



Taxonomic revision of *Disporum* (Colchicaceae) from Thailand including four new species

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Key words

Colchicaceae
Disporum
Flora of Thailand
leaf anatomy
Liliales
new species
pollen morphology
taxonomy
Uvularieae

Abstract We present a taxonomic revision of the genus *Disporum* in Thailand based on Thai specimens including descriptions of the genus and species, a key to the species, illustrations and lectotypifications. The dorsifixed anther attachment is a new character for the genus. There is a total of six species in Thailand, including the four new species described here, namely *D. chiangdaoense*, *D. dorsifixerum*, *D. phuhinrongklaensis* and *D. scabridum*, and two well-known species *D. calcaratum* and *D. cantoniense*. Anatomical and pollen morphological characters can be used for species diagnoses and they strongly support the morphological recognition of the four new species. New lectotypifications of synonyms are provided for *D. wallichii*, *Uvularia calcarata* and *U. hamiltoniana*.

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INTRODUCTION

The genus *Disporum* Salisb. belongs to the tribe *Uvularieae* of the family *Colchicaceae* (Vinnersten & Reeves 2003, Vinnersten & Manning 2007, Nguyen et al. 2013, Petersen et al. 2013). There are 24 species of *Disporum* in Asia that are distributed in India, China, Nepal, Bhutan, Myanmar, Thailand, Malaysia, Laos, Vietnam, Korea, and Japan (Songyun & Tamura 2000). They are characteristically perennial erect herbs with simple stems that are sometimes branched distally. The stem consists of aerial and underground parts. The underground stem is a rhizome with storage roots. The aerial stem has cataphylls with short or absent petioles. The leaves are simple and alternate or opposite. The inflorescences are umbels with an axillary position opposite to the leaves or terminating the stem. The perianth consists of 6 tepals. The anther attachment is basifixed and has longitudinal dehiscence. The ovary is trilocular with axile placentation and the fruits are berries (Don 1839, Nordenstam 1998, Songyun & Tamura 2000, Vinnersten & Manning 2007).

Britton (1888) divided *Disporum* into two groups, which Jones (1951) termed section *Eudisporum* (nom. illeg., no autonym) and sect. *Prosartes* (D. Don) Q. Jones. Section *Prosartes*, consisting of six species, is now recognized as the North American genus *Prosartes* D. Don (Tamura et al. 1992, Shinwari et al. 1994).

The 24 Asian species form *Disporum* s.str. Dahlgren et al. (1985) classified *Disporum* s.lat. in tribe *Uvulariae* (*Uvulariaceae*). They retained the Asian species in the genus *Disporum* (s.str.) based on not well visible reticulated venation of the tepals and the tepals with a spur. However, they recognized the American species as genus *Prosartes* based on a reticulate tepal venation and non-spurred tepals. Furthermore, Hara (1988) classified the Asian *Disporum* into three sections:

1. sect. *Disporum* has the inflorescence terminal or pseudo-lateral; flowers rotate to cylindrical-campanulate; perianth white, greenish, yellow, or dark purple; tepals lanceolate to obovate, basally mostly gibbose or spurred and the main veins parallel with sparse transverse connecting veinlets; style with 3 short stigmas at the apex or deeply 3-cleft up to the middle; ovules ascending; berries dark blue to black.
2. sect. *Ovalia* H. Hara has terminal inflorescences and flowers that are rotate with the tepals basally saccate and berries that are red.
3. sect. *Paradisporum* H. Hara has terminal, umbellate, 5–8-flowered inflorescences and the basal perianth parts are basally spurred.

Disporum sessile D. Don ex Schult. & Schult. f. from Japan (part of Asian *Disporum* s.lat.) is similar in flower shape and chromosome number to the North American *Prosartes*. Therefore, Hara (1988) suggested that *D. sessile* has a parallel evolution with *Prosartes*. The chromosomes of *Disporum* are longer than those of *Prosartes* in the mitotic metaphase. The chromosome length of *Disporum* ranges from 4.3–19.5 μm and the range in *Prosartes* is 2.5–5.0 μm ; these differences support the recognition of *Prosartes* at the generic level (Jones 1951, Chao et al. 1963, Tamura et al. 1992, Tamura 1995). Conover (1991) also raised sect. *Prosartes* to generic level using leaf anatomical characters as the guard cells are smaller in *Disporum* (48–

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64 µm) than in *Prosartes* (29–41 µm). Furthermore, studies into the phylogenetic relationships of *Disporum* and *Prosartes* using *rbcl* plastid DNA found that *Disporum* and *Prosartes* do not form a monophyletic group and that *Disporum* grouped into tribe *Uvulariae* and *Prosartes* into tribe *Tricyrtideae* (Shinwari et al. 1994). Therefore, chromosome size, guard cell size and phylogenetic analyses supported the recognition of *Prosartes* at generic level. APG IV (2016) now places *Disporum* in the *Colchicaceae* tribe *Uvularieae* and *Prosartes* in the *Liliaceae*. Tamura et al. (2013) reconstructed a phylogeny of *Disporum* using plastid *trnK*, *trnL-F* and *atpB-rbcL* DNA sequences of 13 species, two varieties and two forms. Basally in the phylogeny two sister clades are present, both supported by morphological characters. The first clade included two species with widely opening or infundibular flowers. The other clade consists of 11 species that have tubular, campanulate or obconical flowers.

In Thailand, only two *Disporum* species were previously enumerated, namely *D. calcaratum* D. Don and *D. pullum* Salisb. (nowadays a synonym of *D. cantoniense* (Lour.) Merr.), but these lacked detailed descriptions (Charoenphol 1973). Therefore, we have revised *Disporum* and found several new taxa in Thailand using morphology, leaf anatomy and pollen morphology. We report our findings here, including the description of four new *Disporum* species and some necessary lectotypifications.

MATERIAL AND METHODS

The revision was undertaken using morphological, leaf anatomical and pollen morphological characters. Preliminary assessments of the conservation status follow the IUCN (2021) criteria. The morphological characters were described from fresh and dried specimens. The fresh specimens were collected from field sites throughout Thailand. Voucher specimens were prepared and deposited in BK, BKF, KCU and QBG (acronyms following Thiers continuously updated). Herbarium specimens were consulted from BK, BKF, KCU, QBG and from online herbarium databases including BM, C, E, G, K, K-W, L, P, S, W and WU. The specimens studied are enumerated in the Identification List. Anatomical characters of stem, petiole and leaf were studied. Samples were fixed in FAA 30 % and transverse sections were made with a rotary microtome (Leica RM 2165). The samples were stained with Saffranin O and Fast green (Johansen 1940, Kermanee 2008) and mounted in paraffin. Slides of the epidermal surface were prepared using a peeling method and staining by only Saffranin O (Thammathaworn 1995). All permanent slides were investigated under a light microscope (Carl Zeiss Primo Star).

Pollen morphological characters were studied using a modified acetolysis technique followed by light microscopy and scanning electron microscopy (Erdtman 1960). Pollen were mounted in paraffin for light microscopy with a Carl Zeiss Primo Star. Pollen were also prepared for scanning electron microscopy (FEI, Quanta 450) by placing them on a metal stub and coating them with 99.99 % gold (Halbritter et al. 2018). The anatomical and pollen permanent slides are stored at the Palynology Special Research Unit, Department of Botany, Faculty of Science, Kasetsart University, Bangkok. The material used is listed in Table 1.

TAXONOMIC TREATMENT

Disporum Salisb.

Disporum Salisb. (1812) 331; D. Don (1825) 50, (1839) 44; Baker (1874) 588; Benth. & Hook.f. (1883) 831; Hook.f. (1894) 359; Q. Jones (1951) 5; Backer & Bakh.f. (1968) 94; Char. (1973) 88; Jessop (1979) 217; H. Hara (1988) 163; B. Nord. (1998) 184; Songyun & M.N. Tamura (2000) 154. — Type: *Disporum pullum* Salisb., nom. illeg. = *Uvularia chinensis* Ker Gawl. (= *D. cantoniense* (Lour.) Merr.).

Perennial erect herbs. *Rhizomes* short vertical and horizontal, creeping, densely noded with storage roots. *Roots* fleshy. *Aerial stems* erect and arching, simple or distally 2–7-branched; lower part of aerial stem rounded with adventitious roots at first and second node, the axis with two grooves, green or dark purple; the upper part rounded or rectangular, the axis with ridges, green. *Cataphylls* 2–9, sheathing lower part of stem, papery, glabrous, green or brown, venation palmately netted. *Leaves* simple, alternate or opposite, lamina narrow-lanceolate, elliptic or ovate, lower surface glabrous, upper surface glabrous or with peltate scales, base obtuse, margin dentate, renovate or involute, apex acuminate with mucro, papery when dried, glabrous, green, venation palmately netted; petiole absent or very short, V-shaped, heart-shaped or crescent shaped, with or without marginal ridges, green or light green, papillose on the ridges. *Inflorescences* axillary, leaf-opposed, umbellate, 2–11-flowered, pendulous; peduncle rectangular, papillose on the ridges, green. *Flowers* campanulate, tubulate or rotate; pedicel rectangular, papillose on the ridges, green. *Perianth* 6 tepals in 2 whorls, lanceolate, obovate, elliptic, oblong or ovate, white, pink or purplish red, base cuneate, glabrous or scabrous, margin entire or dentate, apex acute to acuminate, papery or membranous when dried, 1–3-keeled, venation reticulate. *Spurs* gibbous or straight, rounded or cylindrical or funnel-shaped, glabrous or densely scabrous, apex obtuse, white, green, or dark red, 1- or 3-ridged, thick or membra-

Table 1 Specimens used for anatomy and pollen morphology and their area of origin.

| Species | Collector No. | Locality |
|------------------------------|---------------|--|
| <i>D. calcaratum</i> | A. Sarapan 18 | Pha Dok Seaw Waterfall, Chiang Mai |
| | A. Sarapan 19 | Mon Lhong, Chiang Mai |
| <i>D. cantoniense</i> | A. Sarapan 25 | Doi Hua Sua, Chiang Mai |
| | A. Sarapan 31 | Doi Khun Tan, Lampang |
| | A. Sarapan 42 | Mon Lhong, Chiang Mai |
| | A. Sarapan 44 | Doi Suthep-Pui, Chiang Mai |
| <i>D. chiangdoense</i> | A. Sarapan 26 | Mhong Microwave Village, Mae Hong Son |
| | A. Sarapan 46 | Chiang dao, Chiang Mai |
| <i>D. dorsifixerum</i> | A. Sarapan 9 | Thung Yai Naresuan Wildlife Sanctuary, Tak |
| | A. Sarapan 33 | Doi Khun Tan, Lampang |
| | A. Sarapan 53 | Pha La Ta Waterfall, Tak |
| | A. Sarapan 54 | Doi Rod May, Thung Yai Naresuan Wildlife Sanctuary, Tak |
| | A. Sarapan 55 | Nong Daeng, Thung Yai Naresuan Wildlife Sanctuary, Tak |
| <i>D. phuhinrongklaensis</i> | A. Sarapan 6 | Sri Lan Na National Park, Chiang Mai |
| | A. Sarapan 40 | Phu Hin Rong Kla National Park, Pitsanulok |
| <i>D. scabridum</i> | A. Sarapan 8 | Mhun Deang Waterfall, Phu Hin Rong Kla National Park, Pitsanulok |

nous, glabrous or scabrous. *Stamens* 6; filament flat, narrow-obclavate to oblong, white, green, pink or dark purplish red, glabrous or papillose; anthers 2-thecate, basifixed or dorsifixed, oblong, yellow or purplish red, opening extrorse with longitudinal slits. *Ovaries* superior, oblong, obovate or obovate to oblong, glabrous, 3-locular, 6 ovules (2 ovules/locule), placentation axilar; style oblong, with 3 shallow grooves, white or dark dull red, glabrous or densely papillose; stigma trifid, revolute or slightly revolute. *Fruit* a berry, globose or oblate, glabrous, pendulous, blue to black. *Seeds* 1–5, subglobose or triangular, brown or light brown, surface rough when dried.

