya [30 July 1973, *Murata & Fukuoka T-17320* (**L** [L2924915]); 18 Aug. 1998, *Esser et al. 98-16* (**L** [L2924910], **P** [P03984577]); Bang Phloeng Subdistrict, Bang Pahan District, 3 Dec. 2020, *Ngernsaengsaruay et al. Md03-03122020*, *Md04-03122020*, *Md05-03122020* (**BKF**)]; Saraburi [Khok Yai Forest, Nong Khae, May 1947, *Si 118* (**BKF**); 30 July 1973, *Murata & Fukuoka T-17349* (**BKF**, **L** [L2924914], **P** [P03984585])]; Pathum Thani [Sam Khok, 7 July 1997, *Wongprasert s.n.* (**BKF**)]; Nakhon Nayok [Ngernsaengsaruay own observation]; Bangkok [along Khlong Bang Khen, 7 Oct. 1974, *Maxwell 74-942* (**L** [L2924916]); Royal Forest Department (cultivated), 20 Sept. 1984, *Smitinand s.n.* (**P** [P03984310, P03984311, P03984312]); Chitralada Palace (cultivated), Aug. 1992, *Santisuk s.n.* (**BKF** [96464]); Lat Yao Subdistrict, Chatuchak District, 4 Nov. 2020, *Ngernsaengsaruay et al. Md01-04112020* (**BKF**); Shell Petrol Station, Ngamwongwan Road, Thung Song Hong Subdistrict, Lak Si District (cultivated), 4 Nov. 2020, *Ngernsaengsaruay et al. Md02-*

04112020 (**BKF**); SOUTH-EASTERN: Prachin Buri [5 Aug. 1977, *Phengklai et al. 3723* (**BKF**); Wetland, Kabin Subdistrict, Kabin Buri District, 5 Dec. 2020, *Ngernsaengsaruay et al. Md06-05122020* (**BKF**); Paddy field, Kabin Subdistrict, Kabin Buri District, 5 Dec. 2020, *Ngernsaengsaruay et al. Md07-05122020*, *Md08-05122020*, *Md09-05122020*, *Md10-05122020* (**BKF**)]; PENINSULAR: Surat Thani [Bang Bao Forest, 7 Aug. 1955, *Phloenchit 844* (**BKF**); Khao Tok, Khian Sa, 20 Dec. 1956, *Sanan 413* (**BKF**); Si Wichai Subdistrict, Phunphin District, 26 Mar. 2021, *Ngernsaengsaruay et al. Md16-26032021*, *Md17-26032021*, *Md18-26032021*, *Md19-26032021*, *Md20-26032021* (**BKF**)]; Nakhon Si Thammarat [reported by Puff *et al.* (2021)]; Satun [reported by Puff *et al.* (2021)]; REGION NOT SPECIFIED: Thailand [1 Aug. 1930, *Kerr 19619* (**L** [L2924906])].

Distribution.— Bangladesh, Myanmar, China (Yunnan), Indochina, Peninsular Malaysia, Indonesia (Java), Philippines.

Ecology.— Along the edge of paddy fields, lowlands, flood plains, freshwater swamp forest (lowland flood plain forest), along streams, disturbed open areas, along roadsides, along the edge of deciduous dipterocarp forest and mixed deciduous forest, open areas in dry evergreen forest, 0–400 (–750) m alt.

Phenology.— Flowering July–December (–February); fruiting September–February.

Vernacular.— Kra thom khi mu (กระท่อมขี้หมู) (Northern, Central); ka tam (กะตำ) (Khmer-Surin); ka thom (กะทม) (Suai-Surin); kra thum (กระทุ่ม) (Central); kra thum khi mu (กระทุ่มขี้หมู) (Northern); kra thum dong (กระทุ่มดง) (Kanchanaburi); kra thum na (กระทุ่มนา), kra thum nam (กระทุ่มน้ำ) (Central); ka tum (กาตูม) (Khmer-Prachin Buri); tam (ตำ) (Suai-Surin); tum sae (ตุ้มแซะ), tum noi (ตุ้มน้อย), tum nam (ตุ้มน้ำ) (Northern); thom phai (ถ่มพาย) (Loei); thom (ท่ม), thom tham (ท่มทาม), thom noi (ท่มน้อย), thom na (ท่มนา), thom nam (ท่มน้ำ) (Isan = North-Eastern and Eastern according to Thailand floristic regions); thom khi mu (ท่อมขี้หมู) (Songkhla); thom na (ท่อมนา) (Surat Thani); thom noi (โทมน้อย) (Phetchabun).

Uses.— The wood is locally used in construction, and used for making farming utensils, furniture, firewood, and charcoal. Cultivated as shade and ornamental trees.

IUCN conservation status.— Least Concern (LC) (IUCN, 2022). This species is widely distributed from Bangladesh to Indochina and Peninsular Malaysia extending to Java and the Philippines, and has a large extent of occurrence (EOO of 6,058,002.08 km^2) and area of occupancy (AOO of 192 km^2). Also, considering it grows mainly in secondary forests and disturbed open areas, often common at roadsides, it is considered as LC.

Notes.— The laminas of *Mitragyna diversifolia* (5–14 × 2–9 cm) are typically smaller than those of *M. hirsuta* (15–32.5 × 10–23 cm) and *M. rotundifolia* (15–36.5 × 10–29.5 cm). In addition, the laminas of *M. diversifolia* are glabrescent or pubescent above, and pubescent along veins or pubescent on the laminas below but those of the other two are always pubescent on both surfaces.

Puff *et al.* (2021) reported this species is a small tree up to ca 8 m tall, rarely taller, but from our field observations and examined specimens, it grows up to 20 m tall.

The shapes of leaves of this species are oblong, obovate and orbicular (Puff *et al.* 2021). In addition, from our study, we found the laminas are more variable in shape including elliptic-oblong, oblong-obovate, pentagonal-like-obovate, elliptic, broadly elliptic, oblanceolate-obovate and suborbicular. The diameter of flowering heads of this species is 0.6–1 cm, the angle of secondary veins is 10°–30° (Puff *et al.* 2021), but we found the flowering heads 1.5–2 cm in diam., the angle of secondary veins 15°–50° in this study.

The natural distribution in Lampang, Tak, Sukhothai, Maha Sarakham, Nakhon Ratchasima, Buri Ram, Ubon Ratchathani, Sing Buri, Lop Buri, Phra Nakhon Si Ayutthaya and Nakhon Nayok are newly recorded here.

Puff *et al.* (2021) reported this species occurring in dry dipterocarp forest and dry deciduous forest, often in disturbed sites such as old rice fields in Thailand, at 0–400 m alt, but the specimen *Charoenchai 467* was collected from open areas in dry evergreen forest, at 750 m alt. Furthermore, from our observations, we can confirm it grows in more variable environments including flood plains, freshwater swamp forest (lowland flood plain forest), and gaps or edge of mixed deciduous forest and dry evergreen forest.

2. Mitragyna hirsuta Havil., J. Linn. Soc., Bot. 33: 72. 1897.— *Paradina hirsuta* (Havil.) Pit. in Lecomte *et al.*, Fl. Indo-Chine 3: 39. fig. 4: 1–4. 1922. Type: Vietnam, Crescit ad Bao Chiang, July 1877, *Pierre 1835* (holotype **K** [K000729976 digital image!], isotypes **E** [E00130750 digital image!], **P** [P01900236, P01900237 digital images!]). Figs. 3 & 4.

