

# *Begonia fimbristipula* subsp. *siamensis* (sect. *Diploclinium*, Begoniaceae), a new taxon of the megadiverse genus endemic to Thailand

Sirilak Radbouchoom<sup>1,2</sup>, Thamarat Phutthai<sup>3</sup>, Harald Schneider<sup>1</sup>

**1** Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun 666303, Yunnan, China **2** University of Chinese Academy of Sciences, Beijing 100049, China **3** Faculty of Environment and Resource Studies, Mahidol University (Salaya Campus), Nakhon Pathom 73170, Thailand

Corresponding authors: Harald Schneider ([harald@xtbg.ac.cn](mailto:harald@xtbg.ac.cn)), Thamarat Phutthai ([thamarat.phu@mahidol.edu](mailto:thamarat.phu@mahidol.edu))

Academic editor: Jan Wieringa | Received 11 May 2022 | Accepted 25 September 2022 | Published 10 January 2023

**Citation:** Radbouchoom S, Phutthai T, Schneider H (2023) *Begonia fimbristipula* subsp. *siamensis* (sect. *Diploclinium*, Begoniaceae), a new taxon of the megadiverse genus endemic to Thailand. *PhytoKeys* 218: 1–10. <https://doi.org/10.3897/phytokeys.218.85699>

## Abstract

The genus *Begonia* has not only been recognised to be one of the mega-diverse plant genera but also as one found to comprise many undiscovered species. In particular, the increase of extensive field surveys in tropical regions of Southeast Asia has added to the discovery of many new species that are often found only in a few localities. In this study, the new taxon *Begonia fimbristipula* subsp. *siamensis* **subsp. nov.** from Thailand is described. The Thailand accessions are highly similar in their morphology to accessions of *B. fimbristipula* from southern China but differ in their tuber shape, peduncle trichomes, petiole trichomes and number of female tepals. The new taxon has been found only in the northern parts of Thailand occurring at elevations above 1,300 meters. The new findings not only contribute to our knowledge of the plant diversity of Thailand but provide also critical information contributing to the protection of this species. In China, this species is endangered which is of special concern given its utilisation as a medicinal herb in traditional Chinese medicine. Considering IUCN Red List Categories, the new subspecies is considered to be Vulnerable. The disjunct distribution of the two subspecies of *B. fimbristipula* encourages urgently needed comparative taxonomic studies across the Indo-Burma biodiversity hotspot.

## Keywords

China, endemic, new subspecies, taxonomy, Thailand

## Introduction

With about 2,000 accepted species, the pantropical, herbaceous flowering plant genus *Begonia* L. (Linnaeus 1753) (Begoniaceae, Cucurbitales) is an outstanding example of a mega-diverse plant genus (Stevens 2001; Hughes et al. 2015; Li et al. 2022). In recent years, the number of known species has rapidly expanded as a consequence of a combination of factors including extensive field surveys in tropical regions (Hughes et al. 2015; Moonlight et al. 2018). Species surveys are especially needed to document the diversity in subtropical to tropical Asia because this region, with 1,159 recorded species, is a diversity hotspot of *Begonia* (Hughes et al. 2015). Taxonomic studies of this mega-diverse genus are challenged by several aspects including (1) the vast number of species required to be compared, (2) the high frequency of disjunct local occurrences, and (3) phenotypic plasticity observed in many species (McLellan 2000; Wang et al. 2016; Wahlsteen 2021). Until now, 58 species of *Begonia* have been recorded as occurring in Thailand of which about 40 percent are endemic (Phutthai et al. 2019). Here, we report results of our ongoing efforts to improve the documentation of this mega-diverse genus in Thailand. These research activities have been motivated by two key-assumptions. Firstly, the diversity of *Begonia* in Thailand is incompletely known and thus several species await to be found. Secondly, at least some, if not many, species of Thailand's *Begonia* are threatened as a consequence of the ongoing biodiversity crisis caused by anthropogenic activities.

In our studies, we focused specifically on occurrences of *Begonia* section *Diploclinium* (Lindl.) A.DC. (Lindley 1847; de Candolle 1859). This section requires a re-definition because the currently used circumscription has been considered to be a taxonomic dustbin (Shui et al. 2002; Rubite et al. 2013). This expectation has been confirmed in phylogenetic studies recovering the section to be polyphyletic (Thomas et al. 2011; Rubite et al. 2013). As a consequence, all species of this section occurring in the Philippines were reassigned to *Begonia* sect. *Baryandra* (Rubite et al. 2013). 19 out of the 58 *Begonia* species occurring in Thailand have been assigned to *Begonia* sect. *Diploclinium* (Phutthai et al. 2019). These placements have not yet been confirmed using phylogenetic studies and the current definition of the section is somewhat ambiguous, in that it is a combination of two key characters for the section, namely tuberous habit and bifid placentae (Doorenbos et al. 1998). Besides the challenges of classification of recognised species, many species of this section are expected to still await their discovery. The main aim of our study is to estimate the real number of species belonging to *Begonia* sect. *Diploclinium* that occur in Thailand. As a first step toward achieving this goal, field surveys were carried out in remote parts of Thailand to collect accessions of putative unknown taxa. These accessions were then carefully compared to previously described species by considering not only species known to occur in Thailand but also species occurring in other parts of continental Asia including southern China.

## Methods

New accessions were examined and photographed in their natural habitats during field surveys in northern and north-eastern Thailand. They were consequently carefully compared to previously described species and as far as possible voucher specimens either by access to the voucher itself or to images. Special attention was given to type vouchers. To avoid describing an already published species, extensive comparisons were carried out with known species that showed high similarity in our first round of examination. The newly obtained voucher specimens were deposited at the two key herbaria in Thailand namely Forest Herbarium at Bangkok (BKF) and Queen Sirikit Botanic Garden Herbarium at Chiang Mai (QBG) besides several prominent international herbaria (K, E, P, HAST). Distribution maps were generated using QGIS software (QGIS 2021) by combining the records obtained during our field surveys with records from specimens deposited in herbaria. The assessment of the International Union for Conservation of Nature (IUCN) Red List status was evaluated using information from field observation and the available specimen records.

## Results

The newly recognized taxon has a tuberous habit, cymose bisexual inflorescences with four male tepals and three to five-female tepals, trilocular fruit, and axillary bifid placentation. This character combination is found exclusively in *Begonia* sect. *Diplocinium*. The new taxon resembles *B. fimbristipula* Hance (Hance 1883), not previously recorded in Thailand. Comparisons of living plants and herbarium specimens recovered morphological characters that distinguished the accessions from Thailand from accessions of that species collected in southern China (Table 1). The distribution in Thailand and southern China shows a disjunct range with no records reported for eastern Myanmar, northern Laos and northern Vietnam (Fig. 2).

**Table 1.** Comparison of diagnostic morphological characteristics among *Begonia fimbristipula* Hance subsp. *siamensis* Phutthai & S.Radbouchoom, *B. fimbristipula* Hance subsp. *fimbristipula* and *B. poilanei* Kiew.

	<i>B. fimbristipula</i> subsp. <i>siamensis</i>	<i>B. fimbristipula</i> subsp. <i>fimbristipula</i>	<i>B. poilanei</i>
<b>Stem</b>	globose or sub-elongate tubers	globose or sub-globose tubers	elongate tubers
<b>Petiole</b>	densely red villous and pubescent	villous	densely hairy
<b>Leaf blade abaxially</b>	densely villous	sparsely pubescent and densely villous to red villous	sparsely pubescent
<b>Peduncle</b>	sparsely red villous	glabrous	hairy
<b>Tepal number in pistillate flowers</b>	5	3	3
<b>Placentation</b>	axile	axile	sepal
<b>Distribution</b>	Northern and North-eastern Thailand (Chiangmai, Nan, Phitsanulok)	Southern China (Fujian, Guangdong, Guangxi, Hainan, Hunan, Jiangxi, Zhejiang)	China (Hainan); Vietnam (Haut Donai district)

## Taxonomic treatment

***Begonia fimbristipula* Hance subsp. *siamensis* Phutthai & S.Radbouchoom, subsp. nov.**

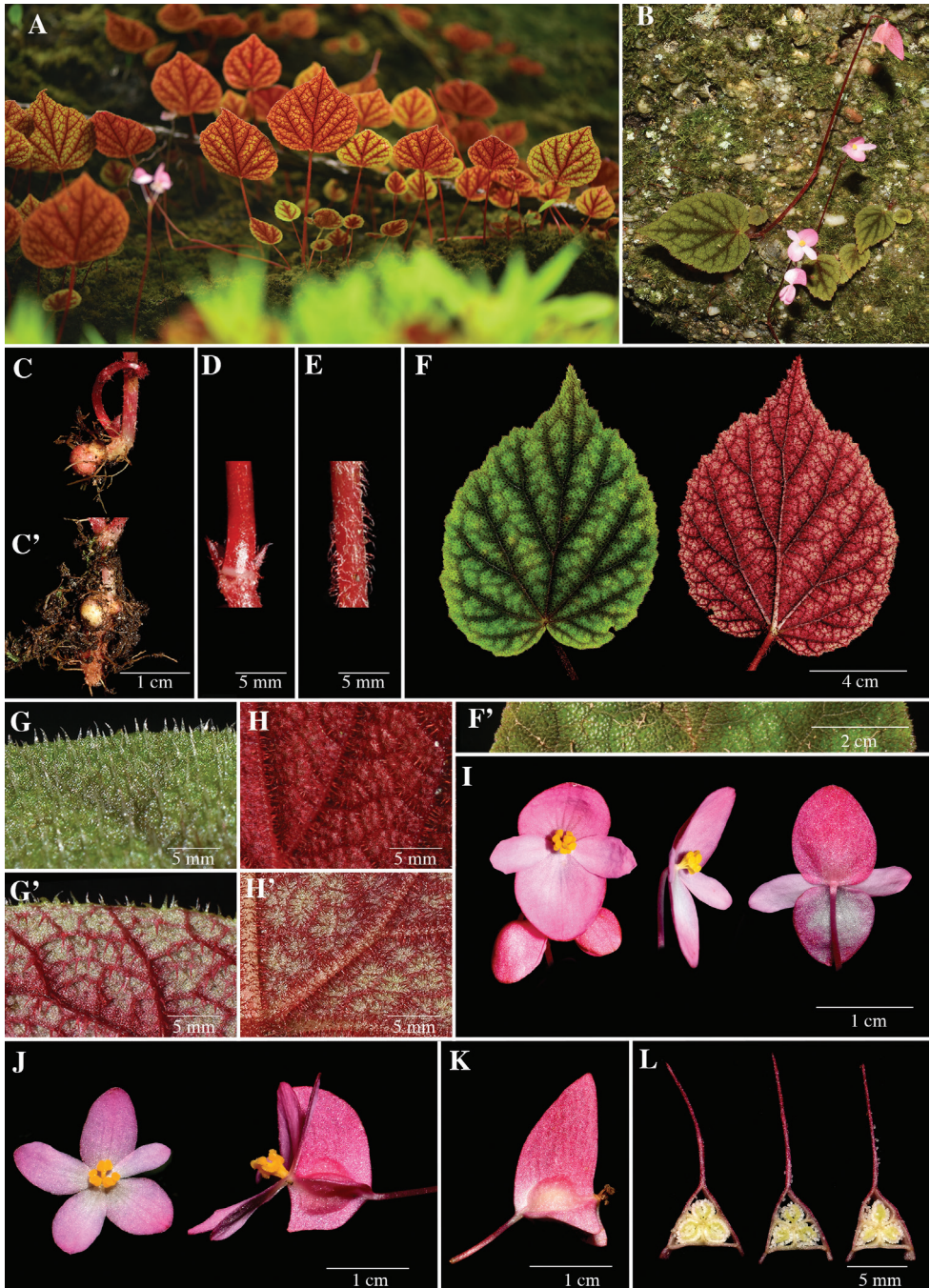
urn:lsid:ipni.org:names:77311666-1

Figs 1, 2

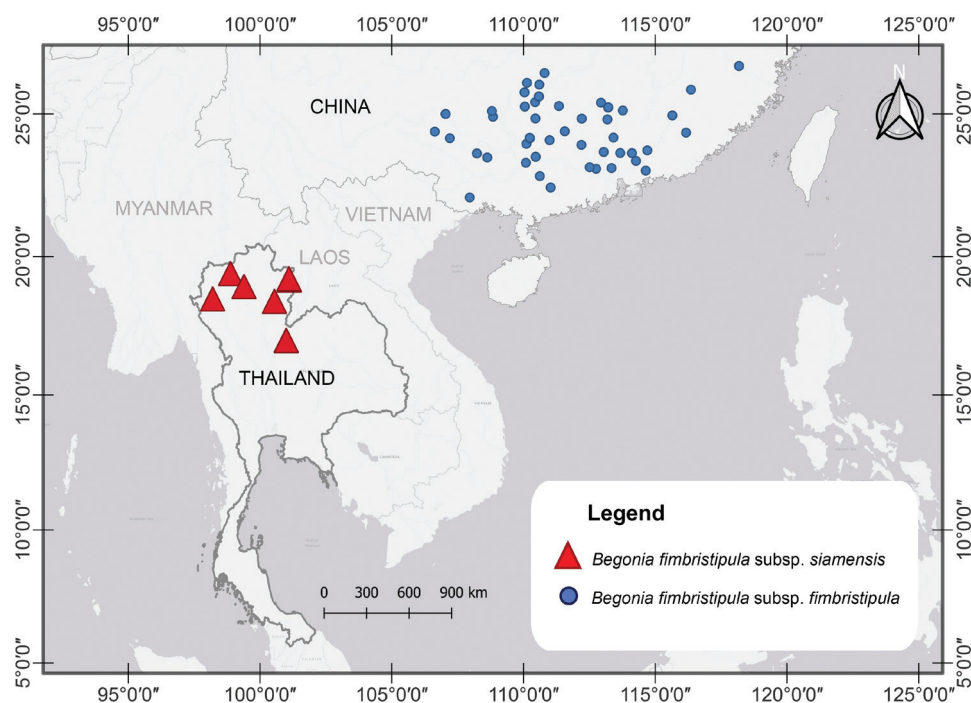
**Type.** THAILAND • Phitsanulok Province, Nakornthai, Phu Hin Rong Kla national park, Lan Hin Pum rout; 1300 m a.s.l.; 29 Oct. 2001; S. Wathana, P. Suksathan 1570; herb on sand stone rather shed and wet; (holotype QBG! 21778, isotype BKF! SN187939).

**Description.** Perennial monoecious acaulescent herb, 10–25 cm tall. **Tuber** globose or sub-elongate 0.7–2.0 cm long, with fibrous roots. **Leaves** 1–3; petiole maroon, 9.0–13.5 cm long, densely red villous and pubescent; lamina basifixed, succulent, broadly ovate, symmetric or slightly asymmetric, adaxial surface green, sometimes sparsely white spotted, densely villous, conspicuous dark green band 2–3 mm wide along the midrib, secondary and tertiary veins, abaxial surface green or red, densely red villous, conspicuous maroon band 2–3 mm wide along the secondary and tertiary veins, 6.5–15×4.6–12 cm, base cordate, margin denticulate and ciliate, apex acuminate, venation palmate-pinnate, primary veins 6–7, secondary veins branching dichotomous 2–4, prominent beneath. **Stipules**, ovate-triangular, apex acute, margin ciliate, 2.0–3.0×1.2–1.7 mm, red villous. **Inflorescences** arising directly from tuber, bisexual, cymose, branching 1–3 times; peduncles maroon, 11.5–25 cm long, sparsely red villous; bracts soon falling, membranaceous, oblong, glabrous, apex obtuse, margin fimbriae. **Staminate flowers**: pedicel maroon, 1.5–2.0 cm long, glabrous, erect; tepals 4, white-pinkish to pink with the pale pink flash at the centre, glabrous both sides; outer 2 ovate to suborbicular, 0.8–1.0×0.3–0.5 cm, base rounded to cuneate, margin entire, apex obtuse to rounded; inner 2 narrowly elliptic or lanceolate-elliptic, 0.7–1.2×0.7–1.0 cm, base cuneate, margin entire, apex obtuse to rounded; androeceum zygomorphic; stamens 10–25, yellow; filaments fused at base, c.1.0 mm long; anthers clavate, apex rounded, 0.3–1.0 mm long, basifixed, dehiscing by 2 short slits. **Pistillate flowers**: pedicel maroon, 1.5–2.0 cm long, tepals 5, white-pinkish to pink with a pale pink flash at the centre, glabrous both sides; outer 3, ovate-broadly ovate, 0.7–1×0.3–0.4 cm, apex obtuse to rounded, margin entire, base cuneate; inner 2, ovate to lanceolate-elliptic, 0.6–0.9×0.3–0.6 cm, apex obtuse to rounded, margin entire, base cuneate; styles 3, yellow, fused at base 1.0–2.0 mm long, bilobed, crescent-shaped, spirally twisted; ovary with 3 unequal wings, oblong, 0.5–1.0×0.4–0.6 cm, glabrous; placentation axile, placentae bilamellate, locules 3. **Fruit** oblong, unequally 3 winged, capsule, nodding, pink to pale green, 1.0–2.2×0.9–1.1 cm included wings, abaxial wing falcate or elliptic, extended 1.0–1.3×0.7–0.9 cm, wider than lateral wings, lateral wings, narrowly triangular, 0.7–1×0.2–0.3 cm.

**Habitat.** The new taxon is currently known from seven collections obtained from three provinces located in northern and north-eastern Thailand (Fig. 2), where it grows on both limestone and sandstone outcrops in evergreen forest at high elevation (1300–1900 m). Individuals growing on limestone rocks are distinct from individuals



**Figure 1.** *Begonia fimbristipula* Hance subsp. *siamensis* Phutthai & S.Radbouchoom subsp. nov. **A** habitat **B** habit **C** tuber globose **C'** tuber sub-elongate **D** peduncle **E** petiole **F** leaf adaxial and abaxial surface **F'** close-up of white spots on adaxial surface of leaf **G** close-up of trichome on adaxial surface of greenish leaf **G'** close-up of trichome on abaxial surface of leaf **H** close-up of abaxial surface of reddish leaf **H'** close-up of abaxial surface of reddish leaf **I** staminate flower visualised using face view, side view, back view **J** pistillate flower visualised using face view, side view **K** fruit **L** cross sections of young ovary in the sequence top, middle and bottom.



**Figure 2.** Distribution of *B. fimbristipula* Hance subsp. *siamensis* Phutthai & S.Radbouchoom subsp. nov. (red triangle) and *B. fimbristipula* Hance subsp. *fimbristipula* (blue circle).

growing on sandstone rocks by the presence of a dense indumentum formed by red trichomes. The indumentum of individuals growing on sandstone is less dense and the trichomes have a brighter colour. Accessions of *Begonia fimbristipula* subsp. *siamensis* show high phenotypic variation among individuals of the same population especially in leaf size and abaxial leaf surface colour (Fig. 1H, H'). The notable phenotypic disparity resembles reports from occurrences of *B. fimbristipula* subsp. *fimbristipula* in southern China (Wang et al. 2016; Tian et al. 2018). Phenotypic plasticity has been considered to result from adaption to the harsh environments occupied by these plants (Wang et al. 2016).

**Phenology.** Flowering Time: June–September; Fruiting Time: August–December.

**Etymology.** The subspecific epithet *siamensis* alludes to the nativity of this taxon to “Siam”, the exonym that was used for Thailand before 1949.

**Conservation assessment.** The recorded occurrences of the new subspecies were mostly obtained in protected areas, e.g. National Parks. The high protection is arguably reduced by threats caused by tourism activities. In Phisanulok province, this species creates a beautiful landscape by growing on the sandstone cliff along the trekking trail, which is a famous spot among tourists. Some of its populations are outside the protected area where the new taxon has been threatened by illegal trade in wild ornamental

plants, and habitat infringement. Until now, there is still no conservation plan for the new subspecies at any of these localities. Further surveys are arguably required to obtain a more accurate description of the distribution of this species in Thailand but also in Laos, Myanmar and Vietnam. The currently known area of occupancy (AOO) has been estimated as 32 km<sup>2</sup> (Bachman et al. 2011; <http://geocat.kew.org/>). Based on IUCN criteria, the status assigned is “Vulnerable” (VU: B2 a, c (iii, iv); C2 (ai, ii)) (IUCN 2019).

**Additional specimens examined.** **THAILAND – Chiang Mai Prov.** • Pang Hin Fon, Mae Chaem District; 1300 m a.s.l.; 09 June 2017; W. Pongamornkul 6422; herb 20 cm high in dry evergreen forest, flowers pink; QBG 105946 • Dong Yen, Doi Chiang Dao; 1900 m a.s.l.; 20 Nov. 1999; P. Suksathan 2134; on mossy rock in shade; QBG16461. – **Phitsanulok Prov.** • Phu Hin Rong Kla national park; 1300–1600 m a.s.l.; 22 Jan. 2005; O. Kudjabnak, D. Watanachaiyingcharoen BRT (NU) 0046; herb on sand-stone; BKF SN152894. – **Nan Prov.** • Doi Phu Kha National Park, hill evergreen forest; 19°13'N, 101°06'E; 1750 m a.s.l.; 26 July 1999; P. Srisanga 918; herb on rock, leaves dark greenish-red, flower pink, stamen and stigma yellow; QBG15203 • *ibid*, Pua; 19°10'N, 101°07'E; 1800 m a.s.l.; 31 Aug. 2000; P. Srisanga 1533; hill evergreen forest, herb on rock, leaves greenish red, stem and pedicel red; QBG17980; BKF SN193126 • *ibid*, trail from Lan Doo Dao Phatang; 1700 m a.s.l.; 26 June 2008; R. Pooma, M. Tamura 7104; on moist rock surfaces, densely mosses, lower montane forest; BKF SN188535 • Doi Pha Phung, Nam Tok, Na Noi District; 18°24'22.06"N, 100°32'50.24"E; 992 m a.s.l.; 18 December 2018; P. Phaosrichai, M. Wongnak, S. Wongwan, S. Sitthisuk 1265; herb about 20 cm high, fruit brownish-red; QBG112488.

