



The Genus *Butea* (Leguminosae-Papilionoideae) in Thailand

Sakuntala Ninkaew and Pranom Chantaranotha

Applied Taxonomic Research Center
 Author for Correspondence; e-mail: [redacted]

[redacted]
 Sakuntala Ninkaew and Pranom Chantaranotha

Khon Kaen 40002, Thailand.

[redacted]

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ABSTRACT

A taxonomic revision of the genus *Butea* in Thailand is presented. Two species, *B. monosperma* and *B. superba* are enumerated. Key to species, descriptions, distributions and vernacular names are given. The habit, bark, the length of anthers, an outline and ridge of petiole, shape of epidermal cells on adaxial surface and crystal types are characteristics that could be complementary for species identification. The pollen morphology is, however, not taxonomically useful for identification at specific level.

Keywords: *Butea*, leaf anatomy, Leguminosae, pollen morphology, Thailand, taxonomy

1. INTRODUCTION

Butea (Leguminosae-Papilionoideae) is a small genus comprising two species and it is mainly distributed in Southeast Asia from sea level up to 1,000 m, predominantly in dry habitats and the habit is the most important characteristic for species identification [1]. The genus is closely related to *Kunstleria*, *Meizotropis* and *Spatholobus* but it differs in the number of leaflets, the shape of the pod and the flower [2].

The leaflet anatomy of *Butea* was studied and described by a number of authors [3-5]. The basal cell of the hair is absent in the palisade layer. The glandular hairs consist of a multicellular head with 2-6 cells and a stalk with 1-2 cells. The stomata are found only on the abaxial surface. Tannin is presented between the phloem and xylem and in the bundle sheath [3]. Secretory elements were also found in the pith and phloem [4]. Moreover, uniseriate hairs and paraveinal mesophyll were

reported in *B. monosperma* [5].

The pollen grains of *Butea*, *Kunstleria*, *Meizotropis* and *Spatholobus* are isopolar, tricolporate and sometimes parasyncolporate. The ectoapertures are distinct colpi with obtuse or acute ends. The nexine is thinner to distinctly thicker than the sexine. The foot layer is less than 1/10 to twice as thick as the endexine. The infratectum usually consists of indistinct, short, irregular granule-like columellae or (coarse) granules, and sometimes the columellae are distinct. The pollen differs from each other in ectoaperture morphology, exine sculpturing and slightly in size [6].

The aim of this study is to contribute knowledge of taxonomy, leaf anatomy and pollen morphology of *Butea* in Thailand.

2. MATERIAL AND METHODS

Specimens from field collections in Thailand and the herbaria ABD, BCU, BK,

BKF, BM, C, CMU, E, K, KKU, PSU, QBG and Herbarium Department of Biology, Chiang Mai were consulted, All voucher specimens were deposited at KKU.

Fresh leaves were fixed in 70% alcohol. For epidermal studies, samples were prepared by mechanical scraping at midway between the base and apex of a mature lamina, stained with safranin O and then mounted with DePeX artificial mounting medium. Transverse sections (TS) of petioles, midribs, leaf margins and middle part between the midrib and margin of the lamina were sectioned using a sliding microtome and stained with safranin O and fast green. Photographs were taken with the aid of an Olympus BH₂ light microscope.

Pollen samples were obtained from field collections and examined by light microscopy (LM) and scanning electron microscopy (SEM). Pollen was prepared by acetolysis [7]. For LM, pollen was mounted in silicone oil and sealed with paraffin. At least 10 pollen grains per species were used to measure the polar axis (P), equatorial axis (E), exine thickness (EX), colpus length (CL) and colpus width (CW). For SEM, pollen was suspended in a drop of absolute alcohol, then transferred to stubs and coated with gold-palladium mixture. Photomicrographs were taken with Leo 1450VP SEM. The terminology follows Erdtman [7].