Anatomical characters

STEM. *Cuticle* echinate. *Epidermal cells* rounded or rectangular. *Ground tissue* consisting of parenchyma and sclerenchyma; forming a ring. *Vascular system* closed-collateral; lower part rounded to sub-rectangular; parenchyma accumulating tannin.

PETIOLE. *Cuticle* echinate. *Epidermal cells* rounded or rectangular; papillae present or absent. *Ground tissue* comprising parenchyma and collenchyma; some species accumulate tannin in ground tissue. *Vascular system* closed-collateral with sclerenchyma surrounding the bundles; vascular bundles 8–19, round or elliptic.

LEAVES. Leaf in surface view: epidermal cells with sinuous anticlinal walls; adaxially peltate scales present or absent; abaxially glabrous, stomata anomocytic (hypostomatic). Leaf in transverse view: dorsiventral. *Epidermis* with 2 zones, costal and intercostal with smooth or echinate cuticle. *Palisade*: 1 or 2 layers, cells rectangular. *Spongy mesophyll* sparse, cells irregularly shaped. *Midrib*: vascular system U-shaped to V-shaped. *Margin*: involute or revolute. Upper epidermal cells with smooth or echinate cuticle. Lower epidermal cells with echinate cuticle.

Pollen morphology

Monad, asymmetrical or bilateral in equatorial view, spheroidal, sub-spheroidal or prolate; equatorial axis 27 ± 0.60 – 44 ± 0.72 μm long; polar axis 25 ± 0.73 – 40 ± 0.53 μm long; 2–3-porate or monosulcate; exine thickness 1 – 3 ± 0.71 μm ; rugulate with granulate surface, or rugulate with perforate ornamentation.

KEY TO THE THAI SPECIES OF DISPORUM

1. Spur straight or recurved with 1 ridge, 5–10 mm long . . . 2
1. Spur gibbous with 3 ridges, 1–3 mm long 2. *D. cantoniense*
2. Basal tepal and spur glabrous or papillate 3
2. Basal tepal and spur scabrous 6. *D. scabridum*
3. Spur and ridge glabrous and smooth; the upper leaf-surface without peltate scales 4
3. Spur glabrous and ridge with papillae; the upper leaf-surface with peltate scales 1. *D. calcaratum*
4. Flower rotate form; perianth margin entire 5
4. Flower campanulate form; perianth margin dentate 3. *D. chiangdaoense*
5. Anther dorsifixed; filament without papillae; ovary 13–15 mm long 4. *D. dorsifixerum*
5. Anther basifixed; filament with papillae; ovary 8–12 mm long 5. *D. phuhinrongklaensis*

1. *Disporum calcaratum* D. Don — Fig. 1, 2, 3, 4, 5; Map 1

Disporum calcaratum D. Don (1839) 44; Baker (1874) 588; Hook. f. (1894) 359; Char. (1973) 88; H. Hara, Stearn & L. H. J. Williams (1987) 72; H. Hara (1988) 163; Songyun & M. N. Tamura (2000) 154. — [*Uvularia calcarata* Wall. (1832) no. 5087, *nom. nud.*]. — Lectotype (designated here): *Wallich Cat. No. 5087* (lecto K-W sheet no. 001104701; isolecto BM sheet no. 000559854), India (nowadays Bangladesh), Sylhet, Jentya Mountain.

Disporum hamiltonianum D. Don (1839) 45. — [*Uvularia hamiltoniana* Wall. (1832) no. 5088A, *nom. nud.*]. — [*Uvularia betua* Buch.-Ham. ex D. Don (1839) 45, *nom. inval.*, manuscript name]. — Lectotype (designated here): *Wallich Cat. No. 5088A* (lecto K-W, sheet no. 001104702; isolecto P [P00730481]), Nepal, Kirat province, Morang district, Morang Mountain, 18 June 1810.

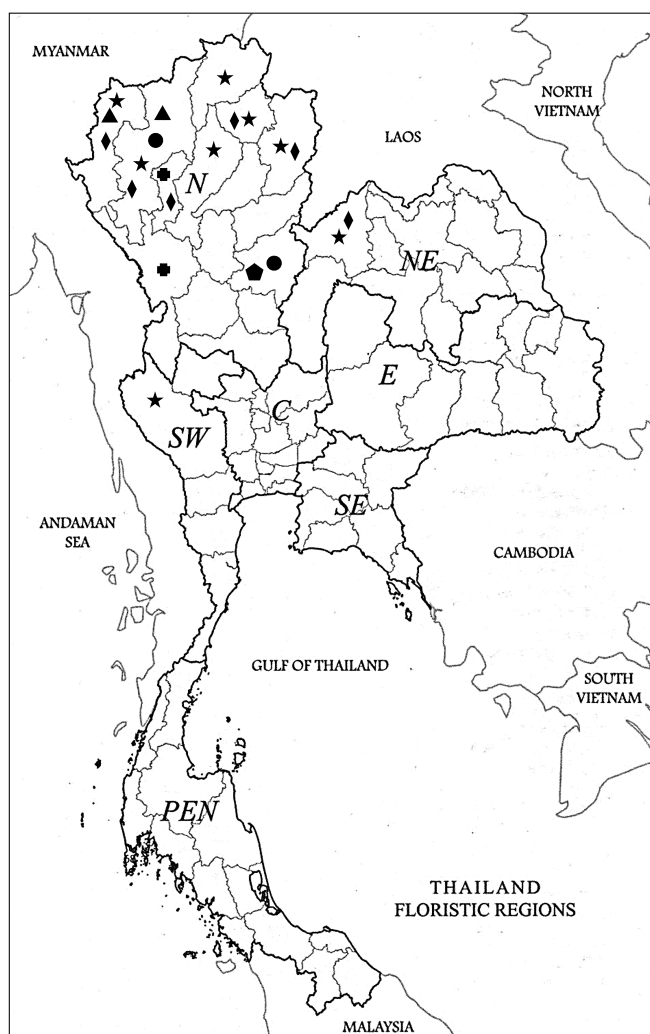
Disporum wallichii D. Don (1839) 45. — [*Disporum wallichii* Wall. (1832) no. 5088B, *nom. nud.*]. — Lectotype (designated here): *Wallich Cat. No. 5088B* (lecto K-W sheet no. 000639620, left side (marked 1 and red dotted in Fig. 2); isolecto P [P00734078]), Nepal, Buniya, Sylhet Mountain.

Disporum latipetalum Collett & Hemsl. (1890) 139. — Type: *Collett 808* (holo K [K.000099943]), [Myanmar,] Burma, Shan Hills, May 1888.

Disporum pedunculatum H. Li & J. L. Huang (1989) 294. — Type: S. Z. Wang 821 (holo KUN, not seen) China, Yunnan, Marlipo, 28 June 1964.

Disporum jiangchengense Y. Y. Qian (1990) 184. — Type: *Qian Yi-yong 1783* (holo SMAO, not seen), China, Yunnan, Simao.

Perennial erect herbs. *Rhizomes* short, vertical or horizontal. *Aerial stems* 20–72 cm long; the lower part 10–56 cm long, green; the upper part 7–30 cm long with 2 ridges, usually simple or rarely distally 2–3 branched; internode 2–15 cm long. *Cataphylls* 2–4, 1.5–4.5 by 0.5–1.8 cm, brown or reddish brown. *Leaves*: lamina narrowly lanceolate or ovate, 3–13.5 by 1–4.5 cm, upper surface with peltate scales, base obtuse, margin dentate, revolute, dark purple, apex acuminate, veins 3–10; petiole \pm absent or very short, 1–3 mm long, pale green or green with purple at proximal end. *Inflorescences* umbellate, 2–6 flowers; peduncle 1–15 mm long, green with purple at both ends. *Flowers* campanulate, 10–23 mm long;



Map 1 Distribution of *Disporum calcaratum* D. Don (★), *D. cantoniense* (Lour.) Merr. (◆), *D. chiangdaoense* Sarapan & Suwanph. (▲), *D. dorsifixerum* Sarapan & Suwanph. (■), *D. phuhinrongklaensis* Sarapan & Chamch. (●), *D. scabridum* Sarapan & Hodk. (●) in Thailand.



Fig. 1 *Disporum calcaratum* D.Don. a. Plant showing distal branching and inflorescences; b. inflorescence; c. flowers; d. tepals with spur; e. stamens; f. pistil; g. fruits. — Photos by S. Nansai.

