

The Genus *Abrus* Adans. (Leguminosae-Papilionoideae) in Thailand

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Abstract.— Two species and four taxa of the genus *Abrus* Adans. are found in Thailand viz. *A. precatorius*, *A. pulchellus* ssp. *pulchellus*, *A. pulchellus* ssp. *cantoniensis* and *A. pulchellus* ssp. *mollis*. Keys to species and subspecies are provided. Micromorphology of leaf surface and pollen were prepared by peeling and acetolysis methods, respectively. The leaf surface characteristics are used to construct a key. Pollen of *Abrus* is monad, isopolar, radial symmetry and tricolporate apertures.

KEY WORDS: *Abreae*, Leaf surface, Pollen, Revision

INTRODUCTION

Abrus Adans. is the only one genus of tribe Abreae (Leguminosae-Papilionoideae) with ca. 17 species, distributed mainly in tropical and subtropical regions particularly in Asia, Africa and probably introduced in the New World. The word “*Abrus*” comes from “habro-” (Greek) which it means delicate, elegant, pretty or soft that referred to delicate leaflets and beautiful flowers. Plants are climbers, lianas or herbs, which its common characteristics are paripinnately compound leaves and 9 connate stamens (Lewis *et al.*, 2005). Seeds of *A. precatorius* are known as rosary pea and used in jewelry. Nevertheless, the pea’s seeds have “Abrin”, which is poisonous for animals and humans because that its stop protein synthesis (Jang *et al.*, 2010).

The leaf surface of the genus was described by Metcalfe and Chalk (1957), which epidermal cells are papilose or sub-papilose. The stomata are found in abaxial

surface only. Rod-shaped crystals are possibly found in epidermis or palisade mesophyll.

The pollen morphology of the genus has not been extensively examined. Only two species of *Abrus*, *A. precatorius* and *A. shimperi* were described by Erdtman (1966). The pollens are tricolporate, medium-sized (39 x 26 µm in *A. precatorius* and 31 x 19 µm in *A. shimperi*). Pollen surface of *A. precatorius* is undulate and the exine is thicker than the nexine.

The aims of this study are to revise the genus for the Flora of Thailand, to compare the leaf surface and pollen morphology and to provide additional evidence for the delimitation of the species occurring in Thailand and supporting the identification based on morphological data.

MATERIALS AND METHODS

Plant specimens were collected from fieldworks in Thailand. Specimens at AAU,

ABD, BK, BKF, BM, E, K, KKU and TCD (acronyms according to Thiers, 2016) were consulted. The leaves were fixed in 70% ethanol. Peeling method was used to study the leaf surfaces, stained with toluidine blue O, mounted in DePeX artificial mounting medium and photographs with Olympus BH30 light microscope. Pollen was investigated by light microscopy (LM) and scanning electron microscopy (SEM). Pollen samples were obtained from fieldworks and prepared according to the standard method of acetolysis (Erdtman, 1966). For LM, pollen was mounted by silicone oil and photographs with Olympus BH30 light microscope. For SEM, pollen was placed on specimen stubs, dried, coated with gold-palladium mixture and photographs with Leo 1450VP SEM. Measurements of pollen grains have made using a projecting LM and based on at least 10 grains and descriptive terminology used follows Punt *et al.* (2007).

RESULTS

TAXONOMIC TREATMENT

ABRUS

Adanson, Fam. Pl. 2: 327. 1763.

Plants woody or suffrutescent, twining. *Leaves* paripinnately compound, with numerous, opposite leaflets, terminating in a bristle; stipules and stipels present. *Inflorescence* racemose, terminal or axillary. *Flowers* papilionaceous. *Calyx* campanulate with 5 short, subequal teeth or lobes. *Corolla* white, pinkish or purplish. *Stamens* 9, the vexillar stamen lacking; filaments united to midpoint, separate above; anther uniform. *Ovary* many-ovuled; style short,

glabrous, sometimes curved; stigma capitate. *Pod* not articulated, 2-valved, dehiscent. *Seeds* subglobose or compressed.

Key to the species

1. Stipe of standard present. Pod turgid, 3–4 cm long. Apex of ovary emarginate below style. Seeds red with black spot, sometimes whitish, subglobose or ellipsoid **1. *A. precatorius***
1. Stipe of standard absent. Pod compressed, (3–) 5–7 cm long. Apex of ovary slightly acuminate. Seeds dark brown or greyish-brown and black, compressed, oblong **2. *A. pulchellus***

1. *Abrus precatorius* L., Syst. Nat. 2: 472. 1767. Based on *Glycine abrus*. (Fig. 1A & 1B) *Glycine abrus* L., Sp. Pl.: 753. 1753. Type: Sri Lanka (Ceylon), *Herbarium Hermann*, vol. 2, p. 6, *P. Hermann* s.n. (lectotype BM designated by Fawcett & Rendle, 1920).

