

New generic record of *Tirpitzia* Hallier f. (Linaceae) for Laos, with the description of a new species

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Abstract

Tirpitzia laotica (Linaceae) is described and illustrated from limestone karst in Vang Vieng District, central Laos, representing the first record of the genus *Tirpitzia* in the country. The new species is distinguished from previously known species in the genus by a combination of strikingly long inflorescences up to 15 cm long, glandular bracteoles and sepals, white corollas with yellow markings at the throat, and a 2-locular ovary. An updated key and a distribution map of the five species currently recognized in the genus are provided.

Key words: flora, Indochina, karst-associated, Malpighiales, taxonomy

Introduction

Tirpitzia Hallier (1921: 5) (Linaceae) is a small genus of subshrubs to small trees. The type species of the genus is *Tirpitzia sinensis* (Hemsley 1899: 2594) Hallier (1921: 5), which was originally described as a member of *Reinwardtia* Dumort (1822: 19), but Hallier segregated it from *Reinwardtia* based on the following characteristics: terminal panicle inflorescences, tubular white flowers, and 4-locular ovaries and capsules (Hallier 1921). Subsequent taxonomic studies, however, have revealed additional variation within the genus, including species with pinkish flowers, and 2- or 5-locular ovaries and capsules (Suksathan & Larsen 2006, Liu & Zhou 2008, Chen *et al.* 2026). The genus is currently characterized by its ovate, elliptic to obovate-elliptic leaf blades, white to pink corollas, and 2-, 4-, or 5-merous pistils. Currently, four species are known from northern Myanmar, northern Thailand, central and southern China, and northern Vietnam: *T. bilocularis* Suksathan & Larsen (2006: 202), *T. meiguensis* D.J.Xie & R.B.Zhang in Xie *et al.* (2023: 54), *T. ovoidea* Chun & F.C.How ex W.L.Sha in Sha (1982: 189), and *T. sinensis*.

During a botanical survey in karst limestone areas of central Laos in September 2025, an interesting specimen of Linaceae was collected and identified as belonging to the genus *Tirpitzia*, representing a new generic record for Laos. Preliminary morphological observations suggested that this specimen, with its notably longer inflorescence than those of other known species in the genus, represents an undescribed species. To confirm its taxonomic status, we conducted detailed morphological comparisons and phylogenetic analyses. Consequently, it is here confirmed as a hitherto undescribed taxon and is described below as a new species, *Tirpitzia laotica* Phonep. & Tagane. Information on its habitat, phenology, vernacular name, and a preliminary conservation assessment is also provided.

Material and methods

Field survey

Botanical surveys were conducted in limestone areas of Vang Vieng District, Vientiane Province, central Laos, in September 2025. Voucher specimens were collected for morphological examination and deposited at the herbaria FOF, KAG and VNM. Silica gel-dried leaf material was also collected for molecular analyses.

Morphological examination

Morphological measurements and descriptions were made based on dried voucher specimens except for floral measurements that were made on a rehydrated specimen. We consulted the taxonomic literature of this genus (Hallier 1921, Sha 1982, Suksathan & Larsen 2006, Liu & Zhou 2008, Xie *et al.* 2023, Chen *et al.* 2026), and also herbarium specimens including digitized images of AAU, FOF, KAG, HUH, LE, P, and VNM to validate the novelty of this species.

DNA barcoding and phylogenetic analyses

Total genomic DNA was extracted from silica gel-dried leaf material using a modified CTAB (cetyltrimethylammonium bromide) protocol (Doyle & Doyle 1987). The nuclear ribosomal internal transcribed spacer (ITS) region and chloroplast maturase K (*matK*) were selected for DNA barcoding and phylogenetic analyses following established protocols (Souvannakhoummane *et al.* 2025, Tagane *et al.* 2026). PCR products were purified using ExoSAP-IT (USB Products Affymetrix, Inc., Cleveland, OH, USA) and used as templates for direct sequencing. Sequencing reactions were prepared using the SuperDye ver. 3.1 Cycle Sequencing Kit (Edge BioSystems, San Jose, CA, USA). The reaction mixtures were analyzed using an ABI 3130 Genetic Analyzer (Applied Biosystems, Foster City, CA, USA) at the Makino Herbarium, Japan.

In this study, all *Tirpitzia* sequences available in GenBank, together with newly generated sequences of *T. laotica*, were included, representing four species of the genus for ITS and three species for *matK*, with the exception of *T. bilocularis*. Two species of *Linum* Linnaeus (1753) were additionally included, together with *Anisadenia* Wallich ex Meisner (1838: 96) and *Reinwardtia*, which are closely related genera, for comparative purposes (see Appendix 1). DNA sequence alignment was performed using MAFFT (Kato *et al.* 2019) followed by manual checking and editing in AliView (Larsson 2014). Maximum likelihood (ML) analyses were conducted using MEGA12 (Kumar *et al.* 2024) with 1,000 bootstrap replicates.