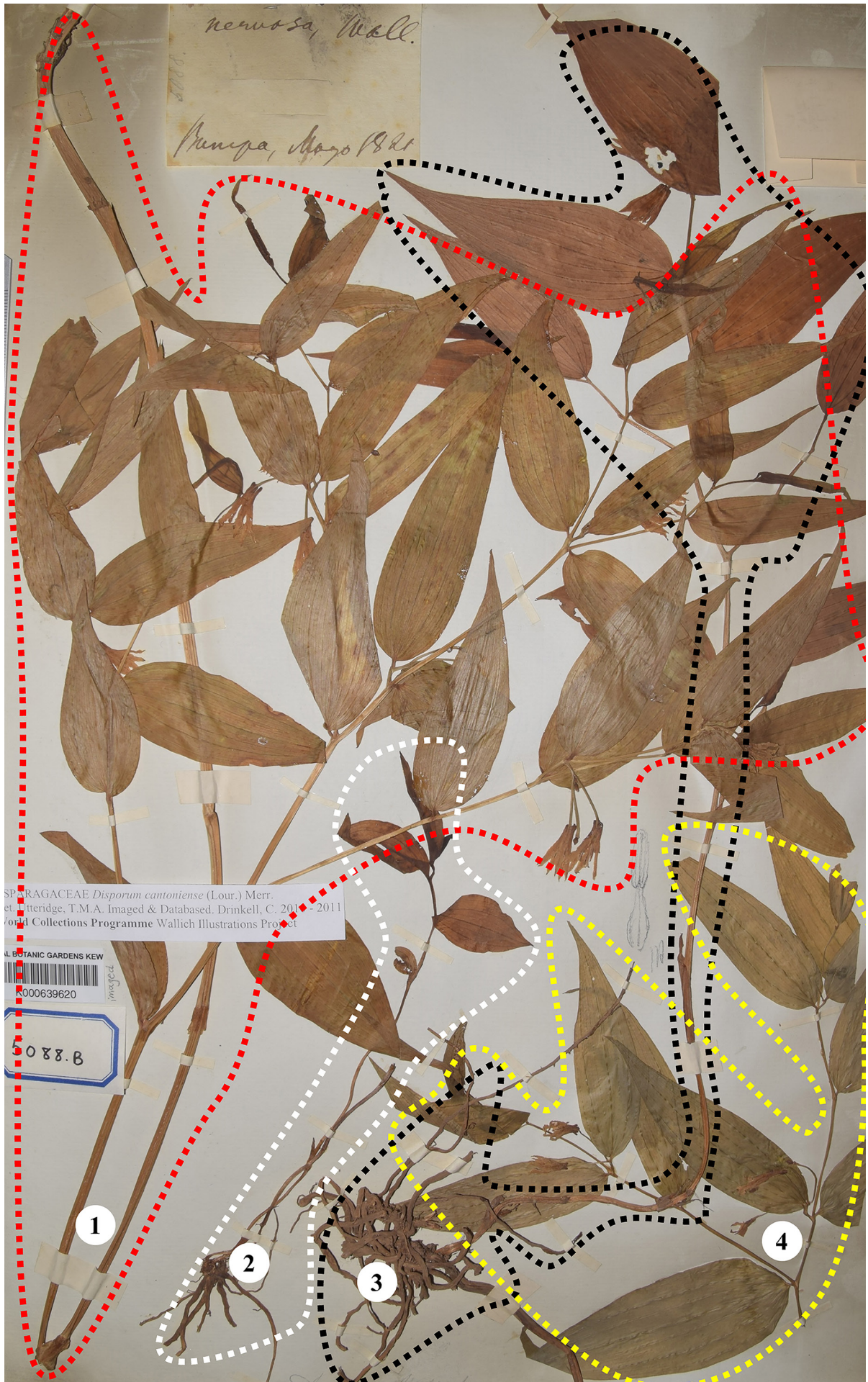


Fig. 2 Type specimen of *Disporum wallichii* D.Don: *Wallich Cat. No. 5088B* (K-W). 1 and red dotted line: *D. wallichii*; 2 and white dotted line: unidentified species; 3 and black dotted line: *D. cantoniense* (Lour.) Merr.; 4 and yellow dotted line: *D. wallichii*.

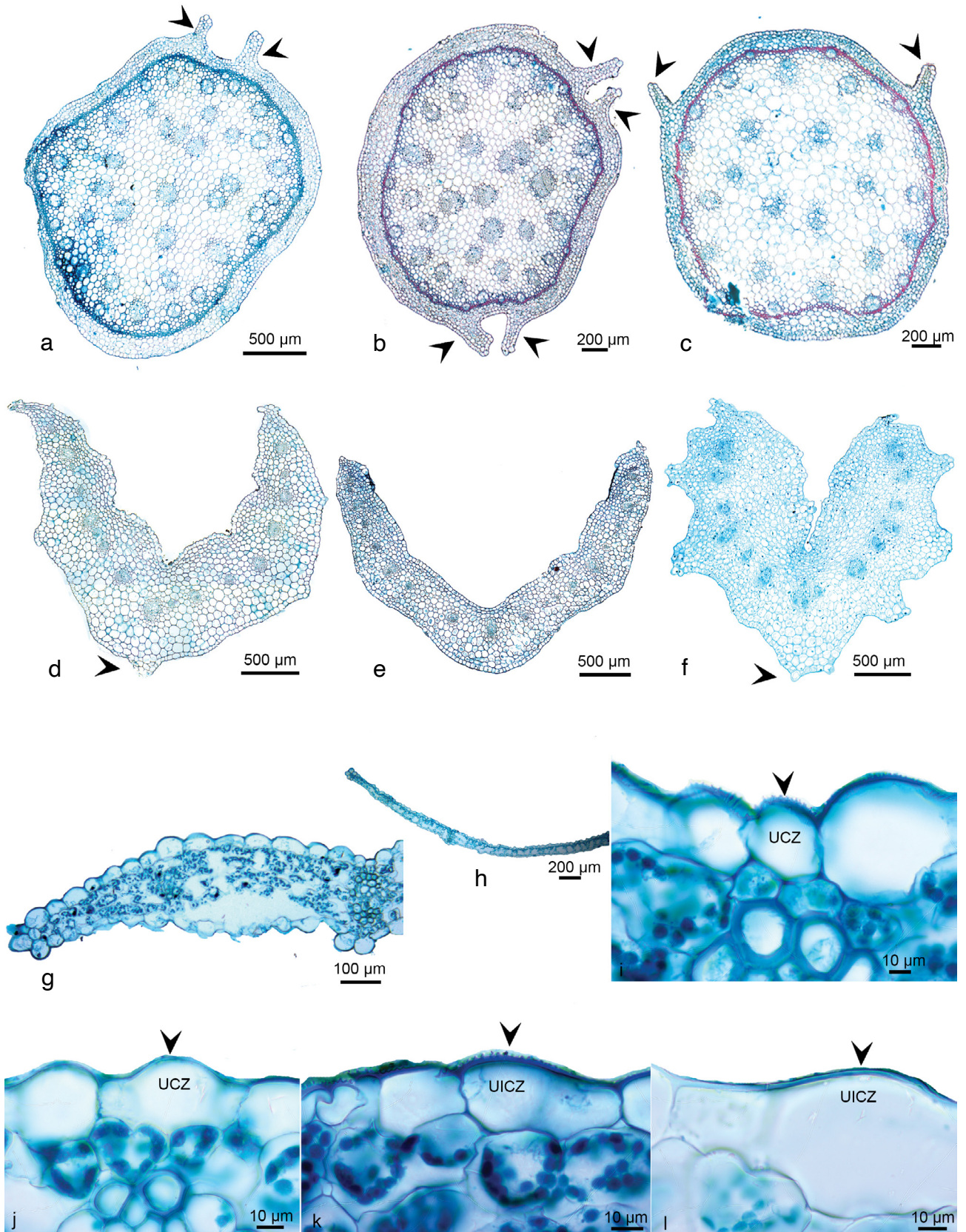


Fig. 3 Stem, petiole and leaf anatomy. The upper part of stem with ridges (arrowheads): a. *D. calcaratum*; b. *D. chiangdaoense*; c. *D. cantoniense*. Petiole: d. *D. calcaratum* with a ridge (arrowhead); e. *D. chiangdaoense* without ridge; f. *D. cantoniense* with ridge (arrowhead). Margin: g. revolute in *D. calcaratum*; h. involute in *D. scabridum*. Cuticle thickening on costal zone of upper epidermis, UCZ (arrowhead): i. echinate in *D. calcaratum*; j. smooth in *D. scabridum*; the cuticle thickening on intercostal zone of upper epidermis, UICZ (arrowhead): k. echinate in *D. calcaratum*; l. smooth in *D. dorsifixerum*.

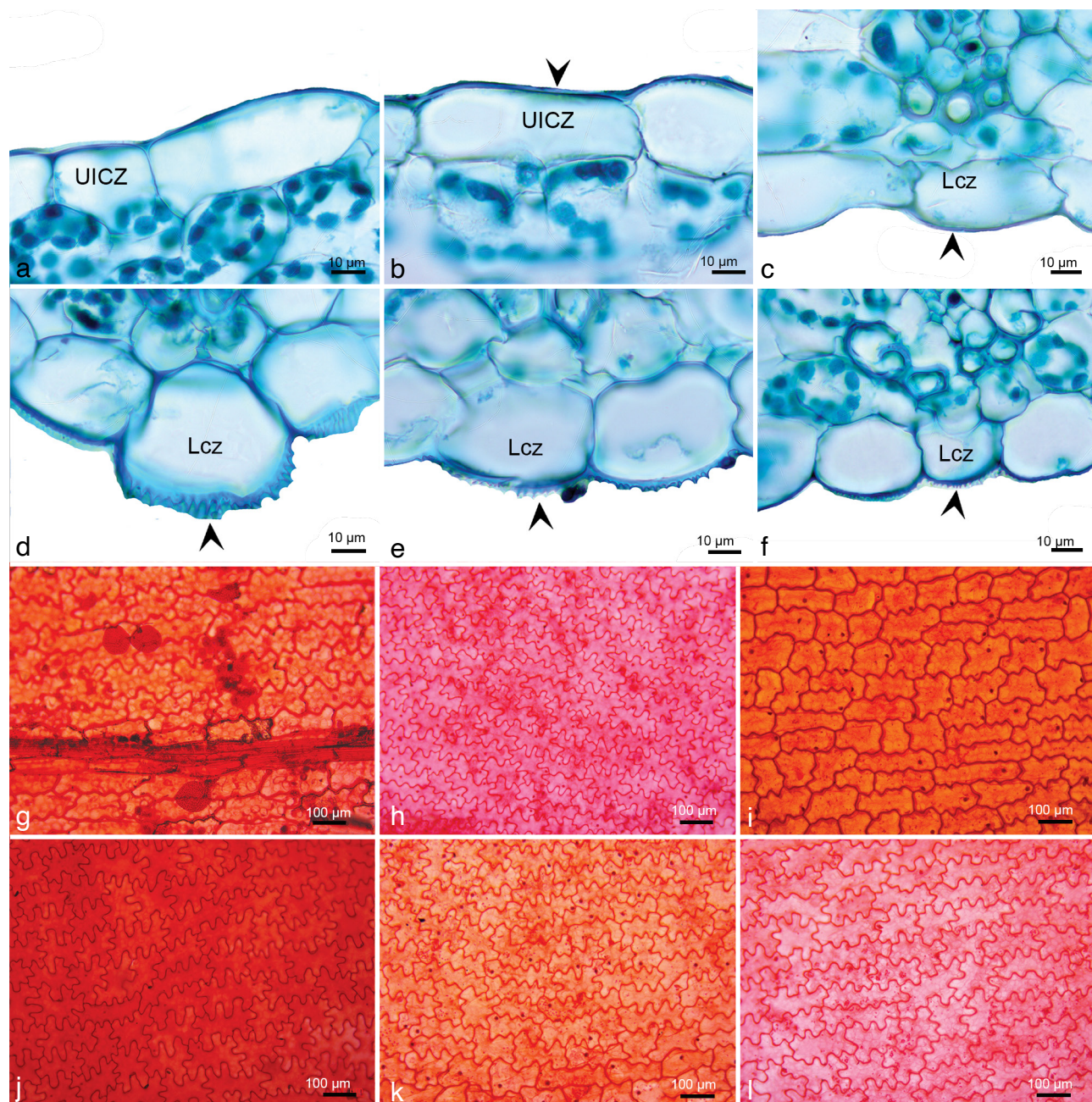


Fig. 4 Cuticle thickening on intercostal zone of upper epidermis, UICZ (arrowhead): a. smooth in *D. phuhinrongklaensis*; b. smooth in *D. scabridum*. Cuticle thickening on costal zone of lower epidermis, LCZ (arrowhead): c. smooth in *D. calcaratum*; d. echinate in *D. chiangdaoense*; e. echinate in *D. dorsifixerum*; f. echinate in *D. phuhinrongklaensis*. The upper epidermis surface with sinuate anticlinal walls: g. *D. calcaratum* with peltate scale (arrowheads); h. *D. cantoniense*; i. *D. chiangdaoense*; j. *D. dorsifixerum*; k. *D. phuhinrongklaensis*; l. *D. scabridum*.

pedicel 13–25 mm long, green with purple at both ends. *Tepals* obovate to lanceolate or obovate, 1.2–2.4 by 0.3–0.6 cm, pale pink, pink or dark purplish red, 1–3 keeled with few papillae, base glabrous and pale pink, margin dentate, apex pink or dark purplish red. *Spurs* straight or recurved with a ridge, cylindrical or funnel-shaped, 6–10 mm long, glabrous, light pink or pink; ridge membranous, papillose, dark purplish red. *Stamens* 8–13 mm long; filament 5–10 mm long, papillose, pink or white; anther basifixed, yellow. *Ovaries* obovate to oblong, 10–14 by 2–3 mm, purple or green; style 2–9 mm long, white or purple, glabrous. *Fruits* globose, 4–5 by 3–7 mm, turning black when ripening. *Seeds* 1–3, subglobose, brown or light brown, rugose when dried.