Abrus abrus (L.) W.F. Wight, Contr. U.S. Herb. 9: 171. 1905.

Perennial climber; young stems puberulent, glabrescent. *Leaves* 6–12 (–15) cm long; petiole 1–1.8 cm long, hairy; stipules lanceolate, 3–5 mm long, with white hairs, free, caducous; leaflets 28–32 (14–16-jugate), lamina oblong or obovate, 14–25 by 5–8 mm, apex obtuse with short mucro, base obtuse, oblique or cuneate, margin entire; both surfaces puberulose. *Inflorescence* compound racemose, terminal or axillary, 10–11 cm long; bracts deltoid, minute, caducous; bracteoles suborbicular, ca. 1 mm diam. *Flowers* 9–12 mm long. *Calyx* sparsely pubescent; tube 2–3 mm long; teeth ca. 1 mm long. *Corolla* pinkish to purplish or white, glabrous; standard

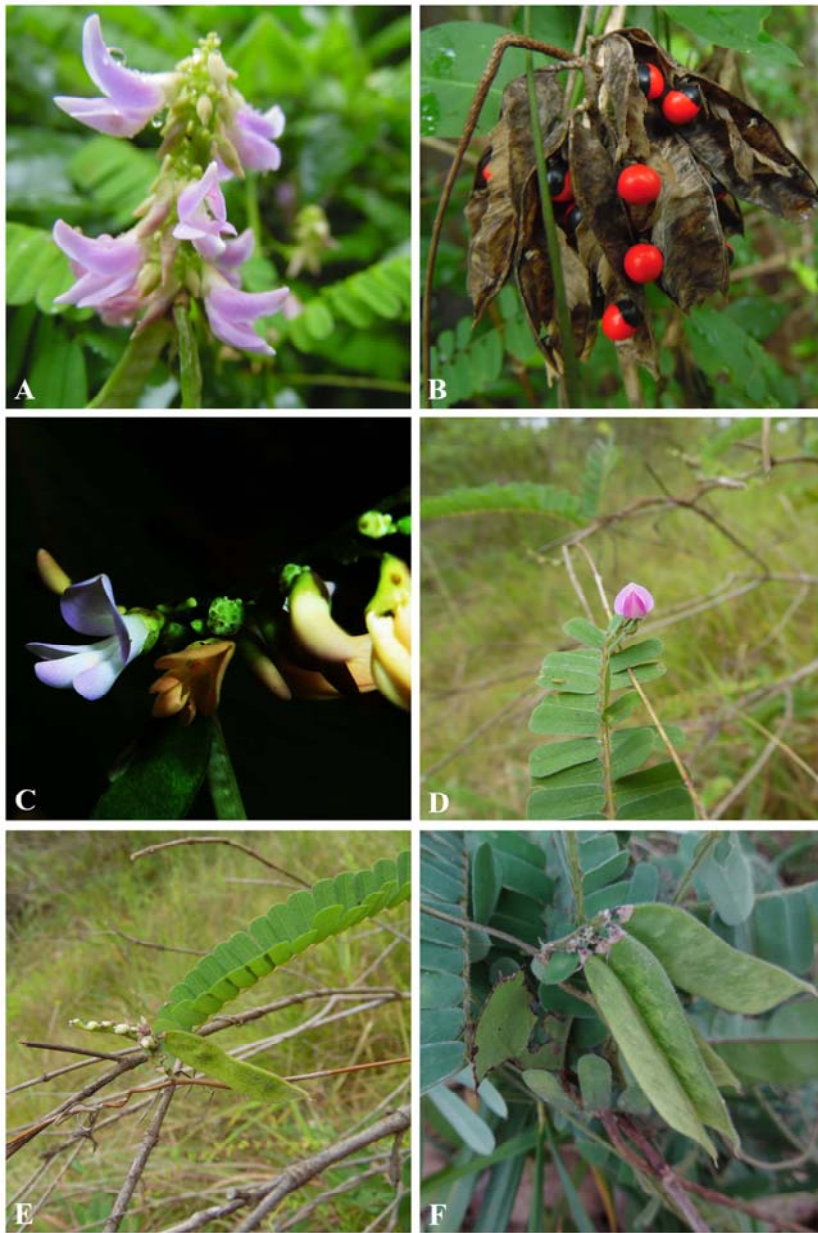


FIGURE 1. A-B. *Abrus precatorius*; C. *A. pulchellus* ssp. *pulchellus*; D-E. *A. pulchellus* ssp. *cantonensis*; F. *A. pulchellus* ssp. *mollis*, A., C. and D. flowers; B. pods and seeds; E. and F. pods.

ovate, 8–10 by 6–7 mm, apex obtuse, stipe *ca.* 2 mm long; wings linear, 10–13 by 2–3 mm, base auriculate, stipe *ca.* 2 mm long; keel linear, 9–10 by 3–4 mm, stipe *ca.* 2 mm long. *Stamens* 0.8–1 cm long, white; anther

yellow or orangish. *Pod* turgid, green, oblong, 3–4 by 1.3–1.5 cm, apex with beak and white hairs, 3–5-seeded. *Seeds* subglobose or ellipsoid, shining, 5–7 mm long, 4–5 mm in diam., commonly red with a

black spot surrounding the hilum, or sometimes completely whitish.