3. RESULTS

3.1 Taxonomic Treatment

Butea Roxb. [Asiat. Res. 3: 469. 1792, Pl. Coromandel 1: 22, t. 21. 1795] ex Willd., Sp. Pl. 3: 917. 1802; DC., Prodr. 2: 414. 1825; Kuntze, Rev. Gen. Pl. 1: 202. 1891 & in Engl. & Prantl, Nat. Pflanzenf. 3(3): 365. 1894; Prain, Bull. Misc. Inform., Kew 9: 385. 1908; Baudet, Bull. Jard. Bot. Nat. Belg. 48: 210. 1978; Sanjappa, Bull. Bot. Surv. India 29(1-4): 202. 1987.
— *Plaso* Adans., Fam. Pl. 2: 325. 1763.

Trees or woody climbers. **Leaves** alternate, pinnately trifoliate; rachis pulvinate, infrajugal

rachis longer than ultrajugal rachis; terminal leaflet larger than lateral leaflets; stipules triangular; stipels present. **Inflorescence** axillary or terminal, racemose; bracts triangular; bracteoles absent. **Flowers** papilionaceous, usually orange-red or orange-yellow, sometimes yellow. **Calyx** cup-shaped, green, 4-lobed, tomentose, connate at base. **Corolla**: standard ovate, densely silverly pubescent without, glabrous or sparsely silverly pubescent within, strongly reflexed during anthesis; wing petals equal to or slightly longer than standard, falcate, reflexed, oblong or lanceolate, pubescent on both surfaces; keel petals connate along the ventral margin, elliptic, densely silverly pubescent without, densely silverly pubescent at margin within. **Stamens** diadelphous (9+1), vexillary stamen short and free; filaments glabrous, pubescent at base; anthers uniform. **Ovary** stipitate. **Pods** a samara, oblong. **Seeds** reniform, glabrous.

Key to the species

1. Tree; anthers less than 3 mm long
..... **1. B. monosperma**
Woody climber; anthers more than 3 mm long
..... **2. B. superba**

1. *Butea monosperma* (Lam.) Taub. in Engl. & Prantl, Nat. Pflanzenf. 3(3): 366. 1894.

— *Erythrina monosperma* Lam. in Encycl. 2: 391. 1790. Type: India, Malabar, *Herb. Lamarck* (P-microfische).

— *B. frondosa* Roxb. [Asiat. Res. 3: 469. 1792 & Pl. Coromandel 1: 21, t. 21. 1795] ex Willd., Sp. Pl. 3: 917. 1802, *nom. superfl.* Type: as *E. monosperma*.

— *Rudolphia frondosa* (Roxb. ex Willd.) Poir, Encycl. 6: 333. 1804.

— *B. braamaina* DC., Prodr. 2: 445. 1825. Type: Bohte's Icones Plantarum Sponte China nacentium e bibliotheca Braamiana excerptae: t. 23. 1821.

— *Plaso monosperma* (Lam.) Kuntze, Rev. Gen. Pl. 1: 202. 1891.

— *P. monosperma* (Lam.) Kuntze var. *flava* Kuntze, Rev. Gen. Pl. 1: 202. 1891. Type: not located

— *P. monosperma* (Lam.) Kuntze var. *rubra* Kuntze, Rev. Gen. Pl. 1: 202. 1891. Type: not located

— *B. frondosa* Roxb. ex Willd. var. *lutea* Witt, For. Fl. Berar Cir.: 75. 1956. Type: India, Maharashtra, Yeotmal Division, Kharbi, alt. 900, 17 Mar. 1909, C.G. Rogers s.n. (CAL).

— *B. monosperma* (Lam.) Taub. var. *lutea* (Witt) Mahesh, Bull. Bot. Surv. India 3: 92. 1961.