Results and Discussion

Morphological observation

The collected specimens possess a unique combination of characters distinguishing them from all described species of *Tirpitzia*, including narrowly triangular stipules sometimes with marginal glands, long inflorescences up to 15 cm long, white corollas with yellow markings at the throat, two styles, 2–4-toothed staminodes, and a 2-locular ovary. These morphological differences support its recognition as a new species. Detailed morphological comparisons with all known species in the genus *Tirpitzia* are shown in Table 1.

Phylogenetic analysis

The new species represents the basal lineage of the *Tirpitzia* clade and is clearly separated from the closely related genera *Anisadenia*, *Reinwardtia* and *Linum*. It was resolved as sister to all other known species in the genus *Tirpitzia* based on both the nuclear ITS and chloroplast *matK* datasets. This sister relationship to the remaining *Tirpitzia* species received moderate support in the ITS tree (BS = 67%) (Fig. 1A) and strong support in the *matK* tree (BS = 99%) (Fig. 1B), while the monophyly of the genus *Tirpitzia* inclusive of the new species is highly supported (BS = 100% and 99%, respectively) (Fig. 1).

TABLE 1. Comparison on morphology, habitat and distribution between *Tirpitzia laotica* and related species.

Characters	<i>T. laotica</i>	<i>T. bilocularis</i> ¹	<i>T. meiguensis</i> ^{2,3}	<i>T. ovoidea</i> ^{1,4}	<i>T. sinensis</i> ^{1,4}
Habit	shrubs up to 40 cm tall	subshrubs up to 50 cm tall	herb-like to semi shrubs 20–30 cm tall	shrubs, 0.5–4 m tall	shrubs or trees, 1–5 m tall
Leaf blades	elliptic to obovate-elliptic, (1–)1.6–6.2 × (0.5–)1.0–3.6 cm	elliptic to narrowly ovate, 2.9–6.5 × 1.4–3.5 cm	ovate, 0.6–1.5 × 0.6–1.2 cm	elliptic, ovate, or rarely obovate-elliptic, 2–7 × 1.2–3.5 cm	elliptic, obovate-elliptic, or ovate, 3–8.5 × 2.8–4.5 cm
Corolla color	white, with yellow marking at throat	pink	mostly white, occasionally pale pink	white	white
Corolla tube length (cm)	1.8–2.7	2.8–3.3	0.5–0.8	2–3.5	2–3.8
Sepal size (mm)	8–9 × 1.6–1.8	10–12 × 2.0–2.5	ca. 4 × 1.5	5–7 × 2.5–3.5	5–9 × 2–3.8
Filament tube length (mm)	ca. 3	6–7	1–1.5	ca. 2.5	2–4.8
Anther length (mm)	3–4	3–3.5	ca. 1	ca. 2	N/A
Number of styles	2	2	3–5	5	4
Staminodes	2–4-toothed	2–4-toothed	0 or 2–3-toothed	0-toothed	0-toothed
Number of locule in ovaries	2	2	4–5	5	4
Number of ovules per locule	2	2	2	2	2
Style length in long-styled flower (cm)	1.5–1.7	3.3–3.5	6–9	N/A	N/A
Style length in short-styled flower (mm)	3.8	20–23	6–9	N/A	N/A
Capsule length (mm)	9–10	15–17.5	4–6	5–7	10–19
Dehiscent	2-valved	2-valved	4-valved	5-valvis	4-valved
Habitat	limestone karst ridge, 420–430 m a.s.l.	limestone mountain ridges, 1,200–1,300 m a.s.l.	river valleys and hillslopes, 1,300–1,600 m a.s.l.	valleys, rock crevices in forests, calcareous soil, 300–2,000 m a.s.l.	mountain slopes, calcareous soil, 300–2,000 m a.s.l.
Distribution	central Laos	northern Thailand	China	China, Vietnam	China, Myanmar, Vietnam

Note: ¹Suksathan & Larsen (2006), ²Chen *et al.* (2026), ³Xie *et al.* (2023), ⁴Liu & Zhou (2008)

Based on both morphological distinctiveness and phylogenetic evidence, it is clear that this taxon represents an undescribed species of *Tirpitzia*, which is formally described below.

Taxonomic treatment

Tirpitzia laotica Phonep. & Tagane, *sp. nov.* (Figs. 2–4).

TYPE:—LAOS. Vientiane Province, Vang Vieng District, Ban Phon Nguen, along trail to Pha Hornkham Viewpoint, 424 m a.s.l., 21 September 2025, *S. Tagane, P. Souladeth, V.S. Dang, T. Vongthavone, A. Sengthong, D. Kongxaisavath, K. Phengmala, Q.T. Pham, K. Takahashi, K. Yamazaki, A. Takeguchi* Z3299 (holotype: FOF [FOF0010670], isotypes: FOF [FOF0009798], KAG [KAG202818], VNM [VNM00076419]).