Thailand.— NORTHERN: Chiang Mai (Doi Pui, Doi Saket, Muang), Lamphun (Doi Khun Tan National Park); NORTH-EASTERN: Phetchabun (Nam Nao National Park), Loei (Wang Saphung), Nong Khai (Phu Wua Wildlife Sanctuary), Mukdahan (Mukdahan National Park), Maha Sarakham (Kosum Pisai), Khon Kaen (KKU Campus); EASTERN: Chaiyaphum (Phu Khieo); SOUTH-WESTERN: Kanchanaburi (Khao Kamen-Saiyok), Phetchaburi (Huay Saai), Prachuap Khiri Khan (Bangsaphan); CENTRAL: Lop Buri, Bangkok; SOUTH-EASTERN: Chon Buri (Ko E-Lao, Ko Khram-Sattahip, Ko Si Chang, Si Racha, Thung Prong), Rayong (Klang), Chanthaburi (Khlung, Khung Kra Ben), Trat (Ko Kut); PENINSULAR: Nakhon Si Thammarat, Songkhla (Boripath Waterfall, Gao Seng, Satingpra, Suan Toon Waterfall), Pattani, Narathiwat (Tak Bai).

Distribution.— Pantropical, India, Sri Lanka, Myanmar, China, Laos, Vietnam, Philippines, New Caledonia.

Ecology.— Climbing on bushes and trees in open disturbed, fire-damaged, very degraded in mixed deciduous, deciduous dipterocarp evergreen and scrub forests, along roadsides, sandy soil, shale or granite bedrock, 0-850 m alt.

Vernacular.— Klam khrua (กล้วยเครือ), Klam ta kai (กล้วยเครือ), Ma klam khrua (มะกล้วยเครือ), Ma klem daeng (มะกล้วยแดง), Ma khaek (มะเข็ก) (Chiang Mai), Kem krom (เกมกรอม) (Surin), Mak klam ta daeng (หมากกล้วยแดง) (North-Eastern), Cha em thet (ชะเอมเทศ), Ta klam (ตาลลำ), Ma klam ta nu (มะกล้วยตานะ) (General); Ma kham thao (มะขามเถา), Mai fai (ไม้ไฟ); Crab's eye vine, American pea.

Use.— The seeds are poisonous unless boiled.

Specimens examined.— *K. Chayamarit* 150 (BKF-2 sheets); *D.J. Collins* 14 (TCD) & 273 (TCD); *G. Congdon* 124 (AAU) & 130 (AAU); *Din* 268 (BKF); *J. Leerativong* 99-113 (KKU), 99-140 (KKU) & 99-169 (KKU); *C. Hamilton & G. Congdon* 124 (BKF); *A.F.G. Kerr* 1479 (TCD) & 13013 (ABD, BK, BM, TCD); *F.H.W. Kerr* 62 (TCD) & 449 (TCD); *A. Marcan* 210 (ABD, BM), 696 (BM) & 1829 (ABD, BM); *J.F. Maxwell* 71-80 (AAU), 87-1239 (BKF), 93-144 (BKF-2 sheets), 94-1046 (BKF), 01-6 (BKF) & s.n. (AAU); *K. Larsen, S.S. Larsen, I. Nielsen & T. Santisuk* 32499 (AAU); *W. Munsuk* 1 (KKU); *K. Larsen, S.S. Larsen, Chr.T. Nørgaard, K. Phasen, P. Puudjaa & W. Uearchirakan* 44122 (AAU) & 44198 (AAU); *A. Marcan* 1479 (ABD, BM-2 sheets); *G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan* T-5165 (BKF) & T- 41699 (BKF); *W. Nanakorn* 228 (BKF); *I. Nielsen, T. Jonganurak, N. Hemrath & J. Rithipheth* 1500 (AAU, TCD) & 1575 (AAU); *C. Niyomdham* 1653 (AAU), 5210 (BKF) & 5870 (BKF-2 sheets); *M. Norsaengsri* 1328 (QBG); *C. Phengklai et al.* 11218 (BKF), 12003 (BKF), 12343 (BKF), 12370 (BKF), 13136 (BKF), 13237 (BKF) & 13275 (BKF); *R. Pooma, V. Chamchumroon, M. Phuphat & S. Trakulkomchai* 3142 (BKF); *R. Pooma, K. Phattahirankanok, S. Sirimongkol & M. Phuphat* 4674 (BKF); *Sawai & Rob* s.n. (KKU); *E. Smith* 88 (BK, BM); *D.D. Soejarto, T. Santisuk, K. Taylor & N. Nantasan* 5999 (BKF); *W. Nanakorn* 228 (BKF); *BGO Staff* 1725 (QBG-2 sheets) & s.n. (QBG 8399); *S. Suwannavong* 175064 (KKU); *K. Warintorn* 08-141 (BKF, QBG) & 08-232 (QBG).