**Specimens examined of *Begonia fimbristipula* Hance subsp. *fimbristipula*.** **CHINA – Fujian Prov.** • Wuyishan, on the way from ticketing entrance to Tienyoufeng; 270 m a.s.l.; 30 May 1997; Ching-I Peng 16885; HAST132046. – **Guangdong Prov.** • Ding-hu Shan; 06 May 1882; C. Ford 6; isoelectotype K K000251078 • *ibid*; 150 m a.s.l.; 15 Apr. 1964; K.C. Ting, K.L. Shi 1402; BKF SN006485 • *ibid*; 6 May 1928; W.Y. Chun 6393; E E00299226 • *ibid*, Qingyuan Shi, Liannan Xian, Dalongshan Forest Plantation; 310 m a.s.l.; 4 Apr. 2005; Ching-I Peng 19496; on mossy rocky slope; HAST122379 • *ibid*; 26 May 1918; C.O. Levine 2027; E E00299227 • South of Ping Yung; 60–175 m a.s.l.; June 1924; R.C. Ching 2002; P P06844316. – **Guangxi Prov.** • Zhuangzu Zizhiqu, Laibin Shi, Jinxiou Yiaozu Zizhixian, Dayaoshan national nature reserve; 1200 m a.s.l.; 18 September 2003; Wai-Chao Leong 3673; on mossy rock face, mixed Cathaya and broadleaf forest; HAST 97112.

### Key to the subspecies of *Begonia fimbristipula* Hance

- 1 Tuber globose or sub-globose; petiole villous; peduncle glabrous; female tepals 3 ..... **subsp. *fimbristipula***
- Tuber globose or sub-elongate; petiole densely red villous and pubescent; peduncle sparsely red villous; female tepals 5 ..... **subsp. *siamensis***

## Discussion

The new finding of *Begonia fimbriatipula* subsp. *siamensis* supports our expectation that several begonia species occurring in Thailand are still awaiting discovery. Our results are consistent with the accumulation of new species reported in recent studies, such as *B. exposita* Phutthai & M.Hughes, *B. fulgurata* C.I Peng, C.W.Lin & Phutthai, *B. pengchengii* Phutthai & M.Hughes, *B. pseudosubperfoliata* Phutthai & M.Hughes, *B. phutthaii* M.Hughes, *B. sirindhorniana* Phutthai, Thananth., Srisom & Suddee, *B. tenasserimensis* Phutthai & M.Hughes (Peng et al. 2017; Phutthai and Hughes 2017a, 2017b; Phutthai et al. 2019, 2021). In this study, we report a new subspecies of *Begonia* sect. *Diploclinium* from Thailand, resulting in the number of *Begonia* sect. *Diploclinium* species known from Thailand increasing to 20 species (of which one is an endemic subspecies). We treat the newly found taxon as subspecies *B. fimbriatipula* subsp. *siamensis* because of the distinct morphological affinity to *B. fimbriatipula* subsp. *fimbriatipula*. A comparison between these two taxa and a third similar species, namely *B. poilanei* Kiew (Kiew 2007; Shui and Chen 2017), was assembled (Table 1). Our taxonomic conclusions consider also the geographic isolation of the new taxon occurring only in northern and north-eastern Thailand (Chiangmai, Nan, Phitsanulok,) away from typical *B. fimbriatipula* occurring exclusively in southern China (Fujian, Guangdong, Guangxi, Hainan, Hunan, Jiangxi, Zhejiang). Thus, they are geographically disjunct taxa but future studies need to confirm the absence of occurrences bridging the gap in eastern Myanmar, northern Laos and northern Vietnam. In this context, it is worth noting that several putative relatives based on shared morphological similarities are known to occur in this region including *B. poilanei* from China and Vietnam (Kiew 2007) and *Begonia mengdongensis* H.H.Xi from southeastern Yunnan, China (Xi et al. 2020). Currently, it is also not known if the Thailand accession may also be harvested as a natural resource similar to the typical *B. fimbriatipula*, whose plants are used to brew herbaceous teas, and as herbal medicine (Zhao et al. 2016).

## Acknowledgements

We are grateful to Chinese Government Scholarship (CSC Scholarship) for supporting the first author's study and financial support provided by the Chinese Academy of Sciences and the Yunnan Province to HS. We sincerely thank the curators of QBG and BKF for providing access to herbarium specimen deposited in their collections.

## References

- Bachman S, Moat J, Hill AW, de la Torre J, Scott B (2011) Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. In: Smith V, Penev L (Eds) e-Infrastructures for data publishing in biodiversity science. ZooKeys 150: 117–126. <https://doi.org/10.3897/zookeys.150.2109>

- de Candolle A (1859) Mémoire sur la famille des Bégoniacées. In: Brongniart MM AD, Decaisne J (Eds) Annales des Sciences Naturelles. Botanique. ser. 4: t.11. Librairie De Victor Masson, Paris, 116–145.
- Doorenbos J, Sosef MSM, de Wilde JJFE (1998) The sections of *Begonia* including descriptions, keys, and species lists (studies in Begoniaceae VI). Wageningen Agricultural University Papers 98(2): 1–266. <https://edepot.wur.nl/282968>
- Hance HF (1883) Three new Chinese *Begonia*. In: Henry T, James B, John R, Berthold S, Alfred Barton R (Eds) Journal of botany, British and foreign 21: 202. London: Robert Hardwicke. <https://www.biodiversitylibrary.org/item/109766> [accessed 28.05.2021]
- Hughes M, Moonlight P, Jara A, Tebbitt M, Pullan M (2015) *Begonia* Resource Centre. The Royal Botanic Gardens, Kew. <https://padme.rbge.org.uk/begonia/page/home> [accessed 01.06.2021]
- IUCN (2019) Guidelines for using the IUCN Red List Categories and Criteria. Version 14. IUCN Standards and petitions committee. IUCN Red List, 1–60. <https://www.iucn-redlist.org/resources/redlistguidelines> [accessed 10.06.2021]
- Kiew R (2007) Notes on Vietnamese *Begonia* (Begoniaceae), including three new species. *Adansonia* 29(2): 229–238. <https://sciencepress.mnhn.fr/sites/default/files/articles/pdf/a2007n2a4.pdf>
- Li LF, Chen XL, Fang DM, Dong SS, Guo X, Li N, Campos-Doinguez L, Wang WG, Liu Y, Lang XA, Pen Y, Tian DK, Thomas DC, Mu WX, Liu M, Wu CY, Yang Y, Zhang SZ, Yang LL, Yang JF, Liu ZJ, Zang LS, Zhang XT, Chen F, Jiao YN, Guo YL, Hughes M, Wang W, Liu XF, Zhong CM, Li AR, Sahu SK, Yang HM, Wu E, Sarbrough J, Lisby M, Liu X, Xu X, Soltis DE, van de Peer Y, Kinder C, Zhang SZ, Liu H (2022) Genomes shed light on the evolution of *Begonia*, a mega-divers genus. *The New Phytologist* 234(1): 295–310. <https://doi.org/10.1111/nph.17949>
- Lindley J (1847) The vegetable kingdom: Or, The structure, classification, and uses of plants illustrated upon the natural system. Bradbury & Evans, London 911. <https://doi.org/10.5962/bhl.title.109531>
- Linnaeus C (1753) Species Plantarum, Exhibentes Plantas Rite Congnitas, ad Genera Relates, cum Differentiis Specificis, Nominibus Trivialibus, Synonymis Selectis, Locis Natalibus, Secundum Systema Sexuale Digestas (Vol. 1). Salvius, Stockholm, 1200 pp. <https://doi.org/10.5962/bhl.title.669> [accessed 28.05.2021]
- McLellan T (2000) Geographic variation and plasticity of leaf shape and size in *Begonia dregei* and *B. homonyma* (Begoniaceae). *Botanical Journal of the Linnean Society* 132(1): 79–95. <https://doi.org/10.1111/j.1095-8339.2000.tb01855.x>
- Moonlight P, Ardi WH, Padilla LA, Chung KF, Fuller D, Girmansyah D, Hollands R, Jara-Muñoz A, Kiew R, Leong WC, Liu Y, Mahardika A, Marasinghe LDK, Connor MO, Peng CI, Pérez ÁJ, Phutthai T, Pullan M, Rajbhandary S, Reynel C, Rubite RR, Sang J, Scherberich D, Shui YM, Tebbitt MC, Thomas DC, Wilson HP, Zaini NH, Hughes M (2018) Dividing and conquering the fastest-growing genus: Towards a natural sectional classification of the mega-diverse genus *Begonia* (Begoniaceae). *Taxon* 67(2): 267–323. <https://doi.org/10.12705/672.3>
- Peng C, Lin C, Phutthai T (2017) *Begonia fulgurata* (sect. *Diploclinium*, Begoniaceae), A new species from northern Thailand. *Blumea* 62(3): 163–167. <https://doi.org/10.3767/blumea.2017.62.03.01>

- Phutthai T, Hughes M (2017a) Four new species of *Begonia* (Begoniaceae) from Thailand. *Edinburgh Journal of Botany* 74(2): 149–161. <https://doi.org/10.1017/S0960428617000051>
- Phutthai T, Hughes M (2017b) A new species of *Begonia* section *Parvibegonia* (Begoniaceae) from Thailand and Myanmar. *Blumea* 62(1): 26–28. <https://doi.org/10.3767/000651917X695083>
- Phutthai T, Hughes M, Sridith K (2019) Begoniaceae. In: Santisuk T, Balslev H (Eds) *Flora of Thailand*. The Forest Herbarium, Bangkok.
- Phutthai T, Thananthaisong T, Daonurai K, Srisom P, Suddee S, Hughes M (2021) *Begonia sirindhorniana*. *Thai Forest Bulletin (Botany)* 49(2): 201–205. <https://doi.org/10.20531/tfb.2021.49.2.07>
- QGIS.org (2021) QGIS Geographic Information System. QGIS Association. <http://www.qgis.org>
- Rubite RR, Hughes M, Alejandro GJD, Peng CI (2013) Recircumscription of *Begonia* sect. *Baryandra* (Begoniaceae): Evidence from molecular data. *Botanical Studies (Taipei, Taiwan)* 54(1): 1–5. <https://doi.org/10.1186/1999-3110-54-38>
- Shui YM, Chen WH (2017) *Begonia* of China. Yunnan Publishing Group Corporation and Yunnan Science & Technology Press, Kunming, 285 pp.
- Shui YM, Peng CI, Wu CY (2002) Synopsis of the Chinese species of *Begonia* (Begoniaceae), with a reappraisal of sectional delimitation. *Botanical Bulletin of Academia Sinica* 43(4): 313–327.
- Stevens PF (2001[ onwards]) Angiosperm Phylogeny Website. Version 14, July 2017. <http://www.mobot.org/MOBOT/research/APweb/> [accessed 01.06.2021]
- Thomas DC, Hughes M, Phutthai T, Rajbhandary S, Rubite R, Ardi WH, Richardson JE (2011) A non-coding plastid DNA phylogeny of Asian *Begonia* (Begoniaceae): Evidence for morphological homoplasy and sectional polyphyly. *Molecular Phylogenetics and Evolution* 60(3): 428–444. <https://doi.org/10.1016/j.ympev.2011.05.006>
- Tian D, Xiao Y, Tong Y, Fu N, Liu Q, Li C (2018) Diversity and conservation of Chinese wild begonias. *Plant Diversity* 40(3): 75–90. <https://doi.org/10.1016/j.pld.2018.06.002>
- Wahlsteen E (2021) Synonymization of *Begonia putaoensis* (Begoniaceae) with *Begonia dicressine*. *Phytotaxa* 480(1): 091–093. <https://doi.org/10.11646/phytotaxa.480.1.9>
- Wang Y, Shao L, Wang J, Ren H, Liu H, Zhang QM, Guo QF, Chen XW (2016) Comparison of morphological and physiological characteristics in two phenotypes of a rare and endangered plant, *Begonia fimbristipula* Hance. *Photosynthetica* 54(3): 381–389. <https://doi.org/10.1007/s11099-016-0199-5>
- Xi HH, Xiao SY, Wang YQ, Xiao B, Wang WG (2020) *Begonia mengdongensis*, a new tuberous species of *Begonia* (Begoniaceae) from southeastern Yunnan, China. *Nordic Journal of Botany* 38(4): e024645. <https://doi.org/10.1111/njb.02645>
- Zhao B, Du YQ, Li JJ, Tang WX, Zhong SH (2016) Development of 18 novel micro satellite primers for *Begonia fimbristipula* (Begoniaceae), an endangered medicinal plant in China. *Applications in Plant Sciences* 4(7): e1600004. <https://doi.org/10.3732/apps.1600004>

# *Yushania tomentosa* (Poaceae, Bambusoideae), a new combination from Guangxi

Xing Li<sup>1,2,3</sup>, Jing-Bo Ni<sup>1,2</sup>, Fei Tan<sup>4</sup>, Yi-Hua Tong<sup>1,2</sup>, Nian-He Xia<sup>1,2</sup>

**1** Key Laboratory of Plant Resources Conservation and Sustainable Utilization & Guangdong Provincial Key Laboratory of Applied Botany, South China Botanical Garden, Chinese Academy of Sciences, CN-510650, Guangzhou, China **2** South China National Botanical Garden, CN-510650, Guangzhou, China **3** University of Chinese Academy of Sciences, CN-100049, Beijing, China **4** The Administration Bureau of Jiuwan Mountain National Natural Reserve, CN-545300, Rongshui, China

Corresponding authors: Yi-Hua Tong ([yh-tong@scbg.ac.cn](mailto:yh-tong@scbg.ac.cn)), Nian-He Xia ([nhxia@scbg.ac.cn](mailto:nhxia@scbg.ac.cn))

Academic editor: E. Ruiz-Sanchez | Received 8 November 2022 | Accepted 3 December 2022 | Published 10 January 2023

**Citation:** Li X, Ni J-B, Tan F, Tong Y-H, Xia N-H (2023) *Yushania tomentosa* (Poaceae, Bambusoideae), a new combination from Guangxi. *PhytoKeys* 218: 11–18. <https://doi.org/10.3897/phytokeys.218.97312>

## Abstract

*Sasa tomentosa* is transferred to the genus *Yushania* following a reassessment based on a new collection with pachymorph and long-necked rhizomes from its type locality in Guangxi, China. Morphologically, it is most similar to *Yushania doupengshanensis*, but differs in culm, branch complement and foliage leaf characters. A revised description of its morphology and color photos are also provided.

## Keywords

bamboo, Jiuwan Mountain, *Sasa*, taxonomy

## Introduction

*Sasa* Makino & Shibata (1901) with 43 species (Soreng et al. 2022) distributed in East Asia, is characterized by leptomorph rhizomes, solitary branches at each node, panicle-like synflorescences, and six stamens and three stigmas per floret. The results of previous molecular phylogenetic analyses showed that *Sasa* is polyphyletic with species dispersed in several clades or subclades (Triplett and Clark 2010; Zeng et al. 2010; Zhang et al. 2012). In China, eight species (all endemic) were recognized under *Sasa*, of which only *S. sinica* was reported based on flowering material (Keng 1936; Hu 1985, 1996;

Wang and Stapleton 2006). Hu (1985) divided the Chinese *Sasa* into two subgenera, i.e., *S.* subg. *Sasa* and *S.* subg. *Sasamorpha* (Nakai) C. H. Hu. Based on newly collected flowering material, Qin et al. (2021) described a new genus, *Sinosasa* L. C. Chia ex N. H. Xia, Q. M. Qin & Y. H. Tong, to accommodate some species of *S.* subg. *Sasa* from China with raceme-like synflorescences, two to three florets per spikelet with a rudimentary terminal floret, three stamens and two stigmas per floret, strongly raised culm supranodal ridges, and relatively long (> 1 cm) foliage leaf ligules. Hitherto, seven species are recognized in this new genus, including three previously recognized species of *S.* subg. *Sasa* and four new species. However, due to the limitations of sampling and time, not all the species of *Sasa* from China were studied by Qin et al. (2021), and the taxonomic position of some species without raised supranodal ridges on culm and very long foliage leaf inner ligules was still uncertain. More recently, a little-known *Sasa* species from China, *S. guangdongensis* W. T. Lin, was synonymized with *Acidosasa carinata* (W. T. Lin) D. Z. Li & Y. X. Zhang based on morphological considerations (Li et al. 2022).

*Sasa tomentosa* C. D. Chu & C. S. Chao was described in 1981 based on two specimens of the only collection of *S. H. Chun 15320* from Jiuwan Mountain in Guangxi, China (Chao and Chu 1981), with the one in IBK designated as the holotype and the other in NAS as the isotype. We have not found the holotype yet, although an attempt to search for it in IBK was made. The line drawing of *S. tomentosa* in the protologue is obviously based on the isotype in NAS (Fig. 1A), as they are nearly the same. Judging from the line drawing in the protologue or the isotype in NAS, it is hard to determine which genus this species should be assigned to, because the specimen does not have a rhizome and only contains a very young culm before branching development, while both rhizome and branch complement are key characters to differentiate genera of bamboos. Fortunately, we found another three duplicates of the collection *S. H. Chun 15320* deposited in IFP, N and WUK. The isotype deposited in WUK (Fig. 1B) possesses two branches at a node of culm, which conflicts with the strictly solitary branch at each culm node of *Sasa*. Thus, *S. tomentosa* should not belong to *Sasa*, although the treatment of its assignment to *Sasa* has been accepted by many floras, such as Flora Reipublicae Popularis Sinicae, Flora of China and Flora of Guangxi (Hu 1996; Wang and Stapleton 2006; Xia et al. 2016) over the past 40 years. This species has neither strongly raised culm supranodal ridges nor long foliage leaf ligules, so it should not be assigned to *Sinosasa* either. Thus, the taxonomic position of this species needs further study.

## Materials and methods

The complete specimens, including rhizome, culm, branches and leaves of *S. tomentosa*, were collected from the type locality, viz., Jiuwan Mountain National Natural Reserve, Rongshui County, Guangxi Zhuang Autonomous Region, China during a field trip in September 2022. Observations and measurements were taken using a magnifier and a ruler with the scale of 0.5 mm. Some minor characters such as indumentum on ligules

of both culm leaves and foliage leaves were observed with a stereomicroscope (Mshot MZ101). The description was made based on both living and dried material and also consultation with the relevant literature (Chao and Chu 1981; Hu 1996; Wang and Stapleton 2006; Huang and Dai 2009; Xia et al. 2016). Herbarium acronyms follow Thiers (2022).

## Results and discussion

When the first and second authors visited the type locality of *Sasa tomentosa* in September 2022, only two bamboo species were found, i.e., *Chimonobambusa angustifolia* C. D. Chu & C. S. Chao and one *Yushania* species. The young culm without branches of the latter bamboo species (Fig. 2) that we collected matched the isotype in NAS (Fig. 1A) very well, and shares the same key characters, such as the abaxially densely hirsute culm leaf sheath (Fig. 3B), the falcate auricles, the radiate oral setae and the short ligules of culm leaves, the glabrous internodes, the slightly prominent nodes, the white powdery infranodal region, and the culm sheath 1/2–1/3 as long as the internode, as described in the protologue. Thus, we are certain that the specimens we collected are *S. tomentosa*.

However, except for the characters mentioned above, some of its other characters fit well with the circumscription of *Yushania* Keng f. (Keng 1957) rather than *Sasa*, such as pachymorph rhizome with long necks (Fig. 3F), the branch complement with mostly solitary branch at lower culm nodes, one to two at mid and upper culm nodes and rarely three at upper culm nodes (Fig. 3G) and persistent culm leaf sheaths. Thus, *Sasa tomentosa* is obviously a member of the genus *Yushania*.

Chao and Chu (1981) perhaps misunderstood the young culm as an ultimate leafy branch, because they described the ultimate branches with two to three wavy foliage leaves when dried in the protologue. In fact, this bamboo has ultimate branches with four to eight much smaller foliage leaves than those described by Chao & Chu.

After examining the specimens of similar species and referring to the related literature (Yi 1986; Li et al. 2006; Zhang and Xia 2021), it is found that *S. tomentosa* is most similar to *Yushania doupengshanensis* Y. Y. Zhang et N. H. Xia (Zhang and Xia 2021) in sharing several vegetative characters, such as falcate auricles, radiate oral setae and truncate ligules of culm and foliage leaves, reflexed and lanceolate culm leaf blades, glabrous foliage leaf blades and white puberulous pseudopetioles, but differs in having nearly solid (vs. hollow) culms, branch complements with usually solitary branch at lower culm nodes, one to two at mid and upper culm nodes and rarely three at upper culm nodes (vs. solitary at each culm node), glabrous (vs. densely white puberulous) internodes with (vs. without) dense purple spots, and densely hirsute (vs. sparsely setose) foliage leaf sheath with ciliate (vs. glabrous) margins. A more detailed comparison between the two species is provided in Table 1. Thus, it is confirmed that *S. tomentosa* represents a distinct species of *Yushania*. Accordingly, a new combination of *S. tomentosa* under *Yushania* is made as follows.