Diagnosis:—*Tirpitzia laotica* is similar to *T. bilocularis* of Thailand in having stalked glands on sepal margin, a 2-locular ovary, and 2 styles, but clearly distinguished by its narrowly triangular stipules (vs. depressed-reniform in *T. bilocularis*), absence of glands on the petiole and leaf blade margin (vs. presence), longer inflorescences 7–15 cm

long (vs. 2.5–7 cm long), white corollas with yellow markings at the throat (vs. entirely pink corollas), shorter corolla tubes 1.8–2.7 cm long (vs. 2.8–3.3 cm long), shorter styles, 1.5–1.7 cm long in long-styled flowers and 0.3 cm long in short-styled flowers (vs. 3.3–3.5 cm and 2–2.3 cm long, respectively), and shorter capsule 9–10 mm long (vs. 15–17.5 mm long).

Description:—Small few-branched shrubs, up to 40 cm tall. Bark dark brown with numerous small black dots, flaking, dull brownish yellow. Twigs 1–4 mm in diam., covered with short pilose hairs when very young, soon becoming glabrous. Stipules narrowly triangular, 0.3–0.6 mm long, glabrous on both surfaces, apex acute, sometimes with a gland. Leaves alternate; petioles 0.6–1.8 cm long, covered with short pilose hairs when very young, soon glabrous; blades elliptic to obovate-elliptic, (1–)1.6–6.2 × (0.5–)1–3.6 cm, dark yellow-green, glabrous adaxially, dull greenish yellow, pilose abaxially, apex acute to rounded, margin entire, shallowly recurved when dry, base cuneate to attenuate, midrib prominent abaxially, secondary veins 5–10 pairs, prominent abaxially, tertiary veins scalariform-reticulate, slightly prominent abaxially. Inflorescence terminal, 7–15 cm long, 1–3-branched, with 2–9 flowers per branch. Bracts obovate-oblong, 4–6 × 1–1.6 mm, glabrous adaxially, covered with pilose hairs abaxially, apex obtuse, with a stalked gland, margin with 6–9 stalked glands on each side, stalked glands 0.7–1.1 mm long, bluish-purple. Flowers white, heterostylous, sessile. Sepals 5, partly fused at the base, lanceolate, 8–9 × 1.6–1.8 mm, gray-green, glabrous adaxially, covered with pilose hairs abaxially, apex acute, with a stalked gland, margin with 4–5-stalked glands on each side. Corolla salver-shaped, white, with yellow markings at throat, glabrous; tube 1.8 cm long in long-styled flowers, 2.5–2.7 cm long in short-styled flowers, ca. 2 mm in diam., lobes 5, broadly obovate, 1.2–1.4 × 1.2–1.4 cm, apex rounded. Stamens 5, 1.5 cm long in short-styled flowers, 1–1.3 cm long in long-styled flowers, filaments basally connate forming a tube ca. 3 mm long, staminodes 5, alternating with fertile stamens, 1.8–2.2 mm long, 2–4-toothed, anthers cylindric, 3–4 mm long, yellow. Ovary ovoid, 2-locular, 1.8–1.9 mm long, glabrous, each locule with 2 ovules, styles 2, filiform, glabrous, basally fused for at least 5/6 of the length with a visible suture, 1.5–1.7 cm long in long-styled flowers, 3.8 mm long in short-styled flowers, stigma clavate, ca. 0.2 mm long, papillate. Capsules ellipsoid, 9–10 × 2.5–2.6 mm, glabrous, surrounded by the persistent sepals, septicidally dehiscent, 2-valved. Seeds 2, winged, 6.7 × 1.2 mm (including wing).