2. *Abrus pulchellus* Wall. ex Thwaites, Enum. Pl. Zeyl.: 91. 1859. Type: Sri Lanka (Ceylon), Dambulla, July 1853, G.H.K.

Thwaites 1467 (holotype PDA, isotypes K, P, PDA).

Perennial climber; young stems pubescent with appressed hairs, glabrescent. *Leaves* with petioles, stipules narrowly deltate or linear, 3 by 1 mm, caducous; leaflets 14–34, (7–17-jugate); lamina oblong or obovate, 2–5 by 2 cm, margin entire; adaxial surface puberulous, abaxial surface hairy. *Inflorescence* compound racemose, terminal or axillary; bracts lanceolate to deltoid, 1–3 by 1 mm; bracteoles ovate or suborbicular, ca. 1 mm in diam. *Flowers* 8–10 mm long. *Calyx* 2–3 mm long, subtruncate, moderately pubescent with minute, appressed hairs. *Corolla* white to pinkish; standard without stipe; wings and keel with stipes ca. 2 mm long. *Pod* compressed, puberulent, 5–7 by 1 cm, apex with beak, 5–10-seeds. *Seeds* compressed, oblong, ca. 5 in diam., 1.5–2 mm thick, dark-brown or greyish-brown and black.

Key to the subspecies

1. Adaxial surface of leaflets glabrous or sparsely puberulous, abaxial surface puberulous **a. subsp. *pulchellus***
1. Both surfaces of leaflets puberulous or villous **2**
2. Leaflets 0.5–1.2 cm long, both surfaces puberulous **b. subsp. *cantoniensis***
2. Leaflets 1.0–2.5 cm long, both surfaces villous **c. subsp. *mollis***

a. subsp. *pulchellus* (Fig. 1C)

Twining. *Leaves* 6–15 (–18) cm long; petioles 2–3 cm long, with white hairs; stipules narrowly deltate, 1–2 mm long, with white hairs, free, caducous; leaflets 16–24 (8–12-jugate); lamina oblong or obovate, 2.5–4 by 0.5–1.5 cm, apex acuminate, base

cordate or attenuate, margin entire; adaxial surface glabrous or sparsely puberulous, abaxial surface puberulous. *Inflorescence* compound racemose, 3.5–12 cm long, with white hairs. *Flowers* ca. 1 cm long. *Calyx* with white hairs; tube 3–4 mm long; teeth ca. 1 mm long. *Corolla* white to pinkish; standard obovate, 8–10 by 5–7 mm, apex emarginate; wings linear, 7–9 by 2–3 mm, base auriculate; keel ovate, 6–8 by 3–5 mm, base auriculate. *Stamens* 8–10 mm long. *Ovary* with white hairs. *Pod* 4–5 by 1–1.2 cm, 8–10-seeded.

Thailand.— **NORTHERN:** Mae Hong Son, Chiang Mai (Doi Suthep-Pui National Park, Mae Rim, Mae Tang, Muang, Samoeng), Chiang Rai (Mae Sai), Lamphun (Doi Khun Tan National Park), Lampang (Jae Sawn National Park); **NORTH-EASTERN:** Loei (Phu Kradung), Mukdahan (Mukdahan National Park-Na Sinuan, Phu Sradokbua National Park-Don Tan); **EASTERN:** Chaiyaphum (Phu Khieo, Tungkamang), Nakhon Ratchasima (Bua Yai); Buri Ram, Si Sa Ket (Khao Phra Vihan National Park-Kantaralak), Ubon Ratchathani (Khong Chiam); **SOUTH-WESTERN:** Prachuap Khiri Khan (Bangsaphan); **CENTRAL:** Saraburi (Sahm Lahn), Nakhon Nayok (Muang); **SOUTH-EASTERN:** Chanthaburi, Prachin Buri (Krabin Buri), Trat (Khao Sing, Ko Chang); **PENINSULAR:** Ranong (Ngao Waterfall), Nakhon Si Thammarat (Chwang), Songkhla.