**Table 1.** Comparison of *Yushania tomentosa* and *Y. doupengshanensis*.

Characters	<i>Y. tomentosa</i>	<i>Y. doupengshanensis</i>
Culm internode	Nearly solid, 15–27 cm long, glabrous, green and densely purple-spotted, not powdery except infranodal region	Hollow, 14–18 cm long, densely white puberulous, green without purple spots, thinly white powdery and densely so on infranodal region
Branch complement	Usually 1 at the basal culm nodes, 1 to 2 at mid and upper culm nodes, rarely 3 at upper culm nodes	Solitary at each culm node
Culm leaf auricle	Falcate, 2–5 × 1–2 mm	Broadly falcate, 2.5–3 × 1–1.5 mm
Abaxial surface of foliage leaf sheath	Densely hirsute	Sparsely setose
Margin of foliage leaf sheaths	Ciliate with trichomes readily deciduous	Glabrous
Type locality	Guangxi (Rongshui County)	Guizhou (Duyun County)

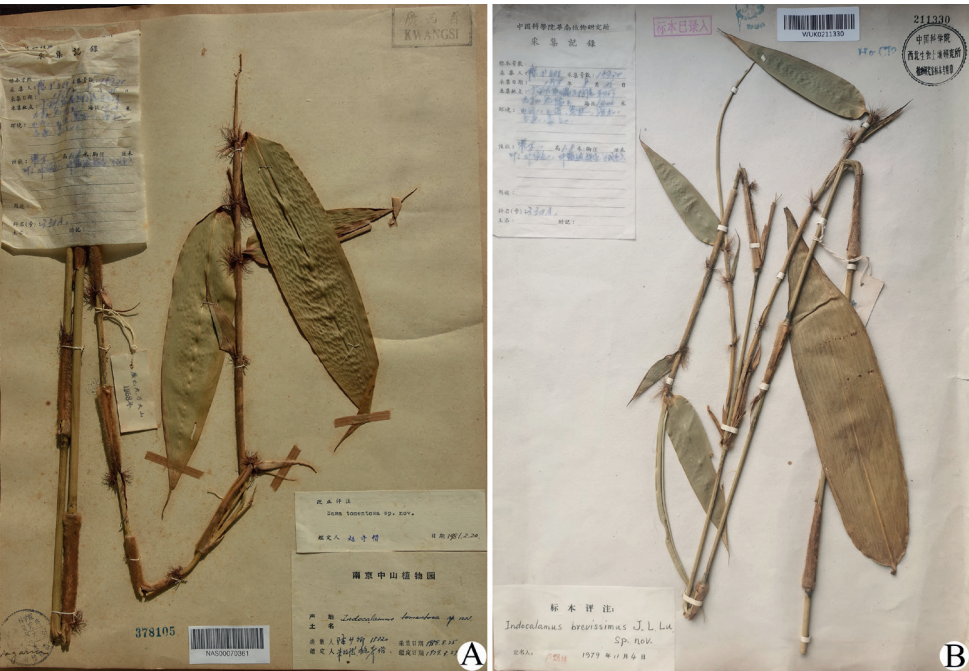
Taxonomic treatment

*Yushania tomentosa* (C.D.Chao & C.S.Chao) N.H.Xia, Y.H.Tong, J.B.Ni & X.Li, **comb. nov.**

urn:lsid:ipni.org:names:77311667-1

Figs 1–3

*Sasa tomentosa* C. D. Chu & C. S. Chao, J. Nanjing Technol. Coll. Forest Prod. 3(3): 35 (1981). Basionym.

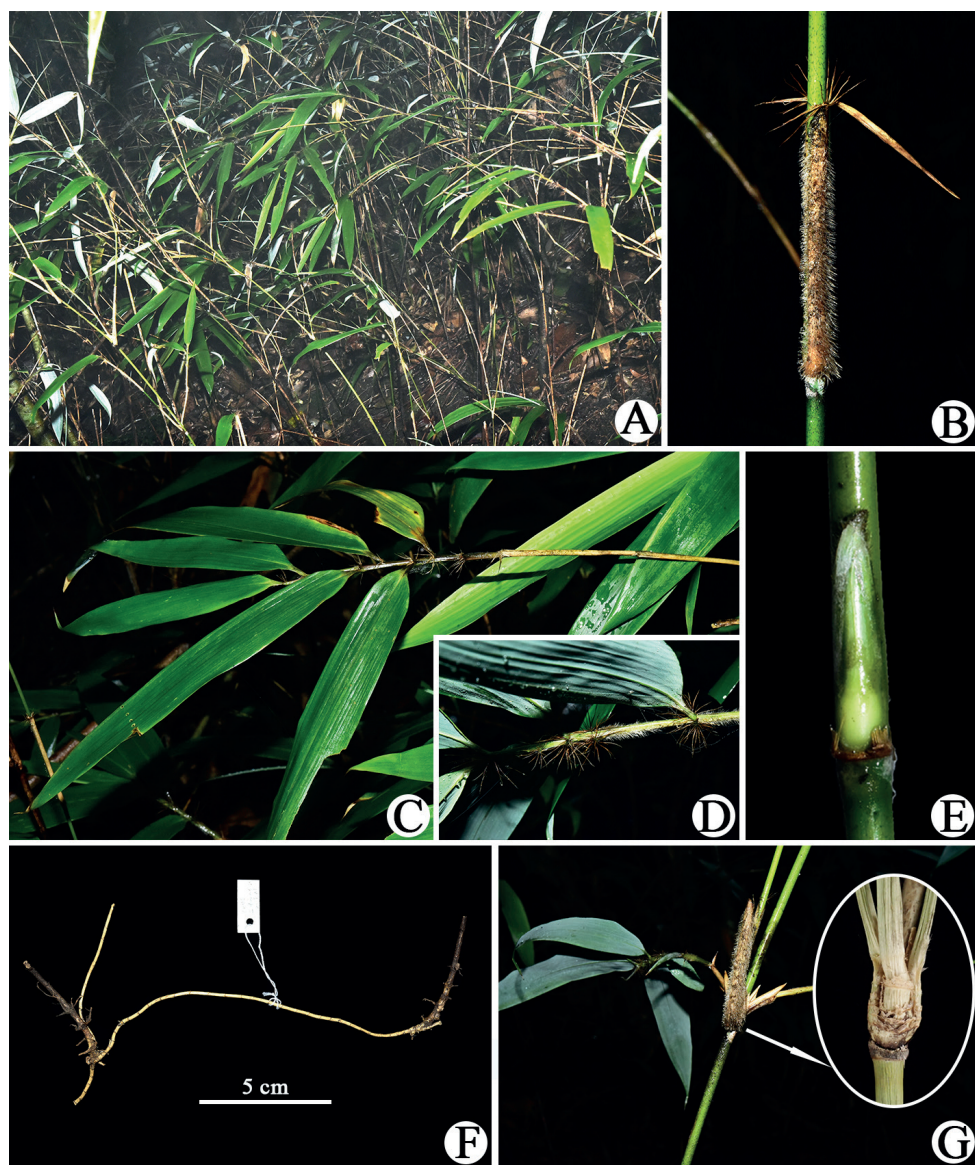


**Figure 1.** Isotypes of *Sasa tomentosa* (S. H. Chun 15320, **A** NAS00070361 **B** WUK0211330). Photo **A** by Wei Zhou, **B** by Liang Zhao.

**Type.** CHINA. Guangxi: Rongshui County, Jiuwan Mountain, elev. 1400 m, 25 August 1958, S. H. Chun 15320 (holotype: IBK, not seen; isotypes: NAS00070361, image!; WUK0211330, image!; N019023167, image!; IFP15899999w0005, image!).



**Figure 2.** Specimen of *Yushania tomentosa*, X. Li & J. B. Ni LX168 (IBSC).



**Figure 3.** *Yushania tomentosa* **A** habit **B** culm leaf and partial culm **C** foliage leaf branch **D** part of foliage leafy branch, showing tomentose sheath and radiate oral setae **E** culm bud **F** pachymorph rhizome with long neck **G** three branches at an upper culm node. All photos by Xing Li.

**Description.** Shrubby bamboo. Rhizomes pachymorph, necks 20–30 cm long, 3–5 mm in diameter, solid. Culms 1–2 m tall, 2–6 mm in diameter, diffuse; branches intravaginal, developing from 4<sup>th</sup> to 5<sup>th</sup> nodes upwards, usually solitary at lower culm nodes, 1–2 at mid and upper culm nodes and rarely 3 at upper culm nodes; internodes terete, 15–27 cm long, glabrous, densely purple-spotted, thickly white powdery below nodes, nearly solid; nodes slightly prominent; supranodal ridges flat or slightly raised;

intranodes 3–5 mm long, glabrous. Culm buds solitary, long-ovate to lanceolate, yellow to light green, ciliate on the margin, apex attenuate, base obtuse. Culm leaf sheaths persistent, 1/2–1/3 as long as internodes, densely white to yellowish-brown hirsute with trichomes 3–5 mm long, densely ciliate on the margin; sheath scar prominent, with persistent remains of sheath base; auricles falcate, 2–5 × 1–2 mm; oral setae developed, radiate, 8–12 mm long; ligule truncate, 0.5–1 mm high, ciliolate on the margin; blades linear-lanceolate to lanceolate, 1.2–3.5 × 0.2–0.7 cm, reflexed, ca. 1/2 as long as culm sheath, glabrous, margin serrulate. Foliage leaves 4–8 per ultimate branch; sheath densely white hirsute with trichomes ca. 2 mm long, margin ciliate, sometimes glabrescent, longitudinal ribs conspicuous; auricles falcate, 1–3 × 0.5–1.5 mm; oral setae radiate, 10–13 mm long; inner ligule ca. 1 mm high, truncate or oblique-truncate, ciliolate on the margin; outer ligule ca. 0.5 mm high, margin white ciliate with trichomes 0.5–1 mm long; pseudopetioles white puberulous, initially white powdery, 5–8 mm long; blades long-lanceolate to lanceolate, 13–22 × 1.5–2.6 cm, wavy when dry, glabrous, apex long-acuminate, base cuneate to obtuse, margin sparsely serrulate or sometimes entire; secondary veins 7–9 pairs, transverse veins conspicuous. Inflorescence unknown.

**Phenology.** New shoots from August to September.

**Vernacular name.** Róng Máo Yù Shān Zhú (Chinese pronunciation); 绒毛玉山竹 (Chinese name).

**Additional specimens examined.** *Yushania tomentosa*: CHINA. Guangxi: Rongshui County, Wangdong Township, Jiuwan Mountain, Weilinjiang, 23 September 2022, 25°18'39.3"N, 108°38'13.2"E, elev. 1358 m, X. Li & J. B. Ni LX168 (IBSC). *Yushania doupengshanensis*: CHINA. Guizhou: Duyun County, Doupeng Mountain, 29 November 2020, 26°22'39"N, 107°21'25"E, elev. 1200 m, Y. Y. Zhang 2004 (holotype: IBSC0865924!; isotypes: IBSC0865925!, IBSC0865926!).

## Acknowledgements

We thank the staff of Sancha, Yangmei'ao and Weilinjiang Protection Station, Jiuwan Mountain National Nature Reserve for their assistance in the fieldwork. Our thanks also go to Dr. Wei Zhou from Institute of Botany, Jiangsu Province and Chinese Academy of Sciences, Prof. Liang Zhao from Northwest A & F University and Prof. Hai-sheng Yuan from Institute of Applied Ecology, Chinese Academy of Sciences for taking the photos of the type specimens of *Sasa tomentosa*. This research was funded by the Natural Science Foundation of Guangdong Province (grant no. 2114050002139) and National Natural Science Foundation of China (grant no. 32270227).

## References

- Chao CS, Chu CD (1981) New taxa and combinations of Bambusoideae in China. *Journal of Nanjing Technological College of Forest Products* 3(3): 35–36.
- Hu CH (1985) A revision of the genus *Sasa* from China. *Bamboo Research* 2: 56–63.

- Hu CH (1996) *Sasa* Makino et Shibata. In: Geng BJ, Wang ZP (Eds) *Flora Reipublicae Popularis Sinicae* (Vol. 9). Science Press, Beijing, 662–675.
- Huang DY, Dai QH (2009) *Bamboos of Guangxi*. Guangxi Science and Technology Press, Nanning, 228 pp.
- Keng YL (1936) A new *Sasa* from southeastern China. *Sinensia* 7(6): 748–751.
- Keng PC (1957) One new genus and two new species of Chinese bamboos. *Acta Phytotaxonomica Sinica* 6: 355–362.
- Li DZ, Guo ZH, Stapleton CMA (2006) *Yushania* Keng f. In: Wu ZY, Raven P (Eds) *Flora of China* (Vol. 22). Science Press, Beijing & Missouri Botanical Garden Press, St. Louis, 57–73.
- Li X, Tong YH, Xia NH (2022) *Sasa guangdongensis*, a new synonym of *Acidosasa carinata* (Poaceae: Bambusoideae). *Phytotaxa* 568(2): 204–212. <https://doi.org/10.11646/phytotaxa.568.2.5>
- Makino T, Shibata K (1901) On *Sasa*, a new genus of Bambuseae, and its affinities. *Botanical Magazine Tokyo* 15(168): 18–31. [https://doi.org/10.15281/jplantres1887.15.168\\_18](https://doi.org/10.15281/jplantres1887.15.168_18)
- Qin QM, Tong YH, Zheng XR, Ni JB, Xia NH (2021) *Sinosasa* (Poaceae: Bambusoideae), a new genus from China. *Taxon* 70(1): 27–47. <https://doi.org/10.1002/tax.12422>
- Soreng RJ, Peterson PM, Zuloaga FO, Romaschenko K, Clark LG, Teisher JK, Gillespie LJ, Barberá P, Welker CAD, Kellogg EA, Li DZ, Davidse G (2022) A worldwide phylogenetic classification of the Poaceae (Gramineae) III: An update. *Journal of Systematics and Evolution* 60(3): 476–521. <https://doi.org/10.1111/jse.12847>
- Thiers B (2022) Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/ih>
- Triplett JK, Clark LG (2010) Phylogeny of the temperate bamboos (Poaceae: Bambusoideae: Bambuseae) with an emphasis on Arundinaria and allies. *Systematic Botany* 35(1): 102–120. <https://doi.org/10.1600/036364410790862678>
- Wang ZP, Stapleton CMA (2006) *Sasa* Makino et Shibata. In: Wu ZY, Raven P (Eds) *Flora of China* (Vol. 22). Science Press, Beijing & Missouri Botanical Garden Press, St. Louis, 109–112.
- Xia NH, Dai QH, Tang SC (2016) Bambusoideae. In: Guangxi institute of Botany, Guangxi Zhuang Autonomous Region and the Chinese Academy of Sciences (Eds) *Flora of Guangxi* (Vol. 5). Guangxi Science & Technology Publishing House Press, Nanning, 739–823.
- Yi TP (1986) Studies on the genus *Yushania*. *Journal of Bamboo Research* 5(1): 8–66.
- Zeng CX, Zhang YX, Triplett JK, Yang JB, Li DZ (2010) Large multi-locus plastid phylogeny of the tribe Arundinarieae (Poaceae: Bambusoideae) reveals ten major lineages and low rate of molecular divergence. *Molecular Phylogenetics and Evolution* 56(2): 821–839. <https://doi.org/10.1016/j.ympev.2010.03.041>
- Zhang YY, Xia NH (2021) *Yushania doupengshanensis* (Poaceae, Bambusoideae), a new bamboo species from south Guizhou, China. *Phytotaxa* 505(2): 229–234. <https://doi.org/10.11646/phytotaxa.505.2.9>
- Zhang YX, Zeng CX, Li DZ (2012) Complex evolution in Arundinarieae (Poaceae: Bambusoideae): Incongruence between plastid and nuclear GBSSI gene phylogenies. *Molecular Phylogenetics and Evolution* 63(3): 777–797. <https://doi.org/10.1016/j.ympev.2012.02.023>

## *Raphiocarpus taygiangensis* (Gesneriaceae), a new species from central Vietnam

Cuong Huu Nguyen<sup>1</sup>, Khoa Van Phung<sup>1</sup>, Khang Sinh Nguyen<sup>2</sup>,  
Leonid V. Averyanov<sup>3</sup>, Vuong Ba Truong<sup>4</sup>, Chu Van Tran<sup>1</sup>, Hai Xuan Cao<sup>1</sup>,  
Quan Ngoc Chu<sup>5</sup>, Hau Bich Thi Vu<sup>6</sup>, Thoa Kim Thi Pham<sup>7</sup>

**1** Vietnam National University of Forestry, Xuan Mai, Chuong My, Ha Noi, Vietnam **2** Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Road, Nghia Do, Cau Giay, Hanoi, Vietnam **3** Komarov Botanical Institute Russian Academy of Sciences, Prof. Popov str., 2, St. Petersburg, 197376, Russia **4** Institute of Tropical Biology Vietnam Academy of Science and Technology, 85 Tran Quoc Toan, District 3, Ho Chi Minh City, Vietnam **5** Ba Vi National Park, Tan Linh, Ba Vi, Hanoi, Vietnam **6** Department of agriculture and rural development, Hai Chau District, Danang City, Vietnam **7** The University of Danang – University of Science and Technology, 54 Nguyen Luong Bang str., Lien Chieu District, Danang City, Vietnam

Corresponding authors: Cuong Huu Nguyen ([nguyenhuucuong.tvr@gmail.com](mailto:nguyenhuucuong.tvr@gmail.com)),  
Thoa Kim Thi Pham ([ptkthoa@dut.udn.vn](mailto:ptkthoa@dut.udn.vn))

Academic editor: Bo Li | Received 19 October 2022 | Accepted 30 November 2022 | Published 10 January 2023

**Citation:** Nguyen CH, Van Phung K, Sinh Nguyen K, Averyanov LV, Truong VB, Tran CV, Cao HX, Chu QN, Vu HBT, Pham TKT (2023) *Raphiocarpus taygiangensis* (Gesneriaceae), a new species from central Vietnam. *PhytoKeys* 218: 19–27. <https://doi.org/10.3897/phytokeys.218.96511>

### Abstract

*Raphiocarpus taygiangensis*, a new species of Gesneriaceae family discovered in Tay Giang District, Quang Nam Province, Central Vietnam, is here described and illustrated. The new species is diagnosed by the combination of its stem up to 2 m long, sericeous hairs on young stem, leaf petiole and adaxial mid-vein, sparsely and minutely serrate leaf margin, axillary inflorescence spreading along stem, sparsely long gland-tipped hairs on peduncle, pedicel, calyx, outside corolla and pistil, calyx 5-disparted from base, purplish white flower with purple stripes inside corolla tube, and dish-shaped stigma formed by 2 semi-orbicular lobes horizontally expanding. Distinct features of the new species and its morphologically closest congener, *Raphiocarpus axillaris*, are compared and discussed. The conservation status of the described species is estimated as Vulnerable (VU D2) according to the IUCN Red List Criteria.

**Keywords**

endemism, flora of eastern Indochina, new taxon, plant diversity, plant taxonomy

**Introduction**

The genus *Raphiocarpus* Chun (1946) from Gesneriaceae family includes about 16 species, distributed from southwest China (Weber et al. 1998, 2020; Li and Wang 2005; Wei et al. 2010; Zhang et al. 2010; Chen et al. 2015; Wei 2018; Wei et al. 2022) to central Vietnam (Pham 2000; Phuong 2005; Phuong and Xuyen 2010; Phuong et al. 2012; Luu et al. 2018; Vu 2018; Middleton et al. 2021; Hassler 2022; Powo 2022; Xin et al. 2022). There are presently ten species of *Raphiocarpus* found and described in Vietnam, namely *R. annamensis* (Pellegr.) B.L.Burtt (Weber et al. 1998), *R. asper* (Drake) B.L.Burtt (Weber et al. 1998), *R. axillaris* D.J.Middleton (Middleton et al. 2021), *R. begoniifolius* (Levl.) Burtt (Weber et al. 1998), *R. clemensiae* (Pellegr.) B.L.Burtt (Weber et al. 1998), *R. evrardii* (Pellegr.) B.L.Burtt (Weber et al. 1998), *R. macrosiphon* (Hance) Burtt (Weber et al. 1998), *R. petelotii* (Pellegr.) B.L.Burtt (Weber et al. 1998), *R. tamdaoensis* Phuong Xuyen & Y.G.Wei (Phuong et al. 2012), and *R. sinovietnamicus* Z.B.Xin, L.X.Yuan & T.V.Do (Xin et al. 2022).

During the botanical fieldwork in Quang Nam Province, Tay Giang District, A Xan Village in central Vietnam in April 2022, we collected several samples of Gesneriaceae. These plants have subshrub habit, opposite leaves spreading along stem, axillary 1–3-flowered cyme, 5-lobed calyx dissected from the base, 4 fertile stamens arranged in two pairs, and 2-lobed stigma, which allows us to identify them as a representatives of the genus *Raphiocarpus*. After consulting the relevant literatures (Pellegrin 1930; Chun 1946; Wang et al. 1998; Weber et al. 1998; Ho 2000; Wei et al. 2010; Zang et al. 2010; Phuong et al. 2012; Chen et al. 2015; Luu et al. 2018; Vu 2018; Wei 2018; Middleton et al. 2021; Wei et al. 2022; Xin et al. 2022) and examining *Raphiocarpus* specimens housed in such herbaria as E, K, P, LE, PE, IBK, KUN, and VNMN, we assume our plants as a new species, well segregated from all known species of the genus by its morphological characters. This discovered new species is described and illustrated below.

**Materials and methods**

All collected and studied herbarium specimens of the newly discovered species are presently stored in the herbaria of Vietnam (HN, VNF) and Russia (LE). Color photos of plants were taken in natural habitats. Morphological observations and measurements were made on living plants, dried specimens, and on alcohol preserved materials. Morphological characters were described using the terminology proposed by Wang et al. (1998) Harris and Harris (2001).