Deciduous tree, 5–20 m tall, up to 160 cm girth; bark scaly, grey to greyish brown; inner bark pinkish to pinkish brown. *Leaves* opposite, decussate; laminas variable in shape, elliptic, broadly elliptic, elliptic-oblong, obovate, elliptic-obovate, pentagonal-like-obovate, ovate, broadly ovate or suborbicular, (8–)15–32.5 × (6–)10–23 cm; apex acute, obtuse or rounded; base rounded, obtuse, cuneate, cordate, subcordate, oblique or truncate; margin ciliate, sometimes distally distantly dentate; chartaceous to subcoriaceous, pubescent on both surfaces; midrib raised below; secondary veins 8–16 pairs, 0.5–3 cm apart, departing from the midrib at an angle of 30°–70°, curving and connected in loops near the margin, raised below; tertiary veins scalariform; veinlets reticulate; petioles reddish green or pale green, 1.5–3(–6.5) cm long, 1.5–6 mm in diam., shallowly grooved above, densely pubescent; leaves turning yellow and falling off. *Domatia* present, densely hairy in the axil of secondary veins. *Stipules* interpetiolar, red or reddish green, keeled, ovate, oblong, elliptic or broadly elliptic, 1–2.5 × 0.5–1.3 cm; apex obtuse, rounded or acute; margin entire, densely hairy along ridge; inside with dense colleters interspaced with hairs at the base, colleters lanceolate or oblong. *Inflorescences* consisting of globose, many-flowered flowering heads, terminal on main and lateral branches, arrangement like simple or compound dichasia; flowering heads 2–2.5 cm in diam.; peduncle 0.2–2 cm long, densely pubescent; common receptacle densely long hairy. *Bracts* one pair, small, leaf-like, subtending flowering heads, obovate, ovate, broadly ovate or oblanceolate, 1.5–4.5(–13) × 0.7–2.5(–7) cm; apex acute or obtuse; base cuneate, oblique, attenuate, obtuse or rounded; margin ciliate; petioles 0.3–2 cm long. *Interfloral bracteoles* keeled, spathulate or linear-spathulate, 2–3.5 × 0.2–1 mm, apical part ciliate. *Flowers* fragrant. *Calyx* pale green, tubular, 0.3–0.8 × 1–1.5 mm, glabrous or glabrescent outside, glabrous inside, deeply 5-lobed, lobes spathulate-oblong or oblong, 1.5–2.5 × 0.5–1 mm; apex acute; margin ciliate. *Corolla* creamy white to pale yellow, turning dark yellow to orangish yellow with age, hypocrateriform, 3.5–4 × 0.5–1.5 mm, glabrous outside, densely long hairy inside, hairs protruding from the corolla throat, 5-lobed, lobes narrowly elliptic or narrowly elliptic-oblong, 2.5–3 × 0.5–1 mm; apical part involute and fused like toe box, glabrous outside, hairy inside, with a median vein. *Stamens* 5; filaments 0.3–1 mm long; anthers 1–1.5 mm long, protruding from the corolla throat. *Ovary* obovoid, 1–2 × 0.6–1 mm; style slender, 0.7–1 cm long, glabrous; stigma mitriform, clavate or cylindrical, 1.3–2 × 0.5–0.8 mm; apical part of style and stigma protruding from the corolla throat. *Fruiting heads* 1–2(–2.5) cm in diam.; stalks 0.2–2 cm long, densely pubescent. *Fruits* obovoid or turbinate, 4–5(–7.5) × 2–3 mm, dark green, turning brown or blackish brown when dry, long hairy becoming glabrescent or glabrous with age, with persistent calyx. *Seeds* numerous, brown or blackish brown, flattened, narrowly elliptic, 1.3–2.5 × 0.3–0.7 mm (include wings), winged at both ends, acuminate at both ends or lower wing bifid.

Thailand.— NORTHERN: Chiang Mai [Doi Suthep, 30 May 1909, *Kerr 661* (**L** [L2924838]); Doi Suthep, 2 July 1958, *Sørensen et al. 3846* (**BKF**, **L** [L2924836]); 10 km west of Chiang Mai, 5 June 1963, *King et al. 5459* (**L** [L2935340]) (misidentified as *M. rotundifolia*); Doi Pha Dam between Hang Dong and Bo Luang, 5 July 1968, *Larsen et al. 2122* (**BKF**, **L** [L2924814]); Bo Luang–road down Mae Chaem, 16 Dec. 1969, *van Beusekom & Phengklai 2570* (**BKF**, **L** [L2924879, L2924880]); Bo Luang, 12 June 1973, *Geesink et al. 5845* (**BKF**, **L** [L2935359]); Doi Suthep, 22 July 1978, *Phengklai et al. 4055* (**BKF**); Doi Suthep, 16 Dec. 1984, *Yahara T-50156* (**BKF**); Doi Suthep, east side of Huai Kaeo Waterfall, Mueang Chiang Mai, 21 Oct. 1987, Doi Suthep, east side, above Pha Ngoeb, Mueang Chiang Mai, 16 Jan. 1988, *Maxwell 88-55* (**L** [L2924873]); *Maxwell 87-1228* (**BKF**, **L** [L2924824]); at foot of Doi Suthep, 16 July 1988, *Fukuoka T-62006* (**BKF**); Doi Inthanon, the south side of Mae Klang River, 1 Aug. 1988, *Fukuoka T-62400* (**BKF**, **L** [L2924818]); Borichinda Cave, Doi Inthanon, Chom Thong, 20 Oct. 1999, *Wongprasert s.n.* (**BKF** [131199]); Sop Poeng, Mae Taeng, 3 Sept. 2000, *Maxwell 00-424* (**BKF**, **L** [L2924876, L2924877, L2924878])]; Nan [west of Nan along road to Phayao, 27 July 1992,

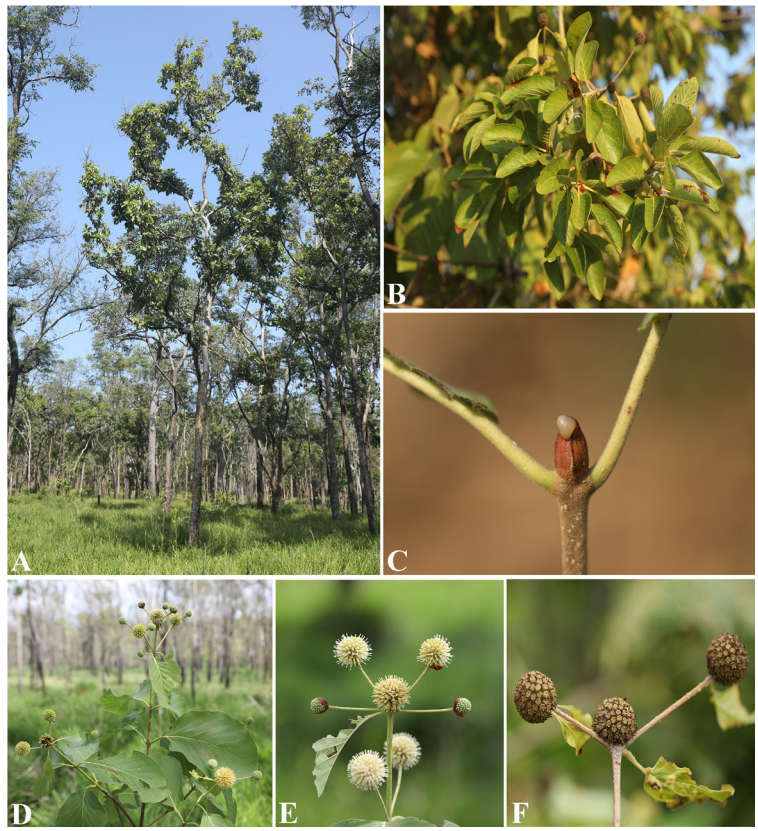

Figure 3. *Mitragyna hirsuta* Havil.: A. habitat and habit; B. fruiting branches; C. interpetiolar stipules, keeled and with sticky substance produced from dense colleters inside; D. flowering branches; E. inflorescences with young and mature flowering heads; F. infructescence. Photographed by Chatchai Ngernsaengsaruay.

Figure 4. *Mitragyna hirsuta* Havil.: A. calyces; B. flowers showing corollas, stamens, styles and stigmas; C. interfloral bracteoles; D. fruits with persistent calyx lobes; E. seeds (include wings). Photographed by Weereesa Boonthasak.