Distribution.— Tropical Africa and Asia.

Ecology.— Partly open, disturbed or fire-damaged areas in evergreen forest, clearings in dry evergreen forest, open area in dry dipterocarp and mixed deciduous forests, 0–1,050 m alt.

Vernacular.— Khokio (คอกิ้ว), Ma kham pa (Chanthaburi), Ma klam phueak (มะกล่ำเตือก), Ma klam ta nu (มะกล่ำตาหนู), Paep fang (แปบฝาง)

(Chiang Mai), Ma kham yan (มะขามย่าน);
Liquorice root.

Specimens examined.— *Ch. Charoenphol*, *K. Larsen & E. Warncke* 4994 (AAU, K); *Chit* 195 (BKF); *D.J. Collins* 1668 (BK, K) & 1697 (ABD, BK, K); *C. Hamilton & G. Congdon* 130 (BKF); *A.F.G. Kerr* 1912 (ABD, E, K), 6393 (BK, K) & 6393A (ABD, BK, BM, K); *K. Larsen* 5996 (BKF); *K. Larsen & S.S. Larsen* 34309 (AAU, BKF); *J. Leerativong* 98-22 (KKU) & 99-138 (KKU); *S. Mattapha* 430(KKU); *J.F. Maxwell* 73-450 (AAU), 73-454 (AAU), 87-1085 (BKF), 90-1172 (AAU), 93-1309 (BKF-2 sheets), 95-951 (BKF), 96-44 (BKF), 97-1329 (BKF), 01-465 (BKF) & 02-348 (BKF); *A. Marcan* 2568 (ABD, E, K, TCD); *W. Munsuk* 2 (KKU); *G. Murata*, *C. Phengklai*, *S. Mitsuta*, *T. Yahara*, *H. Nagamasu & N. Nantasana* T-50038 (BKF); *W. Nanakorn et al.* 12152 (QBG); *M. Norsaengsri* 4294 (QBG); *M. Norsaengsri & N. Tathana* 7245 (QBG); *C. Phengklai et al.* 3396 (BKF-2 sheets); *C. Phengklai & T. Smitinand* 6098 (BKF-2 sheets); *S. Phusomsaeng* 23 (BKF-2 sheets); *R. Pooma*, *P. Karaket*, *N. Pattharahirantricin & U. Kawatkul* 7219 (BKF); *R. Pooma*, *K. Phattarahirankanok*, *S. Sirimongkol & M. Poopath* 5990 (BKF); *Put* 1413 (ABD, BK, K); *Snan* 976 (BKF); *R. Schlutze & S. Pattanavibul* 60382 (K); *Soradet* 263 (BKF); *Th. Sørensen*, *K. Larsen & B. Hansen* 6271 (BKF); *BGO Staff* 180 (QBG-2 sheets); *C.F. van Beusekom*, *C. Phengklai*, *R. Geesink & B. Wongwan* 404 (BKF) & 4323 (K); *Th. Wongprasert* s.n. (BKF-122114) & s.n. (QBG-9958).

b. subsp. *cantoniensis* (Hance) Verdc., Kew Bull. 24(2): 248. 1970. (Fig. 1D & 1E)

A. cantoniensis Hance, Journ. Bot. 6: 112. 1868. Type: China, Canton, August

1866. *G.T. Sampson & H.F. Hance* 13417 (holotype K K000898365).

A. cantoniensis Hance var. *hossei* Craib, Bull. Misc. Inform. Kew 1911: 39. 1911. Type: Thailand, Nakhon Sawan, Khao Pa Deng (Khao Phra Dang), 320 m, 19 October 1904. *C.C. Hosseus* 155 (holotype K K000898370).

Twining. Leaves 4–7 (–9) cm long; petioles 3–5 mm long, with white hairs; stipules 1–2 mm long, hairy; leaflets 24–28 (12–14-jugate); lamina oblong or obovate, 5–12 by 2–5 mm, apex mucronate, base emarginate, margin entire; both surfaces puberulose. Inflorescence compound racemose, terminal or axillary, 2–4 cm long. Calyx pubescent; tube 2–3 mm long; teeth ca. 1 mm long. Corolla pinkish; standard obovate, 7–8 by 5–6 mm, apex emarginate; wings oblong, 6–7 by 1–2 mm, apex acute; keel ovate, 6–7 by 2–3 mm. Stamens 6–7 mm long. Ovary with white hairs. Pod compressed, oblong, 28–47 by 7–8 mm, apex beaked, 6–8-seeded. Seeds oblong, dark brown, with aril around hilum, shiny.