Distribution — India, China, Nepal, Bhutan, Myanmar, Thailand (Mae Hong Son, Chiang Mai, Chiang Rai, Nan, Lumpang, Loei, Kanchanaburi), Malaysia, Laos, Vietnam, Korea, and Japan.

Habitat & Ecology — In open areas, along roadsides in pine and oak forests at 1450–1800 m elevation. Flowering: May to July; fruiting: July to December.

Preliminary IUCN Conservation Status — A conservation status of Least Concern (LC) is proposed. *Disporum calcaratum* is a very widespread species with extent of occurrence (EOO of 3 136 890 km²) and area of occupancy (AOO of 320 km²) that covers most of SE Asia. This species is distributed in protected areas in Northern, Northeastern and South-Western Thailand.

Anatomical characters — *Upper stem*: two ridges (Fig. 3a). *Petiole* U- to V-shaped with ridges (Fig. 3d). *Leaves*: upper epidermal cells of costal and intercostal zones with echinate cuticles (Fig. 3i, k); lower epidermal cells of costal and intercostal zones with smooth cuticles (Fig. 4c); margin revolute (Fig. 3g); upper epidermal cells in surface view with sinuous anticlinal walls and peltate glands (Fig. 4g).

Pollen morphological characters — For polar and equatorial views see Fig. 5a, b. Pollen in equatorial view with bilateral

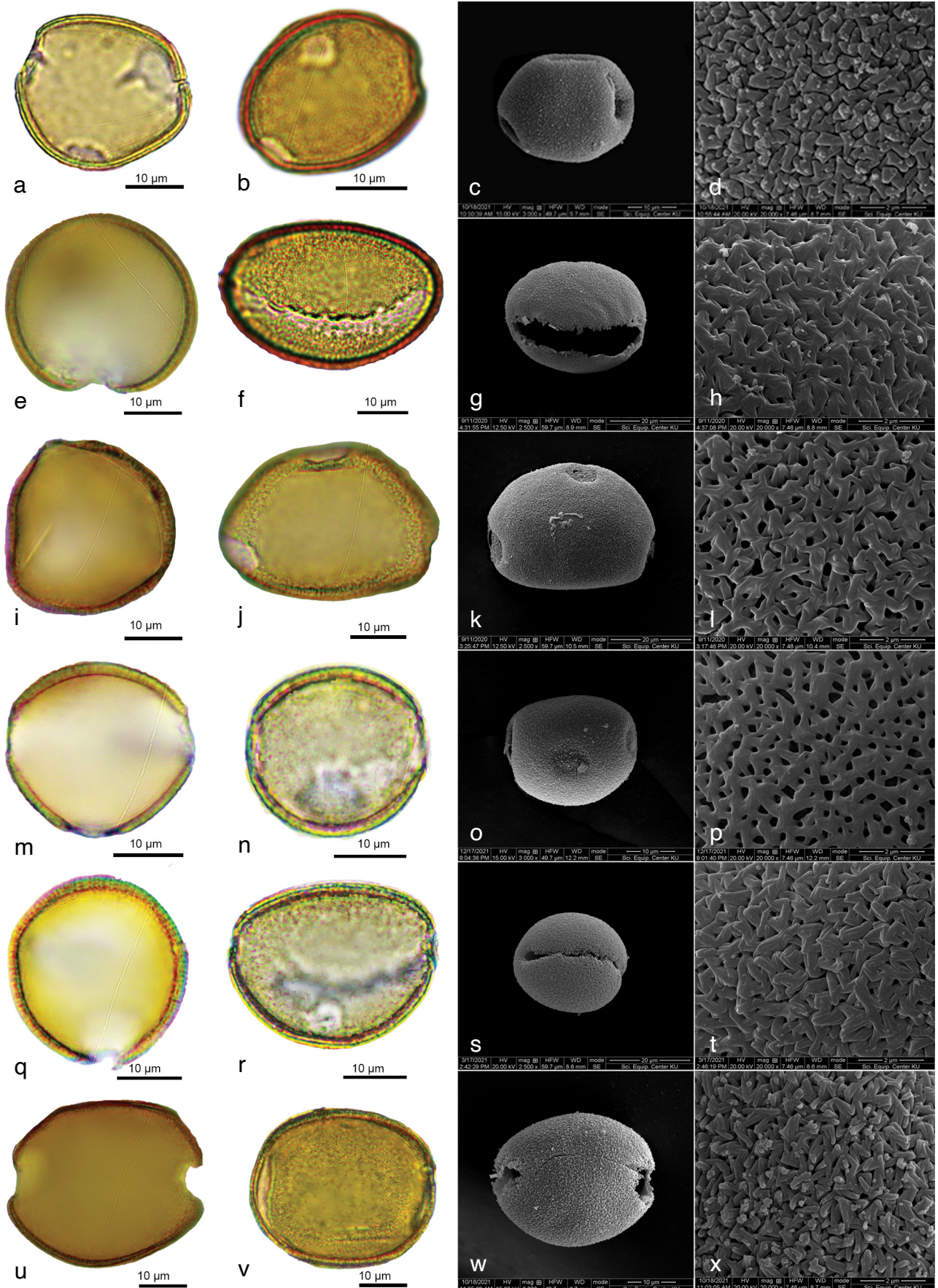


Fig. 5 Pollen morphology by light microscopy (polar and equatorial views) and scanning electron microscopy. *Disporum calcaratum*: a. Polar view; b. equatorial view; c. triporate; d. rugulate and granulate; *D. cantoniense*: e. polar view; f. equatorial view; g. monosulcate; h. rugulate and granulate; *D. chiangdaoense*: i. polar view; j. equatorial view; k. triporate; l. rugulate and perforate; *D. dorsifixerum*: m. polar view; n. equatorial view; o. triporate; p. rugulate and perforate; *D. phuhinrongklaensis*: q. polar view; r. equatorial view; s. monosulcate, t. rugulate and granulate; *D. scabridum*: u. polar view; v. equatorial view; w. diporate; x. rugulate and granulate.



Fig. 6 *Disporum cantoniense* (Lour.) Merr. a. Plant with distal branching and inflorescence; b. inflorescences; c. flowers; d. tepals with spur; e. stamens; f. pistil; g. fruits. — Photos by C. Suwanphakdee.

symmetry, sub-spheroidal ($P/E = 1.25\text{--}1.33 \mu\text{m}$), medium-sized ($38\text{--}40 \pm 0.62$ by $30\text{--}32 \pm 0.65 \mu\text{m}$). *Aperture* triporate (Fig. 5c). *Exine* $2\text{--}3 \pm 0.35 \mu\text{m}$ thick; ornamentation rugulate with granulate surface (Fig. 5d).

Notes — 1. Don (1839) based *Disporum calcaratum* on *Wallich Cat. No. 5087*. We found two specimens in BM & K-W. We selected the K-W specimen as the lectotype because this specimen was better preserved; the specimen at BM is therefore an isolectotype.

2. Don (1839) based *D. hamiltonianum* on another *Wallich* collection, *Cat. No. 5088A*. We found specimens in K-W and P and selected the herbarium sheet in K-W as the lectotype because this specimen has flowers and is well preserved; thus the P specimen is an isolectotype.

3. *Disporum wallichii* was also based by Don (1839) on *Wallich* collections, *Cat. No. 5088B* (K-W, P) and *Wallich Cat. No. 5088C* (K-W, P). The *Wallich Cat. No. 5088B* (K-W) consists of four specimens on the same sheet (Fig. 2). The specimen on the right-hand side of the sheet (no. 1) and the fourth specimen (no. 4), on the left-hand side, are *D. wallichii*. The second specimen (no. 2) is only a vegetative part and cannot be identified. The third specimen (no. 3) is *D. cantoniense*. The herbarium sheet of *Wallich Cat. no. 5088B* in P only comprises *D. wallichii*. *Wallich Cat. No. 5088C* (K-W) is *D. cantoniense*, and in P it is *D. wallichii*. We selected *Wallich Cat. No. 5088B* (the first specimen on the right hand side of the sheet (Fig. 2 no. 1)) at K-W as the lectotype because this specimen is well-preserved; and P is an isolectotype.

4. Collett & Hemsley (1890) described *D. latipetalum* based on a specimen from the Shan Hills of Myanmar, but did not designate a type specimen. Later, Hooker (1894) reduced this species to *D. calcaratum*. We found only *Collett 808*, a specimen in K. According to ICN Art. 9.1 (Turland et al. 2018) this specimen can be regarded as the holotype.

5. *Disporum calcaratum* is distinguished by the stems that are usually simple or distally 2–3-branched and 20–72 cm in length. The leaves are green with a purple margin. The flowers are campanulate with a pink or dark purplish to red perianth. The spur is 6–10 mm long, glabrous, and the ridge has papillae. The filament is pink or white with papillae. The style is white or purple and glabrous.

2. *Disporum cantoniense* (Lour.) Merr. — Fig. 3, 5, 6; Map 1

Disporum cantoniense (Lour.) Merr. (1919) 229; H.Hara, Stearn & L.H.J. Williams (1987) 72; H.Hara (1988) 183; Songyun & M.N. Tamura (2000) 154. — *Fritillaria cantoniensis* Lour. (1790) 206. — Type: not indicated.

Uvularia chinensis Ker Gawl. (1806) pl. 916. — *Disporum pullum* Salisb. (1812) 331, nom. superfl.; D. Don (1841) 521; Baker (1874) 589; Hook.f. (1894) 360; Char. (1973) 88. — Lectotype (designated by Merrill 1919): Ker Gawler (1806) pl. 916.

Perennial, erect herbs. *Rhizomes* short, horizontal. *Aerial stems* 44–170 cm long; the lower part 25–131 cm long, green; the upper part 13–60 cm long with 2 ridges; distally 2–7-branched; internodes 2.5–19 cm long. *Cataphylls* 3–9, 3–9.5 by 0.8–4 cm, brown or reddish brown. *Leaves*: lamina narrow-lanceolate to elliptic or ovate, 5.5–17.5 by 1.8–7 cm, upper surface glabrous, base obtuse, margin dentate, revolute, apex acuminate, veins 3–10; petiole very short, 2–7 mm long, green with purple at proximal end. *Inflorescences* umbellate, 2–11 flowers; peduncle 1–15 mm long, green. *Flowers* campanulate, 8–20 mm long; pedicel 2–15 mm long, green with purple at both ends. *Tepals* oblong to narrow-obovate or lanceolate or elliptic, 1.3–1.8 by 0.3–0.6 cm, keeled without papillae, dark red or a dark dull red, base densely scabrous on both sides, green or light green, margin dentate, apex dark (dull) red. *Spurs* gibbous, 1–3 mm long,

rounded, glabrous, light green; ridges 3, thickened, glabrous, dark purple. *Stamens* 5–15 mm long; filament 4–10 mm long, glabrous, white; anther basifixed, yellow. *Ovaries* obovate to oblong, 7–15 by 2–3 mm, green or light green; style 4–15 mm long, white or purple, glabrous. *Fruits* globose, 5–7 by 8–10 mm, green and dark blue to black when ripening. *Seeds* 2–5, triangular or subglobose, brown or light brown, glabrous.