Tree, 8-10 m high; bark dark grey, fissured. **Leaves:** infrajugal rachis 7.5-29 cm long, rounded, brown tomentose; ultrajugal rachis 4.5-8 cm long; petiolules 7-10 mm long; terminal leaflet obovate, 16-23.5 x 11.5-16 cm, base cuneate, apex truncate, margin entire; lateral veins 8-9 pairs; lateral leaflets ovate, 11.5-20.5 x 8.5-13 cm, base cuneate, apex truncate, margin entire; lateral veins 6-9 pairs; stipules triangular, 4-6 x 2-3 mm, pubescent, caducous; stipels 1-2 mm long. **Inflorescence** axillary or terminal, 22-55 cm long; peduncle 3-5 mm long; pedicels 3 cm long, tomentose; bracts 6-7 x 3-4 mm. **Flowers** 6-7 cm long, usually orange-red, orange-yellow or yellow. **Calyx** green, cup-shaped, 1.5-1.8 cm long. **Corolla:** standard ovate, 5.4-6.5 x 2.8-3 cm, densely silverly pubescent without, glabrous or sparsely silverly pubescent within, apex acuminate, margin entire; wing petals lanceolate, 6.3-7 x 1.3-1.5 cm, pubescent, base oblique, apex acute, margin entire, densely silverly pubescent without, sparsely silverly pubescent at base, apex and margin within; keel petals elliptic, 6.2-7.1 x 1.9-2.5 cm, base oblique, apex acute, margin entire, densely silverly pubescent at base, apex and margin without; densely silverly pubescent at base and margin within. **Stamens:** filaments 6-8.5 cm long; anthers elliptic to oblong, 1-2 x 1 mm. **Ovary** elliptic, 2-2.5 x 0.3-0.5 cm, silverly tomentose, tomentose at base; style 6-6.4 cm long. **Pods** 13.7-15 x 4-4.5 cm, brown pubescent. **Seeds** 3-4.5 x 2-2.5 cm. (figure 1a-c)

Thailand.— NORTHERN: Chiang Mai [20 Feb. 1960, *Bunchoo* 727 (BCU); Chiang Mai University, 16 Feb. 1988, *J.F. Maxwell* 88-188 (BK, CMU); Mae Rim, 20 Feb. 2002, *C. Glamvaewong* 155 (QBG); Muang, 14 Apr. 1992, *J.F. Maxwell* 92-144 (E); 5 Feb. 1911, *A.F.G. Kerr* 1663 (E)]; Chiang Rai [Thoeng, 10 Feb. 1970, *Satisorn* 1648 (BK)]; Lampang [Ngao, 8 May 1946, *Omnat* 32 (BKF)]; Tak [6 Feb. 1974, *C. Phengkklai* 3202 (BKF)]; Sukhothai [Khiri Mat, 26 Jan. 1974, *J.F. Maxwell* 74-103 (BK)]; NORTH-EASTERN: Phetchabun [Nam Nao National Park, 5 Mar. 2005, *S. Mattapha* 1013 (KKU); Srithep District, 6 Feb. 1997, *P. Trisarasri* 86 (BCU); Chon Daen, 26 Jan. 2010, *C. Maknoi* 3571 (QBG)]; Nong Khai [Seka, 28 Aug. 2001, *R. Pooma, W.J.J.O. de Wilde & B.E.E. Duyffjes* 2868 (BKF)]; Bueng Kan [Porn Charoen, 19 Mar. 2008, *M. Norsaengsri* 3520 (QBG)]; Sakon Nakhon [Phu Phan National Park, 11 Jan. 1999, *J. Leeratwong* 99-41 (KKU)]; Khon Kaen [Khon Kaen University, 18 Feb. 2007, *P. Krachai* 484 (KKU)]; EASTERN: Roi Et [Suwannapoom, 7 Jun. 1982, *Y. Paisooksantivatana & S. Sutbeesorn* Y 860-82 (BK)]; Ubon Ratchathani [4 Mar. 1996, *C. Niyomdham* 4593 (BKF)]; SOUTH-WESTERN: Prachuap Khiri Khan [Kaeng Krachan National Park, 20 Jan. 2004, *D.J. Middleton, R. Namdang, R. Pooma, S. Suddee, S. Suwanachat & K. Williams* 2275 (BKF, E)]; CENTRAL: Saraburi [Muang, 14 Apr. 1974, *J.F. Maxwell* 74-283 (BK)]; Tab Kwang, 12 Jan. 1974, *T. Santisuk* 747 (BKF)]; Nakhon Nayok [Khao Yai National Park, 16 Jan. 1985, *F. Konta, W. Nanakorn & T. Santisuk* T-49080 (BKF)]; Krung Thep Maha Nakhon [Bang Khen, 30 Jan. 1955, *M. Beenbralm* 20 (BK)].