Thailand.— NORTHERN: Nakhon Sawan (Khao Phra Dang); NORTH-EASTERN: Sakon Nakhon (Phu Phan National Park).

Distribution.— China, Vietnam.

Ecology.— Dry evergreen forest, open areas.

Vernacular.— Ma kham Thaw (มะขามเถา) (North-eastern).

Specimens examined.— *P. Chantaranothai et al.* 743 (KKU); *A.F.G. Kerr* 1411 (K, TCD); *W. Munsuk* 3 (KKU).

c. subsp. *mollis* (Hance) Verdc., Kew Bull. 24(2): 248. 1970. (Fig. 1F)

A. mollis Hance, Journ. Bot. 9: 130. 1871. Type: China, Canton, Shek-mun, 8 August 1869. *G.T. Sampson & H.F. Hance* 15806 (holotype K K000898366).

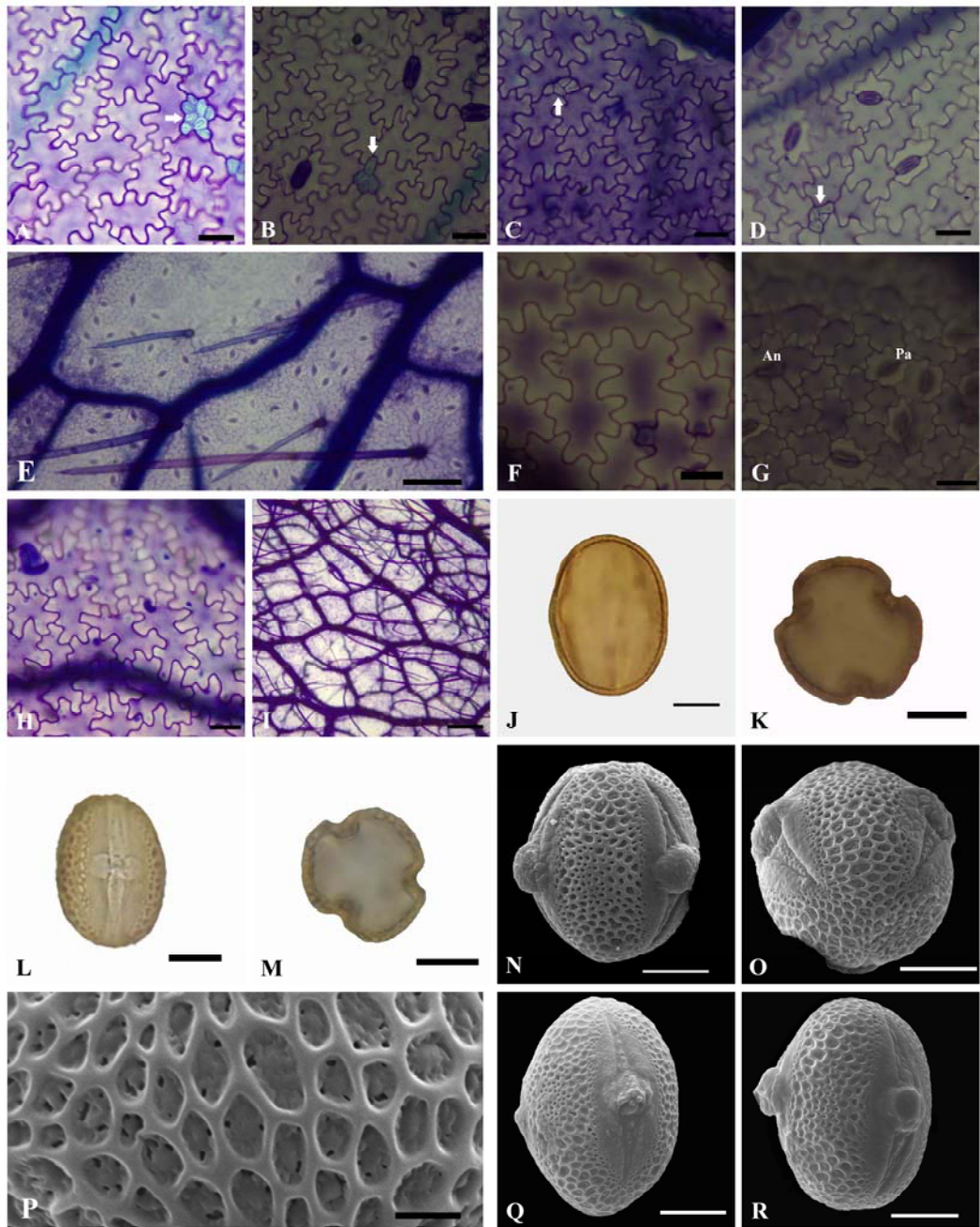


FIGURE 2. (A.-I.) Leaf epidermis: A.-B. *Abrus precatorius*, C.-E. *A. pulchellus* ssp. *pulchellus*, F.-G. *A. pulchellus* ssp. *cantoniensis* and H.-I. *A. pulchellus* ssp. *mollis*; A., C., F. and H. upper epidermis, B., D., E., G. and I. lower epidermis and rod-shaped crystals (arrow) (Scale bars A.-D. and F.-H. = 20 μ m, E. = 100 μ m and I. = 200 μ m) and **(J.-R.)** Pollen morphology: J.-K. and N.-P. *A. precatorius*, L.-M. *A. pulchellus* ssp. *cantoniensis*, Q. = *A. pulchellus* ssp. *pulchellus* and R. *A. pulchellus* ssp. *mollis*; J., L., N., Q. and R. equatorial view, K. andpolar view, O. subpolar view and P. ornamentation (An = anomocytic stomata, Pa = paracytic stomata) (Scale bars P. = 2 μ m, J.-O. and Q.-R. = 10 μ m).

TABLE 1. Characteristic features of the leaf surfaces of *Abrus* species.

Taxa	Upper epidermis			
	Shape	Anticlinal wall	Trichome type	Crystal
<i>A. precatorius</i>	jigsaw-like	undulate	Simple	rod-shaped
<i>A. pulchellus</i> ssp. <i>pulchellus</i>	jigsaw-like	undulate	–	rod-shaped
<i>A. pulchellus</i> ssp. <i>cantoniensis</i>	jigsaw-like	undulate	Simple	–
<i>A. pulchellus</i> ssp. <i>mollis</i>	jigsaw-like	undulate	flagelliform	–

– = absent