Distribution — India, China, Tibet, Nepal, Sri Lanka, Myanmar, Laos, Vietnam Thailand (Mae Hong Son, Chiang Mai, Phayao, Nan, Lamphun, Loei), Malaysia, Indonesia.

Habitat & Ecology — In open areas or along roadsides of mixed deciduous or evergreen forests (pine forest) at 800–1600 m elevation. Flowering: June to August; fruiting: July to December.

Preliminary IUCN conservation status — A conservation status of LC is proposed. *Disporum cantoniense* is a very widespread species across SE Asia. It is distributed in the protected forest regions of the Northern, Northeastern and South-Western phytogeographical areas of Thailand.

Anatomical characters — *Upper stem*: two ridges (Fig. 3c). *Petiole* heart shaped with ridges (Fig. 3f). *Leaves*: upper epidermis cell above costal zone with echinate cuticle and intercostal zone with smooth cuticle; lower epidermal cells of costal zone with echinate cuticle and intercostal zone with smooth cuticle; margin revolute; anticlinal walls of adaxial epidermis sinuate (Fig. 3h).

Pollen morphological characters — For polar and equatorial views see Fig. 5e, f. Pollen in equatorial view with bilateral symmetry, prolate ($P/E = 1.30\text{--}1.41 \pm 0.03 \mu\text{m}$), medium-sized ($38\text{--}41$ by $28\text{--}30 \mu\text{m}$). *Aperture* monosulcate (Fig. 5g). *Exine* $1\text{--}3 \pm 0.43 \mu\text{m}$ thick; ornamentation rugulate with granulate surface (Fig. 5h).

Note — *Disporum cantoniense* is distinguished by its campanulate flowers with dark red or dark dull red perianth. The spur is gibbous, 1–3 mm long, with 3 ridges. The basal tepal is densely scabrous. The filament is glabrous and white.

3. *Disporum chiangdaoense* Sarapan & Suwanph., sp. nov.

— Fig. 3, 4, 5, 7, 8; Map 1

Disporum chiangdaoense differs from *D. calcaratum* in its perianth that is white and green or cream at apex (vs pink and purple in *D. calcaratum*) and the ridge of the spur is glabrous (vs papillose in *D. calcaratum*). — Type: A. Sarapan 46 (holo BKF!; iso BK!, BKF!, KI, KKU!, QBG!), Thailand, Chiang Mai province, Chiangdao district, Chiangdao Wildlife Sanctuary, 10 June 2021.

Etymology. The specific epithet refers to Chiangdao Wildlife Sanctuary, Chiang Mai Province, where the type specimens were collected.

Perennial erect herbs. *Rhizomes* horizontal. *Aerial stems* 15–94 cm long; the lower part 15–68 cm long, purple; the upper part 7–25 cm long with 4 ridges; simple or distally 2–4 branched; internode 1.5–20 cm long. *Cataphylls* 4–6, 1.2–6.5 by 0.5–2.5 cm, light or dark brown. *Leaves*: lamina narrow-lanceolate to elliptic or ovate, 2–10 by 1–3.5 cm, upper surface glabrous, base obtuse, margin dentate, revolute, dark purple, apex acuminate, veins 5–8; petiole ± absent or very short, 1–3 mm long, green. *Inflorescences* umbellate, 2–8 flowers; peduncle 1–20 mm long, green with purple at proximal and distal ends. *Flowers* campanulate, 10–30 mm long; pedicel 10–25 mm long, green with purple at proximal and distal ends. *Tepals* oblong to obovate, 1.4–2.3 by 0.5–0.6 cm, 1–3 keeled with papillae, white, base glabrous, margin dentate, apex green or cream. *Spurs* straight or recurved with a ridge, 5–10 mm long, cylindrical or funnel-shaped, glabrous, white; ridge membranous, glabrous, white. *Stamens* 10–13 mm long; filament 4–10 mm long white, papillose; anther basifixed, yellow. *Ovaries* obovate or oblong, 13–15 by 2–3 mm, green;



Fig. 7 *Disporum chiangdaoense* Sarapan & Suwanph. a. Plant with inflorescences; b. inflorescence; c. flowers; d. tepals with spur; e. stamens; f. pistil; g. fruits. — Photos by P. Limpanasittichai.

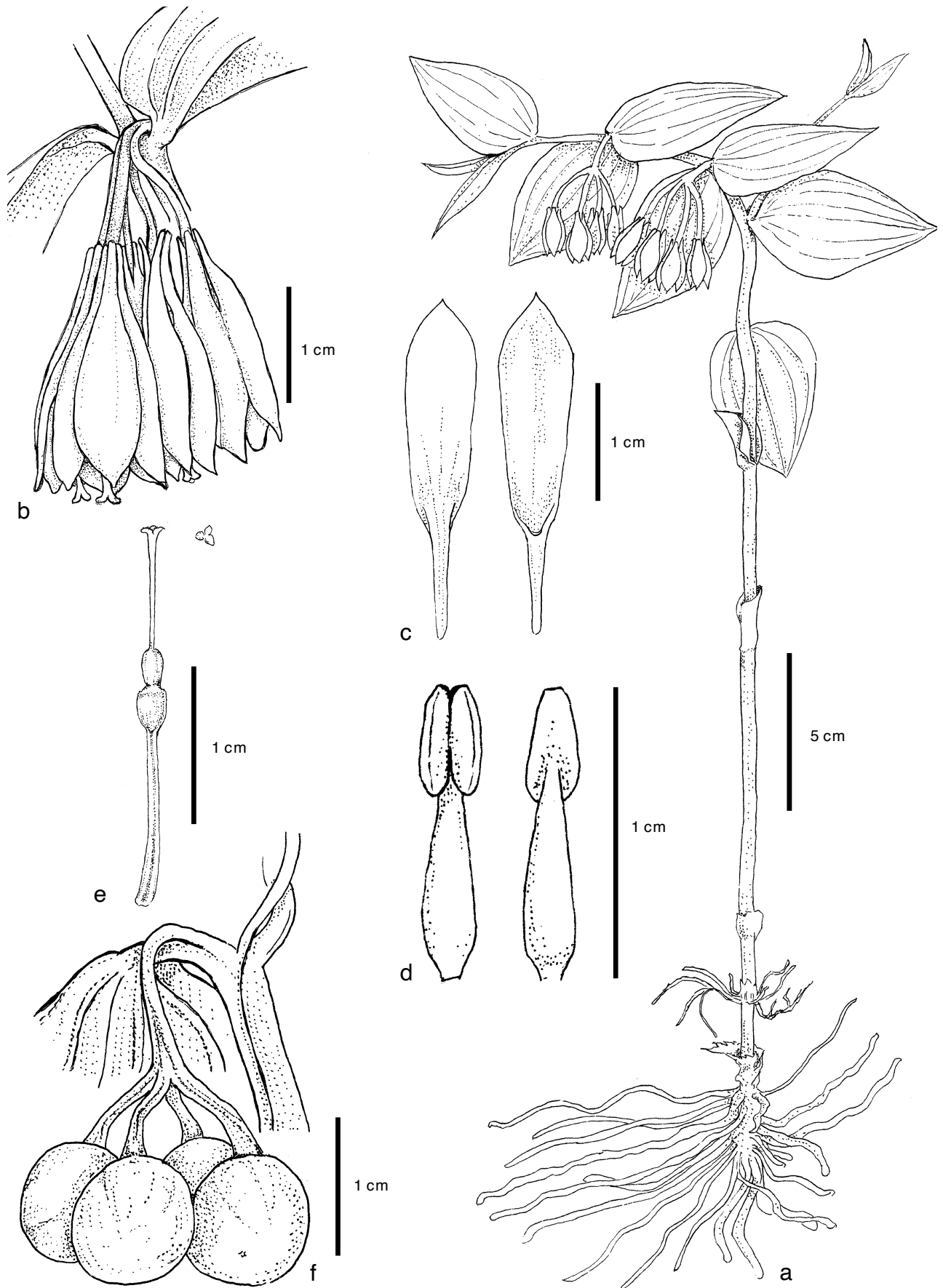


Fig. 8 *Disporum chiangdaoense* Sarapan & Suwanph. a. Habit; b. inflorescence; c. tepals with spur; d. stamens; e. pistil; f. fruits. — Drawn by S. Sriboran (A. Sarapan 46; BK, BKF, K, QBG).

Table 2 A summary of the differences in morphology, anatomy and pollen morphologies between *D. chiangdaoense* Sarapan & Suwanph. and *D. calcaratum* D.Don.

| Characters | <i>D. chiangdaoense</i> | <i>D. calcaratum</i> |
|--------------------------------|----------------------------|------------------------------|
| Morphology | | |
| cataphyll | green or pale green | brown or reddish brown |
| perianth | white, apex green or cream | pink, apex dark purplish red |
| spur | ridges without papillae | ridges with papillae |
| filament | white | pink or white |
| ovary | green | purple or green |
| Anatomy | | |
| ridge in upper part of stem | 4 ridges | 2 ridges |
| ridge of petiole | absent | present |
| petiole accumulated tannin | accumulated tannin | no accumulated tannin |
| costal zone of lower epidermis | echinate cuticle | smooth cuticle |
| peltate scales | absent | present on upper surface |
| Pollen morphology | | |
| polar axis length | 42–44 ± 0.72 µm | 38–40 ± 0.62 µm |
| equatorial axis length | 38–40 ± 0.53 µm | 30–32 ± 0.65 µm |
| ornamentation | rugulate and perforate | rugulate and granulate |

style 3–12 mm long, white, glabrous. *Fruits* globose, 4–6 by 3–6 mm, blue or dark blue when ripe. *Seeds* 2–4, subglobose or triangular, brown or light brown, surface rough when dried.

Distribution — Endemic to Thailand (Provinces: Mae Hong Son (Mueang District); Chiang Mai (Chiangdao Wildlife Sanctuary)).

Habitat & Ecology — In open areas or along roadsides of evergreen forest at 1200–2000 m elevation. Flowering: June to July; fruiting: August to February.

Preliminary IUCN conservation status — A conservation status of Vulnerable (VUD2) is proposed. *Disporum chiangdaoense* is endemic to Thailand and was collected from two localities, each with a small population. The species occurs in the Chiang Dao Wildlife Sanctuary that is a protected area and Hmong Microwave Village in Mae Hong Son province. Further exploration is needed.

Anatomical characters — *Upper stem*: four ridges (Fig. 3b). *Petiole* U-shaped, without ridges (Fig. 3e). *Leaves*: upper epidermal cells above costal and intercostal zones with echinate cuticles; lower epidermal cells of costal zone with echinate cuticles (Fig. 4d) and intercostal zone with smooth cuticles; margin revolute; anticlinal walls of adaxial epidermis sinuate (Fig. 4i).

Pollen morphological characters — For polar and equatorial views see Fig. 5i, j.

Pollen in equatorial view asymmetrical, subspheroidal (P/E = 1.10–1.15 µm), medium-sized (42–44 by 38–40 µm). *Aperture* triporate (Fig. 5k). *Exine* 1–3 ± 0.56 µm thick; ornamentation rugulate with perforate surface (Fig. 5l).

Note — *Disporum chiangdaoense* resembles *D. calcaratum*; both have campanulate flowers. However, they differ in several respects. A summary of the differences in morphology, anatomy and pollen morphologies between *D. chiangdaoense* and *D. calcaratum* is shown in Table 2.