## Taxonomic treatment

***Raphiocarpus taygiangensis* C.H.Nguyen, K.S.Nguyen & Aver., sp. nov.**

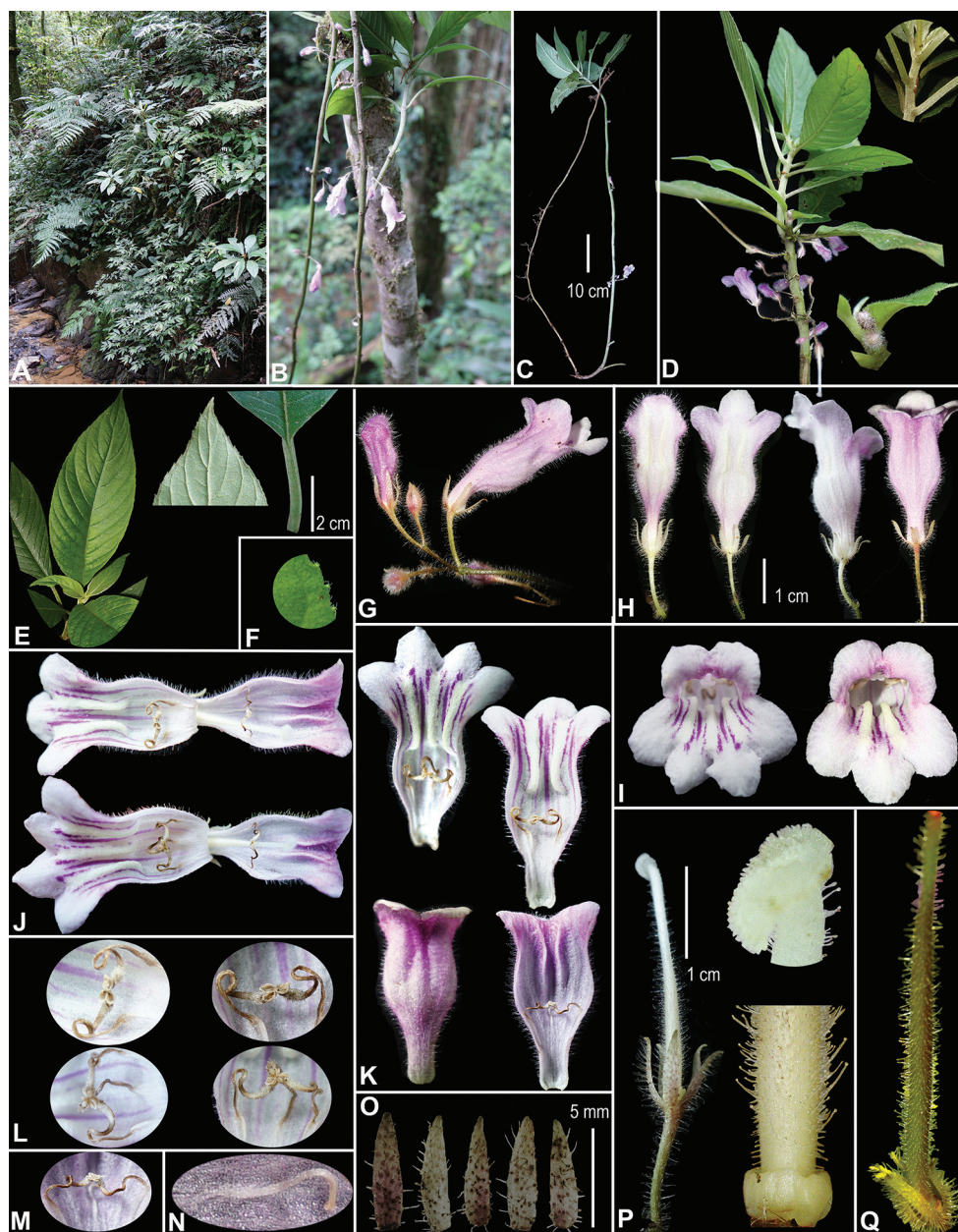
urn:lsid:ipni.org:names:77311676-1

Figs 1–3

**Diagnosis.** The new species differs from closest *R. axillaris* in serrulate leaves, purple spots and glandular hairs on abaxial surface of corolla, purple longitudinal stripes on median lobe of lower lip, and pubescent filaments stamens and pistil (Table 1).

**Type.** VIETNAM. Quang Nam Province, Tay Giang District, A Xan Village, primary evergreen broad-leaved forest, around point 15°48'57"N, 107°19'47"E, elevation 1270 m, 20 April 2022, C.H. Nguyen, K.S. Nguyen, H.X. Cao, CKH 2022042068 (holotype VNF; isotypes HN, LE).

**Description.** Perennial herb with stem to ca. 3 m long ascending to ca. 1 m tall. Stem branching, velutinous when young, glabrescent with age. Leaves opposite, equal to unequal in size; petioles 1.5–3.5 cm long, densely hirsute with appressed hairs; leaf blade symmetrically elliptic, 8–16 × 3.4–6.2 cm, 2.3–2.6 times as long as wide, base cuneate, apex acute to acuminate, hirsute with appressed hairs on both sides, more densely on veins, serrulate along the margin, eucamptodromous venation with 8–14 pairs of secondary veins, tertiary venation ramified. Inflorescences arising in axils of lower leaves and in leaf scar axils, 1- or 2-flowered, up to 3 inflorescences in an individual axil, 5–6 cm long (including flower); all axes with 0.5–1 mm long glandular hairs; peduncle 10–18 mm long; bracts narrowly elliptic, 4–5 × 0.8–1 mm long, greenish, with 0.5–1 mm long glandular hairs; flowers spreading almost horizontally to slightly pendulous; pedicels 10–12 mm long. Calyx of 5 lobes free from the base, lobes 6–7 × 1.3–1.5 mm long, with long glandular hairs outside, glabrous inside. Corolla infundibular, outside white with purple tint to purple, inside white with purple on adaxial lip and purple longitudinal lines on median lobe of abaxial lip, 4.2–4.8 cm long, sparsely covered with long glandular hairs outside, inside with glandular short hairs at apex of adaxial lip, with two to three prominent ridges ventrally at the base of throat, limb distinctly two-lipped; tube 3.5–3.9 cm long, 8–10 mm wide, swelling at middle and narrowing at base, the distal part broadening towards throat; adaxial lip 2-lobed, lobes subequal, half round, 5–6 mm long, 5–6 × 7–9 mm wide, sinus 4–5.5 mm deep; adaxial lip 3(4)-lobed, lobes unequal, 14–16.5 mm long, lateral lobes 6–8 × 7–9 mm wide, middle lobe 7–9.2 × 4.8–6.1 mm wide. Stamens 4(5), in 2 pairs, each pair adnate at the anthers, filaments filiform, distally shortly glandular puberulent, geniculate near the middle; adaxial pair adnate to 14–16 mm above the corolla base, 9–11 mm long, 1 mm in diameter, anthers 0.8–1 × 1.1–1.3 mm long; abaxial pair, adnate at c. 14 mm above the corolla base, 6–8 mm long, 0.8 mm in diameter; staminode 1, slightly hooked, 3–4 mm long. Disc circular, light lemon yellow, 1–1.2 mm high, margin repand, glabrous. Pistil 2–2.2 cm long, puberulent throughout; ovary 12–13 mm long; style 6–7 mm long; stigma c. 2 mm, 2-lobed. Capsule green when young, bent at the base, narrowly fisisiform, pubescent, dehiscing adaxially, straight, not twisted.



**Figure 1.** *Raphiocarpus taygiangensis* C.H.Nguyen, K.S.Nguyen & Aver., sp. nov. **A** natural habitat **B–D** flowering plant in natural habitat **E** leaves **F** leaf margin **G** inflorescences **H** flowers, views from different sides **I** flower, frontal views **J** sagittal section of corolla showing inner surface with stamens and staminodes **K** flower tube inside and outside **L, M** stamens **N** staminode **O** calyx lobes **P** pistil, base of pistil and its apex with stigma **Q** young fruit. Photos by Cuong Huu Nguyen and Khang Sinh Nguyen, correction and design by Cuong Huu Nguyen.



**Figure 2.** *Raphiocarpus taygiangensis* C.H.Nguyen, K.S.Nguyen & Aver., sp. nov. holotype specimen, Cuong et al., CKH 2022042068 (VNF).



**Figure 3.** *Raphiocarpus taygiangensis* C.H.Nguyen, K.S.Nguyen & Aver., sp. nov. **A** flower front view **B** habitat **C** lateral view of flower and fruit; *Raphiocarpus axillaris* D.J.Middleton, sp. nov. **D** flower front view **E** habitat **F** lateral view of flower and fruit. Photos by Ly Van Nguyen (**D–F**), Cuong Huu Nguyen and Khang Sinh Nguyen, correction and design by Cuong Huu Nguyen.

**Distribution and habitat.** The new species is only known from A Xan Commune, Tay Giang District, Quang Nam Province in central Vietnam. *Raphiocarpus taygiangensis* usually grows in moist shady places near waterfalls, along streams and occasionally on the sandstone slopes covered by evergreen broad-leaved forests at elevations of 1200–1300 m a.s.l. As common plants in habitats of the new species have been recorded *Aeschynanthus bracteatus* Wall. ex A.DC., *Angiopteris evecta* (G. Forst.) Hoffm., *Asplenium unilaterale* Lam., *Begonia* spp., *Crepidomanes auriculatum* (Blume) K. Iwats., *Hedyotis* sp., *Impatiens clavigera* Hook. f., *Leptochilus* sp., *Molineria capitulata* (Lour.) Herb., *Mycetia* sp., *Phymatosorus lucidus* (Roxb.) Pic. Serm., *Rhaphidophora decursiva* (Roxb.) Schott, *Rhynchoetechum ellipticum* (Wall. ex D. Dietr.) A. DC., and *Symplocos banaensis* Guillaumin.

**Phenology.** Flowers from April to May, fruiting from May to June.

**Etymology.** The species epithet refers to the name of the district of the type location (Tay Giang District in Quang Nam Province).

**IUCN conservation status.** The special field studies around the type location revealed no other populations outside the occupancy area which was estimated to be about 5 km<sup>2</sup>. The type location consists of approximately 500 mature individuals growing in moist shady places near waterfall and along the stream. The population territory currently does not belong to any protected area, and its future protection is needed. The area has been relatively undisturbed to date due to its significance to the surrounding village, although local people continue to forage in it for firewood. Considering the small population size and fragile habitat, we propose that the new species should be preliminarily assessed as Vulnerable (VU D2) according to criteria IUCN (2019).

**Note.** A comparison of the most significant morphological characters of *Raphiocarpus taygiangensis* and its closest congeners, *R. axillaris*. The new species can be easily distinguished from *R. axillaris* in having basally prostrate and distally ascending stem; sericeous hairs on young stem, leaf petiole and adaxial mid-vein; sparsely serrulate leaf margin; axillary inflorescence; sparse glandular hairs on the peduncle, pedicel, calyx, pistil, and abaxial surface of corolla; calyx 5-lobed, dissected from the base; white or light purplish flowers with purple stripes inside corolla tube; twining filaments; and dish-shaped stigma formed by 2 semi-orbicular lobes spreading horizontally. The comparison of the key morphological characters of *R. taygiangensis*, and *R. axillaris* is presented in Table 1.

**Table 1.** Most significant morphological discriminative characters of *Raphiocarpus taygiangensis* and *R. axillaris*.

Characters	<i>R. taygiangensis</i>	<i>R. axillaris</i>
Stems	to 3 m long, ascending to 1 m tall	to 0.7 cm long and tall
Leaf margin	serrulate	Entire
Corolla	white with purple tint to purple, inside with purple lines; glandular-hairy inside	white to pale pink; glabrous inside
Stamens	4–5; filaments puberulent	4; filaments, glabrous
Staminodes	hooked	clavate
Pistil	puberulent	glabrous

## Acknowledgements

The studies, the results of which are presented in this paper, were supported by Science Funds of Quang Nam province (contract N° 41/HĐKH-CN/2021) and the Ministry of Education and Science of the Russian Federation (contract N° 075-15-2021-1056). The authors would like to thank Mr. Nguyen Van Sinh, Tran Kim Da, Hoih Nhic, Briu Tich, Coor Bieng (Quang Nam Protective Forest, Quang Nam Province, Vietnam) for their assistance during the fieldwork and Mr. Nguyen Van Ly for his photos used as an illustration to this paper.

## References

- Chen WH, Chen RZ, Yu ZY, Zhu XT, Shui YM (2015) *Raphiocarpus jinpingensis*, a new species of Gesneriaceae in Yunnan, China. *Plant Diversity and Resources* 37: 727–732.
- Chun WY (1946) Gesneriacearum Plantae Novae Sinicarum. *Sunyatsenia* 6(3–4): 271–304.
- Harris JG, Harris MW (2001) *Plant identification terminology: an illustrated glossary*, 2<sup>nd</sup> edn. Spring Lake Pub., 216 pp.
- Hassler M (2022) World Plants. Synonymic Checklist and Distribution of the World Flora. Version 14.3; last update November 10<sup>th</sup>, 2022. [www.worldplants.de](http://www.worldplants.de) [Accessed 25 /11/2022]
- Ho PH (2000) Gesneriaceae. An illustrated Flora of Vietnam. Vol. 3. Young Publishing House, Ho Chi Minh City, 12–29.
- IUCN (2019) Guidelines for using the IUCN Red List categories and criteria, ver. 14. Prepared by the Standards and Petitions Subcommittee. <http://cmsdocs.s3.amazonaws.com/RedList-Guidelines.pdf> [Accessed 29 July 2022]
- Middleton D, Nguyễn QB, Trần HĐ, Leong-Škorničková J (2021) A new species of *Raphiocarpus* (Gesneriaceae) from Vietnam. *Edinburgh Journal of Botany* 78: 1–4. <https://doi.org/10.24823/EJB.2021.365>
- Li ZY, Wang YZ (2005) *Plants of Gesneriaceae in China*. H Henan Science and Technology Publishing House, Zhengzhou, Henan, 721 pp. [In Chinese]
- Luu HT, Nguyen TQT, Nguyen QD, Vu NL (2018) An update species checklist of Gesneriaceae in Vietnam. *Proceeding of the 3 National Scientific Conference on Biological Research and Teaching in Vietnam*, Quy Nhon, 16–24.
- Pellegrin F (1930) Gesnéracées. In: Lecomte H, et al. (Eds) *Flore générale de L'Indo-chine*. Vol. 4. Masson, 487–565.
- Phuong VX (2005) Checklist of plant species in Vietnam. Vol. 3. Agriculture Press, 235–246.
- Phuong VX, Xuyen DT (2010) A new occurrence species *Didissandra* C.B. Clarke (Gesneriaceae Dumort) of the Flora of Vietnam. *Journal of Biology* 32(2): 60–62. [In Vietnamese] <https://doi.org/10.15625/0866-7160/v32n2.688>
- Phuong VX, Xuyen DT, Wen F, Wei YG (2012) *Raphiocarpus tamdaoensis* sp. nov. (Gesneriaceae) from Vietnam. *Nordic Journal of Botany* 30(6): 696–699. <https://doi.org/10.1111/j.1756-1051.2012.01361.x>

- POWO (2022) Plants of the World Online. <https://powo.science.kew.org> [Accessed 25 November 2022]
- Vu PX (2018) Gesneriaceae. In: Tran TH (Ed.) Flora of Vietnam, vol. 18. Technology and Science Publishing House, 40–56.
- Xin BZ, Yuan LX, Zhang ZY, Dinh QD, Lu G, Maciejewski S, Do VT (2022) *Raphiocarpus sinovietnamicus* (Gesneriaceae), a new species from southern China and central Vietnam. Nordic Journal of Botany 2022: e03716. <https://doi.org/10.1111/njb.03716>
- Wang WT, Pan KY, Li ZY, Weitzman AL, Skog LE (1998) Gesneriaceae. In: Wu ZY, Raven PH (Eds) Flora of China, Vol. 18. Science Press and Missouri Botanical Garden Press, Beijing and St. Louis, 244–499.
- Weber A, Burt BL (1998) *Didissandra*: redefinition and partition of an artificial genus of Gesneriaceae. Beiträge zur Biologie der Pflanzen 70: 153–177.
- Weber A, Middleton DJ, Clark JL, Möller M (2020) Keys to the infrafamilial taxa and genera of Gesneriaceae. Rheedea 30(1): 5–47. <https://doi.org/10.22244/rheedea.2020.30.01.02>
- Wei YG (2018) The distribution and conservation status of native plants in Guangxi, China. China Forestry Publishing House, 543–566.
- Wei YG, Wen F, Möller M, Monro A, Zhang Q, Gao Q, Mou HF, Zhong SH, Cui C (2010) Gesneriaceae of South China. Guangxi Science and Technology Publishing House, Nanning, 777 pp.
- Wei YG, Do VT, Wen F (2022) A checklist to the plants of northern Vietnam. China Forestry Publishing House, 378–388.
- Zhang MD, Zhang MD, Shui YM, Chen WH, Zhang RM, Li GY (2010) *Raphiocarpus maguanensis* (Gesneriaceae), a new species from China. Annales Botanici Fennici 47(1): 71–75. <https://doi.org/10.5735/085.047.0110>



# *Gelidocalamus zixingensis* (Poaceae, Bambusoideae, Arundinarieae), a new species from southern China revealed by morphological and molecular evidence

Cheng-Kun Wang<sup>1,2</sup>, Rong Guo<sup>1,2</sup>, Chun-Ce Guo<sup>1,2</sup>,  
Guang-Yao Yang<sup>1,2</sup>, Wen-Gen Zhang<sup>1,2</sup>

**1** Jiangxi Provincial Key Laboratory for Bamboo Germplasm Resources and Utilization, Forestry College, Jiangxi Agricultural University, Nanchang 330045, China **2** Collaborative Innovation Center of Jiangxi Typical Trees Cultivation and Utilization, Nanchang 330045, China

Corresponding authors: Wen-Gen Zhang ([wgzhang@jxau.edu.cn](mailto:wgzhang@jxau.edu.cn)), Guang-Yao Yang ([yanggy2004@126.com](mailto:yanggy2004@126.com))

Academic editor: Eduardo Ruiz-Sanchez | Received 1 November 2022 | Accepted 14 December 2022 | Published 10 January 2023

**Citation:** Wang C-K, Guo R, Guo C-C, Yang G-Y, Zhang W-G (2023) *Gelidocalamus zixingensis* (Poaceae, Bambusoideae, Arundinarieae), a new species from southern China revealed by morphological and molecular evidence. *PhytoKeys* 218: 29–45. <https://doi.org/10.3897/phytokeys.218.96849>

## Abstract

The genus *Gelidocalamus* T. H. Wen, endemic to southern China, is a small but taxonomically problematic genus of Arundinarieae (Poaceae, Bambusoideae). During field work, a population of *Gelidocalamus* from Zixing, Hunan, was discovered, appearing to be distinct from our previously identified collection. Comparisons of the population of Zixing were performed by using scanning electron microscopy (SEM) and a plastid genome-based phylogeny. Morphologically, it was mostly similar to *G. multifolius*, but differed by culm leaf erect with densely white pubescence, apical branch sheath much longer than the internodes and foliage leaf larger. Phylogenetically, the new species was well-supported as a sister to the clade of *G. multifolius* + *G. tessellatus*, and the above three taxa were clustered in the *Shibataea* clade (IV) of Arundinarieae. Thus, the new species, formally named as *Gelidocalamus zixingensis* W.G.Zhang, G.Y.Yang & C.K.Wang, was described and illustrated herein.

## Keywords

Gramineae, leaf epidermis, phylogeny, SEM, temperate woody bamboo

## Introduction

Arundinarieae (Poaceae: Bambusoideae), i.e., accommodating the temperate woody bamboos, including ca. 581 species in 31 genera (Clark and de Oliveira 2018), is widely accepted as a monophyletic tribe (Guo et al. 2021; Gallaher et al. 2022; Huang et al. 2022), and has been one of the main focuses of botanical research due to its significant ecological and economic value (Triplett 2008). It is mainly distributed in the tropical and subtropical mountains of East Asia, central and southern Africa, Madagascar and eastern North America (Keng and Wang 1996; Soreng et al. 2022). Due to complex allopolyploid history and adaptive radiation events, Arundinarieae has evolved complex and diverse morphological characters, e.g., semelauctant and iterauctant inflorescences, pachymorph and leptomorph rhizomes, and growth habits from solitary to multiple branches, which made it a taxonomically complicated group (Li et al. 2006; Vorontsova et al. 2016; Guo et al. 2021).

As a small but taxonomically problematic genus of Arundinarieae, *Gelidocalamus* T. H. Wen, 1982, containing ca. 11 species (Li et al. 2006; Zhang et al. 2017; Cai et al. 2021), is endemic to southwestern China, and characterized by a set of morphological features including several branches per node, a single foliage leaf on each ultimate branch typically (except *G. multifolius* B. M. Yang, 1986) (Yang 1986), and semelauctant inflorescence. In addition, the new shoots occurring in autumn to winter are also a key feature of *Gelidocalamus* (Keng and Wang 1996; Liu et al. 2017; Nie et al. 2018). Members of *Gelidocalamus* have a relatively narrow distribution in the southern provinces of China and usually occur along ravines under broad-leaved evergreen forest below 1,000 m elevation, except *G. monophyllus* (Yi et B. M. Yang) B. M. Yang, 1989, distributed at 1250 m (Li et al. 2016; Nie et al. 2018). However, some “spring-shoot” species (as opposed to some others that produce shoots in the autumn-winter period), e.g., *G. rutilans* Wen, 1983, *G. subsolidus* W. T. Lin & Z. J. Feng, 1990, *G. solidus* C. D. Chu & C. S. Chao, 1984, and *G. longinternodus* W. T. Wen & S. C. Chen, 1986, complicate the delimitation of the genus.

Molecular studies of the tribe Arundinarieae have indicated that the conventionally circumscribed *Gelidocalamus* was polyphyletic, and its “spring-shoot” species were nested with members of *Ferrocalamus* Hsueh & Keng f., 1982, *Shibataea* Makino ex Nakai, 1912, *Indocalamus* Nakai, 1925, and other close relatives (Ma et al. 2017; Guo et al. 2019; Qin et al. 2021). Recently, Guo et al. (2021) investigated Arundinarieae using double digest restriction-site associated DNA (ddRAD) sequences, and revealed that six members of *Gelidocalamus* formed a monophyletic clade. These taxa (which may be termed the ‘gelido- taxa’) have identical micromorphological characters (i.e., prominent stomata apparatus surrounded by 8–12 short papillae and a dense waxy covering). On the other hand, other “spring-shoot” members were scattered and grouped with other genera. The “gelido-” members of *Gelidocalamus* are *G. stellatus* T. H. Wen, 1982, *G. tessellatus* T. H. Wen & C. C. Chang, 1982, *G. annulatus* T. H. Wen, 1988, *G. latifolius* Q. H. Dai & T. Chen, 1985, *G. multifolius* and *G. monophyllus*. Two recently reported species *G. xunwuensis* W. G. Zhang & G. Y. Yang, 2017 and *G. fengkaiensis* N. H. Xia & Z. Y. Cai, 2021 appear to also be in this group.

During field work in August 2014, a population of *Gelidocalamus* sp. in Zixing City of Hunan Province, China (25°54'1.75"N, 113°34'9.18"E), was found, and mistakenly identified as *G. multifolius* due to a somewhat similar morphology. In this study, a detailed comparison among the new species, *G. multifolius* and *G. tessellatus*, including characters obtained with scanning electron microscope (SEM) of the foliage leaf epidermis, was made. Moreover, the phylogenetic relationships of the new species including above taxa and allied genera were reassessed based on complete chloroplast genomes.