Larsen et al. 43653 (**BKF**)]; Lampang [Huai Thak Forest, Ban Huat, Ngao, 22 May 1954, *Kantawong 5* (**BKF**) (misidentified as *M. rotundifolia*); Doi Khun Tan NP, Hang Chat, 5 Dec. 1994, *Maxwell 94-1267* (**BKF**, **L** [L2924874]); Tak–Lampang road, near small road to Mae Wa, Mae Phrik, 22 June 2018, *Pooma et al. 7084* (**BKF**); Mae Mok Subdistrict, Thoen District, 19 Feb. 2021, *Ngernsaengsaruay et al. Mh05-19022021* (**BKF**)]; Phrae [11 July 1926, *Winit 1746* (**BKF**); Rong Kwang, ca 2 km east of Mae Jo University, Phrae Campus, 8 July 2006, *Maxwell 06-431* (**L** [L4193300])]; Uttaradit [Huai Maeng, 13 Apr. 1961, *Phengklai 116* (**L** [L2924830])]; Tak [Ban Mae Salit, Tak Aok Subdistrict, Ban Tak District, 20 Feb. 2021, *Ngernsaengsaruay et al. Mh07-20022021* (**BKF**)]; Sukhothai [Na Thung Subdistrict, Sawankhalok District, 19 Feb. 2021, *Ngernsaengsaruay et al. Mh06-19022021* (**BKF**); Mueang Bang Khlang Subdistrict, Sawankhalok District, 20 Feb. 2021, *Ngernsaengsaruay et al. Mh09-20022021* (**BKF**)]; Nakhon Sawan [reported by Puff *et al.* (2021)]; NORTH-EASTERN: Phetchabun [Khao Pha Daeng, Lom Sak, 15 Aug. 1982, *Shimizu et al. T-28629* (**BKF**); Nam Nao NP, near check point of road to National Park, 28 Oct. 1984, *Murata et al. T-51519* (**BKF**, **L** [L2924903]) (misidentified as *M.* cf. *diversifolia*)]; Loei [Wang Saphung, 8 July 1948, *Si 79* (**BKF**); Phu Kradueng, 16 July 1964, *Bunchuai 124* (**BKF**, **L** [L2924819])]; Sakon Nakhon [Phu Phan NP, 30 km southwest of Sakon Nakhon City, 13 Nov. 1984, *Murata et al. T-50687* (**BKF**); ibid., 14 Nov. 1984, *Murata et al. T-50552* (**BKF**)]; Mukdahan [reported by Puff *et al.* (2021)]; Kalasin [20 June 1969, *Sangasri s.n.* (**BKF** [99210])]; Maha Sarakham [Chiang Yuen, 23 May 1970, *Smitinand 10887* (**BKF**, **L** [L2924828])]; Khon Kaen [80 km east of Phetchabun, 8 Nov. 1984, *Murata et al. T-50033* (**BKF**)]; EASTERN: Nakhon Ratchasima [Wang Nam Khiao, 5 July 1967, *Nilphanit 386* (**BKF**, **L** [L2924834]); Sakaerat Environmental Research Station, Udom Sap, Wang Nam Khiao, 1 Nov. 1969, *van Beusekom & Charoenpol 2014* (**BKF**, **L** [L2924881]); ibid., in deciduous dipterocarp forest, 4 Dec. 2020, *Ngernsaengsaruay et al. Mh01-04122020*, *Mh02-04122020*, *Mh03-04122020* (**BKF**); Kham Thale So District, saline soil area, 4 Dec. 2020, *Ngernsaengsaruay et al. Mh04-04122020* (**BKF**); Pak Thong Chai, n.d., *Sono 20* (**BKF**)]; Surin [3 Dec. 1976, *Phengklai et al. 3593* (**BKF**); near Cambodia border, ca. 50 km southwest of Sangkha, 6 Oct. 1984, *Murata et al. T-37686* (**BKF**, **L** [L2924817])]; Si Sa Ket [en route from Si Sa Ket City to Kantharalak, about 10 km form Kantharalak, 8 Oct. 1984, *Murata et al. T-37890* (**BKF**, **L** [L2924821])]; Ubon Ratchathani [Heo Sin Chai Cave, Kaeng Tana NP, 22 Aug. 2001, *Pooma et al. 2367* (**BKF**)]; SOUTH-WESTERN: Kanchanaburi [Ban Kao, Mueang Kanchanaburi, 14 Nov. 1961, *Larsen 8205* (**BKF**, **L** [L2924831, L2924832]); Erawan NP, open grassy deciduous *Shorea-Xylia* Forest (not Narathiwat), 2 July 1974, *K. Larsen & S.S. Larsen 34004* (**BKF**, **L** [L2924823]); north of Srinakarin Dam, Si Sawat, 12 Jan. 1985, *Koyama et al. T-49049* (**L** [L2924913]) (misidentified as *M.* cf. *diversifolia*); 7 Dec. 1993, *Yonebayashi 93022* (**BKF**); Sai Yok, 3 July 2006, *Chongko 560* (**L** [L4189013, L4189014])]; Ratchaburi [reported by Puff *et al.* (2021)]; Phetchaburi [Huai Sai, Cha-am, 19 Sept. 2001, *Puudjaa 1137* (**BKF**) (misidentified as *M. rotundifolia*); ibid., 15 Nov. 2001, *Puudjaa 990* (**BKF**); CENTRAL: Bangkok [Faculty of Forestry, Kasetsart University, Lat Yao, Chatuchak (cultivated), 22 Feb. 2021, *Ngernsaengsaruay et al. Mh08-22022021* (**BKF**); Suan Luang Rama IX, Prawet District (cultivated), 9 July 2021, *Ngernsaengsaruay et al. Mh10-09072021*, *Mh11-09072021*, *Mh12-09072021*, *Mh13-09072021* (**BKF**)]; SOUTH-EASTERN: Chonburi [Khao Khiao, Si Racha, 26 Apr. 1975, *Maxwell 75-441* (**L** [L2924825])]; REGION NOT SPECIFIED: Thailand [1 Nov. 1928, *Put 2092* (**L** [L2924837])].

Distribution.— Myanmar, China (Yunnan), Indochina.

Ecology.— In deciduous dipterocarp forest, mixed deciduous forest, secondary forest, plains, disturbed open areas, along roadsides, near above mean sea level up to 850 m alt.

Phenology.— Flowering June–December (–February); fruiting August–February.

Vernacular.— Kra thum khok (กระทุ่มโคก) (Central, Nakhon Ratchasima, Kanchanaburi); tum khao (ตุ้มเขา), thum khao (ทุ่มเขา) (Northern); thum phai (ทุ่มพาย) (Nakhon Sawan, Prachinburi).

Uses.— The wood is locally used in construction, and used for making farming utensils, firewood, and charcoal. Cultivated as shade and ornamental trees.

IUCN conservation status.— This species is distributed from Myanmar to Indochina, and has a large extent of occurrence (EOO of 985,999.69 km^2)

and area of occupancy (AOO of 164 km^2). Also, considering it grows in secondary forest, disturbed open areas, and along roadsides, it is considered here as Least Concern (LC).

Notes.— *Mitragyna hirsuta* is very similar to *M. rotundifolia*, but it differs in having calyx lobes that are deeply 5-lobed, spathulate-oblong or oblong, 1.5–2.5 mm long, and acute apex (vs lobes shallowly 5-lobed, triangular or semiorbicular, 0.3–0.5 mm long, and obtuse or rounded at apex in *M. rotundifolia*) (Table 1).

This species is a small tree up to ca 10 m tall, rarely taller (Puff *et al.*, 2021), but from our field observations and examined specimens, it can reach 20 m tall. Puff *et al.* (2021) reported the shapes of leaves of this species are broadly ovate, orbicular and elliptic, the length of leaves is up to 18 cm, the width of leaves is up to 15 cm. Furthermore, from our study, we found the laminas are more variable in shape including broadly elliptic, elliptic-oblong, obovate, elliptic-obovate, pentagonal-like-obovate, ovate and suborbicular, the length of leaves is up to 32.5 cm, the width of leaves is up to 23 cm. The diameter of flowering heads of this species is ca 1 cm, the angle of secondary veins is 15°–45° (Puff *et al.* 2021), but we found the flowering heads 2–2.5 cm in diam., the angle of secondary veins 30°–70° in this study.

The natural distribution in Nan, Lampang, Uttaradit, Tak, Sukhothai, Kalasin, Maha Sarakham, Surin, Si Sa Ket, Kanchanaburi and Chonburi are newly recorded here.

3. Mitragyna rotundifolia (Roxb.) Kuntze, Revis. Gen. Pl. 1: 289. 1891.— *Nauclea rotundifolia* Roxb. [Hort. Beng. 86. 1814, **nom. nud.**], Fl. Ind. (Carey & Wall. ed.) 2: 124. 1824. Type: India, *Roxburgh s.n.* (lectotype **BM** [BM000945040 digital image!] first step selected by Ridsdale (1978), second step selected here by C. Ngernsaengsaruay). Figs. 5 & 6.

— *Nauclea brunonis* Wall. [Numer. List no. 6097. 208. 1831–1832, **nom. nud.**] ex G.Don, Gen. Hist. 3: 467. 1834.

— *Mitragyna brunonis* (Wall. ex G.Don) Craib, Fl. Siam. 2: 11. 1932. Type: Myanmar, Tavoy, Gomez in *Wallich Cat. 6097* (holotype **K-W** [K001123026 digital image!]).

Deciduous tree, 5–25 m tall, up to 150 cm girth; bark scaly, grey to greyish brown; inner bark pinkish to pinkish brown. *Leaves* opposite, decussate; laminas variable in shape, elliptic, elliptic-oblong, obovate, elliptic-obovate, pentagonal-like-obovate, ovate, broadly ovate or suborbicular, (8–)15–36.5 × (6)10–29.5 cm; apex acute, obtuse or rounded; base rounded, obtuse, cuneate, cordate, subcordate, oblique or truncate; margin ciliate, sometimes distally distantly dentate; chartaceous to subcoriaceous, pubescent on both surfaces; midrib raised below; secondary veins 8–14 pairs, 0.5–3(–3.5) cm apart, departing from the midrib at an angle of 30°–75°, curving and connected in loops near the margin, raised below; tertiary veins scalariform; veinlets reticulate; petioles reddish green or pale green, 2–3(–5) cm long, 1.5–4 mm in diam., shallowly grooved above, densely pubescent; leaves turning yellow and falling off. *Domatia* present, densely hairy in the axil of secondary veins. *Stipules* interpetiolar, red or reddish green, keeled, ovate, oblong, elliptic, broadly elliptic, obovate or oblanceolate-obovate, 1–7.2 × 0.6–3.7 cm; apex obtuse, rounded or acute; margin entire, densely hairy along ridge; inside with dense colleters interspaced with hairs at the base, colleters lanceolate or oblong. *Inflorescences* consisting of globose, many-flowered flowering heads, terminal on main and lateral branches, arrangement like simple or compound dichasia; flowering heads 2–2.5 cm in diam.; peduncle 0.2–1 cm long, densely pubescent; common receptacle densely long hairy. *Bracts* one pair, small, leaf-like, subtending flowering heads, elliptic, elliptic-oblong or obovate, 1.3–5.5 × 0.7–2.5 cm; apex obtuse, rounded or acute; base rounded or cuneate; margin ciliate; petioles 0.3–1 cm long. *Interfloral bracteoles* keeled, spathulate or linear-spathulate, 2–3.5 × 0.2–1 mm, apical part ciliate. *Flowers* fragrant. *Calyx* pale green, tubular, 1–1.5 × 1–1.3 mm, glabrous or glabrescent outside, glabrous inside, shallowly 5-lobed, lobes triangular or semiorbicular, 0.3–0.5 × 0.5–0.7 mm; apex obtuse or rounded; margin ciliate. *Corolla* creamy white to pale yellow, turning dark yellow to orangish yellow with age, hypocrateriform, 2.7–3.8 × 0.7–1.3 mm, glabrous outside, densely long hairy inside, hairs protruding from the corolla throat, 5-lobed, lobes narrowly elliptic or narrowly elliptic-oblong, 2.7–3.3 × 0.6–1 mm; apical part involute and fused like toe box, glabrous outside, hairy inside, with a median vein. *Stamens* 5; filaments 0.3–1 mm long; anthers

Table 1. The comparison of morphological characteristics within the genus *Mitragyna* in Thailand.