4. *Disporum dorsifixerum* Sarapan & Suwanph., sp. nov. — Fig. 3, 4, 5, 9, 10; Map 1

Disporum dorsifixerum has dorsifixed anthers; it differs from *D. calcaratum* in its flowers which are rotate (vs campanulate in *D. calcaratum*); the ridge of the spur that lacks papillae (vs papillose in *D. calcaratum*), and the tepals that are apically green (vs pale pink in *D. calcaratum*). — Type: A. Sarapan 33 (holo BKF!; iso BK!, BKF!, K!, KKU!, QBG!), Thailand, Lamphun province, Mae Tha district, Doi Khun Tan National Park, 12 June 2021.

Etymology. The specific epithet refers to the dorsifixed anther attachment that is a unique distinguishing character for this species.

Perennial erect herbs. *Rhizomes* horizontal. *Aerial stems* 25–160 cm long; the lower part 5–77 cm long, green; the upper

part 15–62 cm long with 2 ridges; distally 2–6 branched; internodes 1.5–22 cm long. *Cataphylls* 3–6, 1.5–7.8 by 0.4–2.5 cm, brown or reddish brown. *Leaves*: lamina narrow-lanceolate to elliptic or ovate, 4.5–14 by 1.8–7 cm, upper surface glabrous, base obtuse, margin dentate, revolute, apex acuminate, veins 3–12; petiole 1–6 mm long, white or green, papillose. *Inflorescences* umbellate, 2–10 flowers; peduncle 2–40 mm long, green. *Flowers* rotate, 8–20 mm long; pedicel 10–32 mm long, green with purple at proximal and distal ends. *Tepals* lanceolate to obovate or elliptic to ovate, 1–1.7 by 0.3–0.8 cm, keels 1–3, with papillae, pink or dark purplish red or a dark dull red, base glabrous, margin entire, revolute, apex green. *Spurs* straight or recurved with a ridge, 5–7 mm long, cylindrical or funnel-shaped, glabrous, pink or light pink or dark purplish red; ridge membranous, glabrous, dark dull red. *Stamens* 7–14 mm long; filament 4–10 mm long, pink or dark purplish red, smooth; anther dorsifixed, yellow or purplish red. *Ovaries* globose or obovate, 13–15 by 2–4 mm, green or pale green to yellow; style 5–10 mm long, dark dull or dark purplish red, papillose. *Fruits* oblate or globose, 0.4–14 by 0.6–1.4 cm, deep blackish blue when ripe. *Seeds* 1–5, subglobose or triangular, light brown to brown, glabrous.

Distribution — Endemic to Thailand (Lamphun: Doi Khun Tan National Park; Tak: Thung Yai Naresuan Wildlife Sanctuary).

Habitat & Ecology — In open areas and along roadsides of mixed deciduous and evergreen forests at 1300–1800 m elevation. Flowering: July to August; fruiting: July to December.

Preliminary IUCN conservation status — A conservation status of Vulnerable (VUD2) is proposed. *Disporum dorsifixerum* is endemic to Thailand and is known from two localities, each with a small population where a few individuals were observed. The species might occur in other areas in the Northern region of Thailand. A further survey is needed to reassess the conservation status.

Anatomical characters — *Upper stem*: two ridges. *Petiole* V-shaped with ridges. *Leaves*: upper epidermal cells above costal zone with echinate cuticles and intercostal zone with smooth cuticles (Fig. 3l); lower epidermal cells of costal zone with echinate cuticles (Fig. 4e) and intercostal zone with smooth cuticles; margin slightly revolute; anticlinal walls of adaxial epidermis sinuate (Fig. 4j).

Pollen morphological characters — For polar and equatorial views see Fig. 5m, n.

Pollen in equatorial view asymmetrical, spheroidal (P/E = 1.03–1.12 µm), medium-sized (27–29 by 25–27 µm). *Aperture* triporate (Fig. 5o). *Exine* 1–3 ± 0.52 µm thick; ornamentation rugulate with granulate surface (Fig. 5p).



Fig. 9 *Disporum dorsifixerum* Sarapan & Suwanph. a. Plant with inflorescences; b. inflorescence; c. flowers; d. tepals with spur; e. stamens; f. pistil; g. fruits. — Photos by Y. Banchong.

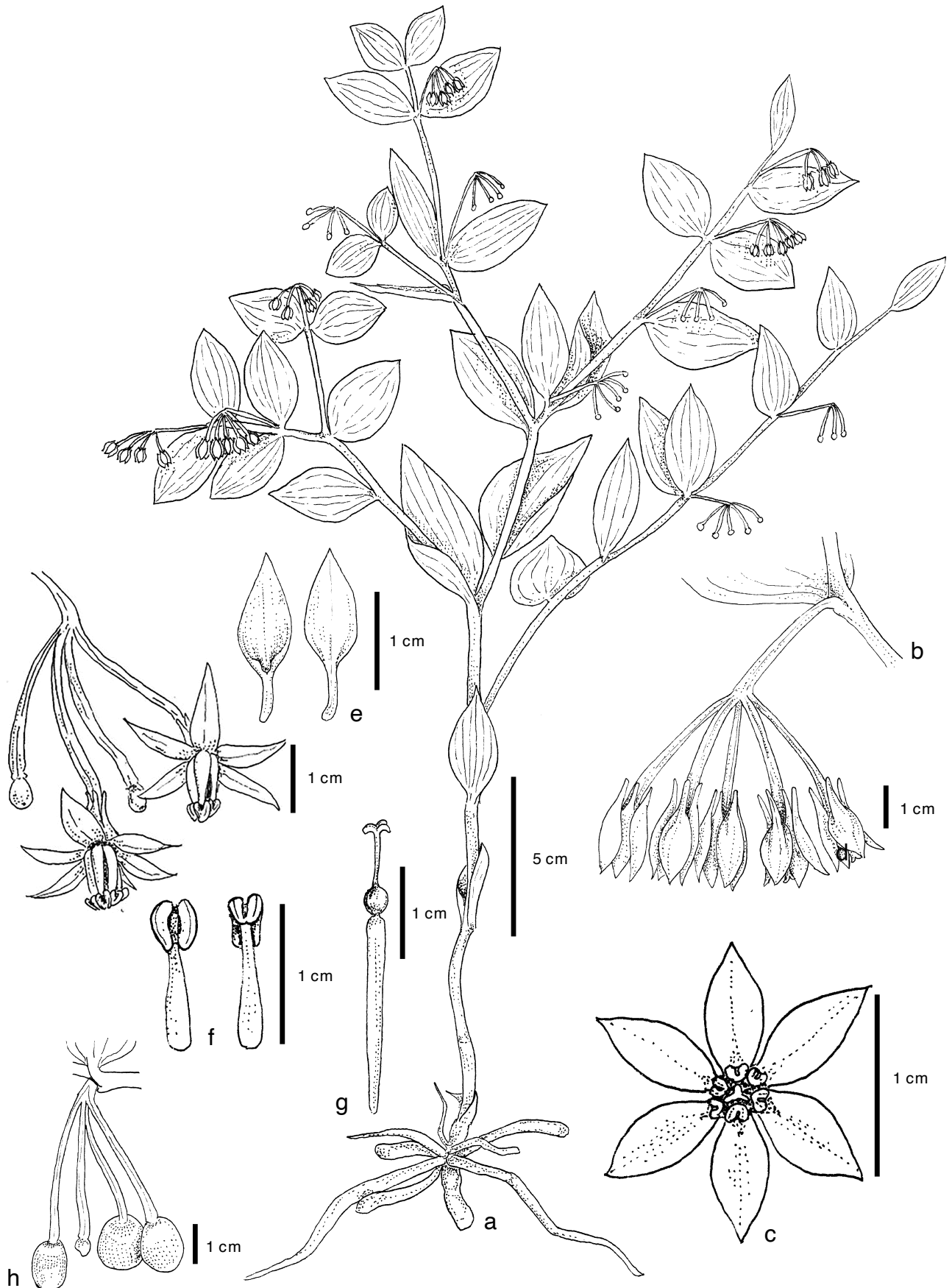


Fig. 10 *Disporum dorsifixerum* Sarapan & Suwanph. a. Whole plant; b. inflorescence; c. flower (top view); d. flowers (side view); e. tepals with spur; f. stamens; g. pistil; h. fruits. — Drawn by S. Sriboran (A. Sarapan 33; BK, BKF, K, QBG).

Table 3 A comparison of morphology, anatomy and pollen characteristics between *D. dorsifixerum* Sarapan & Suwanph. and *D. calcaratum* D. Don.

| Characters | <i>D. dorsifixerum</i> | <i>D. calcaratum</i> |
|-------------------------------------|---------------------------|--------------------------|
| Morphology | | |
| lower part of stem | 5–77 cm long | 10–56 cm long |
| leaf | margin green | margin dark purple |
| flower | rotate | campanulate |
| perianth | margin entire | margin dentate |
| spur | ridges glabrous | ridges with papillae |
| anther | dorsifixed | basifixed |
| filament | pink or dark purplish red | pink or white |
| style | papillose | glabrous |
| Anatomy | | |
| intercostal zone of upper epidermis | smooth cuticle | echinate cuticle |
| costal zone of lower epidermis | echinate cuticle | smooth cuticle |
| peltate scale | absent | present on upper surface |
| Pollen morphology | | |
| polar axis long | 27–29 ± 0.60 µm | 38–40 ± 0.62 µm |
| equatorial axis long | 25–27 ± 0.73 µm | 30–32 ± 0.65 µm |
| shape | spheroidal | subspheroidal |
| ornamentation | rugulate and perforate | rugulate and granulate |

Note — *Disporum dorsifixerum* is similar to *D. calcaratum* in its pink to purple perianth. The differences are provided in Table 3.

5. *Disporum phuhinrongklaensis* Sarapan & Chamch., sp. nov. — Fig. 4, 5, 11, 12; Map 1

Disporum phuhinrongklaensis differs from *D. calcaratum* in its flowers that are rotate and white and green at the apex (vs campanulate and pink or dark purplish red in *D. calcaratum*); the ridge of the spur is glabrous (vs papillose in *D. calcaratum*); the filaments and style are white (vs pink or purple in *D. calcaratum*). — Type: A. Sarapan 40 (holo BKF!; iso BK!, BKF!, K!, KKU!, QBG!), Thailand, Pitsanulok province, Nakhon Thai district, Phu Hin Rong Kla National Park, 2 June 2021.

Etymology. The specific epithet refers to Phu Hin Rong Kla National Park, Phitsanulok province, where the type specimens were collected.

Perennial erect herbs. *Rhizomes* short, vertical or horizontal. *Aerial stems* 40–105 cm long; the lower part 27–57 cm long, green; the upper part 8–54 cm long with 3 ridges, distally 2–6 branched; internodes 3–17 cm long. *Cataphylls* 2–4, 2.5–6.5 by 0.4–2 cm, green or pale green. *Leaves:* lamina narrow-lanceolate to ovate, 6–11 by 1–5 cm, upper surface glabrous, base obtuse, margin dentate, revolute, apex acuminate, veins 4–9; petiole absent or short, 1–3 mm long, green. *Inflorescences* umbellate, 3–8 flowers; peduncle 2–30 mm long, green with purple at proximal and distal ends. *Flowers* rotate, 10–20 mm long; pedicel 10–30 mm long, green with purple at proximal and distal ends. *Tepals* oblong to narrow-ovate or obovate, 1.4–2 by 0.4–1 cm, keels 1–3, with papillae, white,

base glabrous, margin entire, apex green. *Spurs* straight or recurved with a ridge, 5–9 mm long, cylindrical or funnel shaped, glabrous, white; ridge membranous, glabrous, white. *Stamens* 10–15 mm long; filament 7–12 mm long, white, papillose; anther basifixed, yellow. *Ovaries* obovate or oblong, 8–12 by 2–3 mm, green; style 2–8 mm long, white, glabrous. *Fruits* globose to oblong, 4–10 by 4–8 mm, green and black when ripening. *Seeds* 2–3, subglobose, brown or light brown, rugose when dried.