Distribution.— Pakistan, India, Sri Lanka, Nepal, Myanmar, Cambodia, Laos, Vietnam, Indonesia, New Guinea.

Ecology.— Dry deciduous and mixed deciduous forests, open areas.

Vernacular.— Kwao (กวาว), Kao (ก่อ), Chom thong (จอมทอง), Cha (จ่า), Chan (จ่าน), Thong kwao (ทองกวาว), Thong thammachat (ทองธรรมชาติ),

Thong phrommachat (ทองพรมชาติ), Thong ton (ทองตัน).

2. *Butea superba* Roxb. [Asiat. Res. 3: 473. 1792 & Pl. Coromandel 1: 23, t. 22. 1795, *nom. invalid*] ex Willd., Sp. Pl. 3: 917. 1802. Type: Roxb., Pl. Coromandel 1: 23, t. 22. 1795.
— *Rudolphia superba* (Roxb. ex Willd.) Poir, Encycl. 6: 332. 1804.
— *Plaso superba* (Roxb. ex Willd.) Kuntze, Rev. Gen. Pl. 1: 202. 1891.

Woody climber, 8-12 m long; bark pale greyish brown, flaking. **Leaves:** infrajugal rachis 15-27 cm long; ultrajugal rachis 4.5-8 cm long; petiolules 1 cm long; terminal leaflet broadly ovate or orbiculate, 13-27 x 13.5-27 cm, base broadly obtuse, cuneate or obtuse, apex cuspidate, margin entire, tomentose on both surfaces when young; lateral veins 7-9 pairs; lateral leaflets ovate, 15-25.5 x 12-20 cm, base oblique, apex cuspidate, margin entire, tomentose on both surfaces; lateral veins 6-8 pairs; stipules 5-7 x 2-3 mm; stipels 3-5 mm long. **Inflorescence** terminal, racemose, 24-30.5 cm long; peduncle 2-4 mm long; pedicels 2.8-3 cm, tomentose; bracts 4-5 x 1-2 mm. **Flowers** 8-9 cm long, orange-red. **Calyx** 1-1.2 cm long. **Corolla:** standard ovate, 4-6.5 x 1.8-3 cm, densely silverly pubescent without, densely silverly pubescent only at base within, apex acute, margin entire; wing petals oblong, 4.5-7 x 1-1.2 cm, apex acute, base oblique, tomentose on both surfaces; keel petals elliptic, 6-6.5 x 1.5-2 cm, apex acute, base oblique, margin entire, densely silverly tomentose without, densely silverly tomentose at margin within. **Stamens:** filaments 6-8.5 cm long; anthers elliptic, 4-5 mm long. **Ovary** oblong 1.7-3 x 0.3-1 cm, densely tomentose; style 5.7-6 cm long, sparsely pubescent. **Pods** 11-19 x 2.9-4 cm, brown tomentose. **Seeds** 2.8-3.2 x 1.5-2 cm. (figure 1e-g)