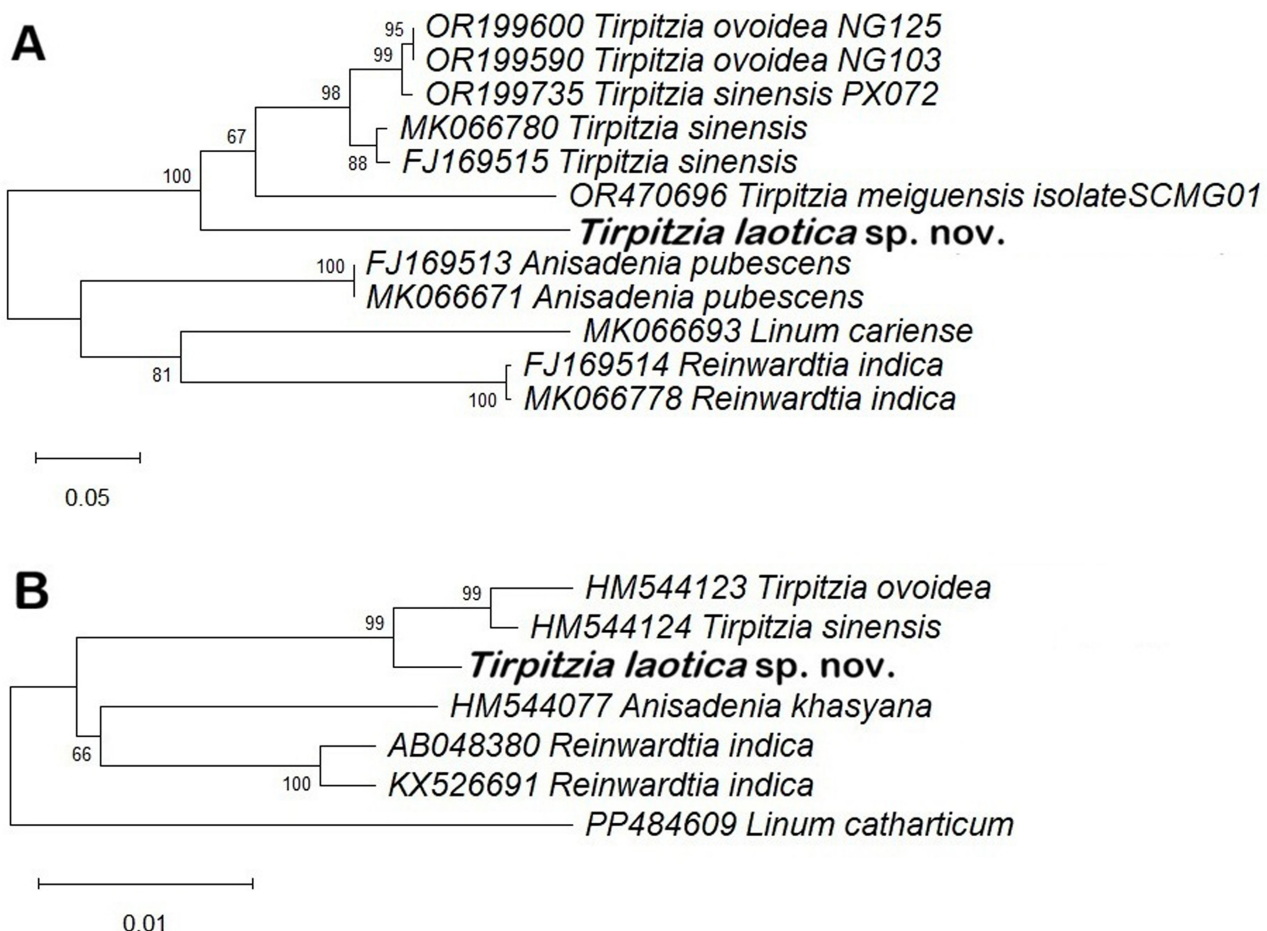


FIGURE 1. A ML tree of *Tirpitzia* and related genera based on nuclear ribosomal ITS sequences (A) and *matK* sequences (B).