Distribution — Endemic in Thailand (Chiang Mai: Si Lanna National Park, Phitsanulok: Phu Hin Rong Kla National Park).

Habitat & Ecology — In open areas or along roadsides of mixed deciduous and evergreen forests at 800–1200 m elevation. Flowering: May to June; fruiting: July to December.

Preliminary IUCN conservation status — A conservation status of Vulnerable (VUD2) is proposed. *Disporum phuhinrongklaensis* is endemic to Thailand and is known from two localities, each with a small population where a few individuals were observed. The species might occur in other areas in the Phu Hin Rong Kla National Park and Si Lanna National Park. Further exploration is needed.

Anatomical characters — *Upper stem:* three ridges. *Petiole* V-shaped with ridges. *Leaves:* upper epidermal cells above costal zone with echinate cuticles and intercostal zone with smooth cuticles (Fig. 4a); lower epidermal cells of costal zone with echinate cuticles (Fig. 4f) and intercostal zone with smooth cuticles; margin revolute; anticlinal walls of adaxial epidermis sinuate (Fig. 4k).

Table 4 A comparison of morphology, anatomy and pollen morphology between *D. phuhinrongklaensis* Sarapan & Chamch. and *D. calcaratum* D. Don.

| Characters | <i>D. phuhinrongklaensis</i> | <i>D. calcaratum</i> |
|-------------------------------------|----------------------------------|--|
| Morphology | | |
| cataphyll | green or pale green | brown or reddish brown |
| flower | rotate form | campanulate form |
| perianth | white, margin entire, apex green | pink, margin dentate, apex dark purplish red |
| spur | ridges without papillae | ridges with papillae |
| filament | white | pink or white |
| ovary | green | purple or green |
| Anatomy | | |
| upper epidermis of intercostal zone | smooth cuticle | echinate cuticle |
| costal zone of lower epidermis | echinate cuticle | smooth cuticle |
| peltate gland | absent | present on upper surface |
| Pollen morphology | | |
| polar axis long | 35–37 ± 0.66 µm | 38–40 ± 0.62 µm |
| equatorial axis long | 28–30 ± 0.67 µm | 30–32 ± 0.65 µm |
| aperture | monosulcate | triporate |

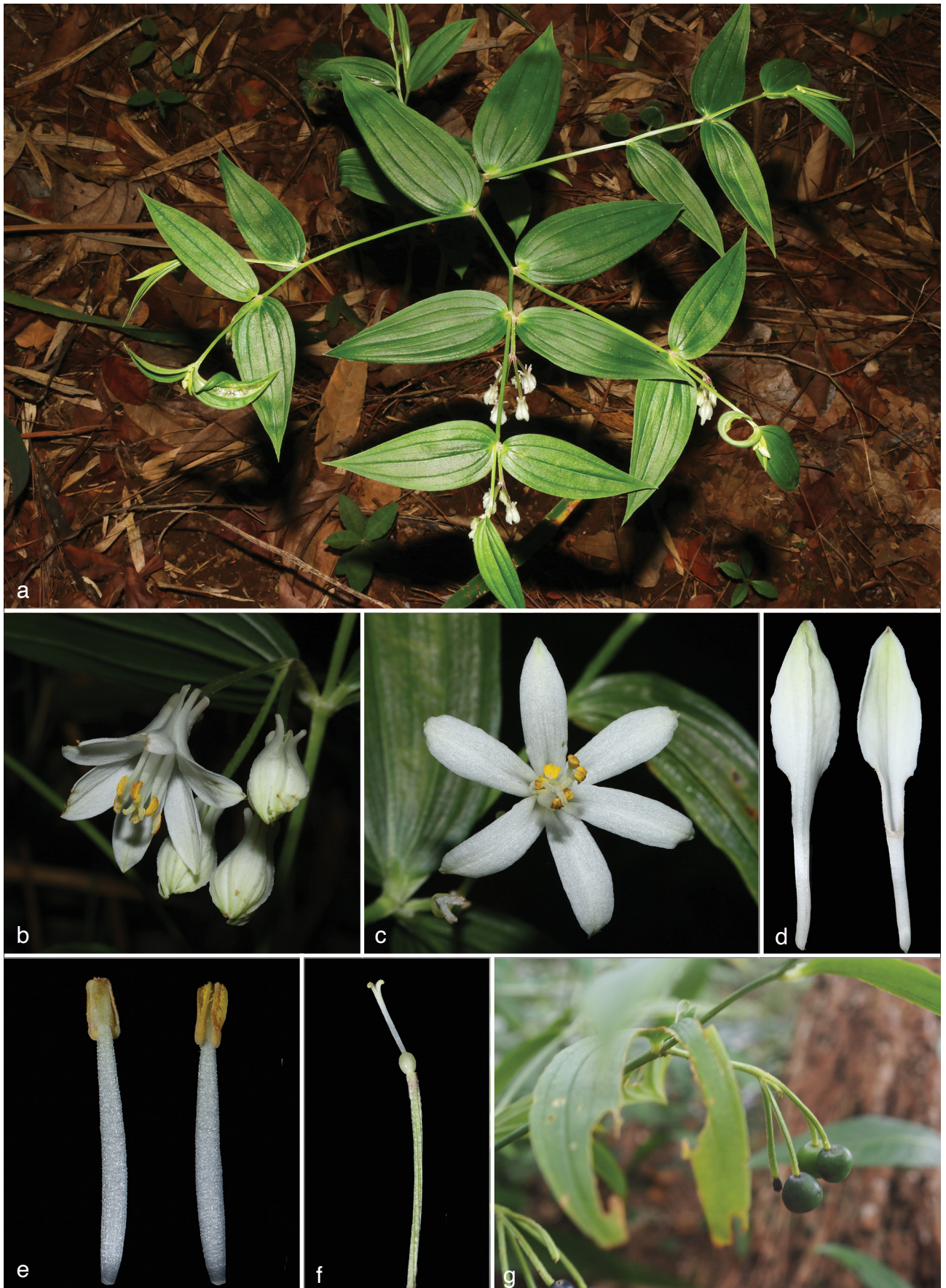


Fig. 11 *Disporum phuhinrongklaensis* Sarapan & Chamch. a. Whole plant; b. inflorescences; c. flowers; d. tepals with spur; e. stamens; f. pistil; g. fruits. — Photos by P. Limpanasittichai.

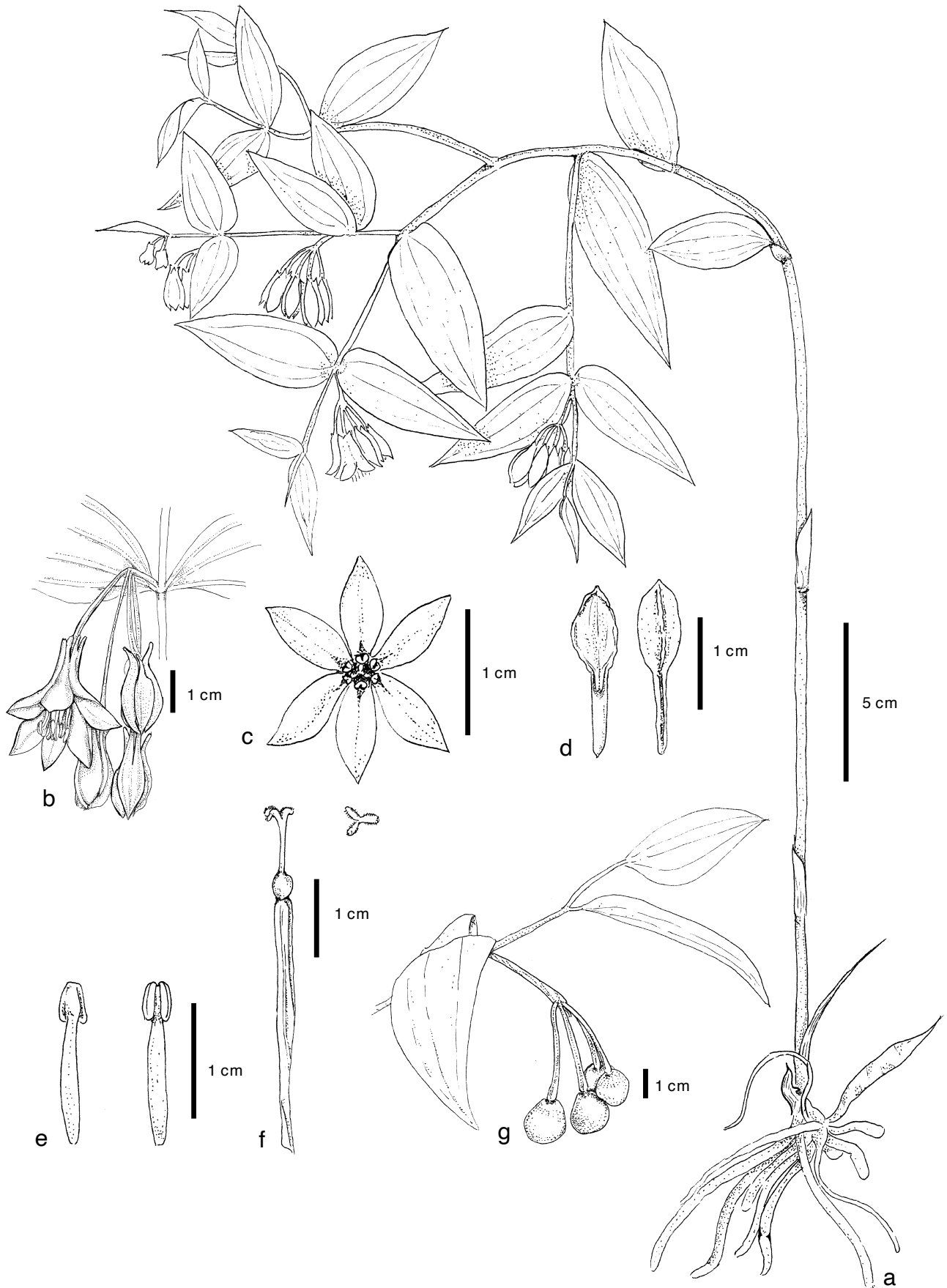


Fig. 12 *Disporum phuhinrongklaensis* Sarapan & Chamch. a. Whole plant; b. inflorescence; c. flower; d. tepals with spur; e. stamens; f. pistil; g. fruits. — Drawn by S. Sriboran (A. Sarapan 40; BK, BKF, K, QBG).



Fig. 13 *Disporum scabridum* Sarapan & Hodk. a. Whole plants; b. inflorescences; c. flowers; d. tepals with spur; e. stamens; f. pistil; g. fruits. — Photos by C. Suwanphakdee.