Thailand.— NORTHERN: Mae Hong Son [Mae Sariang, 20 Feb. 2007, *S. Watbana* 2269 (QBG); Muang, 20 Feb. 1979, *T. Koyama*, *C. Phengklai*, *C. Niyombham*, *M. Tamura*, *H. Okada* & *P.J. Cornor* 15460 (BKF); Mae Sariang-Khun Yuam Road, 23 Feb. 1994, *R. Pooma* & *C. Phengklai* 796 (BKF); Khun Yuam, *Chusie* KY 328 (QBG); Chiang Mai [Mae Klang Waterfall, 1 Dec. 1965, *P. Sangkhabhand* 109 (BK); Mae Rim, 10 Feb. 1987, *R. Pooma* 19 (BKF)]; Nan [Wiang Sa, 12 Jan. 2004, *T. Seelananont et al.* 280 (BCU)]; Lampang [Doi Khun Tan National Park, 29 Nov. 1994, *J.F. Maxwell* 94-1329 (BKF); Wang Nua, 7 Feb. 1991, *J.F. Maxwell* 91-129 (CMU)]; Phrae [Mae Yom National Park, 15 Oct. 1991, *J.F. Maxwell* 91-907 (E)]; Tak [Tee Lor Zu Waterfall, 17 Jan. 2004, *S. Mattapha* 544 (KKU)]; Khamphaeng Phet [50 km, East of Kamphaeng Phet, *T. Sørensen*, *K. Larsen* & *B. Hansen* 6652 (BKF, E)]; Nakhon Sawan [Tha Tako, 14 Jan. 1965, *Sakol* 331 (BK)]; NORTH-EASTERN: Sakhon Nakhon [Phu Phan National Park, 12 Feb. 1999, *J. Leeratwong* 99-40 (KKU)]; Khon Kaen [Phu Wiang, 5 Feb. 1931, *A.F.G. Kerr* 20000 (ABD, BK, E)]; Maha Sarakham [11 Sept. 1972, *S. Sutheesorn* 2162 (BK)]; SOUTH-WESTERN: Kanchanaburi [Khao Wang Khamen (Sai Yok), 28 Jan. 1999, *W. Chatan* 196 (BCU); Pong Phu Ron (Thong Pha Phum), 13 Dec. 2001, *P. Darumas et al.* 36 (BCU), 2 Jan. 2002, *P. Darumas et al.* 154 (BCU); Srisawat, 13 Jan. 1926, *A.F.G. Kerr* 10201 (ABD, BK, E); Sangkhlaburi, 24 Feb. 1973, *C.P.*, *B.N.* & *S.S.* 3038 (BKF); 14 Jan. 1994, *J.F. Maxwell* 94-50 (BKF)]; CENTRAL: Saraburi [Kaeng Khoi, 3 Feb. 2005, *P. Darumas et al.* 7 (BCU); Muak Lek, 18 Jan. 1916, *T. Santisuk* 500 (BKF); Tha Thung Na, 13 Feb. 1959, *B.S.* 785 (BKF); 15 Jan. 1960, *L.B.*, *L.B.*, *E.C. Abbe* & *T. Smitinand* 9479 (BKF)]; SOUTH-EASTERN: Chon Buri [Sriracha, 13 Jan. 1928, *D.J. Collins* 1967 (ABD, BK, E), 28 Jan. 1975, *J.F. Maxwell* 75-49 (BK)]; Chanthaburi [Pong Nam Ron, 22 Jan. 1958, *Dee* 1047 (BKF); Khao Soi Dao, 7 Feb. 1966, *K. Imatsuki* & *N. Fukuoka* T-7100 (BKF)].