## Materials and methods

### Field investigation and sample collection

Mature bamboo leaves were collected from the individuals of the type localities: *G. sp* from Zixing, Lianping Township of Zixing City in Hunan; *G. stellatus*, Xiazhuang of Jinggang Mountain in Jiangxi; *G. tessellatus*, Maolan of Libo County in Guizhou; *G. multifolius*, Jiuyi Mountain of Ningyuan County in Hunan. Foliage leaves were fixed with the FAA (acetic acid: formalin: ultrapure water: ethanol = 1:2:3:14), and some dried in silica-gel for storage. All voucher specimens were deposited in the herbarium of the College of Forestry, Jiangxi Agricultural University, China (JXAU).

### Micromorphological observations of foliage leaf epidermis

After cleaning in the ultrasonic cleaner CPX2800H-C (Branson, USA), the middle portion of foliage leaf (5×5 mm) was dried at room temperature, mounted on stubs, and coated with gold sputtering. Using a scanning electron microscope S-4800 (Hitachi, Japan), leaf epidermal characters were observed and photographed. Terminology for epidermal appendages and leaf blades follows previous studies (Ellis 1979; Ellis et al. 2009; Zhang et al. 2014; Leandro et al. 2019).

### Sequencing, assembly and annotation

Total genomic DNA was isolated from foliage leaves dried over silica-gel by a modified CTAB method (Murray and Thompson 1980). Illumina paired-end (2×150 bp) libraries were constructed and sequenced at Novogene Bioinformatics Technology Co. Ltd. (Beijing, China), and ca. 6 GB raw data for each sample was acquired. To improve assembly accuracy, FastQC 0.11.9 (Andrews 2016) and Fastp 0.12.4 (Chen et al. 2018) were used to filter out unpaired and low-depth reads by using default parameters. Complete chloroplast genomes were assembled using the software GetOrganelle 1.7.4 (Jin et al. 2018) with a range of k-mers of 45, 65, 85, 105 and 121, and the filtered reads were transferred to Bandage (Wick et al. 2015) for chloroplast genome scaffolds connection. Then, chloroplast genome sequences were annotated by using

CPGAVAS2 (Shi et al. 2019) and manually checked in Geneious 9.1.4 (Kearse et al. 2012), and illustration of the newly sequenced plastome was drawn in the software Chloroplast with default settings (Zheng et al. 2020).

Phylogenetic analysis

To determine the position of the new species, phylogenetic analyses using maximum likelihood (ML) and Bayesian inference (BI) were performed. Besides *G. sp.* from Zixing (OP920758) and *G. multifolius* (OP920759), another 18 complete chloroplast genomes of the tribe Arundinarieae were obtained from the National Center for Biotechnology Information (NCBI, <https://www.ncbi.nlm.nih.gov/>). *Hsuehochloa calcarea* (C. D. Chu & C. S. Chao) D. Z. Li & Y. X. Zhang, 2018 was selected as out-group (Genbank accession numbers see the Table 1 for details).

After alignment with MAFFT 7.450 (Katoh and Standley 2013), Maximum likelihood (ML) analysis was generated by IQ-TREE (Nguyen et al. 2015), bootstrap analyses were performed with 1,000 replications, and the best-fit BIC model GTR + F + I + G4 was defined by ModelFinder (Kalyaanamoorthy et al. 2017). Bayesian inference (BI) was conducted using MrBayes 3.2.6 (Ronquist et al. 2012) with the same model. 20,000,000 generations were run to ensure average standard deviation of split frequencies (ASDFs) < 0.01 with sampling frequency set as 2,000 generations. Discarding the first 25% burn-in samples, the optimized topology was printed.

**Table 1.** Information on the 20 complete chloroplast genomes used in this study.

Species	GenBank accession
<b>Ingroup</b>	
<i>Acidosasa purpurea</i> (Hsueh & T.PYi) Keng f.	HQ337793
<i>Ampelocalamus actinotrichus</i> (Merr. et Chun) S. L. Chen, T. H. Wen et G. Y. Sheng	MH410123
<i>Arundinaria gigantea</i> (Walter) Muhl.	NC_020341
<i>Bergbambos tessellata</i> (Nees) Stapleton	NC_036816
<i>Gaoligongshania megalothyrsa</i> (Handel-Mazzetti) D. Z. Li	JX513419
<i>Gelidocalamus multifolius</i> B. M. Yang	OP920759
<i>Gelidocalamus tessellatus</i> Wen & C. C. Chang	NC_024719
<i>Gelidocalamus zixingensis</i> W.G.Zhang, G.Y.Yang & C.K.Wang	OP920758
<i>Himalayacalamus gyirongensis</i> (Munro) P. C. Keng	NC_043943
<i>Indocalamus sinicus</i> (Hance) Nakai	NC_036819
<i>Ravenochloa wilsonii</i> (Rendle) D. Z. Li & Y. X. Zhang	JX513421
<i>Kuruna debilis</i> (Thwaites) Attigala, Kaththr. & L.G.Clark	NC_036822
<i>Oldeania alpina</i> (K.Schum.) Stapleton	NC_036813
<i>Phyllostachys edulis</i> (Carriere) J. Houzeau	MW007170
<i>Pleiblastus amarus</i> (Keng) Keng f.	MH988736
<i>Sinoasa longiligulata</i> (McClure) N.H.Xia, Q.M.Qin & J.B.Ni	NC_036825
<i>Shibataea Chiangshanensis</i> Wen	NC_036826
<i>Shibataea kumasasa</i> (Zollinger ex Steudel) Makino ex Nakai	KU523578
<i>Thamnocalamus spathiflorus</i> (Trinius) Munro	JX513425
<b>Outgroup</b>	
<i>Hsuehochloa calcarea</i> (C.D.Chu & C.S.Chao) D.Z.Li & Y.X.Zhang	KJ496369

## Results

### Morphological comparison

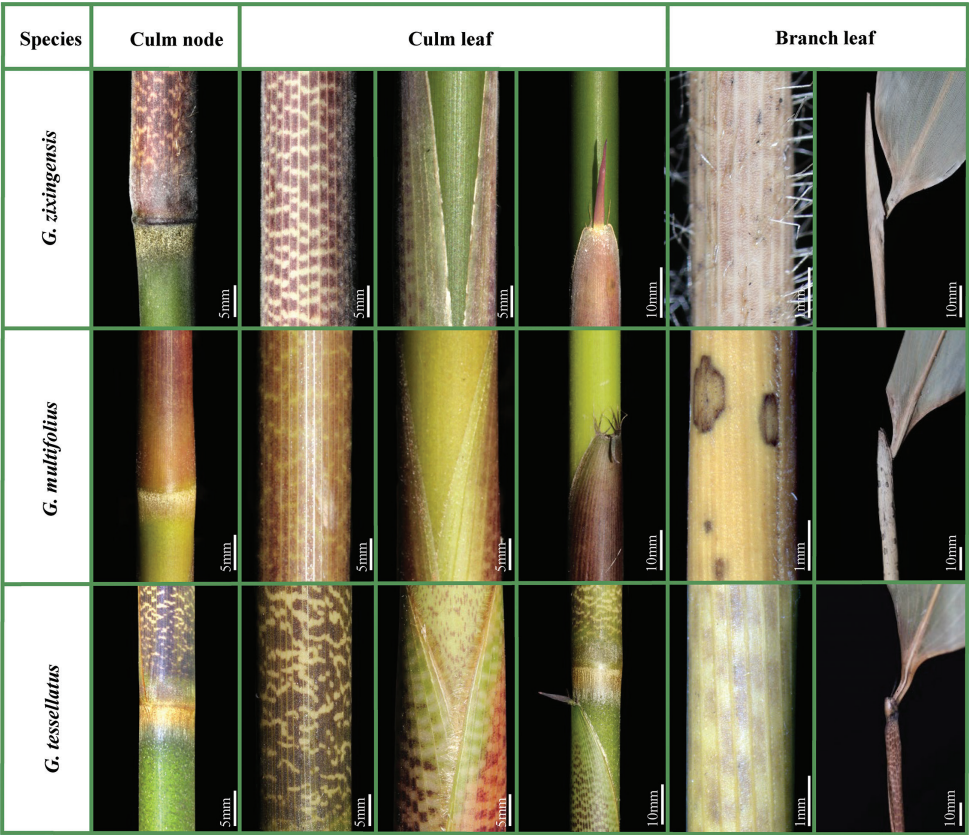
Compared to *G. tessellatus*, *G. zixingensis* was mostly similar to *G. multifolius* in the habit, the morphological characters and new shoots sprouting season, but can be distinguished by the following morphological characters: (a) a ring of white-gray (vs. yellow-brown) appressed pubescence below each culm node; (b) culm leaf sheaths densely white pubescent (vs. glabrous), with brown patches (vs. pale brown), and erect (vs. reflexed) culm sheath blades; (d) branch leaf sheaths setose (vs. glabrous) and much longer, (>3cm) (vs. slightly longer, < 1cm or as long) as the internodes; foliage leaf blades mesophyll (vs. notophyll). (see Table 2, Fig. 1 for details).

**Table 2.** Morphological comparison among *G. zixingensis*, *G. multifolius* and *G. tessellatus*.

Characters	<i>G. zixingensis</i>	<i>G. multifolius</i>	<i>G. tessellatus</i>
Culm	glabrous, each node with a ring of white-gray appressed trichomes below.	glabrous, each node with a ring of yellow-brown appressed trichomes below.	sparsely setae, each node with a ring of golden appressed trichomes below.
Culm leaf	sheath pubescent with brown patches, sparsely setae near the base, margin sparsely ciliate; oral setae 2–4 pairs; blade erect.	sheath glabrous with pale brown patches, margin sparsely ciliate; oral setae 3–6 pairs; blade reflexed.	sheath glabrous with purple patches, black setae, margin densely ciliate; oral setae 2–3 pairs; blade erect or reflexed.
Branch	sheath papery, densely setae, without black spots, apical branch sheath longer ca. 3 cm than that of the internode.	sheath leathery, with black spots, pubescent, apical branch sheath longer 0.5–1cm than that of the internode.	sheath leathery, without black spots, sparsely setae, apical branch sheath equally or shorter than that of the internode.
Foliage leaf	oral setae 1–3 pairs; blade mesophyll, 23–32×3.2–4.9 cm, lateral veins 6–8 pairs	oral setae weak or absent; blade notophyll, 8–14×1.5–2.5 cm, lateral veins 4–6 pairs	oral setae weak or absent; blade mesophyll, 17–35×3.7–5.4 cm, lateral veins 5–6 pairs

### Micromorphological comparison of abaxial foliage leaf epidermis

Epidermal traits of the foliage leaf, e.g., short papillae, microhairs, silica bodies and prickles, can be clearly identified under the scanning electron microscope (Fig. 2). Main characters shared by the four selected taxa were: (a) exposed stomatal apparatus, densely covered with white wax and surrounded by 8–10 short papillae; (b) bicellular microhairs, of which the apical one was withered; (c) saddle-shaped silica body, mainly distributed between veins (Table 3). Prickles were sparsely distributed between the veins in *G. zixingensis* and *G. multifolius*, and more densely distributed in the *G. tessellatus*, while no prickles were observed in *G. stellatus*. Besides, the number of stomatal rows was different, e.g., 3 in *G. tessellatus*, 3 or 4 in *G. stellatus*, 4 in *G. multifolius*, but 5 in *G. zixingensis*.

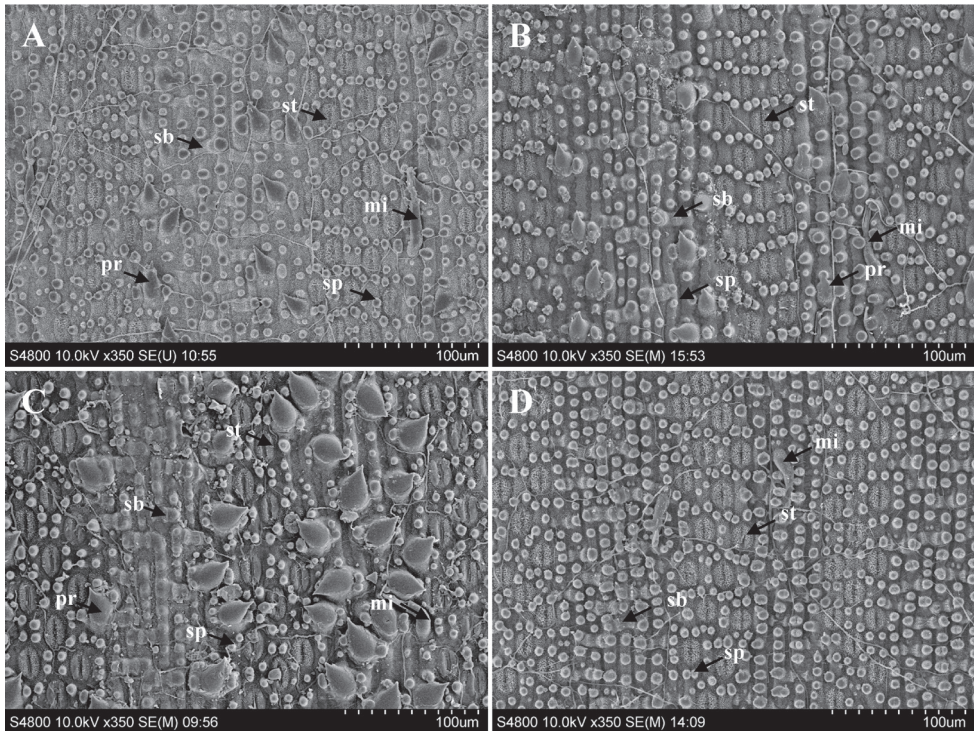


**Figure 1.** Comparison of key characters among *G. zixingensis*, *G. multifolius* and *G. tessellatus*. The corresponding scales are at the bottom right of the figures.

Phylogenetic analyses based on complete chloroplast genomes

The complete chloroplast genome of *Gelidocalamus zixingensis* was 139,500 bp in length, comprising a large single copy (LSC) region of 83,007 bp, a small single copy (SSC) region of 12,809 bp and two inverted repeat (IR) regions of 21,842 bp, and its GC content was 39%. The chloroplast genome contained 132 genes, including 85 protein-coding genes, 39 transfer RNAs and 8 ribosomal RNAs (Fig. 3), and the total length of the aligned plastid matrix data was 143,738 bp.

Compared to that in *G. zixingensis*, the total length of chloroplast genome of *G. multifolius* and *G. tessellatus* was longer (>200bp), and the differences were mainly in the LSC region (Table 4). Moreover, in comparing the chloroplast genomic variant loci of the three species, a total of 123 SNPs (Single-Nucleotide Polymorphism) and 44 INDELs (Insertion-Deletion) were identified, of which 92 SNPs (74.7%) and 40 INDELs (90.9%) were located in the LSC region.

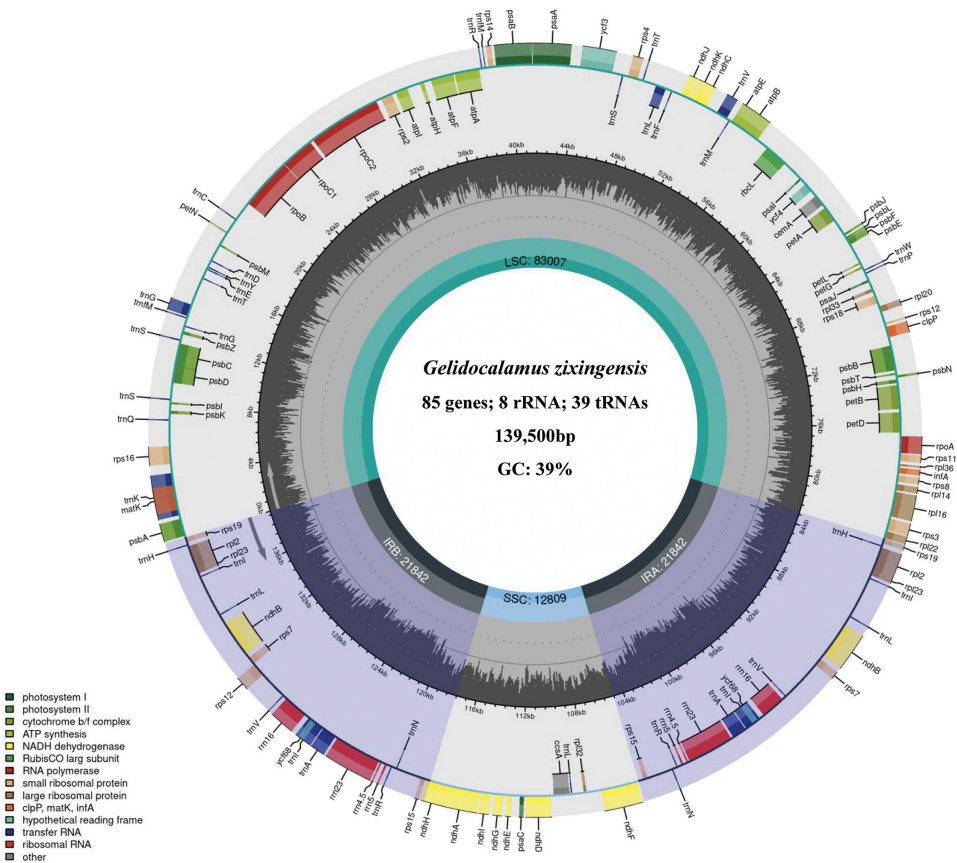


**Figure 2.** SEM images of the abaxial foliage leaf epidermis **A** *G. zixingensis* (Zixing, Hunan, China) **B** *G. multifolius* (Ningyuan, Hunan, China) **C** *G. tessellatus* (Libo, Guizhou, China) **D** *G. stellatus* (Jinggang Mountain, Jiangxi, China). Abbreviations: mi, microhairs; pr, prickles; sb, silica bodies; sp, short papillae; st, stomatal apparatuses.

**Table 3.** Micromorphological comparison among four taxa in the study.

Characters	<i>G. zixingensis</i>	<i>G. multifolius</i>	<i>G. tessellatus</i>	<i>G. stellatus</i>
Stomatal apparatus	5 rows distributed between the veins	4 rows distributed between the veins	3 rows distributed between the veins;	3 or 4 rows distributed between the veins
Papillae	8–10 surrounded the stomatal apparatus			
Microhair	bicellular, apical cell withered			
Prickle	sparsely distributed on the veins	sparsely distributed on the veins	relatively densely distributed on the veins	absent
Silica body	saddle-shaped			

The majority-rule consensus tree with both maximum likelihood (ML) and Bayesian inference (BI) analyses was shown in Fig. 4. Arundinarieae is well-supported as a monophyletic entity, finely divided into 12 lineages (I–XII). There is high support for the *G. zixingensis* being a sister to the *G. multifolius* + *G. tessellatus* clade (bootstrap value of 100% in ML analysis and posterior probability of 1.0 in

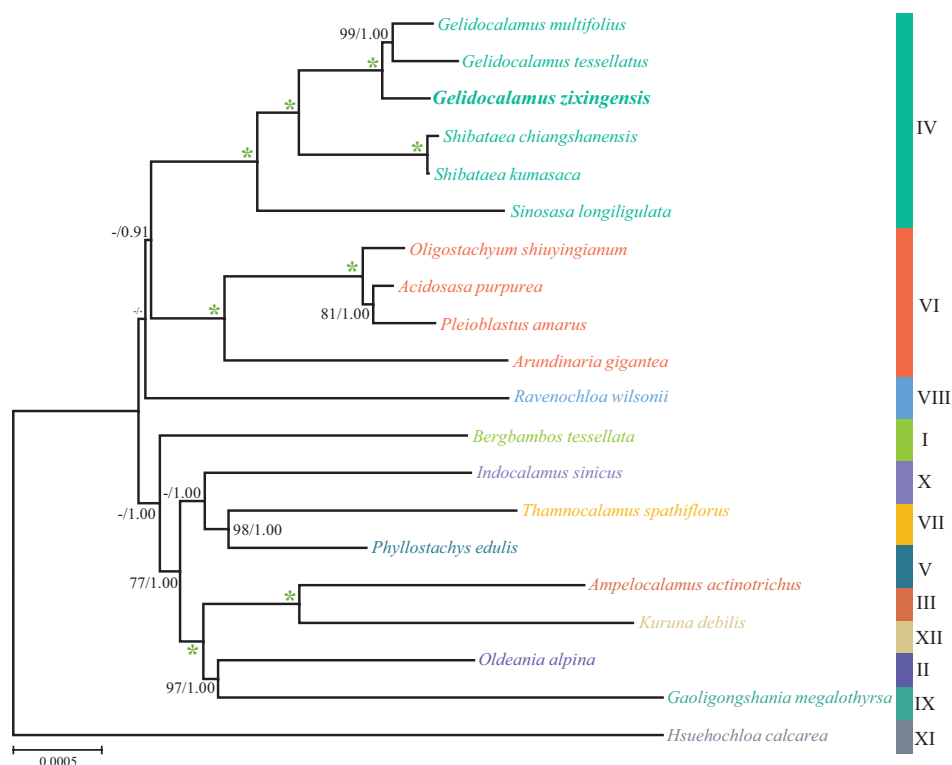


**Figure 3.** Complete chloroplast genome map of the *Gelidocalamus zixingensis*.

**Table 4.** Comparison of complete chloroplast genomes of three taxa in the study.

Characters	<i>G. zixingensis</i>	<i>G. multifolius</i>	<i>G. tessellatus</i>
Total length	139,500	139,745	139,712
LSC region	83,007	83,252	83,220
SSC region	12,809	12,809	12,808
IR region	21,842	21,842	21,842
Total genes	132	132	132
CDS	85	85	85
tRNA	39	39	39
rRNA	8	8	8

BI analysis), and the above 3 species were clustered with members of *Shibataea* e.g., *S. chiangshanensis* and *S. kumasaca*, member of *Sinosasa*, e.g., *S. longiligulata*, to form the IV clade (bootstrap value of 100% in ML analysis and posterior probability of 1.0 in BI analysis).



**Figure 4.** Phylogenetic consensus tree of the *Gelidocalamus zixingensis* based on plastid genome dataset with maximum likelihood and Bayesian analyses. Only bootstrap values (BS)  $\geq 75\%$  and posterior probabilities (PP)  $\geq 0.75$  are indicated at each node, otherwise dashes. The green asterisk indicates support of 100% BS and 1.00 PP. The letters represent the major chloroplast marker-based clade (I–XII) in which the selected taxa are located.