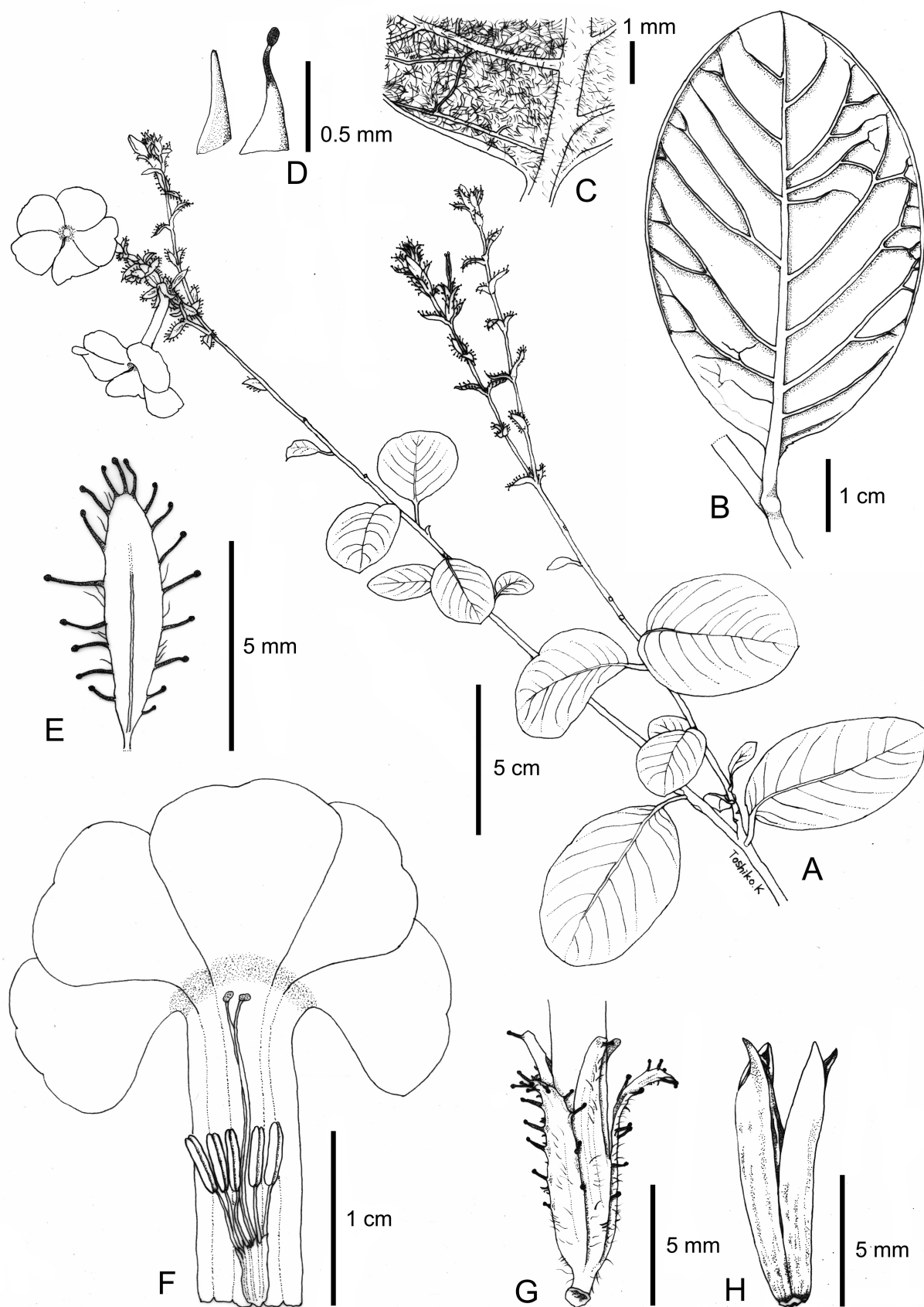


FIGURE 2. *Tirpitzia laotica* Phonep. & Tagane. A. Flowering branch, B. Abaxial leaf surface, C. Portion of abaxial leaf surface, D. Stipules, E. Bract, F. Long-styled flower opened out showing stamens, style and stigma, G. Sepals, H. Fruits. Materials from Tagane *et al.* Z3299 (KAG [KAG202818]). Drawn by Toshiko Kawabata.

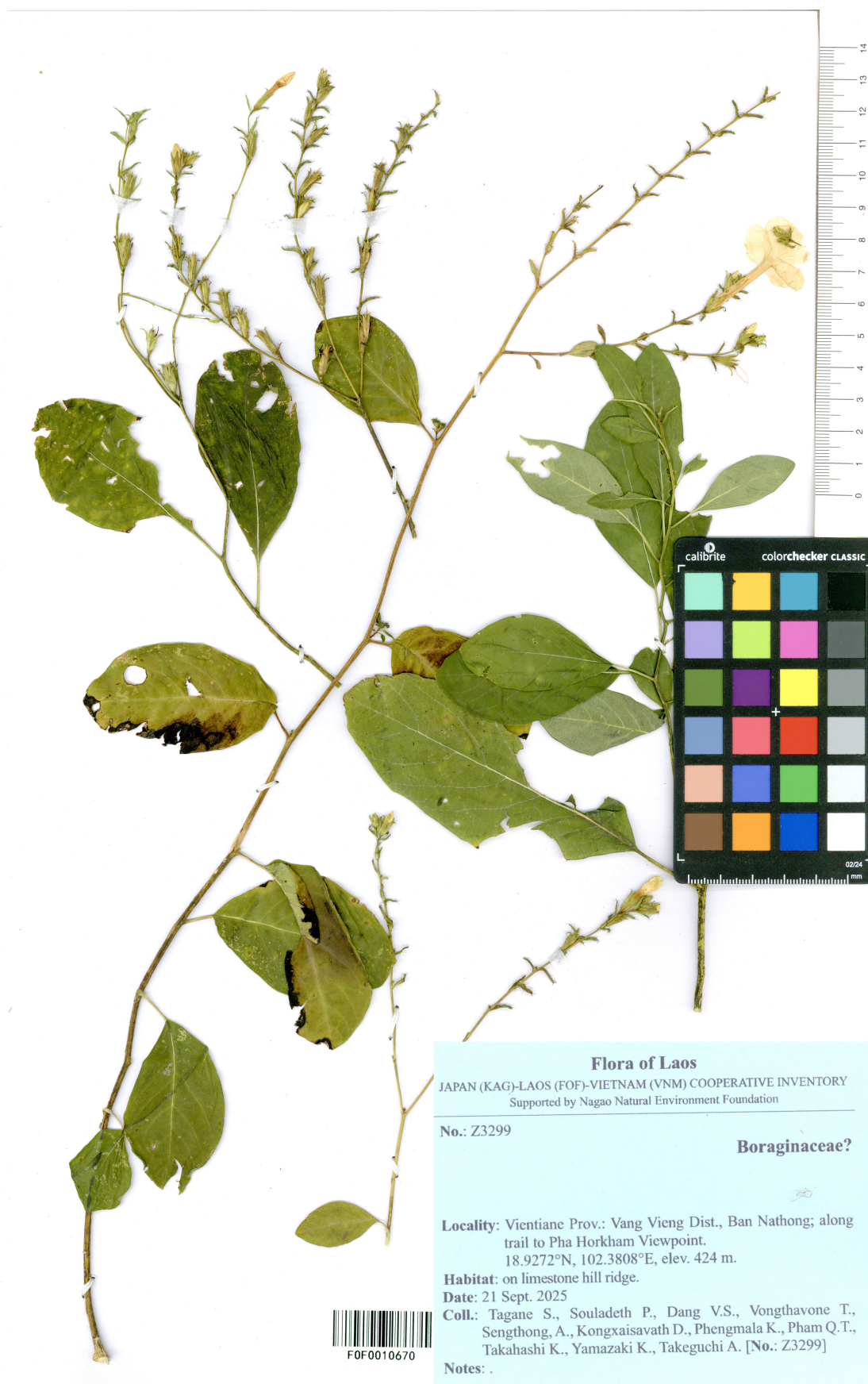


FIGURE 3. Holotype of *Tirpitzia laotica* Phonep. & Tagane (Tagane *et al.* Z3299, FOF [FOF0010670]).