Characteristics	*M. diversifolia*	*M. hirsuta*	*M. rotundifolia*	*M. speciosa*
Deciduous or evergreen tree	deciduous tree	deciduous tree	deciduous tree	briefly deciduous or evergreen tree
Lamina size	(3.5–)5–14 × 2–9 cm	(8–)15–32.5 × (6–)10–23 cm	(8–)15–36.5 × (6–)10–29.5 cm	9–24 × 3.5–12.5 cm
Angle of secondary veins	15°–50°	30°–70°	30°–75°	25°–85°
Indumentum of petiole	pubescent or glabrescent	densely pubescent	densely pubescent	glabrescent
Interval of secondary veins	0.3–1 cm	0.5–3 cm	0.5–3(–3.5) cm	0.4–1.6 cm
Indumentum of interpetiolar stipules	densely hairy along ridge (a central keel)	densely hairy along ridge	densely hairy along ridge	glabrescent along ridge
Flowering heads size	1.5–2 cm in diam.	2–2.5 cm in diam.	2–2.5 cm in diam.	3–4 cm in diam.
Indumentum of peduncle	densely pubescent	densely pubescent	densely pubescent	glabrous
Interfloral bracteoles length	1.7–2.5 mm	2–3.5 mm	2–3.5 mm	5–6 mm
Calyx	subtruncate (not lobed), sometimes unevenly and very shallowly (3–)5-lobed	deeply 5-lobed	shallowly 5-lobed	unevenly and shallowly (3–)5-lobed
Calyx tube width	1–1.5 mm	1–1.5 mm	1–1.3 mm	2.5–3 mm
Calyx lobes	semiorbicular, 0.2–0.5 mm long, apex obtuse	spathulate-oblong or oblong, 1.5–2.5 mm long, apex acute	triangular or semiorbicular, 0.3–0.5 mm long, apex obtuse or rounded	triangular, 0.3–0.7 mm long, apex acute
Corolla tube size	3–3.7 × 0.8–1.3 mm	3.5–4 × 0.5–1.5 mm	2.7–3.8 × 0.7–1.3 mm	5–6 × 2–3 mm
Stigma shape and size	mitriform or clavate, 1.5–1.8 × 0.5–0.7 mm	mitriform, clavate or cylindrical, 1.3–2 × 0.5–0.8 mm	mitriform, clavate or cylindrical, 1.3–2 × 0.5–0.8 mm	mitriform, 2.2–3 × 1–1.5 mm
Indumentum on stalks of fruiting heads	densely pubescent	densely pubescent	densely pubescent	glabrous
Fruits length	2.5–3(–5) mm	4–5(–7.5) mm	4–5.5 mm	5–10 mm long

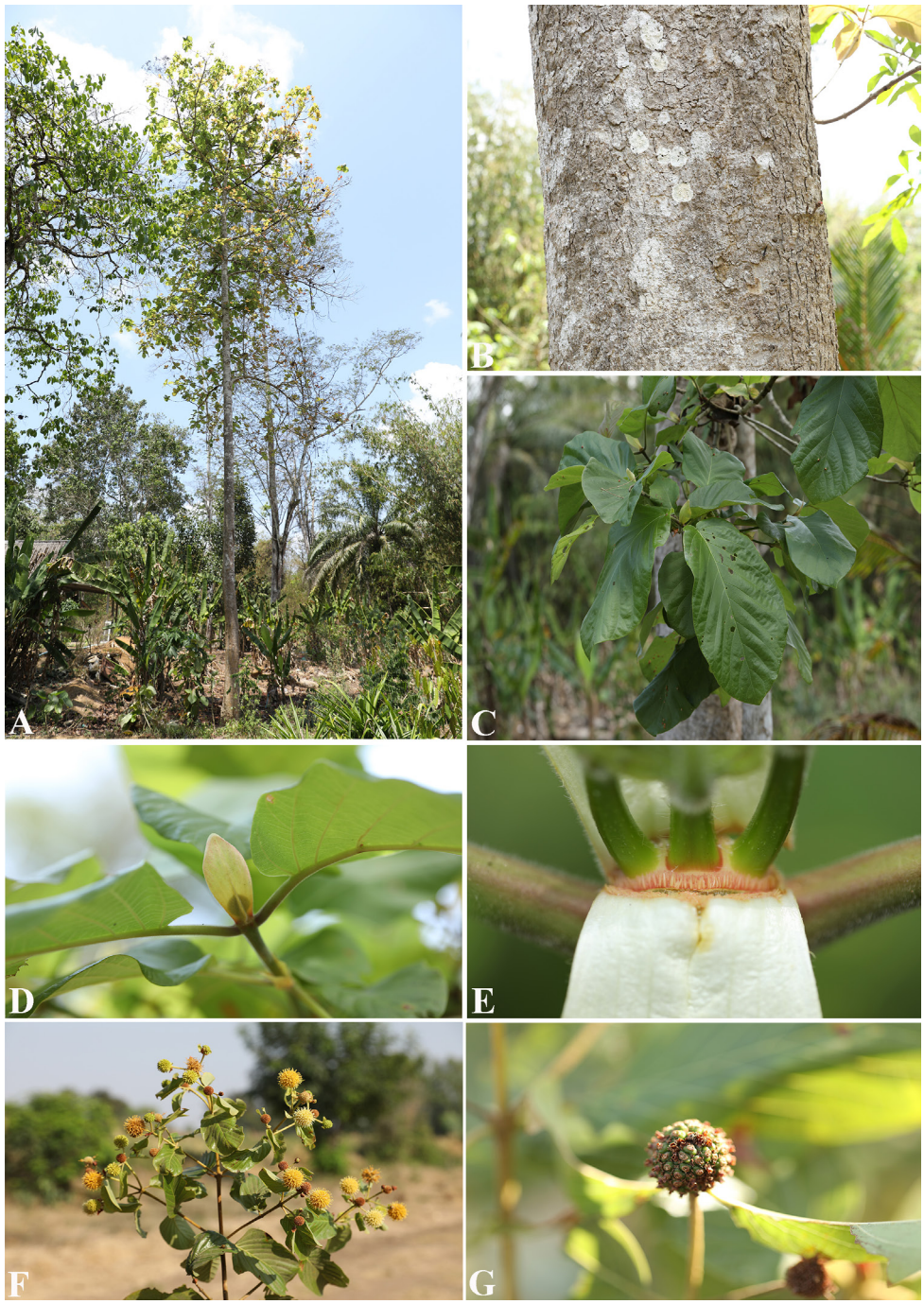

Figure 5. *Mitragyna rotundifolia* (Roxb.) Kuntze: A. habitat and habit; B. bark; C. leafy branches; D. interpetiolar stipules, keeled; E. inside of interpetiolar stipule showing dense colleters at the base; F. flowering branches; G. fruiting head. Photographed by Chatchai Ngernsaengsaruay.

Figure 6. *Mitragyna rotundifolia* (Roxb.) Kuntze: A. calyces; B. flowers showing corollas, stamens, styles and stigmas; C. interfloral bracteoles; D. fruits with persistent calyx lobes; E. seeds (include wings). Photographed by Weereesa Boonthasak.

1–1.6 mm long, protruding from the corolla throat. *Ovary* obovoid, 1–1.5 × 0.5–0.8 mm; style slender, 7–8 mm long, glabrous; stigma mitriform, clavate or cylindrical, 1.3–2 × 0.5–0.8 mm; apical part of style and stigma protruding from the corolla throat. *Fruiting heads* 1–2 cm in diam.; stalks 0.2–1 cm long, densely pubescent. *Fruits* obovoid or turbinate, 4–5.5 × 1.5–2.5 mm, dark green, turning brown or blackish brown when dry, long hairy becoming glabrescent or glabrous with age, with persistent calyx. *Seeds* numerous, brown or blackish brown, flattened, narrowly elliptic, 1.3–3.5 × 0.3–0.7 mm (include wings), winged at both ends, acuminate at both ends or lower wing bifid.