Twining with densely brown hairs. *Leaves* 7–10 cm long; petioles 5–12 mm long, with densely yellowish to brown hairs; stipules narrowly deltate, 3–4 mm long, with densely yellowish to brown hairs; leaflets 24–28 (12–14-jugate); lamina oblong or obovate, 10–25 by 5–7 mm, apex mucronate, base emarginate or oblique, margin entire; both surfaces yellow villous. *Inflorescence* compound racemose, 4–6 cm long, hairy. *Flowers* ca. 1 cm long. *Calyx* densely white villous; tube ca. 3 mm long; teeth ca. 1 mm long. *Corolla* pinkish; standard obovate, 7–9 by ca. 5 mm, apex emarginate; wings linear, ca. 5 by ca. 3 mm, base auriculate; keel ovate, ca. 6 by 3–5 mm, base auriculate. *Stamens* 7–8 mm long, hairy. *Ovary* with densely white hairs. *Pod* compressed, oblong, 2.8–3.9 by 0.8–1 cm, with white hairs, apex with beak, 5–6-seeded. *Seeds* oblong, brown, shiny.

Thailand.– NORTHERN: Phitsanulok (Chattrakarn); NORTH-EASTERN: Phetchabun (Nam Nao National Park); PENINSULAR: Songkhla.

Distribution.– China, Laos, Cambodia, Vietnam, Malaysia, Indonesia.

Ecology.– Mixed deciduous forest.

Vernacular.– Ma kham yan (มะขามย่าน) (Peninsular).

Specimens examined.– *P. Chantaranothai et al.* s.n. (KKU); *A.F.G. Kerr* 11857 (BK, E, K, TCD) & 13588 (ABD, BK, K, TCD); *W. Munsuk* 4 (KKU) & s.n. (KKU); *M. Norsaengsri* & *S. Intamusik* 6089 (QBG).

MICROMORPHOLOGY

Leaf surfaces

The epidermal cells are jigsaw-like and found on the adaxial and abaxial surfaces, with undulate anticlinal wall type (Fig. 2A–2D & 2F–2H). The stomata are restricted to the abaxial surface of the lamina, and that of the anomocytic (Fig. 2B, 2D & 2G) and paracytic (Fig. 2G) types, ranging from 7.5–12.5 µm in width, 12.5–20 µm in length. The unicellular simple hairs are presented on both leaf surfaces of *A. precatorius* and *A. pulchellus* ssp. *cantoniensis* except *A. pulchellus* ssp. *pulchellus* which it has on the abaxial surface

TABLE 1. continued.