## Taxonomic treatment

### *Gelidocalamus zixingensis* W.G.Zhang, G.Y.Yang & C.K.Wang, sp. nov.

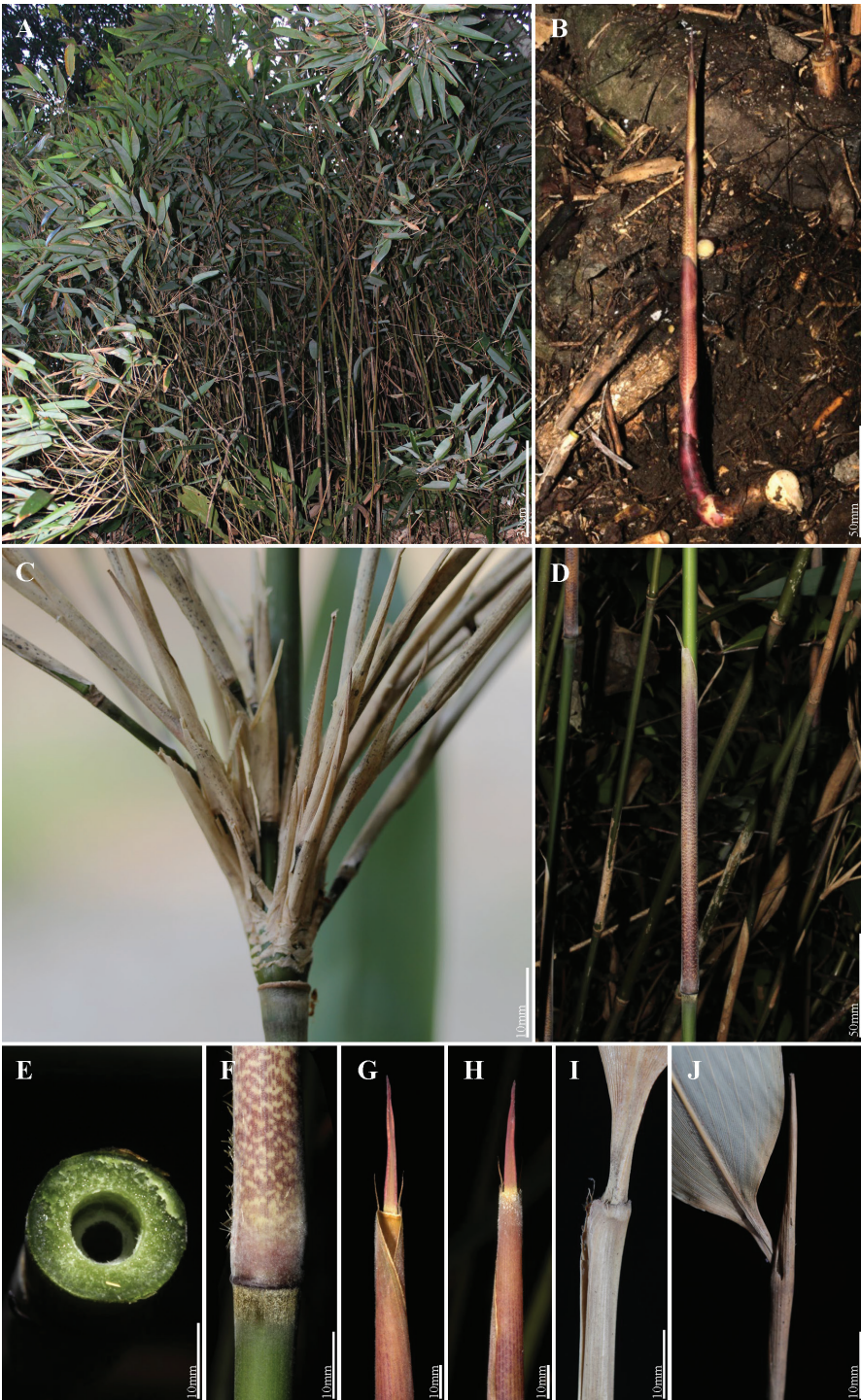
urn:lsid:ipni.org:names:77311677-1

Figs 5, 6

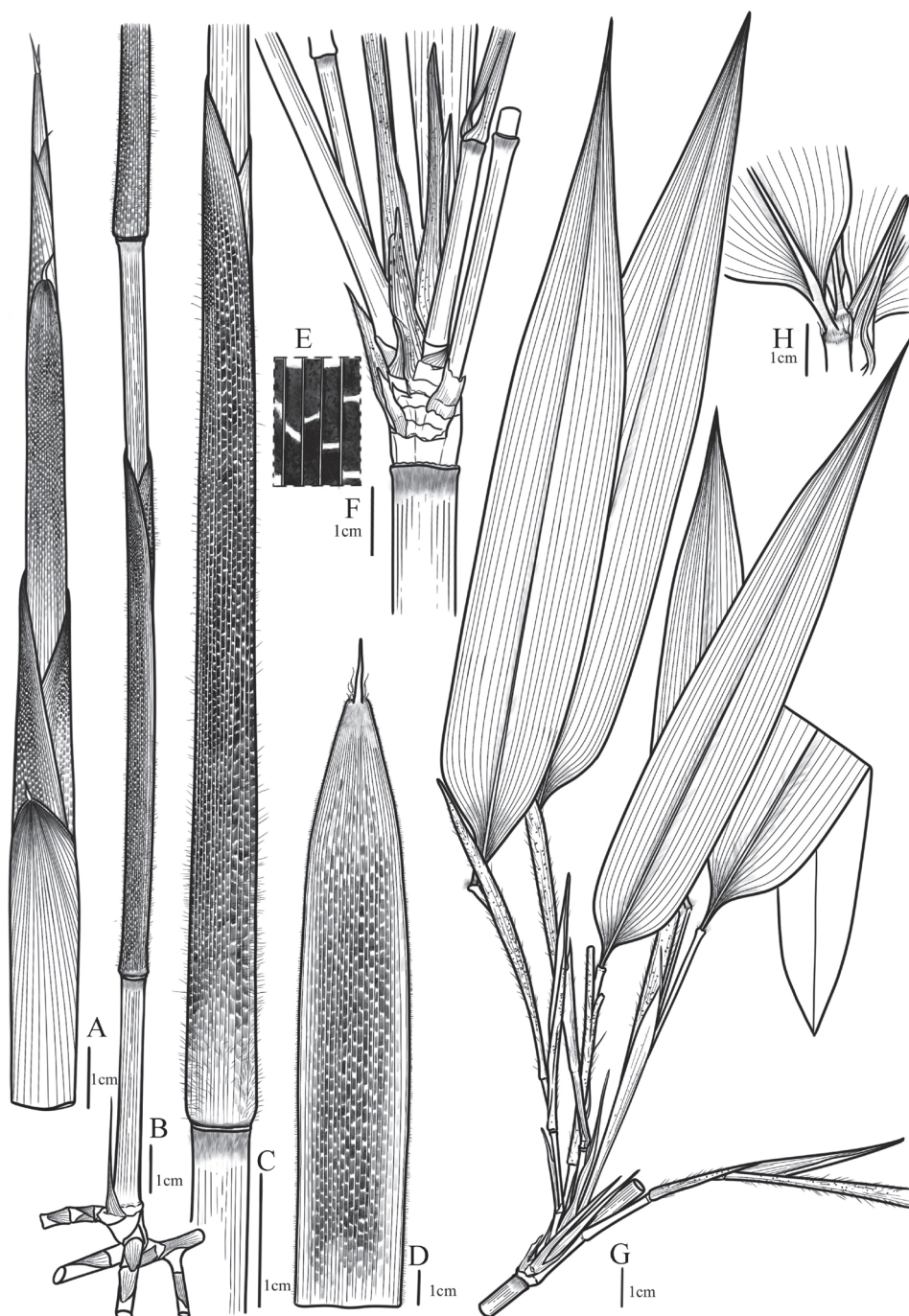
**Diagnosis.** The new species is morphologically similar to *G. multifolius*, but differs by having densely white pubescence (vs. glabrous) on the culm leaf sheaths, culm leaf blades erect (vs. reflexed); apical branch sheaths much longer (vs. slightly longer or equilong) than the internodes; foliage leaf blades mesophyll (vs. notophyll).

**Type.** CHINA. Hunan, Zixing County, Lianping Township, Chengkang Village, under the forest, 25°54'1.75"N, 113°34'9.18"E, elev. ca. 594 m, 18 Oct. 2015, W.G. Zhang et al. LPC031 (holotype: JXAU!)

**Description.** Rhizomes leptomorph. Culms 1.7–4.2 m, 3.5–10 mm in diameter; erect, apically slightly nodding; internodes initially covered with white pubescence, ca.



**Figure 5.** *Gelidocalamus zixingensis* **A** habitat **B** new shoot **C, J** branch and its leaf sheath **D, F, G, H** culm and its leaf sheath **E** transection of culm and pith-cavity **I** leaf Sheath.



**Figure 6.** *Gelidocalamus zixingensis* **A** new shoot **B** leptomorph rhizomes and culm **C-E** culm and its sheath, brown patches **F-H** branch and its sheaths, leaf and leaf sheath.

14–35 cm long, wall 0.6–1.9 mm thick; each node with a ring of white-gray appressed pubescence below sheath scar; branching intravaginal, arising from 5<sup>th</sup> node above ground, ca. 4–11 (16) branches per node; branches equal or subequal, ca. 5–30 cm long. Culm leaves sheaths persistent, 12–19 cm, culm leaf sheath abaxially with brown patches, densely white pubescent and sparsely setose near the base; culm leaf blade erect, linear-lanceolate, 0.5–2 cm long, 2 mm wide, apex acuminate, base blunt or truncate, ca. 1/3 as wide as sheath apex, oral setae 2–4 on each side of the sheath apex, ca. 4 mm long; auricles absent; ligule truncate, ca. 0.5 mm high, scabrous. Branch sheath papery, white setose, without black spots, margins ciliate; sub-apical branch sheath ca. 3 cm beyond the internode. Foliage leaves usually solitary on ultimate branches; ligule truncate, ca. 1 mm, scabrous; auricles absent; oral setae 1–3 pairs straight or curved; leaf blade broadly lanceolate, usually 23.4–32.5×3.2–4.9 cm, lateral veins 6–8 pairs, abaxial surface basally pubescent, base cuneate and asymmetrical, margins serrulate and slightly revolute near base.

**Phenology.** New shoots in October.

**Etymology.** The species epithet refers to the locality of the type specimen: Zixing County, Hunan, China.

**Vernacular names.** Zī Xīng Duǎn Zhī Zhú (Chinese pronunciation), 资兴短枝竹 (Chinese name).

**Distribution and habitat.** To date, this species has only been found under evergreen broad-leaved forest along river banks at 500–600 m in Chengkang Village, Lianping Township, Zixing County. Species growing in the surrounding area include *Quercus myrsinifolia* Blume, 1871 (Fagaceae), *Aralia chinensis* L., 1868 (Araliaceae), *Eurya japonica* Thunb., 1783 (Pentaphragaceae), and *Liriope spicata* (Thunb.) Lour., 1790 (Asparagaceae).

## Morphological key of the species of *Gelidocaldums* of China

- |   |  |                                   |
|---|--|-----------------------------------|
| 1 | Culm internodes glabrous.....  | 2                                 |
| – | Culm internodes hairy.....   | 5                                 |
| 2 | Culm leaf sheaths glabrous.....  | 3                                 |
| – | Culm leaf sheaths pubescent with sparse setae.....   | <i>Gelidocalamus zixingensis</i>  |
| 3 | Culm leaf sheath margins glabrous or one margin ciliate; oral setae absent or small.....   | 4                                 |
| – | Culm leaf sheath margins ciliate; oral setae 3–6 pairs.....  | <i>Gelidocalamus multifolius</i>  |
| 4 | Oral setae of culm leaves 1–2 pairs, small; branch sheath margins glabrous; branch sheaths with black spots.....   | <i>Gelidocalamus stellatus</i>    |
| – | Oral setae of culm leaves none or several; branch sheath margins ciliate at one side, the other side glabrous or apically ciliate; branch sheaths without black spots..... | <i>Gelidocalamus fengkaiensis</i> |
| 5 | Culm leaf sheaths covered with appressed brown short hairs.....  | 6                                 |
| – | Culm leaf sheaths covered with white erect thin hairs.....   | 8                                 |
| 6 | Culms up to 5m tall, more than 1cm in diam.....  | <i>Gelidocalamus tessellatus</i>  |
| – | Culms less than 4m, less than 1cm in diam.....   | 7                                 |

- 7 Culm leaf sheaths with white villus, margins with cilia ..... *Gelidocalamus monophyllus*
- Culm leaf sheaths hairless, margins glabrous ..... *Gelidocalamus xunwuensis*
- 8 Culm leaf sheath margins densely ciliate, oral setae 1 pair, foliage leaves 1(–2) per ultimate branch, lateral veins 6–9 pairs ..... *Gelidocalamus latifolius*
- Culm leaf sheath margins hairless, oral setae 2–3 pairs, foliage leaves 1–3 per ultimate branch, lateral veins 4–6 pairs ..... *Gelidocalamus annulatus*

## Discussion

Morphologically, although its inflorescence is not seen so far, *G. zixingensis* is undoubtedly a member of the genus *Gelidocalamus*, because it possesses all key characters of the genus, i.e., leptomorph rhizomes, several branches per node, typically a single foliage leaf on each ultimate branch, semelauctant inflorescence (Wen 1982; Li et al. 2006; Yi et al. 2008). However, it is obviously different from other species of the genus, e.g., conspicuously longer than the internodes and culm leaf densely white pubescent. At first glance, *G. zixingensis* is similar to *G. multifolius* in appearance, but can be distinguished by a ring of white-gray appressed pubescence below each node, culm sheaths densely pubescent with brown patches, sub-apical branch sheath much longer than the internode, and a single foliage leaf on each ultimate branch.

Previous studies indicated that leaf epidermal features were of taxonomic significance in Bambusoideae (Soderstrom and Ellis 1988; Yang et al. 2008; Zhang et al. 2014; Leandro et al. 2019). According to papilla form and distribution patterns around the stomatal apparatus of the abaxial leaf epidermis, *Gelidocalamus* can be classified into at least three types: (a) short papillae, none on the stomatal apparatus, e.g., *G. stellatus*, *G. multifolius*, *G. tessellatus*; (b) elongate or short papillae overarching the stomata, e.g., *G. subsolidus*, *G. solidus*; (c) many short papillae, completely covering stomatal apparatus, e.g., *G. monophyllus* (Wu et al. 2014). Compared to those of the “spring-shoot” taxa, leaf epidermal characters in the “gelido-” members of *Gelidocalamus* are relatively stable, and can be used as a diagnostic feature. In the present study, epidermal traits of foliage leaf in *G. zixingensis* were found to be consistent with these of six “gelido-” members in *Gelidocalamus* (except *G. monophyllus*, Liu et al. 2017; Nie et al. 2018), and the difference mainly lay in the fact that *G. zixingensis* had 5 rows of stomatal apparatus.

The tribe Arundinarieae was known for its complex phylogenetic relationships. Despite many previous attempts based on different datasets having been made, intractable problems, such as low resolution or heavily conflicting topologies, still arose (Zhang et al. 2012; Yang et al. 2013; Zeng et al. 2014; Ma et al. 2017). Recently, with the wider sampling of Arundinarieae, Guo et al. (2021) provided a robust phylogenetic tree of the tribe, referred from the ddRAD dataset, which was mostly consistent with the morphological data. In the phylogenetic analysis, only six “gelido-” members formed a monophyletic lineage, although all members of *Gelidocalamus* belonged to the leptomorph lineage. Together with our present molecular phylogenetic analysis, we confirm that *G. zixingensis* belongs to the genus *Gelidocalamus*, and it is closely related to *G. multifolius*.

## Acknowledgements

We are grateful to Chun-Ling Long (Zhejiang Normal University), Ting Kong (Jiangxi Matou Mountain National Nature Reserve), Wei-Jian Li (Nanchang Business College, Jiangxi Agricultural University), Yu-Guang Liu (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences) for their work in field surveys and sampling. This study was financially supported by the National Natural Science Foundation of China [31960335, 31260043] and Key R & D Planned Projects of Jiangxi Province [20192BBF60015].

## References

- Andrews S (2016) FastQC: a quality control tool for high throughput sequence data. <https://www.bioinformatics.babraham.ac.uk/projects/fastqc/>
- Cai ZY, Zhou XX, Wong KM, Xia NH (2021) *Gelidocalamus fengkaiensis* (Poaceae: Bambusoideae), a new bamboo species from Guangdong, China, with an analysis of branch development in relation to flowering. *Botanical Studies* (Taipei, Taiwan) 62(1): 12. <https://doi.org/10.1186/s40529-021-00319-4>
- Chen S, Zhou Y, Chen Y, Gu J (2018) fastp: An ultra-fast all-in-one FASTQ preprocessor. *Bioinformatics* (Oxford, England) 34(17): i884–i890. <https://doi.org/10.1093/bioinformatics/bty560>
- Clark LG, de Oliveira RP (2018) Diversity and evolution of the New World bamboos (Poaceae: Bambusoideae: Bambuseae, Olyreae). 11<sup>th</sup> World Bamboo Congress, Xalapa, Mexico: Proceedings, pt. 2. Plymouth: MA: World Bamboo Organization, 35–47.
- Ellis RP (1979) A procedure for standardizing comparative leaf anatomy in the Poaceae. II. The epidermis as seen in surface view. *Bothalia* 12(4): 641–671. <https://doi.org/10.4102/abc.v12i4.1441>
- Ellis B, Daly D, Hickey L, Johnson K, Mitchell J, Wilf P, Wing S (2009) *Manual of Leaf Architecture*. Cornell University Press, New York, 24–25. <https://doi.org/10.1079/9781845935849.0000>
- Gallaher TJ, Peterson PM, Soreng RJ, Zuloaga FO, Li DZ, Clark LG, Tyrrell CD, Welker CAD, Kellogg EA, Teisher JK (2022) Grasses through space and time: An overview of the biogeographical and macroevolutionary history of Poaceae. *Journal of Systematics and Evolution* 60(3): 522–569. <https://doi.org/10.1111/jse.12857>
- Guo C, Guo ZH, Li DZ (2019) Phylogenomic analyses reveal intractable evolutionary history of a temperate bamboo genus (Poaceae: Bambusoideae). *Plant Diversity* 41(4): 213–219. <https://doi.org/10.1016/j.pld.2019.05.003>
- Guo C, Ma PF, Yang GQ, Ye XY, Guo Y, Liu JX, Liu YL, Eaton DAR, Guo ZH, Li DZ (2021) Parallel ddRAD and Genome Skimming Analyses Reveal a Radiative and Reticulate Evolutionary History of the Temperate Bamboos. *Systematic Biology* 70(4): 756–773. <https://doi.org/10.1093/sysbio/syaa076>

- Huang W, Zhang L, Columbus JT, Hu Y, Zhao Y, Tang L, Guo Z, Chen W, McKain M, Bartlett M, Huang CH, Li DZ, Ge S, Ma H (2022) A well-supported nuclear phylogeny of Poaceae and implications for the evolution of C<sub>4</sub> photosynthesis. *Molecular Plant* 15(4): 755–777. <https://doi.org/10.1016/j.molp.2022.01.015>
- Jin JJ, Yu WB, Yang JB, Song Y, Yi TS, Li DZ (2018) GetOrganelle: a simple and fast pipeline for de novo assembly of a complete circular chloroplast genome using genome skimming data. *bioRxiv*: 256479. <https://doi.org/10.1101/256479>
- Kalyaanamoorthy S, Minh BQ, Wong TKF, von Haeseler A, Jermiin LS (2017) ModelFinder: Fast model selection for accurate phylogenetic estimates. *Nature Methods* 14(6): 587–589. <https://doi.org/10.1038/nmeth.4285>
- Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: Improvements in performance and usability. *Molecular Biology and Evolution* 30(4): 772–780. <https://doi.org/10.1093/molbev/mst010>
- Kearse M, Moir R, Wilson A, Stones-Havas S, Cheung M, Sturrock S, Buxton S, Cooper A, Markowitz S, Duran C, Thierer T, Ashton B, Meintjes P, Drummond A (2012) Geneious Basic: An integrated and extendable desktop software platform for the organization and analysis of sequence data. *Bioinformatics (Oxford, England)* 28(12): 1647–1649. <https://doi.org/10.1093/bioinformatics/bts199>
- Keng PC, Wang ZP (1996) Gramineae. *Flora of China*, vol. 9(1). Science Press, Beijing, 622–630.
- Leandro TD, Scatena VL, Clark LG (2019) Comparative leaf blade anatomy and micromorphology in the systematics and phylogeny of Bambusoideae (Poaceae: Poales). *Botanical Journal of the Linnean Society* 192(1): 165–183. <https://doi.org/10.1093/botlinnean/boz074>
- Li DZ, Wang ZP, Zhu ZD, Xia NH, Jia LZ, Guo ZH, Yang GY, Stapleton CMA (2006) Bambuseae (Poaceae). In: Wu ZY, Raven PH, Hong DY (Eds) *Flora of China*. vol. 22 Science Press and Missouri Botanical Garden Press, Beijing and St. Louis, 7–180.
- Li WJ, Zhang WG, Tang M, Ji CF, Yang GY (2016) The Specimen Collection Situation and Species Distribution of *Gelidocalamus*. *Journal of Bamboo Research* 35: 1–7.
- Liu YG, Li WJ, Tang M, Yang GY, Zhang WG (2017) Taxonomic re-evaluation of some *Gelidocalamus* (Poaceae: Bambusoideae) taxa from Southeast China. *Phytotaxa* 299(1): 111–117. <https://doi.org/10.11646/phytotaxa.299.1.9>
- Ma PF, Vorontsova MS, Nanjarisoa OP, Razanatsoa J, Guo ZH, Haevermans T, Li DZ (2017) Negative correlation between rates of molecular evolution and flowering cycles in temperate woody bamboos revealed by plastid phylogenomics. *BMC Plant Biology* 17(1): 260. <https://doi.org/10.1186/s12870-017-1199-8>
- Murray MG, Thompson WF (1980) Rapid isolation of high molecular weight plant DNA. *Nucleic Acids Research* 8(19): 4321–4326. <https://doi.org/10.1093/nar/8.19.4321>
- Nguyen LT, Schmidt HA, von Haeseler A, Minh BQ (2015) IQ-TREE: A Fast and Effective Stochastic Algorithm for Estimating Maximum-Likelihood Phylogenies. *Molecular Biology and Evolution* 32(1): 268–274. <https://doi.org/10.1093/molbev/msu300>
- Nie TJ, Li WJ, Ji XN, Liu YG, Li ZY, Yang GY, Zhang WG (2018) Re-evaluation of the taxonomy of *Gelidocalamus stellatus* (Poaceae: Bambusoideae) and its infraspecific taxa from southern China. *Phytotaxa* 356(3): 215–225. <https://doi.org/10.11646/phytotaxa.356.3.3>