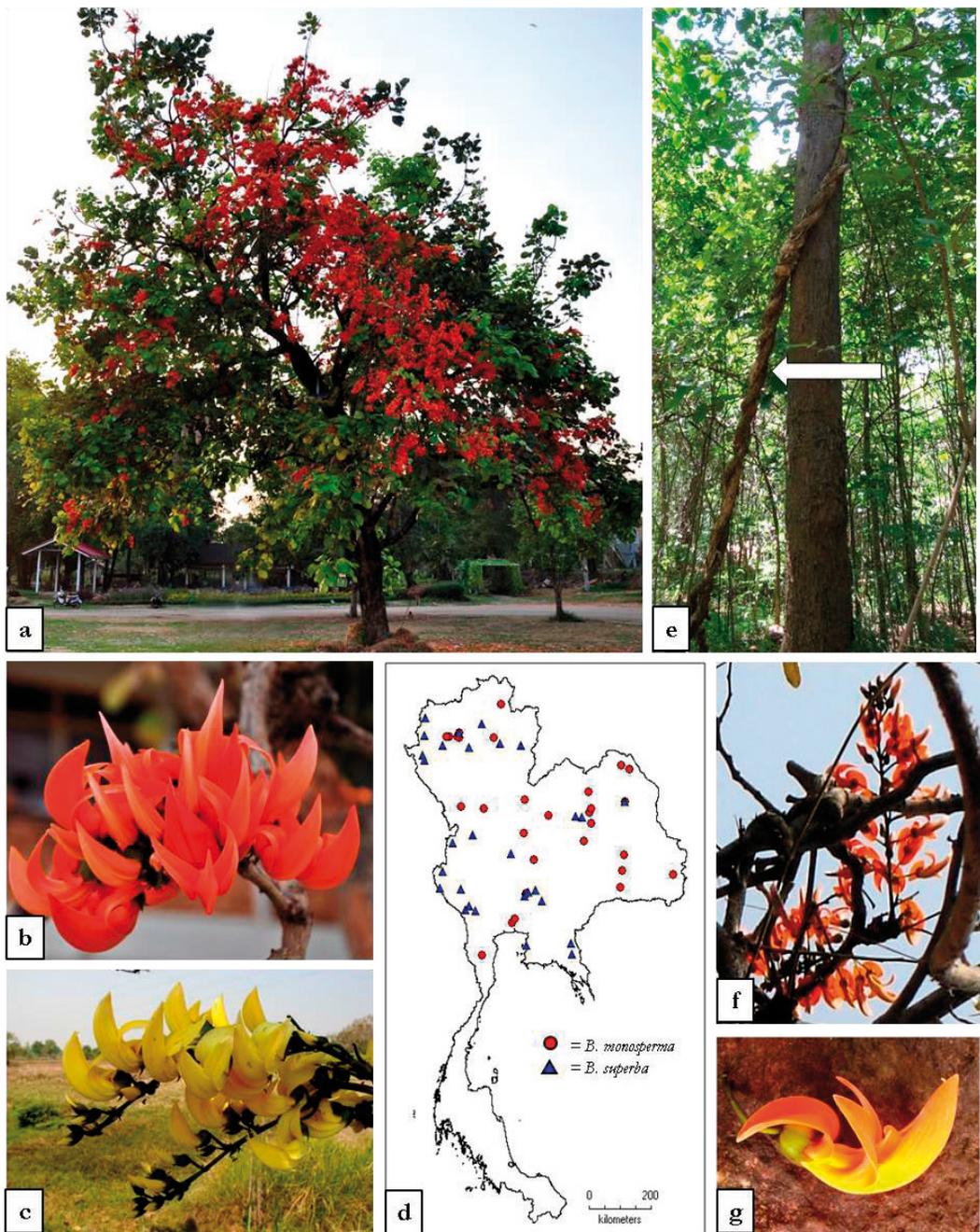


Figure 1. *B. monosperma* (a-c); habit (a); inflorescence (b and c); distribution of genus *Butea* in Thailand (d); *B. superba* (e-g); habit (white arrow) (e); inflorescence (f); flower (g) (f-photographed by C. Maknoi).