Lower epidermis						
Shape	Anticlinal wall	Stomata			Trichome type	Crystal
		type	Width (µm) ($\bar{x} \pm S.D.$)	Length (µm) ($\bar{x} \pm S.D.$)		
jigsaw-like	undulate	anomocytic	10–12.5 (10.7±1.21)	17.5–20 (19.5±1.05)	simple	rod-shaped
jigsaw-like	undulate	paracytic. anomocytic	7.5–10 (9.5±1.05)	15–17.5 (15.8±1.21)	simple	rod-shaped
jigsaw-like	undulate	paracytic. anomocytic	7.5–10 (9±1.29)	12–17.5 (15.5±1.88)	simple	–
jigsaw-like	undulate	paracytic. anomocytic	7.5–10 (8.75±1.32)	12.5–15 (14.5±1.05)	flagelliform	–

only (Fig. 2E). Moreover, *A. pulchellus* ssp. *mollis* has unicellular flagelliform hairs on both surfaces (Fig. 2I). Rod-shaped crystals are presented on both leaf surfaces of *A. precatorius* and *A. pulchellus* ssp. *pulchellus* (Fig. 2A–2D). All data are shown in Table 1.

Key to taxa

1. Crystals present 2
1. Crystals absent 3
2. Unicellular simple hairs on both surfaces ***A. precatorius***
2. Unicellular simple hairs on abaxial surface ***A. pulchellus* ssp. *pulchellus***
3. Hairs simple ***A. pulchellus* ssp. *cantoniensis***
3. Hairs flagelliform ***A. pulchellus* ssp. *mollis***

POLLEN

The pollen grains of the genus *Abrus* are monad, isopolar and radially symmetry, with tricolporate, medium-sized ($P = 27\text{--}38\text{ }\mu\text{m}$, $E = 23\text{--}28\text{ }\mu\text{m}$) and subprolate in shape. The

exine stratification is $1\text{--}2\text{ }\mu\text{m}$ in thickness (Fig. 2J–2O & 2Q–2R). The pollen has reticulate sculpturing (Fig. 2P). The pollen morphology for each species is given in Table 2.

DISCUSSION

Two species, four taxa are enumerated in Thailand, viz. *A. precatorius*, *A. pulchellus* ssp. *pulchellus*, *A. pulchellus* ssp. *cantoniensis* and *A. pulchellus* ssp. *mollis*. This genus is distributed on bedrock in dry deciduous and mixed deciduous forests in Thailand. The flowering and fruiting periods are in August to December. The pods and seeds are useful characteristics for separation of both species, *A. precatorius* has turgid pods and subglobose to ellipsoid seeds whereas *A. pulchellus* has compressed pods and seeds. Hairs and size of leaflet are distinguished characteristics for subspecies classification.

TABLE 2. Characteristic features of the pollen of *Abrus* species.

Taxa	P (μm) ($\bar{x} \pm S.D.$)	E (μm) ($\bar{x} \pm S.D.$)	P/E ratio	Size
<i>A. precatorius</i>	28–32 (30.1±1.10)	24–26 (25.3±0.67)	1.19	medium
<i>A. pulchellus</i> ssp. <i>pulchellus</i>	27–37 (31.6±3.69)	24–27 (25.0±0.94)	1.26	medium
<i>A. pulchellus</i> ssp. <i>cantoniensis</i>	29–38 (32.9±2.60)	23–28 (25.3±1.57)	1.30	medium
<i>A. pulchellus</i> ssp. <i>mollis</i>	29–37 (32.1±2.96)	23–25 (24.6±0.69)	1.30	medium

Cl = Colpus length, E = Equatorial axis, Ex = Exine thickness, P = Polar axis

The epidermal cells are jigsaw-like. The anomocytic and paracytic stomata appear on the abaxial surface of the epidermis of the leaf only. The study of leaf surfaces agrees well with the work of Metcalfe and Chalk (1957), *A. precatorius* has rod-shaped crystal in epidermis. Moreover, rod-shaped crystals are also presented in *A. pulchellus* ssp. *pulchellus*. Leaf micromorphology such as crystals and hairs can be used to construct a key to the taxa. The leaf epidermis of *A. pulchellus* ssp. *pulchellus* is more similar to *A. precatorius* than *A. pulchellus* ssp. *cantoniensis* and *A. pulchellus* ssp. *mollis*.

The pollen study shows that the main characteristic features of the *Abrus* pollen are

similar and cannot be used to clearly their taxonomic difference.

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TABLE 2. continued.

Shape	Aperture	Cl (μm) ($\bar{x} \pm \text{S.D.}$)	Ex (μm) ($\bar{x} \pm \text{S.D.}$)	Exine sculpturing
subprolate	tricolporate	23–28 (25.8 $\pm$ 1.69)	1–2 (1.35 $\pm$ 0.47)	reticulate
subprolate	tricolporate	25–28 (26.5 $\pm$ 0.97)	1–2 (1.55 $\pm$ 0.46)	reticulate
subprolate	tricolporate	27–30 (28.4 $\pm$ 1.17)	1–2 (1.25 $\pm$ 0.42)	reticulate
subprolate	tricolporate	25–27 (26.1 $\pm$ 0.74)	1–2 (1.45 $\pm$ 0.44)	reticulate

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