- Qin QM, Tong YH, Zheng XR, Ni JB, Xia NH (2021) *Sinosasa* (Poaceae: Bambusoideae), a new genus from China. *Taxon* 70(1): 27–47. <https://doi.org/10.1002/tax.12422>
- Ronquist F, Teslenko M, van der Mark P, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: Efficient Bayesian Phylogenetic Inference and Model Choice Across a Large Model Space. *Systematic Biology* 61(3): 539–542. <https://doi.org/10.1093/sysbio/sys029>
- Shi L, Chen H, Jiang M, Wang L, Wu X, Huang L, Liu C (2019) CPGAVAS2, an integrated plastome sequence annotator and analyzer. *Nucleic Acids Research* 47(W1): W65–W73. <https://doi.org/10.1093/nar/gkz345>
- Soderstrom TR, Ellis RP (1988) The woody bamboos (poaceae: bambuseae) of sri lanka: a morphological-anatomical study. *Smithsonian Contributions to Botany* 72(72): 1–75. <https://doi.org/10.5479/si.0081024X.72>
- Soreng RJ, Peterson PM, Zuloaga FO, Romaschenko K, Clark LG, Teisher JK, Gillespie LJ, Barberá P, Welker CAD, Kellogg EA, Li DZ, Davidse G (2022) A worldwide phylogenetic classification of the Poaceae (Gramineae) III: An update. *Journal of Systematics and Evolution* 60(3): 476–521. <https://doi.org/10.1111/jse.12847>
- Triplett JK (2008) Phylogenetic relationships among the temperate bamboos (Poaceae: Bambusoideae) with an emphasis on Arundinaria and allies. PhD Thesis, Iowa State University, America.
- Vorontsova M, Clark LG, Dransfield J, Govaerts R, Baker WJ (2016) *World Checklist of Bamboos and Rattans*. Science Press, Beijing.
- Wen TH (1982) A new genus and some new species of Bambusoideae from China. *Journal of Bamboo Research* 1(1): 20–45.
- Wick RR, Schultz MB, Zobel J, Holt KE (2015) Bandage: Interactive visualization of de novo genome assemblies. *Bioinformatics (Oxford, England)* 31(20): 3350–3352. <https://doi.org/10.1093/bioinformatics/btv383>
- Wu H, Long CL, Yu F, Ji CF, Wang X, Yang GY (2014) Leaf Micromorphology of *Gelidocalamus* Wen and Its Taxonomical Significance. *Zhiwu Kexue Xuebao* 32: 211–215.
- Yang BM (1986) Three new species of bamboo native of Hunan. *Nature Science Journal of Hunan Normal University* 3: 89–94.
- Yang HQ, Wang H, Li DZ (2008) Comparative morphology of the foliage leaf epidermis, with emphasis on papillae characters, in key taxa of woody bamboos of the Asian tropics (Poaceae: Bambusoideae). *Botanical Journal of the Linnean Society* 156(3): 411–423. <https://doi.org/10.1111/j.1095-8339.2007.00736.x>
- Yang HM, Zhang YX, Yang JB, Li DZ (2013) The monophyly of *Chimonocalamus* and conflicting gene trees in Arundinarieae (Poaceae: Bambusoideae) inferred from four plastid and two nuclear markers. *Molecular Phylogenetics and Evolution* 68(2): 340–356. <https://doi.org/10.1016/j.ympev.2013.04.002>
- Yi TP, Shi JY, Ma LS, Wang HT, Yang L (2008) *Iconographia Bambusoidearum Sinicarum*. Science Press, Beijing, 214–215.
- Zeng L, Zhang Q, Sun R, Kong H, Zhang N, Ma H (2014) Resolution of deep angiosperm phylogeny using conserved nuclear genes and estimates of early divergence times. *Nature Communications* 5(1): 4956. <https://doi.org/10.1038/ncomms5956>

- Zhang YX, Zeng CX, Li DZ (2012) Complex evolution in Arundinarieae (Poaceae: Bambusoideae): Incongruence between plastid and nuclear *GBSSI* gene phylogenies. *Molecular Phylogenetics and Evolution* 63(3): 777–797. <https://doi.org/https://doi.org/10.1016/j.ympev.2012.02.023>
- Zhang YX, Zeng CX, Li DZ (2014) Scanning electron microscopy of the leaf epidermis in Arundinarieae (Poaceae: Bambusoideae): evolutionary implications of selected micromorphological features. *Botanical Journal of the Linnean Society* 176(1): 46–65. <https://doi.org/10.1111/boj.12192>
- Zhang WG, Ji XN, Liu YG, Li WJ, Yang GY (2017) *Gelidocalamus xunwuensis* (Poaceae, Bambusoideae), a new species from southeastern Jiangxi, China. *PhytoKeys* 85: 59–67. <https://doi.org/10.3897/phytokeys.85.13804>
- Zheng S, Pocai P, Hyvonen J, Tang J, Amiryousefi A (2020) Chloroplot: An online program for the versatile plotting of organelle genomes. *Frontiers in Genetics* 11: 576124. <https://doi.org/10.3389/fgene.2020.576124>

## Supplementary material I

### *Gelidocalamus zixingensis* complete chloroplast genome sequences

Authors: Cheng-Kun Wang, Rong Guo, Chun-Ce Guo, Guang-Yao Yang, Wen-Gen Zhang

Data type: Phylogenetic.

Copyright notice: This dataset is made available under the Open Database License (<http://opendatacommons.org/licenses/odbl/1.0/>). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: <https://doi.org/10.3897/phytokeys.218.96849.suppl1>



# *Primula wolongensis* (Primulaceae), a new species of the primrose from Sichuan, China

Xiong Li<sup>1,2</sup>, Yue-Hong Cheng<sup>3</sup>, Hong-Qiang Lin<sup>3</sup>,  
Cheng Chen<sup>3</sup>, Xin-Fen Gao<sup>1,2</sup>, Heng-Ning Deng<sup>1,2</sup>,  
Feng Yu<sup>1</sup>, Plenković-Moraj Anđelka<sup>4</sup>, Wen-Bin Ju<sup>1,2,5</sup>, Bo Xu<sup>1,2</sup>

**1** China-Croatia “Belt and Road” Joint Laboratory on Biodiversity and Ecosystem Services, Key Laboratory of Mountain Ecological Restoration and Bioresource Utilization & Ecological Restoration Biodiversity Conservation, Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, Sichuan, China **2** University of Chinese Academy of Sciences, Beijing 100049, China **3** Sichuan Wolong National Natural Reserve Administration Bureau, Wenchuan 623006, Sichuan, China **4** Faculty of Science, University of Zagreb, Zagreb 10000, Croatia **5** Key Laboratory of Bio-Resources and Eco-Environment of Ministry of Education, College of Life Sciences, Sichuan University, Chengdu 610065, Sichuan, China

Corresponding authors: Wen-Bin Ju ([juwb@cib.ac.cn](mailto:juwb@cib.ac.cn)), Bo Xu ([xubo@cib.ac.cn](mailto:xubo@cib.ac.cn))

Academic editor: Avelinah Julius | Received 2 August 2022 | Accepted 13 December 2022 | Published 10 January 2023

**Citation:** Li X, Cheng Y-H, Lin H-Q, Chen C, Gao X-F, Deng H-N, Yu F, Anđelka P-M, Ju W-B, Xu B (2023) *Primula wolongensis* (Primulaceae), a new species of the primrose from Sichuan, China. *PhytoKeys* 218: 47–57. <https://doi.org/10.3897/phytokeys.218.91161>

## Abstract

This paper describes and illustrates a new species of Primulaceae, *Primula wolongensis* **sp. nov.** from Wolong National Nature Reserve in Sichuan Province, China. It is very rare and currently only known from its type locality. The new species belongs to subsection *Chartacea* of the section *Petiolares* on account of lacking bud scales at flowering, being efarinose and having distinct petiolate leaves with more or less rounded lamina. The new species can be differentiated from other members of the subsection by leaf blade margin dentate, and leaf veins which are not raised, scape shorter than or equal to pedicels, yellow flowers and location of stamens of the corolla tube at thrum flower. Molecular phylogenetic analysis based on nuclear ribosome internal transcribed spacer (nrITS) demonstrated that *P. wolongensis* was sister to subgen. *Auriculastrum*. *Primula wolongensis* is currently known from a single location in Wolong Town, and its conservation status is assessed as Data Deficient (DD).

## Keywords

Hengduan Mountains, morphological characters, phylogenetic analysis, *Primula* sect. *Petiolares*, taxonomy

## Introduction

*Primula* L. is the most widespread genus in Primulaceae. It contains about 500 species mainly distributed throughout the moister and cooler regions of the northern hemisphere (Hu 1990; Hu and Kelso 1996; APG 2016). The modern distribution center of the genus is the great mountain chain of the East Himalayan and Hengduan Mountains (Hu 1994; Hu and Kelso 1996). More than 300 species were found in this region, accounting for 78% of the total number of species (Richards 2003). The establishment of *Primula petiolaris* Wall. and its allies as representing a distinct section of the genus was the work of Pax (1889). The sect. *Petiolares* has nearly 60 species, mainly distributed in the Himalayan range and the alpine regions of Western China (Hu 1994; Hu and Kelso 1996; Richards 2003). Its members are easily recognized by the capsule globose, included within the calyx-tube lacking valves and with an apical membrane crumbling at maturity (Hu and Kelso 1996). The sect. *Petiolares* was divided into 5 subsections according to bud-scales conspicuous and persisting at flowering time, length of scapes at flowering, and whether there is a honeycomb-reticulate below the blade, namely subsect. *Chartacea* (Balf.f.) Smith & Forrest, subsect. *Davidii* (Balf.f.) Craib, subsect. *Griffithii* Smith & Forrest, subsect. *Petiolaris-Sonchifoli* Smith & Forrest and subsect. *Tongolensis* Smith & Forrest (Smith and Fletcher 1944). In recent years, many new species have been reported in this section (Hu and Geng 2003; Li and Hu 2009; Rankin 2010; Hu and Hao 2011; Xu et al. 2014, 2015, 2016; Ju et al. 2018; Yuan et al. 2018) and it's likely more undescribed taxon will be discovered.

In May 2021, an unusual population of *Primula* was discovered in moss-covered crevices of wet cliffs above the tree-line, in Sichuan Province. After consulting relevant literature (Smith and Fletcher 1944; Hu 1986; Hu 1990; Fang 1994, 2003; Hu and Kelso 1996; Wu 1999; Richards 2003) and herbarium specimens (BM, CDBI, E, FI, HNWP, IBSC, K, KUN, P, PE, US, and WU), we concluded that it is an undescribed taxon, belonging to *Primula* sect. *Petiolares* in morphology. Based on the morphological data of fresh materials and herbarium specimens, we describe this new species as follows.

## Materials and methods

### Morphological analyses

Morphological description and measurements of *Primula wolongensis* were based on living plants and dried herbarium specimens. The taxonomic description follows the terminology used by Beentje (2012). Voucher specimens and additional silica-gel dried leaves are stored at CDBI Herbarium (herbarium follows Thiers 2021).

## DNA extraction, amplification and sequencing

Except for the newly generated sequence of *Primula wolongensis* in this study, the sequences of the remaining 62 samples representing nine subgenera of *Primula* and two outgroups (*Androsace integra* and *A. paxiana*) in molecular phylogenetic analysis were retrieved from GenBank. Total DNA was extracted exclusively from silica-gel dried leaves via a Plant DNA Isolation Kit (Cat.No.DE-06111). We used the same primers as Xu et al. (2012) to amplify the nuclear ribosome internal transcribed spacer (nrITS) through polymerase chain reaction (PCR). All DNA samples were sent to TSINGKE Biotech Co. Ltd (Chengdu, China) for sequencing and then deposited to GenBank under the accession number OP901719.

## Phylogenetic analyses

All sequences were processed with Sequencher v4.1.4 (Gene Codes, Ann Arbor, Michigan, USA) and aligned using MAFFT v7.475 (Katoh and Standley 2013) with default parameters. We performed Maximum likelihood (ML) analysis based on nrITS dataset using IQ-TREE v1.4.2 (Nguyen et al. 2014) with branch support estimated by 2,000 replicates of ultrafast bootstrapping algorithm (UFboot) (Minh et al. 2013).

## Results

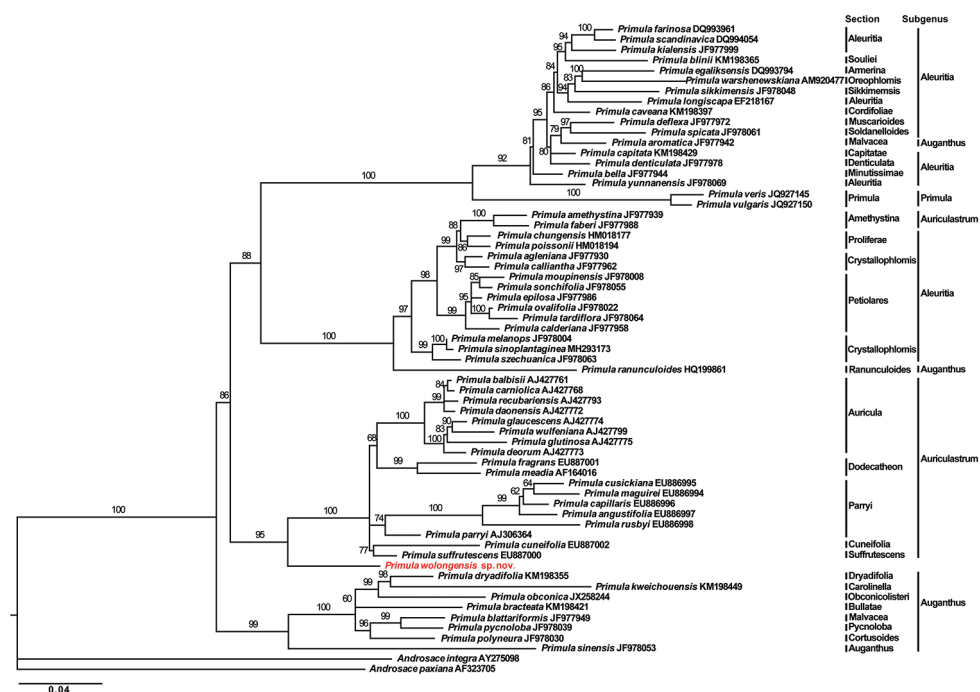
The molecular phylogenetic tree showed that *Primula wolongensis* was sister to subgen. *Auriculastrum* (ML = 95, Fig. 1) which included sect. *Auricula* Duby, sect. *Cuneifolia* Balf.f., sect. *Dodecatheon* (L.) A.R.Mast & Reveal, sect. *Parryi* W.W.Sm. ex Wendelbo and sect. *Suffrutescens* A.J.Richards. Apart from the sect. *Amethystina*, which occurs in the Himalayan-Transverse Mountains, species of all other sections of this subgenus are found in Europe, North America, and northern Japan through to British Columbia. The position of *P. wolongensis* in the genus *Primula* is clearly divergent between morphological and molecular evidence, and more evidence is needed to understand the evolutionary history of the species.

## Taxonomy

***Primula wolongensis* W.B.Ju, Bo Xu & X.F.Gao, sp. nov.**

urn:lsid:ipni.org:names:77311678-1

**Diagnosis.** Amongst the Chinese members of subsect. *Chartacea*, the new species is easily recognized by the following combination of characters: leaf blade margin dentate, leaf veins which are not raised, scape which is shorter or equal with pedicel, corolla yellow and location of stamens of the corolla tube at thrum flower.

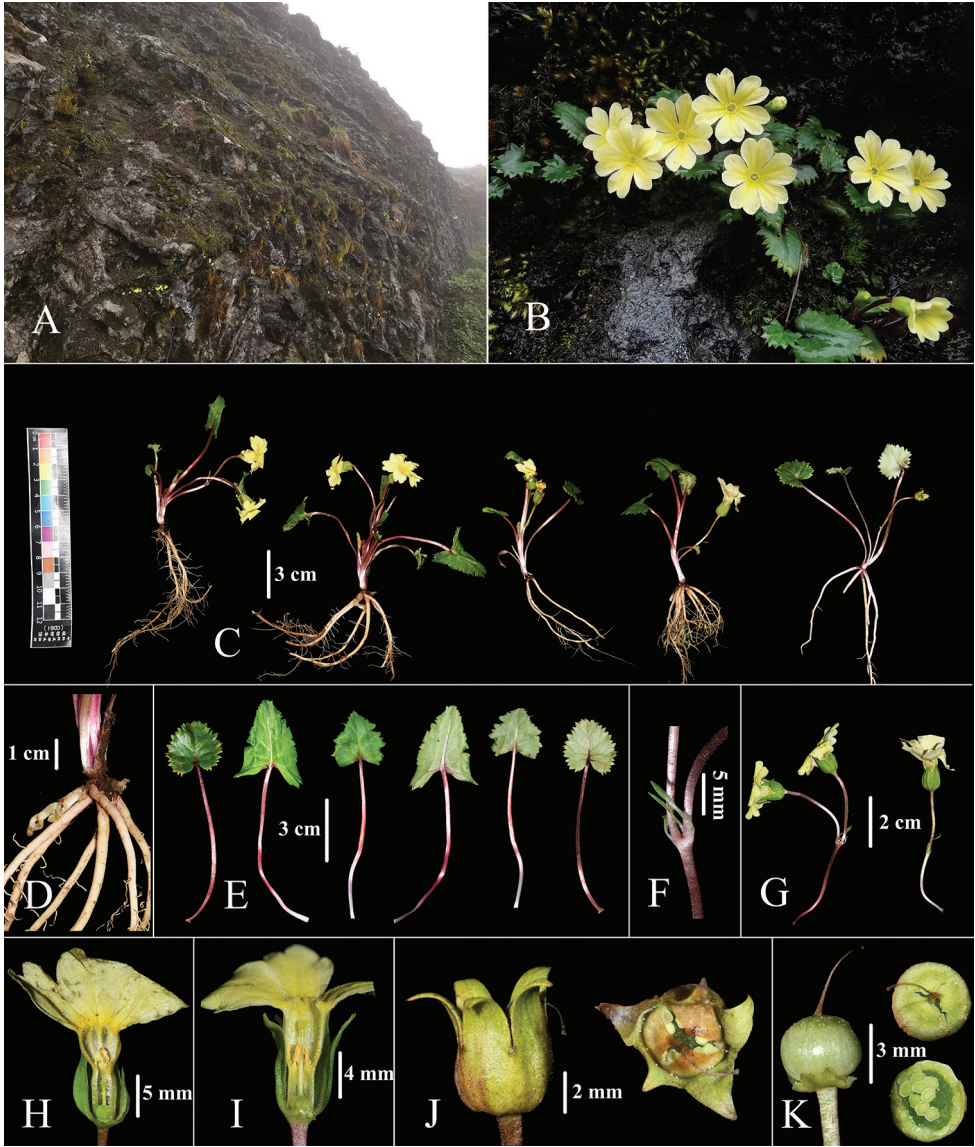


**Figure 1.** Maximum likelihood tree of *Primula* from phylogenetic analysis of nrITS sequence data.

The new species is morphologically similar to *P. arunachalensis* Basak & Maiti and *P. fenghwaiana* C.M.Hu & G.Hao, but can be easily distinguished from *P. arunachalensis* by its shorter rootstocks, petioles 3–5× as long as leaf blade (versus 1–2× as long as leaf blade), reticulation of veins obscure on both surfaces (versus veins slightly impressed adaxially and conspicuous abaxially), corolla lobes apex emarginate (versus corolla lobes margin denticulate to lacerate), heterostylous (versus homostylous). Compared with *P. fenghwaiana*, the difference of the new species is the petioles 3–5× as long as the leaf blade (versus ca.2/3 the length of the leaf blade), leaf blade base cordate (versus base broadly cuneate to almost rounded), leaf blade margin irregular dentate (versus margin remotely denticulate), scapes and pedicels sparsely short-stalked glandular (versus densely covered with minute glandular hairs), corollas yellow (versus pink to white), the position of stamens at thrum flower tube on the middle (versus on the apex).