Distribution:—Laos (so far known only from the type locality) (Fig. 5).

Habitat:—On an open ridge of limestone karst, at elevation 420–430 m. It shares habitat with *Hemionitis* sp. (Pteridaceae), *Phanera scandens* (L.) Lour. ex Raf. (Fabaceae), *Paraboea* spp. (Gesneriaceae), *Phyllanthus mirabilis* Müll.Arg. (Phyllanthaceae), and *Polygala cardiocarpa* Kurz (Polygalaceae).

Phenology:—Specimens with flowers and immature fruits were collected in September.

Etymology:—The specific epithet “laotica” refers to the country Laos, where the new species was discovered.

Vernacular:—ຊຶ້ງບູບຟາລາວ (Sorboubphar Lao) (proposed here). In Lao, “Sorboubphar” means “tube-flowered”, referring to the tubular corolla, and “Lao” refers to the country where this species was discovered.

Preliminary conservation assessment:—The species is currently known from only a single location with ca. 20 individuals at the summit of a limestone hill where the type specimens were collected. Using GeoCAT (Bachman *et al.* 2011), the extent of occurrence (EOO) is estimated as ca. 140 km² in the district, where similar habitat suitable for this species occurs. Although some karst areas have been subjected to quarrying in the past, the full distribution, population size, and potential threats to the species remain insufficiently known. As additional populations may be discovered through more extensive field surveys, the species is here preliminarily assessed as Data Deficient (DD) according to the IUCN Red List Categories and Criteria (IUCN 2024). Further studies are needed to clarify its distribution, population status, and threats.

Notes:—Internal floral characters, such as the number of styles and locules per ovary, are critical for species delimitation within *Tirpitzia* and are commonly used in identification keys (e.g., Suksathan & Larsen 2006, Liu & Zhou 2008, Xie *et al.* 2023). In the present study, we found that the presence or absence of glands on the petioles, leaves, and sepal margins, and the length of the capsule are also useful for distinguishing species (see Table 1 and the updated key below).

The presence of glandular structures on the sepals, together with relatively larger sepals, in the new species may represent an adaptive response to nectar-robbing pressure. In *Tirpitzia sinensis*, which lacks such glands, nectar robbing by bumblebees (*Bombus breviceps*) has been observed at the base of the flowers. Flowers with smaller sepals and petals were more likely to be robbed, and nectar robbing has been shown to negatively affect reproductive fitness by reducing nectar replenishment, decreasing pollen germination and seed set, and reducing visitation by hawkmoth pollinators (Wang *et al.* 2023). The sepals of *T. laotica* (8–9 × 1.6–1.8 mm) and *T. bilocularis* (10–12 × 2.0–2.5 mm), both of which possess marginal glands and occur in limestone karst habitats, are larger than those of *T. sinensis* (5–9 × 2–3.8 mm) (Table 1). These features may provide greater protection to the floral base or act as a physical and/or chemical deterrent against nectar robbers, such as bumblebees (*Bombus breviceps*) and carpenter bees (*Xylocopa sinensis*). Further ecological and anatomical studies are needed to test this hypothesis.

Our molecular phylogenetic analyses indicate that *Tirpitzia laotica* represents the basal lineage of the clade that includes *T. ovoidea*, *T. sinensis* and *T. meiguensis* (Fig. 1). Further phylogenetic studies incorporating *T. bilocularis*, a morphologically similar species absent from our datasets due to the lack of available data in GenBank, are required to clarify species relationships within the genus and its evolutionary history.

An updated key to *Tirpitzia* species (Partly based on Suksathan & Larsen (2006) and Liu & Zhou (2008)).

1. Styles 2; ovary 2-locular; sepals with marginal glands2
- Styles 4 or 5; ovary 4- or 5-locular; sepals without marginal glands3
2. Inflorescences 2.5–7 cm long; corolla pink, tube 2.8–3.3 cm long; capsule 15–17.5 mm long *T. bilocularis*
- Inflorescences 7–15 cm long; corolla white with yellow markings at the throat, tube 1.8–2.5 cm long; capsule 9–10 mm long.....
..... *T. laotica*
3. Leaf margin toothed; corolla white or pale pink; seeds without a membranous wing *T. meiguensis*
- Leaf margin entire; corolla white; seeds winged4
4. Styles 5; ovary 5-locular; capsule 5–7 mm long *T. ovoidea*
- Styles 4; ovary 4-locular; capsule 10–19 mm long *T. sinensis*