Thailand.— NORTHERN: Mae Hong Son [along the road between Mae Sariang and Mae La Noi, 18 Sept. 1967, *Iwatsuki & Fukuoka T10334* (**BKF**, **L** [L2935391]); Mae Sam Laep, Sop Moei, 20 Jan. 1995, *Pooma 1010* (**BKF**); Pang Ma Pha, Tham Nam Lot Wildlife Conservation Development and Extension Station, 25 Sept. 1999, *Sanitjan 11* (**L** [L2935372]); Tham Pla-Namtok Pha Suea NP, Mueang Mae Hong Son, 20 Nov. 2013, *Lakoet 0564* (**BKF**); Chiang Mai [Huai Kaeo, 22 Jan. 1981, *Forestry's student s.n.* (**BKF** [72299]); Doi Suthep, Mueang Chiang Mai, 1 Oct. 1988, *Maxwell 88-1145* (**BKF**, **L** [L2935378]); Chiang Dao, 30. Sept. 1989, *Maxwell 89-1165* (**L** [L2935345]); Pong Dueat Hot Spring, Mae Taeng, 14 Oct. 1990, *Maxwell 90-1154* (**A**, **L** [L2935392, L2935393, L2935394]); Huai Kaeo Arboretum, 6 Nov. 1993, *Pooma 714* (**BKF**); Mae On, 5 Oct. 1995, *Maxwell 95-826* (**BKF**); ibid., 5 Oct. 1995, *Maxwell 95-827* (**BKF**, **L** [L2935341, L2935342, L2935343]); Doi Inthanon, 11 Feb. 1998, *Konta & Khao-Iam 10994* (**BKF**); ibid., 11 Feb. 1998, *Konta et al. 4233* (**BKF**); Ban Mu Soe, Phrao, 10 Oct. 2003, *Wongprasert 0310-23* (**BKF**)]; Chiang Rai [Ban Mai Phattana, Nong Pa Ko Subdistrict, Mae Chan District, 25 Aug. 1985, *Maxwell 85-827* (**L** [L2924912], **P** [P03929800]) (misidentified as *M. diversifolia*); Doi Mae Salong, Mae Chan, 6 Nov. 1993, *Maxwell 93-1344* (**BKF**, **L** [L2935396, L2935397]); Mae Fa Luang, 24 Oct. 2006, *Maxwell 06-784* (**HUH** (**A**), **L** [L4188919, L4188920]); Phayao [Phu Sang NP, 16 Sept. 1997, *Sinbamrung SC15* (**BKF**)]; Nan [Doi Phu Kha, 26 Aug. 1938, *Somkhit 144* (**BKF**)]; Lampang [en route from Pang La to Huai Thak, Ngao, 24 Sept. 1967, *Shimizu et al. T10730* (**BKF**, **L** [L2935373]); Chae Son NP, Mueang Pan, 26 Sept. 1995, *Maxwell 95-807* (**BKF**, **L** [L2935344]); Phrae [18 June 1936, *Unknown 16* (**BKF**); Mae Yom NP, Song, 5 Nov. 1991, *Maxwell 91-959* (**L** [L2935347, L2935348, L2935349]); Kamphaeng Phet [Mae Wong NP, Khlong Lan, 3 km from HQ at km 68, 27 Aug. 1997, *van de Bult 28/70* (**BKF**, **L** [L2924871, L2924872]); Ban Salok

Bat, Salok Bat Subdistrict, Khanu Woralaksaburi District, 21 Feb. 2021, *Ngernsaengsaruay et al. Mr02-21022021* (**BKF**)]; Nakhon Sawan [Nong Pho Subdistrict, Takhli District, 21 Feb. 2021, *Ngernsaengsaruay et al. Mr03-21022021* (**BKF**)]; NORTH-EASTERN: Nong Bua Lam Phu [reported by Puff *et al.* (2021)]; Sakon Nakhon [Phu Phan NP, 30 km southwest of Sakon Nakhon city, 15 Nov. 1984, *Mitsuta et al. T-50476* (**HUH** (**A**), **BKF**)]; Maha Sarakham [reported by Puff *et al.* (2021)]; EASTERN: Nakhon Ratchasima [Pak Thong Chai District (cultivated in the parkway), 4 Dec. 2020, *Ngernsaengsaruay et al. Mr01-04122020* (**BKF**)]; SOUTH-WESTERN: Kanchanaburi [Khwae Noi River Basin, 6 July 1946, *Kostermans 1011* (**L** [L2935351, L2935352, L2935375]); ibid., 23 July 1946, *Kostermans 1307* (**L** [L2935386]); 26 Dec. 1961, *Phengklai 325* (**BKF**); Huai Ban Kao, Mueang Kanchanaburi, 10 Nov. 1971, *van Beusekom et al. 3612* (**BKF**, **L** [L2935354, L2935355]); Forest Research and Demonstration Center, Thong Pha Phum, 12 Dec. 1995, *FRDU & van Welzen 29* (**L** [L2935370, L2935371]); Mar. 1998, *Chayamarit 1282* (**BKF**); roadside to Pilok mine, Sai Yok Yai Waterfall, Sai Yok NP, Thong Pha Phum, 28 Aug. 1999, *Chayamarit et al. 1820* (**BKF**); Ban Wang Kamen, Sai Yok, 23 Sept. 2000, *Phengklai et al. 14018* (**BKF**); Ratchaburi [reported by Puff *et al.* (2021)]; CENTRAL: Lop Buri [Chai Badan, 25 Aug. 1945, *Banthoengsung 12* (**BKF**); Ban Fai Phatthana, Khao Laem Subdistrict, Chai Badan District, 22 Feb. 2021, *Ngernsaengsaruay et al. Mr04-22022021*, *Mr05-22022021*, *Mr06-22022021* (**BKF**); Niyom Chai Subdistrict, Sa Bot District, 22 Feb. 2021, *Ngernsaengsaruay et al. Mr07-22022021* (**BKF**)]; Bangkok [Royal Forest Department, Chatuchak (cultivated), n.d., *Smitinand 69* (**BKF**); ibid., 21 Jan. 1951, *Smitinand 614* (**BKF**)]; SOUTH-EASTERN: Chanthaburi [Khao Soi Dao, 18 June 1960, *Sangkhachand 17* (**BKF**)]; PENINSULAR: Chumphon [Namtok Kapo Forest Park, Hong Charoen Subdistrict, Tha Sae District, 17 Feb. 2012, *Sirimongkol et al. 301* (**BKF**); ibid., 27 Mar. 2021, *Ngernsaengsaruay et al. Mr08-27032021*, *Mr09-27032021*, *Mr10-27032021*, *Mr11-27032021*, *Mr12-27032021* (**BKF**)]; Surat Thani [Ban Na San, 6 Oct. 1955, *Phengnaren 482* (**BKF**); Phangnga [Khlong Nang Yon, Khura Buri, 29 Apr. 1973, *Geesink & Santisuk 5034* (**BKF**, **L** [L2924815, L2924816]) (misidentified as *M. hirsuta*)].

Distribution.— India (Darjeeling, Assam, Andaman Islands, Nicobar Islands), Bangladesh, Myanmar, China (Yunnan), Indochina.

Ecology.— In deciduous dipterocarp forest, mixed deciduous forest, secondary forest, disturbed open areas, along roadsides, lowlands, freshwater swamp forest, along the edge of dry evergreen forest and lower montane rain forest, near above mean sea level up to 1,150 m alt.

Phenology.— Flowering August–November (–February); fruiting September–February.

Vernacular.— Kra thom mu (กระท่อมหมู) (Surat Thani); kra thum noen (กระทุ่มเนิน) (Ratchaburi); kra thum mu (กระทุ่มหมู) (Surat Thani); kaen lueang (แก่นเหลือง), tum kwao (ตุ้มกว้าว) (Northern); thom mu (ท่อมหมู) (Surat Thani); thum khi mu (ทุ่มขี้หมู) (Peninsular).

Uses.— The wood is locally used in construction, and for making farming utensils, firewood, and charcoal. Cultivated as shade and ornamental trees.

IUCN conservation status.— This species is widely distributed from India to Indochina, and has a large extent of occurrence (EOO of 2,555,167.15 km^2) and area of occupancy (AOO of 172 km^2). Because of this and the fact that it grows in secondary vegetations and disturbed open areas, it is assessed here as Least Concern (LC).

Notes.— Ridsdale (1978) cited *Roxburgh s.n.* (**BM**) as the type of this species. Two sheets of Roxburgh's specimens are located at **BM** [BM000945040, BM000945041]. There is a "lectotype" determination slip made by Ridsdale in 1975 on the former sheet while the latter sheet has a slip written as "? Lectotype" by Ridsdale in 1974. This means Ridsdale's selection of the type is considered as a first step lectotypifcation. The specimen BM000945040 contains the original label in which the specific epithet *rotundifolia* was written by Roxburgh himself and it was designated as a lectotype on the sheet by Ridsdale without any question mask. Thus, this specimen is selected here by C. Ngernsaengsaruay as the unicate lectotype.