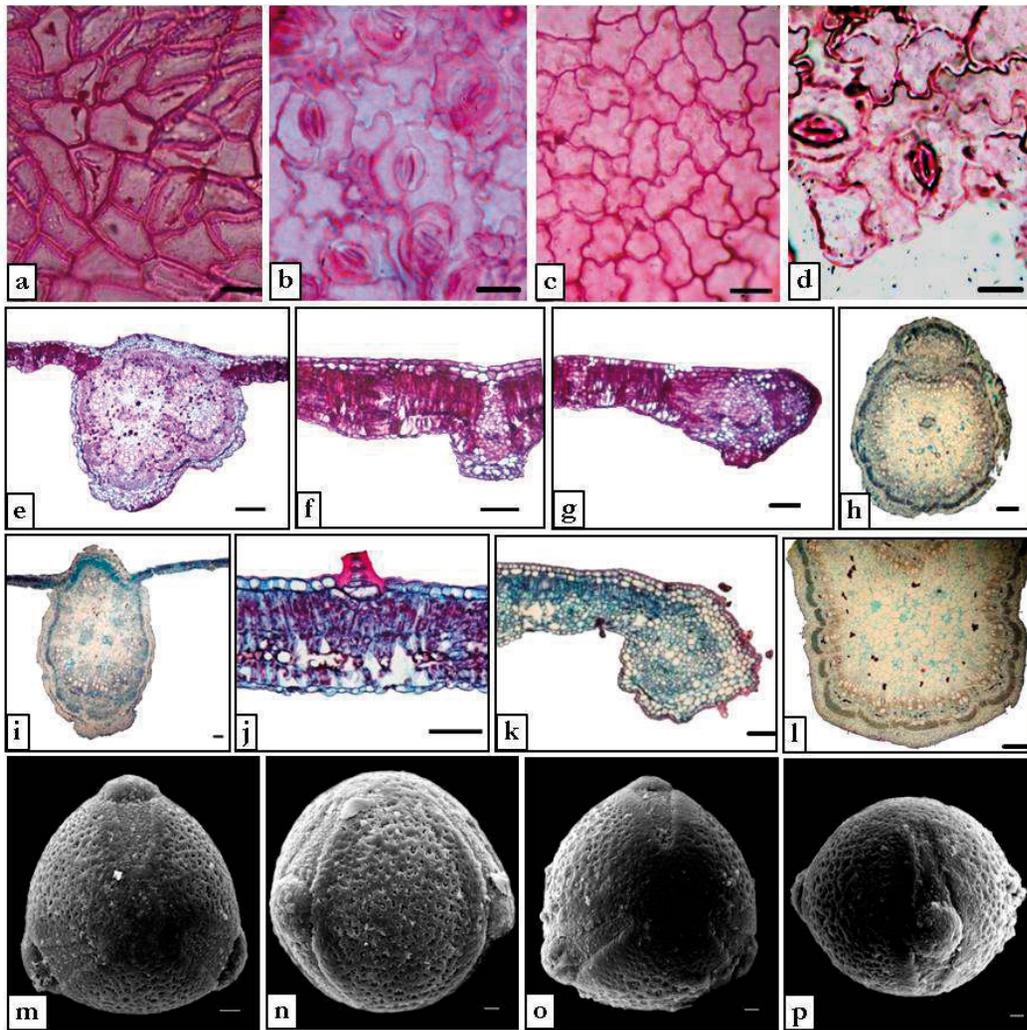


Figure 2. *Butea monosperma* (a, b, e-h, m and n); adaxial (a) and abaxial (b) surfaces view; Transverse section of midrib (e), median lamina (f), margin (g) and petiole (h); SEM micrographs of pollen.; polar view (m) and equatorial view (o); *B. superba* (c, d, i-l, n and p); Adaxial (c) and abaxial (d) surfaces view; Transverse section of midrib (i), median lamina (j), margin (k) and petiole (l); SEM micrographs of pollen.; polar view (n) and equatorial view (p); Bar a, b, c, d = 20 μm ; e, f, j = 100 μm ; e, g, i, k = 200 μm h, l = 400 μm and m-p = 3 μm .

Distribution.— Sri Lanka, India, Myanmar, Cambodia, Laos, Vietnam.

Ecology.— Dry deciduous, mixed deciduous and dry evergreen forests.

Vernacular.— Kwao khrua (กวาวเครือ), Chan khrua (จันทเครือ), Tan chom thong (ตานจอมทอง), Thong khrua (ทองเครือ), Pho-ta-ku (โพตะกู), Pho-mue (โพมื่อ).

3.2 Leaf Anatomy General Description

Lamina Surface

Epidermal cell: in surface view epidermal cells on both surfaces are jigsaw shaped or irregular (figure 2b, c and d); anticlinal walls of adaxial and abaxial cells are curved or undulate except polygonal or irregular of adaxial cells in *B. monosperma* (figure 2a) and also anticlinal walls are straight or curved. **Stomata:** paracytic,

occurring on abaxial surface only. **Trichomes:** unicellular and uniseriate multicellular present on both surfaces except unicellular on adaxial surface of *B. monosperma*.

Lamina TS

Epidermis: adaxial epidermal cells are larger than abaxial epidermal cells. Both adaxial and abaxial epidermal cells on median lamina are rectangular to square (figure 2f and i) and also circular in *B. superba* (figure 2i); periclinal wall of cells are curved and also straight in *B. monosperma*. Epidermal cells on midrib and margin are circular to square (figure 2e, g and k) and periclinal wall of cells are straight or curved except epidermal cells on midrib are rectangular or square in *B. superba* (figure 2i). **Mesophyll:** palisade and spongy cells are similar in shape; palisade cells are cylindrical arranged in 2-3 layers in *B. monosperma* and 1-2 layers in *B. superba*; spongy cells are short cylindrical in both species; paraveinal mesophyll present. **Vascular bundle:** collateral, with closed or semi-closed and surrounded by fibers; tannin present between phloem and xylem. **Cystals:** prisms present in parenchyma cells of ground tissue on midrib.