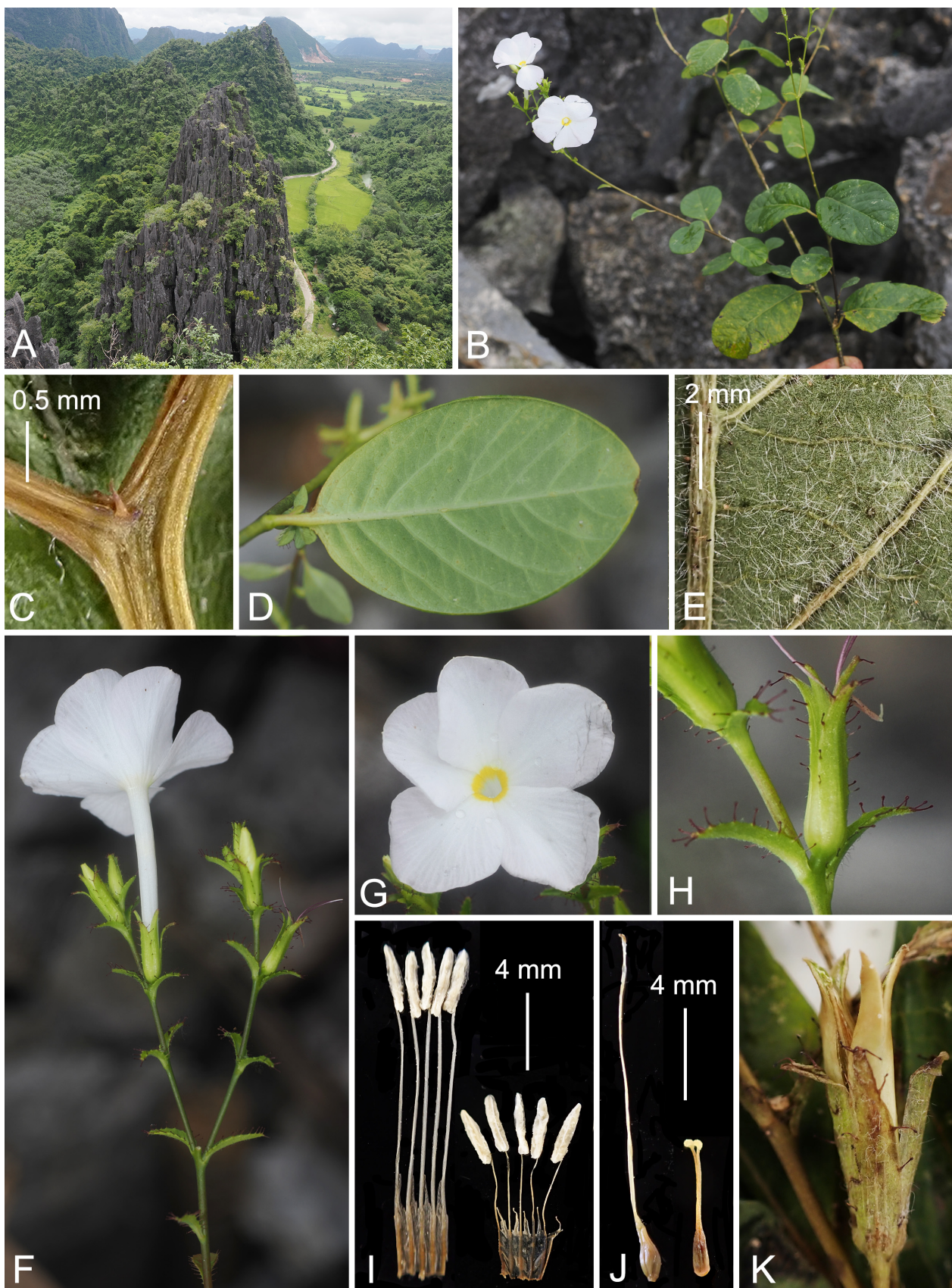


FIGURE 4. *Tirpitzia laotica* Phonp. & Tagane. A. Habitat, showing open limestone karst ridge, B. Flowering branch, C. Stipule, D. Abaxial leaf surface, E. Close-up of the abaxial leaf surface showing prominent veins and pilose hairs, F. Inflorescence, G. Corolla, top view, H. Bracts and sepals, I. Stamens, from short-styled flower (left) and long-styled flower (right), J. Pistils, long-styled flower (left) and short-styled flower (right), K. Immature fruits with persistent sepals. Photos taken by Shuichiro Tagane; C, E, I–K from Tagane *et al.* Z3299 (KAG202818).