The shapes of leaves of this species are orbicular, broadly elliptic and broadly ovate, the length of leaves is up to 25 cm, the width of leaves is up to 20 cm (Puff *et al.* 2021). In addition, from our study, we found the laminas are more variable in shape including elliptic, elliptic-oblong, obovate,

elliptic-obovate, pentagonal-like-obovate, ovate and sub-orbicular, the length of leaves is up to 36.5 cm, the width of leaves is up to 29.5 cm. The diameter of flowering heads of this species is up to 1 cm, the angle of secondary veins is 30°–50° (Puff *et al.* 2021), but we found the flowering heads 2–2.5 cm in diam., the angle of secondary veins 30°–75° in this study.

The natural distribution in Chiang Rai, Phayao, Lampang, Nakhon Sawan, Sakon Nakhon, Nakhon Ratchasima, Lop Buri, Chanthaburi, Chumphon and Phangnga are newly recorded here. It grows mainly in lowlands, at 10–500 m alt. (Puff *et al.*, 2021), but the specimen *Maxwell 93-1344* was collected from lower montane rain forest, at 1,150 m alt.

4. Mitragyna speciosa (Korth.) Havil., J. Linn. Soc., Bot. 33: 69. 1897.— *Stephegyne speciosa* Korth., Verh. Nat. Gesch. Ned. Bezitt., Bot.: 160. t. 35. 1842.— *Nauclea speciosa* (Korth.) Miq., Fl. Ned. Ind. 2: 140. 1856. Type: Indonesia, Borneo, Martapoera, n.d., *Korthals s.n.* (lectotype **L** [L0000744 digital image!] first step selected by Ridsdale (1978), second step selected here by C. Ngernsaengsaruay). Figs. 7 & 8.

— *Nauclea korthalsii* Steud., Nomencl. Bot., ed. 2, 2: 186. 1841, **nom. inval.**

— *N. luzoniensis* Blanco, Fl. Filip., ed. 2: 102. 1845. Type: not known.

Briefly deciduous or evergreen tree, 5–33 m tall, up to 190 cm girth, sometimes buttressed; bark smooth or scaly, grey to greyish brown. *Leaves* opposite, decussate; laminas elliptic, narrowly elliptic, elliptic-oblong, ovate, sometimes obovate, 9–24 × 3.5–12.5 cm; apex acuminate, sometimes acute; base cuneate, obtuse, rounded, cordate, subcordate or truncate; margin undulate, sometimes distally unevenly dentate with 1–5 teeth on each side; chartaceous to subcoriaceous, dark green, glabrous or glabrescent above, paler, pubescent along veins or glabrescent below; midrib and secondary veins red, reddish green or pale green, raised below, secondary veins 10–17 pairs, 0.4–1.6 cm apart, departing from the midrib at an angle of 25°–85°, curving and connected in loops near the margin; tertiary veins distinctly scalariform; veinlets reticulate; petioles red, reddish green or pale green, 2–4.5 cm long, 1–3.5 mm in diam., shallowly grooved above, glabrescent; leaves turning yellow and falling off., *Domatia* present, densely hairy in the axil of secondary veins. *Stipules* interpetiolar, reddish green or green, keeled, elliptic, 3.5–6.5 × 1–2.5 cm; apex acute or obtuse; margin entire, glabrescent along ridge, with veins; inside with dense colleters interspaced with hairs at the base, colleters lanceolate. *Inflorescences* consisting of globose, many-flowered flowering heads, terminal on main and lateral branches, arrangement like simple or compound dichasia; flowering heads 3–4 cm in diam.; peduncle 0.3–1.3 cm long, glabrous; common receptacle densely long hairy. *Bracts* one pair, small, leaf-like, subtending flowering heads elliptic, 2.3–8(–15) × 1–6.8 cm; apex acuminate or acute; base cuneate or attenuate; margin undulate; petioles 1.3–4.6 cm long. *Interfloral bracteoles* keeled, spathulate or linear-spathulate, 5–6 × 0.3–2 mm, apical part ciliate. *Flowers* fragrant. *Calyx* pale green, tubular, 1–1.5 × 2.5–3 mm, glabrous on both sides, unevenly and shallowly (3–)5-lobed, lobes triangular, 0.3–0.7 × 1–1.5 mm; apex acute; margin ciliate. *Corolla* creamy white to pale yellow, turning dark yellow to orangish yellow with age, hypocrateriform, 5–6 × 2–3 mm, glabrous outside, densely long hairy at throat inside, hairs protruding from the corolla throat, 5-lobed, lobes narrowly elliptic, 3–4.5 × 1–2 mm; apical part involute and fused like toe box, glabrous outside, glabrescent inside, with a median vein. *Stamens* 5; filaments 0.3–0.5 mm long; anthers 1.7–2.2 mm long, protruding from the corolla throat. *Ovary* obovoid, 2–2.2 × 1.5–2.2 mm; style slender, 0.9–1.3 cm long, glabrous; stigma mitriform, 2.2–3 × 1–1.5 mm; apical part of style and stigma protruding from the corolla throat. *Fruiting heads* 1.5–2.7 cm in diam.; stalks 0.4–1.5 cm long, glabrous. *Fruits* obovoid or turbinate, 0.5–1 cm × 2–5 mm, green or dark green, turning brown or blackish brown when dry, glabrous, with persistent calyx. *Seeds* numerous, brown, flattened, narrowly elliptic, 3–4 × 0.3–0.6 mm (include wing), winged at both ends, acuminate at both ends or lower wing bifid.

Thailand.— NORTHERN: Chiang Rai [Mueang Chiang Rai (cultivated), 25 Feb. 2021, Ngernsaengsaruay & Leksungnoen own observation]; NORTH-EASTERN: Sakon Nakhon [Ban Nong Paen, Kham Bo, Waritchaphum (cultivated), 13 Mar. 2006, *McClatchey & Mokkamul WCM3802* (**BKF**)]; SOUTH-WESTERN: Ratchaburi (cultivated) [reported by Puff *et al.* (2021)]; Prachuap Khiri Khan [Bang Saphan

Figure 7. *Mitragyna speciosa* (Korth.) Havil.: A. habitat and habit; B. buttress; C. leafy branches; D. interpetiolar stipules, keeled; E. flowering heads; F. fruiting head; G. dried fruiting head. Photographed by Chatchai Ngernsaengsaruay.

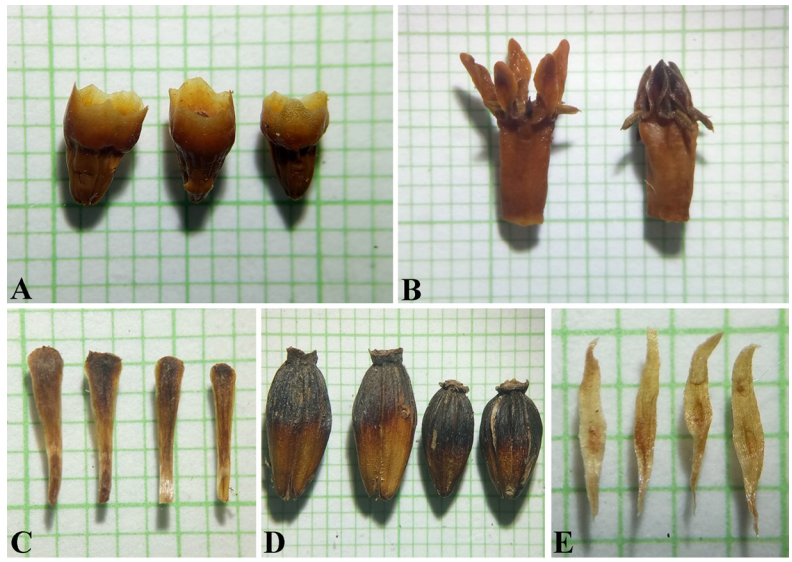

Figure 8. *Mitragyna speciosa* (Korth.) Havil.: A. calyces; B. flowers showing corollas and stamens; C. interfloral bracteoles; D. fruits with persistent calyx rim; E. seeds (include wings). Photographed by Weereesa Boonthasak.