Petiole TS (figure 2h and l)

Outline: circular or square; two ridges present in *B. superba*; **epidermal cells** rectangular or square in *B. monosperma* but circular to square in *B. superba*; periclinal wall of cells straight or curved in both species; **trichome:** unicellular; **vascular bundle:** collateral, closed; **ground tissue:** parenchyma cells are polygonal to circular; **crystal:** prisms present in *B. monosperma* but raphides in *B. superba*.

Key to the species based on anatomy of leaves

1. Outline of petiole circular without ridges, prisms in petiole present; adaxial epidermal cells of leaf polygonal or irregular

..... **1. B. monosperma**
Outline of petiole square with two ridges, raphides in petiole present; adaxial epidermal cells of leaf jigsaw or irregular

..... **2. B. superba**

3.3 Pollen Data General Pollen Description

Pollen is monad, 3-colporate, radially symmetric, isopolar, medium-sized (P = 32-37 μm , E = 30-38 μm in *B. monosperma* and P = 32-46 μm , E = 32-40 μm in *B. superba*); shape prolate spheroidal (P/E = 1.057 μm in *B. monosperma* and P/E = 1.059 μm in *B. superba*); exine thickness 1 μm and exine sculpturing is perforate-free standing columellae (figure 6.).

4. DISCUSSION AND CONCLUSION

Two species, *Butea monosperma* and *B. superba* are enumerated in Thailand. The genus is distributed in dry deciduous, mixed deciduous and dry evergreen forests in all regions of Thailand except in the south (figure 1d). The flowering and fruiting periods are between January and June. Comparing the leaf anatomical data of this study with that reported by Metcalf & Chalk and Lackey [4,5], it appears that both *Butea* species share some typical characters, in the following features: unicellular trichomes, paracytic stomata only on abaxial surface, midrib with a single band of closed or semi-closed vascular bundle and parenchyma cells between phloem and xylem contain tannin. In addition, we found prisms in parenchyma cells of ground tissue in the midrib of both species. Prisms are also founded in the petiole of *B. monosperma* whereas raphides are founded in *B. superba*.

The pollen of both *Butea* species shows similarity in both size and shape (figure 2m-p) which it agrees very well with the work of Ridder-Numan and Ham [6]. We also found that exine sculpturing is perforate-free standing columellae.

Both leaf anatomy and pollen morphology techniques are insufficient for the delimitation of

Table 1. Comparison of *B. monosperma* and *B. superba*.

Characters	<i>B. monosperma</i>	<i>B. superba</i>
1. Morphology		
Habit	tree	woody climber
Bark	fissured, dark grey	flaking, pale greyish brown
Anther length (mm)	1-2	4-5
2. Leaf Anatomy		
Petiole outline in transverse section	circular	square
Ridge of petiole	absent	present
Stomatal type	paracytic	paracytic
Trichome type	unicellular, rarely multicellular	unicellular, rarely multicellular
Shape of epidermal cell at adaxial surface	polygonal, irregular	jigsaw, irregular
Shape of epidermal cell at abaxial surface	irregular, rarely jigsaw	jigsaw, irregular
Crystal in petiole	prisms	raphides
3. Pollen		
Pollen type	3-colporate	3-colporate
Polar axis length (µm)	32-(34.9±1.79)-37	32-(37.5±4.60)-46
Equatorial axis length (µm)	30-(33±2.3)-38	32-(35.4±2.41)-40
Exine sculpturing	perforate-free standing columellae	perforate-free standing columellae

both *Butea* species. In general, it can be supported that the features have considerable systematic value such as habit, bark, the length of anthers, an outline and ridge of petiole, shape of epidermal cells on adaxial surface and crystal types (Table 1) and give additional support to the distinctness of the species. However, like all other taxonomic evidence, features of both techniques must be interpreted with circumspection.

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