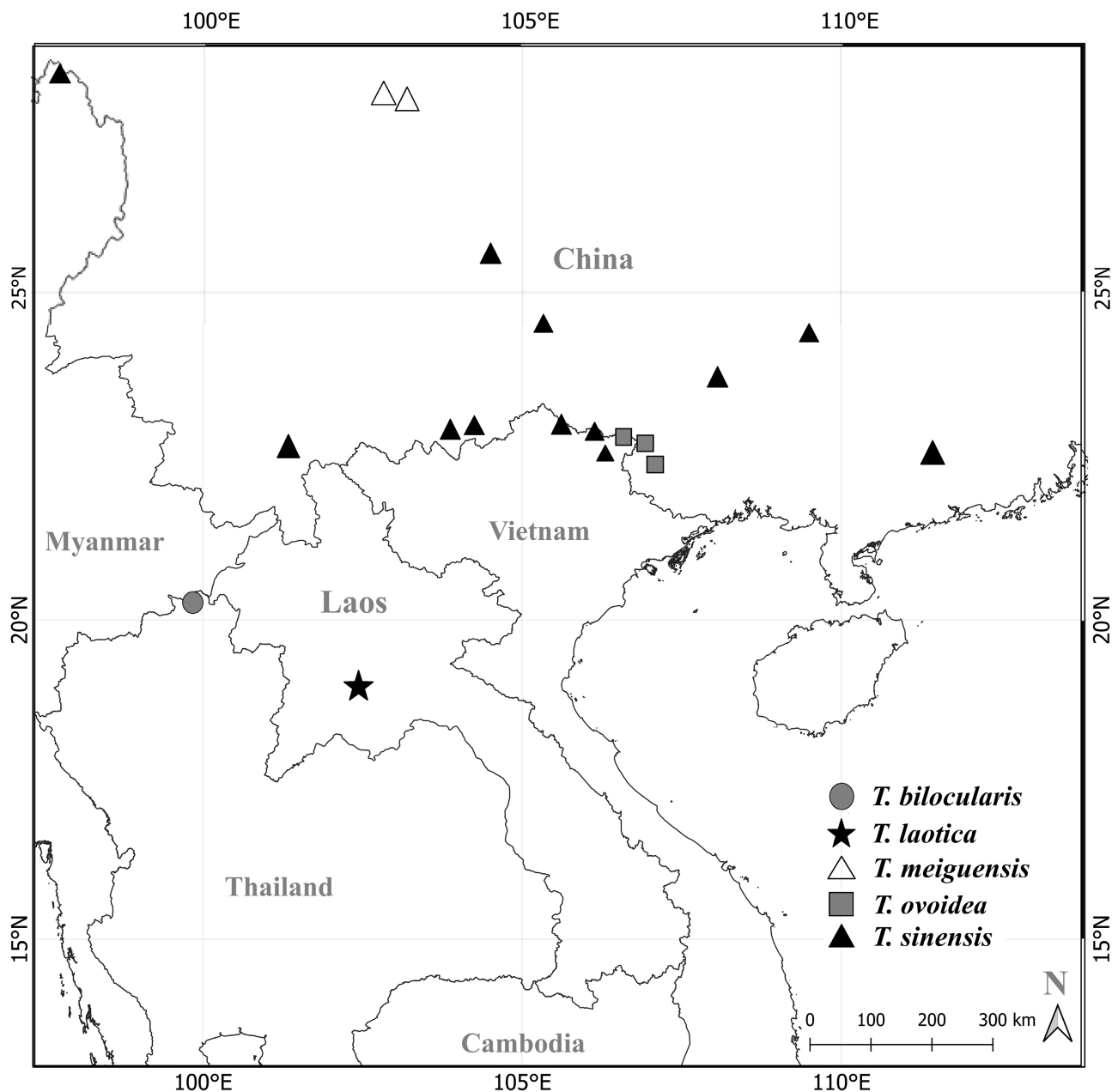


FIGURE 5. Distribution map of five *Tirpitzia* species in Asia (modified from Xu *et al.* 1998, Suksathan & Larsen 2006). Representative localities are shown for the widespread species *T. sinensis* and *T. ovoidea*. For detail localities of *T. sinensis*, see Mao *et al.* (2025).

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Appendix 1.

Taxa (voucher information shown where available) and corresponding GenBank accession number (ITS, *matK*): *Anisadenia pubescens*, FJ169513, –.; *Anisadenia pubescens*: MK066671, –.; *Anisadenia khasyana*: –, HM544077; *Linum cariense*: MK066693, –.; *Linum catharticum* –, PP484609; *Reinwardtia indica* (McDill s.n. 2002 TEX): FJ169514, –.; *Reinwardtia indica*: MK066778, –.; *Reinwardtia indica*: –, AB048380; *Reinwardtia indica* (CPG24971): –, KX526691; *Tirpitzia laotica* (Tagane *et al.* Z3299 FOF): PZ342194, PZ351585; *Tirpitzia meiguensis* (isolate SCMG01): OR470696; –.; *Tirpitzia ovoidea*, (NG125): OR199600, –.; *Tirpitzia ovoidea*, (NG103): OR199590, –.; *Tirpitzia ovoidea*, (Wei Fanan 1806 MO): –, HM544123; *Tirpitzia sinensis* (PX072): OR199735, –.; *Tirpitzia sinensis*: MK066780, –.; *Tirpitzia sinensis* (D.A. Link RG0002 MJG): FJ169515, –.; *Tirpitzia sinensis* (Libo Team 81-6-0105 MO): –, HM544124.