(cultivated), 30 June 1920, *Winit 573* (**BKF**)]; CENTRAL: Phra Nakhon Si Ayutthaya [Chiang Rak Noi Subdistrict, Bang Pa-in District (cultivated), 26 Sept. 2021, *Ngernsaengsaruay et al. Ms01-26092021*, *Ms02-26092021*, *Ms03-26092021*, *Ms04-26092021*, *Ms05-26092021* (**BKF**); Pathum Thani [Sam Khok (cultivated), 20 Mar. 2001, *Champhuak 013-02* (**BKF**)]; Bangkok [cultivated, July 1924, *Kerr s.n.* (**P** [P04935362]); cultivated, Jan. 1951, *Smitinand 70* (**BKF**); PENINSULAR: Chumphon [Namtok Ngao NP (cultivated), 23 Jan. 2005, *Gardner & Sidisunthorn ST2768* (**BKF**)]; Ranong [Nakha Subdistrict, Suk Samran District (cultivated), 21 Oct. 2021, *Ngernsaengsaruay et al. Ms06-21102021*, *Ms07-21102021*, *Ms08-21102021*, *Ms09-21102021*, *Ms10-21102021* (**BKF**); Surat Thani [Ban Ta Khun, tree common along river bank, 16 Aug. 1955, *Smitinand s.n.* (**BKF**); Khlong Sok, Phanom District, 10 Sept. 2019, *John Howes Cat. no. 51115747* (iNaturalist research-grade) (**GBIF**); Ban Wang Lo, Na San Subdistrict, Ban Na San District, two largest trees, 33 m tall, 190 cm girth and 31.5 m tall, 174 cm girth, respectively, 25 Mar. 2021, Ngernsaengsaruay *et al.* own observation]; Phangnga [Khura Buri (cultivated), 10 Dec. 2003, *Pooma et al. 3765* (**BKF**)]; Nakhon Si Thammarat [cultivated, Ngernsaengsaruay own observation]; Satun [Tham Kop, Khao Banthat Wildlife Sanctuary, Manang District, reported by Narcotic Crops Survey and Monitoring Institute, Office of the Narcotics Control Board, Ministry of Justice (2019)].

Distribution.— Peninsular Malaysia, Indonesia (Sumatra), Borneo, Philippines, New Guinea.

Ecology.— Mostly in tropical lowland evergreen rain forest, often in wet places along streams, along river banks, near above mean sea level up to 200 m alt. In Peninsular Malaysia, Wong (1989) reported the species in lowland forest especially near streams and swamps.

Phenology.— Flowering and fruiting nearly all year round.

Vernacular.— Kra thom (กระท่อม) (Central); thom (ท่อม) (Peninsular); i thang (อีถ่าง) (Central); gium (Vietnam); beinsa, beinsaywat (Myanmar); biak, biak-biak, ketum, kutum, sepat (Malaysia); kadamba, puri (Indonesia); lugub, mambog, polapupot (Philippines); krathom (common name).

Uses.— This species has been traditionally used in various purposes, as a mild stimulant, an antidiarrheal, an antidiabetic, a treatment for pain, a cough suppressant, a treatment for stomachaches, an intestinal deworming agent, a wound poultice, a treatment for fever, a substitute for opium. In southern Thailand, the fresh leaves are chewed or brewed into

tea; the dried leaves are occasionally smoked or made into powder and drunk as tea. Local people consume the leaves for their opium-like effect and cocaine-like stimulant ability to enhance tolerance to hard work. Krathom has gained popularity as a recreational drug, due to its narcotic-like effects, producing feelings of euphoria (Puff *et al.*, 2021; Narcotic Crops Survey and Monitoring Institute, Office of the Narcotics Control Board, Ministry of Justice, 2019).

IUCN conservation status.— Least Concern (LC) (IUCN, 2022). This species is widely distributed in Malaysia Peninsula with the northern limit in Surat Thani Province (Peninsular Thailand), Sumatra, Borneo, Philippines and New Guinea, and has a large extent of occurrence (EOO of 6,037,059.01 km^2) and area of occupancy (AOO of 148 km^2). It is appropriate to consider its status as LC.

Notes.— Ridsdale (1978) cited *Korthals s.n.* (**L**) from Borneo as the type of *Mitragyna speciosa.* As there are four different Korthals's *M. speciosa* specimens at **L** [L0000744, L0000745, L0000746, L0000747], Ridsdale's designation of **L** collection constituted the first step lectotypification. Here, the specimen L0000744 is selected by C. Ngernsaengsaruay as the unicate lectotype because it is in the best condition and matches with the description of *Stephegyne speciosa*, the oldest validly published homotypic synonym [basionym] of *Mitragyna speciosa*. Three other sheets at **L** and another sheet at **K** [K000729975] remain Korthals' original material and but could not be isolectotypes as we have not yet been able to prove that these specimens were from the same collection.

The Narcotic Crops Survey and Monitoring Institute, Office of the Narcotics Control Board, Ministry of Justice (2019), Royal Institute (2003) and local people in southern Thailand (from interview data) reported that there are 3 different types of krathom, *Mitragyna speciosa*: (1) kan daeng, means red veins and petioles (2) kan khiao (taeng kwa), means pale green veins and petioles, and (3) hang kang (yak yai), means the apical part of leaves is unevenly dentate with bigger leaves. From our field observations, we realized the difference in colour depends on age of the leaves, as two (red and green veins and petioles) or three types were found in the same plant. The young leaves (at least the midrib and secondary veins), and sometimes also the stipules are reddish, turning green with maturity. Also, we found apical part of leaves unevenly dentate or not dentate in a same plant. We are still uncertain to conclude that *M. speciosa* has 3 or more varieties, but we consider that these differences are only infraspecific variation instead of different varieties.

The reproductive parts (fruiting heads, interfloral bracteoles, calyx tube, corolla tube, corolla lobes, stigma, fruiting heads, and fruits) of *M. speciosa* are usually larger than other three species.

This species is a tree up to 25 m tall (Puff *et al.*, 2021), but from our field observations and examined specimens, it can reach 33 m tall. Puff *et al.* (2021) reported the shapes of leaves of this species are elliptic, ovate and obovate, the length of leaves is up to 17 cm. Furthermore, from our study, we found the laminas are more in shape including narrowly elliptic and elliptic-oblong, the length of leaves is up to 24 cm. The diameter of flowering heads of this species is 0.9–1.3 cm, the angle of secondary veins is 20°–60° (Puff *et al.* 2021), but we found the flowering heads 3–4 cm in diam., the angle of secondary veins 25°–85° in this study.

The natural distribution in Surat Thani and Satun are newly recorded here. We found two large trees, with 33 m tall and 190 cm girth and with 31.5 m tall and 174 cm girth in Ban Wang Lo, Na San Subdistrict, Surat Thani Province. At present, authorities in Thailand allow krathom to be cultivated, and we believe that krathom will grow throughout the country for its leaves.

DISCUSSION

Morphological comparison of Thai *Mitragyna*

For the classification of Thai *Mitragyna*, flowers are necessary, because their vegetative characters are variable and often overlap between species (Puff *et al.*, 2021). The comparison of morphological characteristics is shown in Table 1. The summary of key characters of four species are: (1) *M. diversifolia* is characterized by its smallest flowering head less than 2 cm in diam. (vs more than 2 cm in diam. in the other three species); (2) *M. hirsuta* can be easily distinguished by its calyx lobes longer than 1.5 mm (vs shorter than 0.7 mm in the other three species); (3) *M. rotundifolia* is very similar to *M. hirsuta*, but

it differs in shape, length and apex of calyx lobes; (4) *M. speciosa* has larger flowering heads 3–4 cm in diam. (vs less than 2.5 mm in diam. in the other three species), peduncle glabrous (vs densely pubescent), longer interfloral bracteoles 5–6 mm long (vs less than 3.5 mm long), broader calyx tube 2.5–3 mm wide (vs less than 1.5 mm wide) and larger corolla tube 5–6 mm long, 2–3 mm wide (vs less than 4 mm long, 1.5 mm wide).

We undertook extensive field surveys throughout the country and examined specimens in various herbaria. As a result, we here update full detailed descriptions of four *Mitragyna* species in Thailand. Puff *et al.* (2021) used shape and length of calyx lobes, length of interfloral bracteoles in young flowering heads, length of entire calyx and ovary, size of leaves, number of pairs of secondary veins, and angle of secondary veins construct a key to the species, but for our study, we found number of pairs of secondary veins and angle of secondary veins are overlap between species (see Table 1 and descriptions), do not provide characters for identification within the genus. In this paper, we use several significant characteristics in key to the species, i.e. diameter of flowering heads, length of interfloral bracteoles, width of calyx tube, shape, length and apex of calyx lobes, size of corolla tube, length of fruits, size of leaves, spacing of the secondary veins, and indumentum of petiole and peduncle.

Distribution of *Mitragyna* in Thailand

Distribution of the genus *Mitragyna* in Thailand and surrounding areas are summarized in Table 2 and Fig. 9. Based on our survey, we could show more detailed distribution for Thai four *Mitragyna* species, which is wider than previously known (Puff *et al.*, 2021). Two species, *M. diversifolia* and *M. rotundifolia*, have a wide distribution in all floristic regions in Thailand (Fig. 9A and 9C, respectively) but mostly occur in different habitats (see ecology). *Mitragyna hirsuta* is found in almost all the country except in the Peninsular and the Central Regions (Fig. 9B). The habitat preference of *M. hirsuta* is mostly similar to *M. rotundifolia* in being found in deciduous dipterocarp forest, mixed deciduous forest, secondary forest, disturbed open areas, along roadsides. The natural distribution of *M. speciosa* is confined to the Peninsular Region (Fig. 9D), but it is cultivated throughout the country. Puff *et al.* (2021) recorded its distribution in Ratchaburi, SW Thailand but we consider this as cultivated population.

Table 2. Distribution of the genus *Mitragyna* in Thailand and surrounding areas.