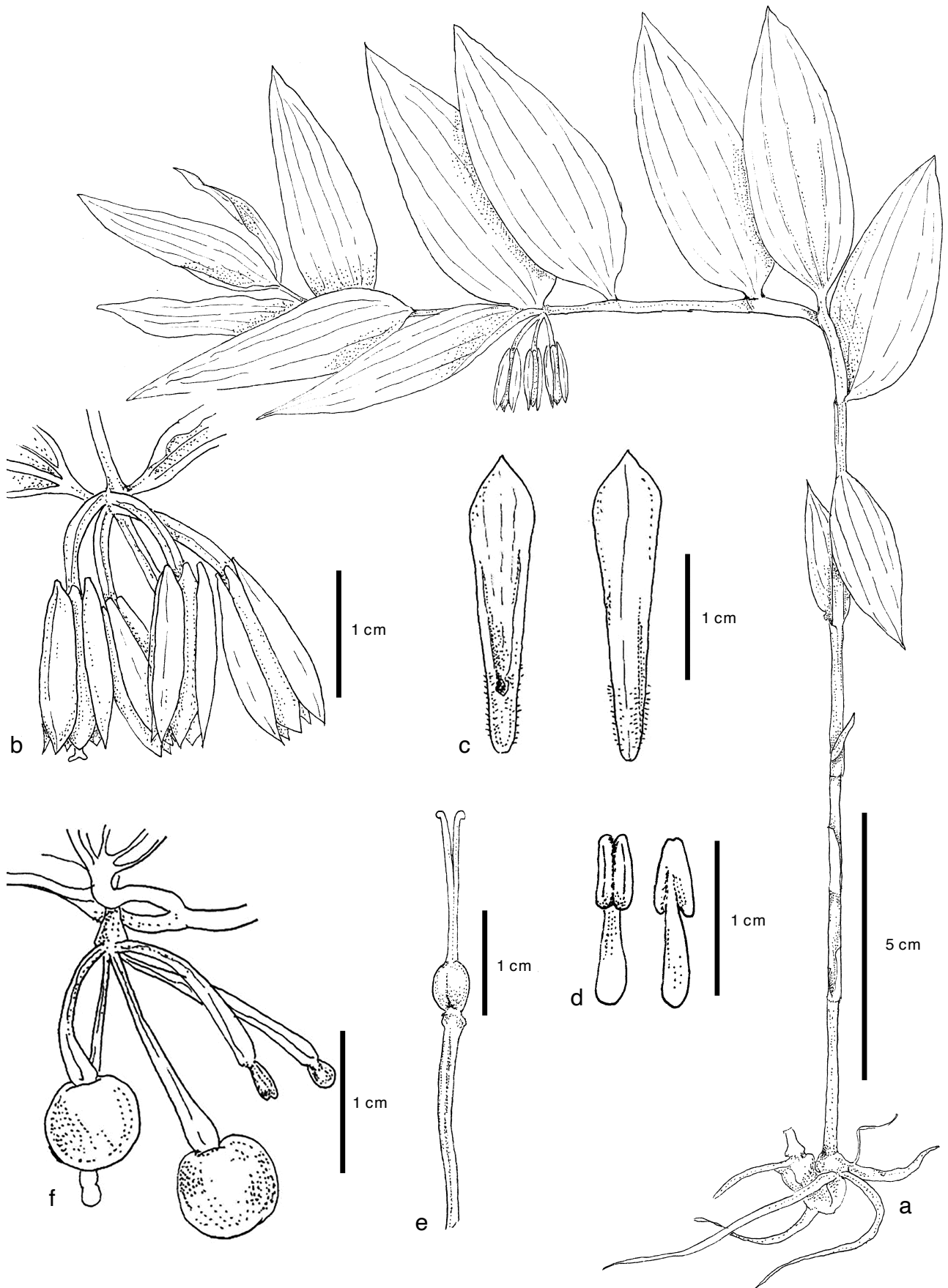


Fig. 14 *Disporum scabridum* Sarapan & Hodk. a. Whole plant; b. inflorescence; c. tepals with spur; d. stamens; e. pistil; f. fruits. — Drawn by S. Sriboran (A. Sarapan 8; BK, BKF, K, QBG).

Table 5 A comparison of morphology, anatomy and pollen characteristics between *D. scabridum* Sarapan & Hodk. and *D. calcaratum* D. Don.

| Characters | <i>D. scabridum</i> | <i>D. calcaratum</i> |
|-------------------------------------|------------------------------|-------------------------------------|
| Morphology | | |
| lower part of stem | 68–73 cm long | 10–56 cm long |
| leaf | margin green | margin dark purple |
| flower | tubulate to campanulate-like | campanulate-like |
| perianth | base scabrous | base glabrous |
| spur | spur and ridges scabrous | spur glabrous, ridges with papillae |
| filament | white or green | pink or white |
| style | papillose | glabrous |
| Anatomy | | |
| intercostal zone of upper epidermis | smooth cuticle | echinate cuticle |
| costal zone of upper epidermis | smooth cuticle | echinate cuticle |
| margin | involute | revolute |
| peltate scale | absent | present on upper surface |
| Pollen morphology | | |
| equatorial axis long | 37–39 ± 0.53 µm | 30–32 ± 0.65 µm |
| shape | spheroidal | subspheroidal |
| aperture | 2-porate | triporate |

Pollen morphological characters — For polar and equatorial views see Fig. 5q, r.

Pollen in equatorial view with bilateral symmetry, subspheroidal ($P/E = 1.20–1.32 \mu\text{m}$), medium-sized (35–37 by 28–30 µm). *Aperture* monosulcate (Fig. 5s). *Exine* 1–3 ± 0.53 µm thick; ornamentation rugulate with granulate surface (Fig. 5t).

Note — *Disporum phuhinrongklaensis* is similar to *D. calcaratum* as they share a long and straight spur. However, they differ in a number of respects, see Table 4.

6. *Disporum scabridum* Sarapan & Hodk., *sp. nov.* — Fig. 3, 4, 5, 13, 14; Map 1

Disporum scabridum differs from *D. calcaratum* in its flowers that are tubulate to campanulate with a deep purple red apex (vs campanulate with pink or pale pink apex in *D. calcaratum*); the basal tepal and spur are densely scabrous (vs glabrous in *D. calcaratum*). — Type: *A. Sarapan 8* (holo BKF!; iso BK!, BKF!, KI, KKU!, QBG!), Thailand, Phitsanulok province, Nakhon Thai district, Phu Hin Rong Kla National Park, Mhan Daeng Waterfall, 7 July 2021.

Etymology. The specific epithet refers to the densely scabrous spur that is characteristic of the species.

Perennial erect herbs. *Rhizomes* short, vertical or horizontal. *Aerial stems* 45–100 cm long; the lower part 68–73 cm long, green; the upper 20–50 cm long with 2 ridges; simple or usually distally 2–3-branched; internode 1–20 cm long. *Cataphylls* 4–5, 4–5.5 by 0.6–1.2 cm, reddish brown. *Leaves*: lamina lanceolate, elliptic or ovate, 11–16 by 0.3–0.5 cm, upper surface glabrous, base obtuse, margin dentate, involute, dark purple, apex acuminate, veins 3–8; petiole absent or short, 2–10 mm long, green. *Inflorescences* umbellate, 3–7 flowers; peduncle 4–10 mm long, green. *Flowers* tubulate to campanulate, 12–20 mm long; pedicel 4–20 mm long, green with purple at proximal and distal ends. *Tepals* lanceolate to obovate, 2–2.2 by 0.4–0.6 cm, 1–3 keels with papillae, dark red to light pure red or deep red with a slight tinge of purple, base densely scabrous on both sides, margin dentate, apex dark dull red. *Spurs* straight or recurved with a ridge, 5–7 mm long, cylindrical or funnel shaped, densely scabrous, dark red; ridges membranous, densely scabrous or papillose, dark dull red. *Stamens* 12–14 mm long; filament 8–12 mm long, white or green, densely papillate; anther basifixed, yellow. *Ovaries* oblong or obovate to oblong, 12–14 by 2–3 mm; style 6–10 mm long, dark purplish red, papillose. *Fruits* globose, 4–6 by 3–7 mm, green and black when ripening. *Seeds* 2–4, subglobose or triangular, light brown to brown, rough surface when dried.

Distribution — Endemic to Thailand (Phitsanulok: Phu Hin Rong Kla National Park).

Habitat & Ecology — In open areas and along roadsides of mix deciduous or evergreen forests at 1000–1800 m elevation. Flowering: June to July; fruiting: July to November.

Preliminary IUCN conservation status — A conservation status of Vulnerable (VUD1) is proposed. *Disporum scabridum* is endemic to Thailand and is known only from one small population where a few individuals were observed. The species might occur in other areas in the Phu Hin Rong Kla National Park. Further exploration is needed.

Anatomical characters — *Upper stem*: two ridges. *Petiole* V-shaped with ridges. *Leaves*: upper epidermal cells above costal and intercostal zones (Fig. 3j) with smooth cuticles (Fig. 4b); lower epidermal cells of costal and intercostal zones with smooth cuticles; margin involute (Fig. 3h); anticlinal walls of adaxial epidermis sinuate (Fig. 4l).

Pollen morphological characters — For polar and equatorial views see Fig. 5u, v. Pollen in equatorial view with bilateral symmetry, spheroidal ($P/E = 1.02–1.10 \mu\text{m}$), medium-sized (39–41 by 37–39 µm). *Aperture* 2-porate (Fig. 5w). *Exine* 2–3 ± 0.48 µm thick; ornamentation rugulate with granulate surface (Fig. 5x).

Note — Morphologically, *Disporum scabridum* is similar to *D. calcaratum*; the differences are shown in Table 5.

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IDENTIFICATION LIST

- 1 = *Disporum calcaratum* D. Don
- 2 = *Disporum cantoniense* (Lour.) Merr.
- 3 = *Disporum chiangdaoense* Sarapan & Suwanph.
- 4 = *Disporum dorsifixerum* Sarapan & Suwanph.
- 5 = *Disporum phuhinrongklaensis* Sarapan & Chamch.
- 6 = *Disporum scabridum* Sarapan & Hodk.

- Collett 808: 1; 835: 1.
- Glamwaewwong 187: 1; 1073: 1.
- La-onsri, Norsaengsri, Punyachan, Tatiya & Satatha 1773: 1; 1931: 1; 2424: 1; 2507: 1; 2976: 3; 4097: 1.
- Maxwell 07-399: 1; 07-693: 1 – Muangyen 106: 3; 1020: 1.
- Nanakorn et al. 1326: 2; 3641: 2; 4567: 2; 4750: 2; 5707: 2; 6282: 2; 6704: 2; 6859: 2; 9201: 2; 9417: 1: 2 – Nguanchoo 299: 2; 412: 2; 523: 2 – Norsaengsri 11993: 1 – Norsaengsri & Tathana 8284: 1; 9724: 1.
- Pongamornkul 3646: 1.
- Sankamthawee 154: 1 – Sarapan 6: 5; 8: 6; 9: 4; 18: 1; 19: 1; 25: 2; 26: 3; 31: 2; 33: 4; 40: 5; 42: 2; 44: 2; 45: 2; 46: 3; 53: 4; 54: 4; 55: 4 – Srisanga 1131: 2; 1412: 2.
- Takahashi T-62748: 1; T-63044: 1 – Tamura f. T-60015: 2 – Thon 17: 1.
- Wallich 5087: 1; 5088 A: 1; 5088 B&C: 1.