Species	Thailand Floristic Regions							Surrounding areas
	N	NE	E	SW	C	SE	PEN	
M. diversifolia	×	×	×	×	×	×	×	Myanmar, China (Yunnan), Indochina, Peninsular Malaysia, Indonesia (Java), Philippines
M. hirsuta	×	×	×	×		×		Myanmar, China (Yunnan), Indochina
M. rotundifolia	×	×	×	×	×	×	×	India (Darjeeling, Assam, Andaman Islands, Nicobar Islands), Bangladesh, Myanmar, China (Yunnan), Indochina
M. speciosa							×	Peninsular Malaysia, Indonesia (Sumatra), Borneo, Philippines, New Guinea

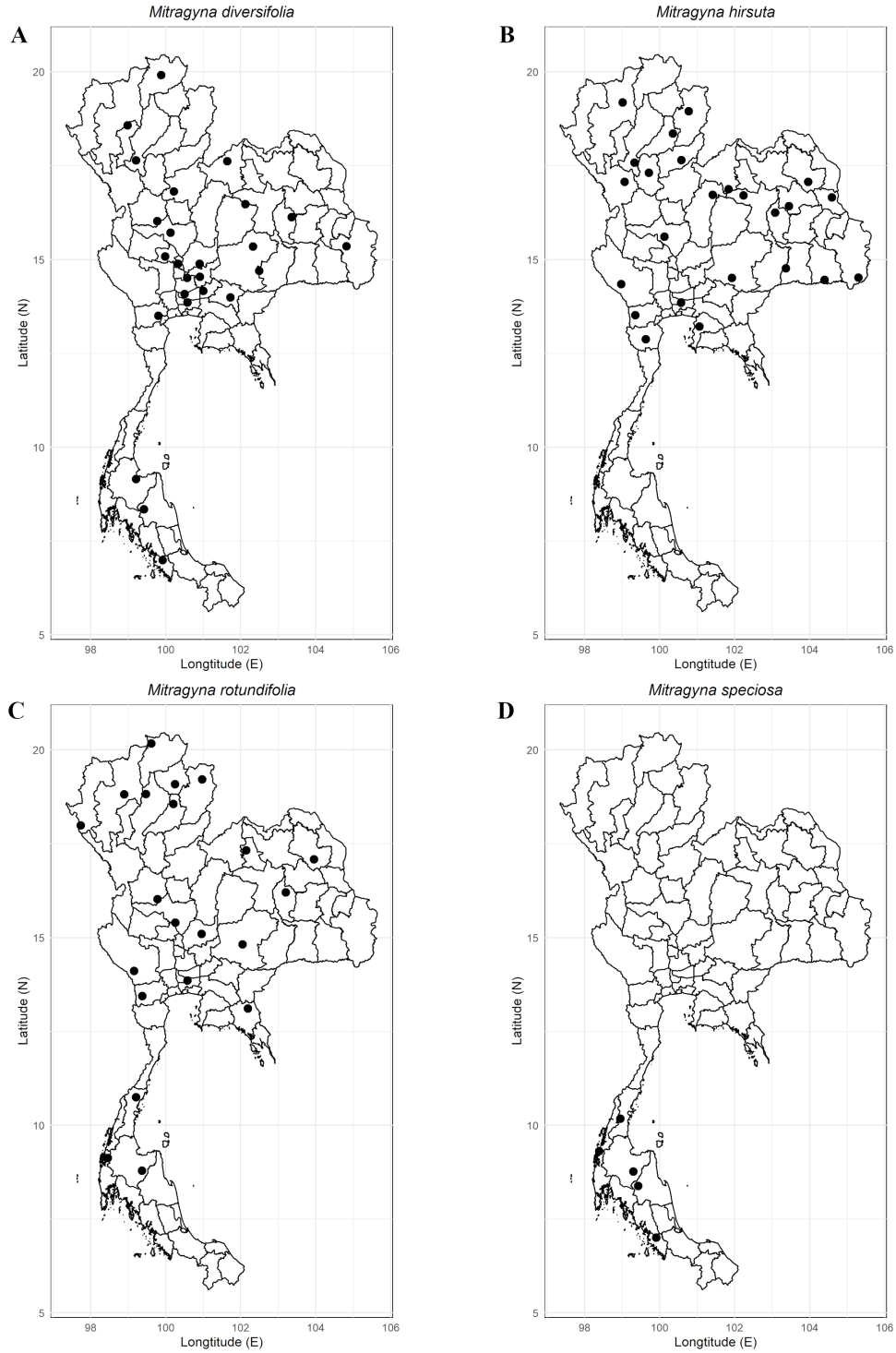

Figure 9. Distribution of the genus *Mitragyna* in Thailand: A. *Mitragyna diversifolia* (Wall. ex G.Don) Havil.; B. *Mitragyna hirsuta* Havil.; C. *Mitragyna rotundifolia* (Roxb.) Kuntze; D. *Mitragyna speciosa* (Korth.) Havil.

ACKNOWLEDGEMENTS

We are grateful to the curators and staff of the BKF for their assistance during visits and allowing access to the herbarium specimens, and also digital herbarium databases, BM, E, HUH (A), K, K-W, L, and P. We would like to thank Mr. Nattanon Meeprom for making distribution maps for four species of *Mitragyna* in Thailand. This work was financially supported by Science, Research and Innovation Promotion Fund of the Thailand Science Research and Innovation (TSRI) through Kasetsart University Research and Development Institute (KURDI). Project No. FF(KU)9.64.

REFERENCES

Bremer, B., Andreasen, K. & Olsson, D. (1995). Subfamilial and tribal relationships in the Rubiaceae based on *rbcL* sequence data. Annals of the Missouri Botanical Garden 82(3): 383–397.

Gledhill, D. (2002). The Names of Plants. 3rd ed. Cambridge University Press, UK. 326 pages.

Govaerts, R., Ruhsam, M., Andersson, L., Robbrecht, E., Bridson, D., Davis, A., Schanzer, I. & Sonk, B. (2021). World Checklist of Rubiaceae. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet, http://wcsp.science.kew.org/. Retrieved 7 August 2021.

IUCN Standards and Petitions Committee (2019). Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. http://www.iucnredlist.org/documents/RedListGuidelines.pdf. Accessed 19 August 2021.

IUCN (2022). The IUCN Red List of Threatened Species. Version 2021-3. http://www.iucnredlist.org/. Accessed 10 January 2022.

Löfstrand, S.D., Krüger, Å., Razafimandimbison, S.G. & Bremer, B. (2014). Phylogeny and generic delimitations in the sister tribes Hymenodictyeae and Naucleeae (Rubiaceae). Systematic Botany 39(1): 304–315.

Narcotic Crops Survey and Monitoring Institute, Office of the Narcotics Control Board, Ministry of Justice (2019). Academic documents on Krathom: utilization of local wisdom and research on Krathom (in Thai). Trio Advertising & Media Co. Ltd., Chiang Mai. 172 pages.

Pooma, R. & Suddee, S. (eds) (2014). Thai Plant Names, Tem Smitinand, Revised Edition 2014. Office of the Forest Herbarium,Department of National Parks, Wildlife and Plant Conservation, Bangkok. 806 pages.

Poopath, M., Karaket, P., Khammongkol, K. & Jirakorn, S. (2018). Lowland Flood Plain Forest, Northeastern (in Thai). Prachachon Co. Ltd., Bangkok. 499 pages.

POWO (2019). Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet, http://www.plantsoftheworldonline.org/. Retrieved 4 August 2021.

Puff, C., Chayamarit, K., Chamchumroon, V. & Esser, H.J. (2021). Rubiaceae (Genera 1–45). In: K. Chayamarit & H. Balslev (eds), Flora of Thailand Vol. 15 Part 1: 1–235. Prachachon Co. Ltd., Bangkok.

Radcliffe-Smith, A. (1998). Three-Language List of Botanical Name Components. Whitstable Litho Ltd., Whistable, Kent, United Kingdom. 143 pages.

Razafimandimbison, S.G. & Bremer, B. (2002). Phylogeny and classification of Naucleeae *s.l.* (Rubiaceae) inferred from molecular (ITS, *rbcL*, and *trnT-F*) and morphological data. American Journal of Botany 89(7): 1027–1041.

Ridsdale, C.E. (1978). A revision of *Mitragyna* and *Uncaria* (Rubiaceae). Blumea 24(1): 43–100.

Royal Institute. (2003). Plant Taxonomy the First Letter of the Thai Alphabet (in Thai). Arun Press, Bangkok. 523 pages.

Stearn, W.T. (1992). Botanical Latin: History, Grammar, Syntax, Terminology and Vocabulary. 4th edition. Redwood Books, Trowbridge for David & Charles Publishers, England. 546 pages.

WCSP (2021). World Checklist of Selected Plant Families. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet, http://wcsp.science.kew.org/. Retrieved 8 August 2021.

Wong, K.M. (1989). Rubiaceae. In: F.S.P. Ng (ed.), Tree Flora of Malaya Vol. 4, pp. 324–425. Art Printing Works Sdn. Bhd., Kuala Lumpur, Malaysia.