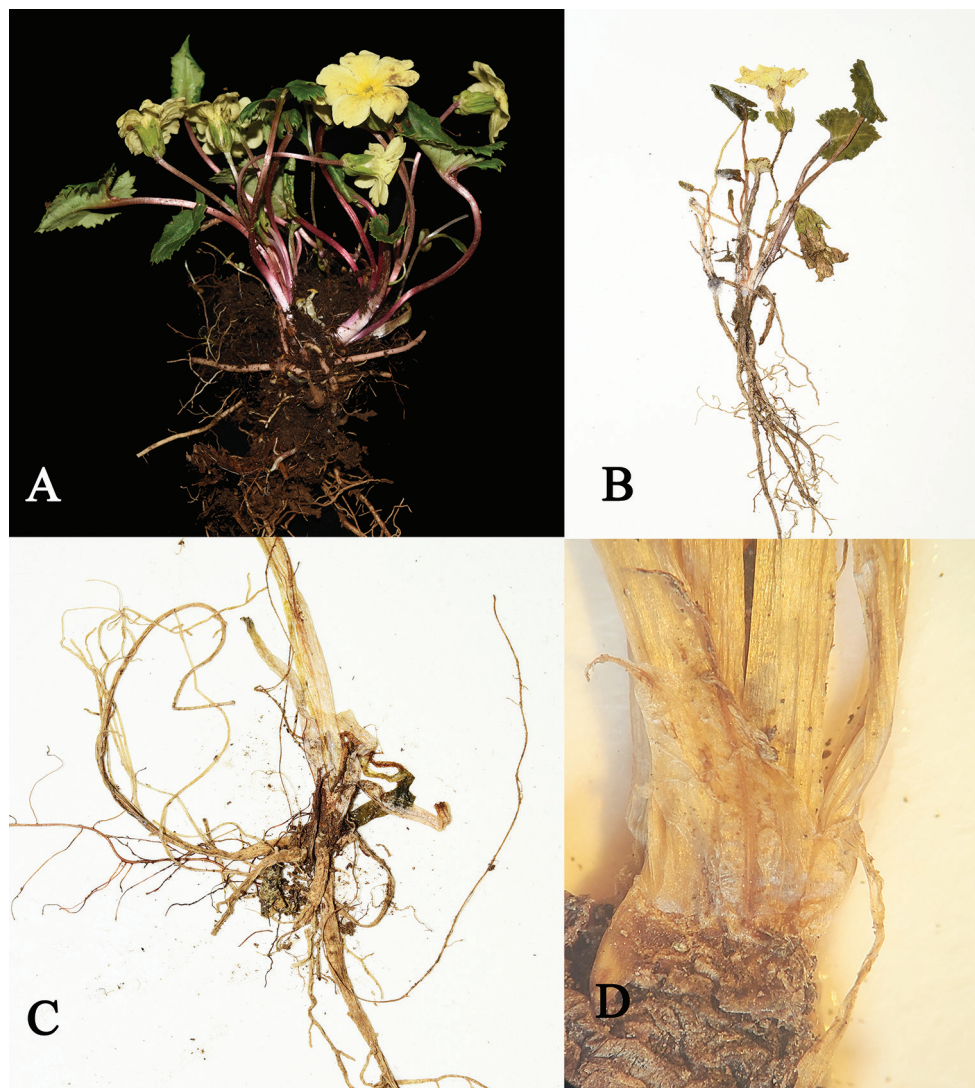
**Type.** CHINA. Sichuan: Wenchuan City, Wolong National Nature Reserve, growing in moist rock crevices covered with moss. 31°04'N, 103°11'E, elevation ca. 3400 m, 18 May 2021 (fl./fr.), *Y.H. Cheng & H.Q. Lin* XuBo2771 (holotype CDBI!; isotypes KUN!, PE!). (Figs 2–4)

**Description.** A perennial plant, efarinose, having reddish-brown basal bud scales, second-year buds at the base and free from bud scales at flowering time, rootstock extremely short. **Roots** numerous, fibrous. **Leaves** forming a loose rosette; young leaf blade often fold, widely ovate to suborbicular at maturity, 1.0–3.5 × 1–2.5 cm, broadly obtuse to rounded at apex, with a cordate base, margin irregular dentate, glabrous on both



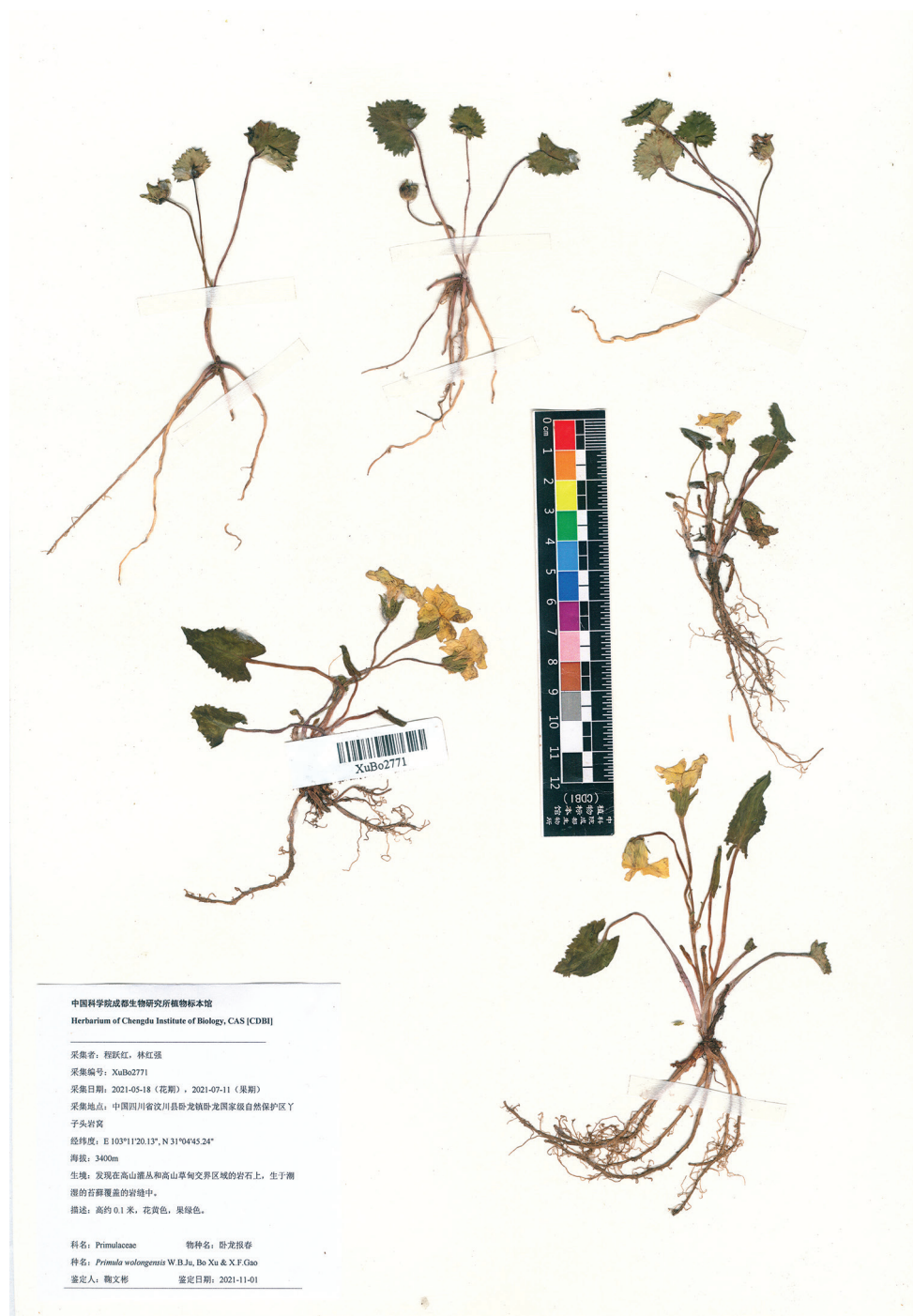
**Figure 2.** *Primula wolongensis* sp. nov. **A** habitat **B** habit **C** whole plant **D** roots and second-year buds **E** leaves **F** bracts **G** scape **H** thrum flower **I** pin flower **J** calyx in fruit **K** capsule.

surfaces, glaucous below, firm papery when dry, lateral veins 3–5 pairs, slightly impressed adaxially, reticulation of veins obscure on both surfaces; petioles 3.0–8.5 cm long, sparsely short-stalked glandular, reddish brown. **Scape** 1, sparsely short-stalked glandular, 1.8–4.5 cm tall, non-elongating at fruiting time; umbel with 1–3 flowers; bracts linear to linear-lanceolate, 0.7–1.5 cm long; pedicels 1.5–4.5 cm long, densely short-stalked glandular, not extended in fruit. **Flowers** heterostylous. **Calyx** green, campanulate, 6–11 mm long, slightly enlarged, poculiform in fruit, short-stalked glandular, parted slightly below



**Figure 3.** *Primula wolongensis* sp. nov. **A** fresh plants **B** pressed specimen **C** decayed persistent petiole **D** remaining scales.

middle to  $2/3$ ; lobes ovate-lanceolate, margin entire, apex acute. **Corolla** yellow with short-stalked glandular, annulate; limb 16–25 mm across, funnellform; lobes spreading,  $7\text{--}12 \times 5\text{--}10$  mm, broadly obovate, emarginate. **Thrum flower:** corolla tubes 8–12 mm in length, 3–4 mm in diameter, slightly longer than calyx, widely amplified above insertion of stamens; stamens inserted slightly above the middle of corolla tube; style ca. 4 mm. **Pin flower:** corolla tubes 7–10 mm in length, ca. 3 mm in diameter, nearly equal to calyx, widely amplified above insertion of stamens; stamens in the middle of corolla tube, style ca.  $2/3$  as long as tube. **Capsule** globose, included in calyx, disintegrating at maturity.



**Figure 4.** Type sheet of *Primula wolongensis*.

**Phenology.** Flowering May–June, fruiting May–August.

**Etymology.** The specific epithet refers to the type locality, Wolong National Nature Reserve.

**Vernacular name.** A Chinese name, wo long bao chun (卧龙报春), is suggested here.

**Distribution and habitat.** The species has so far only been found at its type locality in Wolong Town, Wenchuan county, Sichuan Province. It grows in the cracks of steep wet cliffs covered with moss above the tree-line.

**Conservation status.** Data Deficient (DD). Currently, only one population with more than 100 individuals has been found in the type locality. According to the guidelines for using the IUCN Red List categories and criteria (IUCN Standards and Petitions Subcommittee 2022), the conservation status of the new species is ‘Data Deficient (DD)’. Further explorations in the adjacent mountainous tracts are necessary for an adequate assessment.

**Discussion.** Following Hu’s (1990) taxonomic treatment of this genus, this new species belongs to *Primula* section *Petiolares* on account of globose capsule included within the calyx-tube that does not open by valves but apically crumbling at membrane apex at maturity (Figs 2–4).

Further morphological analysis shows that the new species is allied with subsect. *Chartacea* by having glabrous and efarinose plants, at flowering time devoid of basal bud-scales, more or less rounded blades and slender petioles.

**Table 1.** Comparison of morphological characters among *Primula wolongensis*, *P. arunachalensis* and *P. fenghuaiana*.

Characters	<i>P. wolongensis</i>	<i>P. arunachalensis</i>	<i>P. fenghuaiana</i>
Habitat	moss-covered crevices of wet cliffs	on hill slope	secondary evergreen broad-leaved forests
Rootstock	less than 0.3 cm long	ca. 2 cm long	1–2 cm long
Petioles	3–5× as long as leaf blade	1–2× as long as leaf blade	ca.2/3 the length of the leaf blade
Leaf blade	widely ovate to suborbicular	orbicular	broadly elliptic to broadly obovate
	the veins are not raised on both sides	the veins are raised on both sides	the veins are raised on both sides
	base cordate	base cordate to truncate	base broadly cuneate to almost rounded
	margin dentate	margin irregularly and shallowly dentate to denticulate	margin remotely denticulate
Scapes	1.8–4.5 cm, sparsely short-stalked glandular	ca. 1.5 cm, glabrous	0.8–1.2 cm, densely covered with minute glandular hairs
	as long as pedicel	longer than pedicel	shorter than pedicel
Calyx	campanulate, poculiform in fruit	campanulate	narrowly campanulate
Corolla	yellow, heterostylous, annulate	pale yellow, homostylous, exannulate	pink to white, heterostylous, annulate
	lobes emarginate	lobules dentate or lacerate	lobes bilobed, lobules entire or toothed
Stamens	inserted on the middle of the corolla tube at thrum flower	inserted on the apex of the corolla tube at thrum flower	inserted on the apex of the corolla tube at thrum flower

Including the newly described here, there are nine species reported so far for this subsection (Smith and Fletcher 1944; Hu 1990; Basak and Maiti 2000; Rankin 2010; Hu and Hao 2011; Xu et al. 2015; Wei et al. 2022). Amongst the Chinese members of subsect. *Chartacea*, the new species, is morphologically most similar to *P. arunachalensis* and *P. fenghwaiana* in its bud-scales lacking at anthesis, slender petioles, rounded blades, and scape shorter than or equal to pedicels, but can be recognized by almost absent rhizomes, morphological features of leaves, inflorescences, and flowers. Further morphological comparisons among *P. wolongensis*, *P. arunachalensis* and *P. fenghwaiana* are shown in Table 1.

## Acknowledgements

We would like to thank Huaicheng Li of Freie Universität Berlin for assistance with relevant literature. We thank Min Liao and Lisha Jiang of Chengdu Institute of Biology for photographing the new species. We are grateful to the staff of BM, CDBI, E, FI, HNWP, IBSC, K, KUN, P, PE, US, and WU for providing online access to specimens. The study was financially supported by the National Key Research and Development Program of China (2020YFE0203200), Wild Plants Sharing and Service Platform of Sichuan Province, and 2021 Subsidy Projects of Prohibited Developmental Areas from the Transfer Payment of the National Key Ecological Functional Areas.

## References

- APG [Angiosperm Phylogeny Group] (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181: 1–20. <https://doi.org/10.1111/boj.12385>
- Basak SK, Maiti GG (2000) *Primula arunachalensis* sp. nov. (Primulaceae) from the Eastern Himalaya. *Acta Phytotaxonomica et Geobotanica* 51(1): 11–15. <https://doi.org/10.18942/bunruichiri.KJ00001077444>
- Beentje H (2012) *The Kew Plant Glossary, an illustrated dictionary of plant terms*. Kew Publishing, Richmond, 164 pp.
- Fang RZ (1994) Primulaceae. In: Wang WT, Wu SG (Eds) *Vascular Plants of the Hengduan Mountains*. Science Press, Beijing, 1477–1524.
- Fang RZ (2003) Primulaceae. In: *Institutum Botanicum Kunmingense Academiae Sinicae (Org.) Flora of Yunnanica*, vol. 15. Science Press, Beijing, 326–514.
- Hu CM (1986) Primulaceae. In: Wu ZY (Ed.) *Flora Xizangica*, vol. 3. Science Press, Beijing, 745–847.
- Hu CM (1990) *Primula*. In: Chen FH, Hu CM (Eds) *Flora Reipublicae Popularis Sinicae*, vol. 59 (2). Science Press, Beijing, 1–277.
- Hu CM (1994) On the geographical distribution of the Primulaceae. *Redai Yaredai Zhiwu Xuebao* 2(4): 1–14.

- Hu CH, Geng YY (2003) Two new species of *Primula* (Primulaceae) from China. *Novon* 13(2): 196–199. <https://doi.org/10.2307/3393518>
- Hu CM, Hao G (2011) New and noteworthy species of *Primula* (Primulaceae) from China. *Edinburgh Journal of Botany* 68(2): 297–300. <https://doi.org/10.1017/S096042861100014X>
- Hu CM, Kelso S (1996) Primulaceae. In: Wu ZY, Raven PH (Eds) *Flora of China*, vol. 15. Science Press, Beijing & Missouri Botanical Garden Press, St. Louis, 99–185. <http://www.iplant.cn/info/Primulaceae?t=foc>
- IUCN Standards and Petitions Subcommittee (2022) Guidelines for using the IUCN Red List categories and criteria. Version 8.1. Prepared by the Standards and Petitions Subcommittee in July 2022.
- Ju WB, Huang Q, Sun ZY, Huang WJ, Li HC, Gao XF (2018) *Primula luteoflora* (Primulaceae), a new species from Sichuan, China. *Phytotaxa* 367(3): 297–300. <https://doi.org/10.11646/phytotaxa.367.3.10>
- Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: Improvements in performance and usability. *Molecular Biology and Evolution* 30(4): 772–780. <https://doi.org/10.1093/molbev/mst010>
- Li R, Hu CM (2009) *Primula libengiana* (Primulaceae), a new species from Yunnan, China. *Annales Botanici Fennici* 46(2): 130–132. <https://doi.org/10.5735/085.046.0208>
- Minh BQ, Nguyen MAT, von-Haeseler A (2013) Ultrafast approximation for phylogenetic bootstrap. *Molecular Biology and Evolution* 30(5): 1188–1195. <https://doi.org/10.1093/molbev/mst024>
- Nguyen LT, Schmidt HA, Von-Haeseler A, Minh BQ (2014) IQ-TREE: A fast and effective stochastic algorithm for estimating Maximum-Likelihood phylogenies. *Molecular Biology and Evolution* 32(1): 268–274. <https://doi.org/10.1093/molbev/msu300>
- Pax FA (1889) Monographische Übersicht über die Arten der Gattung *Primula*. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 10(3): 75.
- Rankin DWH (2010) *Primula nghialoensis*. *Curtis's Botanical Magazine* 27(2): 132–139. <https://doi.org/10.1111/j.1467-8748.2010.01689.x>
- Richards J (2003) *Primula*. Timber Press, Portland, Oregon, 346 pp.
- Smith WW, Fletcher HR (1944) The genus *Primula*: Section *Petiolares*. *Transactions of the Royal Society of Edinburgh* 61(1): 271–314. <https://doi.org/10.1017/S0080456800004750>
- Thiers B (2021) Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/science/ih>
- Wei D, Wang W, Xu Y, Hao G (2022) *Primula tsaiiana* (Primulaceae), a New Species from Yunnan, China, and a New Synonym of *P. wenshanensis*. *Annales Botanici Fennici* 59(1): 111–116. <https://doi.org/10.5735/085.059.0117>
- Wu YT (1999) *Flora Sichuanica*, vol. 13. Sichuan Science and Technology Press, Chengdu, 288 pp.
- Xu B, Wu N, Gao XF, Zhang LB (2012) Analysis of DNA sequences of six plastid and nuclear genes suggests incongruence, introgression, and incomplete lineage sorting in the evolution of *Lespedeza* (Fabaceae). *Molecular Phylogenetics and Evolution* 62(1): 346–358. <https://doi.org/10.1016/j.ympev.2011.10.007>

- Xu Y, Yuan S, Hu CM, Hao G (2014) *Primula dejuniana* (Primulaceae), a new species from Sichuan, China. *Annales Botanici Fennici* 51(6): 372–374. <https://doi.org/10.5735/085.051.0602>
- Xu Y, Hu CM, Hao G (2015) A New Species of *Primula* (Primulaceae) from Sichuan, China. *Redai Yaredai Zhiwu Xuebao* 23(2): 147–150. <https://doi.org/10.5735/085.052.0518>
- Xu Y, Li CH, Hu CM, Hao G (2016) *Primula wawushanica* sp. nov. (Primulaceae) from Sichuan, southwestern China. *Nordic Journal of Botany* 34(2): 156–158. <https://doi.org/10.1111/njb.00894>
- Yuan S, Zhang DX, Hao G (2018) *Primula chimingiana* sp. nov. (Primulaceae) from Sichuan, China. *Nordic Journal of Botany* 36(1–2): njb-01390. <https://doi.org/10.1111/njb.01390>



# *Glossoloma magenticristatum* (Gesneriaceae), a new species from the Cordillera Oriental of the Colombian Andes

David Hoyos<sup>1,2,3</sup>, Laura Clavijo<sup>4</sup>, John L. Clark<sup>5,6</sup>

**1** Grupo de Investigación en Recursos Naturales Amazónicos - GRAM, Facultad de Ingenierías y Ciencias Básicas, Instituto Tecnológico del Putumayo - ITP, Mocoa, Putumayo, Colombia **2** Herbario Etnobotánico del Piedemonte Andino Amazónico HEAA, Instituto Tecnológico del Putumayo - ITP, Cra. 17 14-85 (Corpoamazonia), Mocoa, Putumayo, Colombia **3** Instituto Multidisciplinario de Biología Vegetal (IMBIV), CONICET-UNC, Universidad Nacional de Córdoba, CC 495, 5000, Córdoba, Argentina **4** Universidad Nacional de Colombia –Sede Bogotá, Facultad de Ciencias, Instituto de Ciencias Naturales, Bogotá, D.C., 111321, Colombia **5** Marie Selby Botanical Gardens, 1534 Mound St., Sarasota, FL 34236, USA **6** Science Department, The Lawrenceville School, Lawrenceville, NJ 08648, USA

Corresponding author: John L. Clark ([jlclark@selby.org](mailto:jlclark@selby.org))

Academic editor: Ricardo Kriebel | Received 15 November 2022 | Accepted 18 December 2022 | Published 10 January 2023

**Citation:** Hoyos D, Clavijo L, Clark JL (2023) *Glossoloma magenticristatum* (Gesneriaceae), a new species from the Cordillera Oriental of the Colombian Andes. *PhytoKeys* 218: 59–68. <https://doi.org/10.3897/phytokeys.218.97590>

## Abstract

A narrowly endemic new species of *Glossoloma* is described from the Cordillera Oriental of the northern Andes, in the Colombian departments of Caquetá and Huila. *Glossoloma magenticristatum* J.L.Clark, D.Hoyos & Clavijo, **sp. nov.** differs from most other congeners by a habit that is usually epiphytic with elongate scandent subwoody shoots, the presence of a magenta corolla tube, and a creased calyx formed by tightly appressed adjacent lobes. A brief summary of Gesneriaceae diversity in the Colombia departments of Caquetá and Huila is discussed with an emphasis on the old highway between Florencia and Guadalupe. The conservation status of *G. magenticristatum* is assessed as Endangered (EN) based on IUCN Criteria.

## Resumen

Se describe una especie de *Glossoloma* endémica de la Cordillera Oriental de los Andes del norte, en los departamentos de Caquetá y Huila. *Glossoloma magenticristatum* J.L.Clark, D.Hoyos & Clavijo, **sp. nov.** se diferencia de otras especies en el género por el hábito usualmente epífito con ramas alargadas, escandentes y subleñosas, el tubo de la corola magenta, y un cáliz con los lóbulos estrechamente adpresos y con margen ondulada. Se presenta una breve síntesis de la diversidad de Gesneriaceae en los departamentos de Caquetá y Huila, con un énfasis en la vieja carretera entre Florencia y Guadalupe. Se evalúa el estado de conservación de *G. magenticristatum* y se propone que se debería categorizar como En Peligro (EN), de acuerdo a los criterios de la UICN.

## Keywords

Andes, biodiversity, Caquetá, *Glossoloma*, Huila, taxonomy

## Introduction

The flowering plant family Gesneriaceae is in the order Lamiales and comprises more than 3400 species and 150+ genera (Weber 2004; Weber et al. 2013). Gesneriaceae is a strongly supported monophyletic family classified into three subfamilies, seven tribes, and nine subtribes (Ogutcen et al. 2021). *Glossoloma* Hanst. is a member of the subtribe Columneinae, the largest clade in the subfamily Gesnerioideae with more than 560 species represented in 28 genera (Weber et al. 2020). The Columneinae comprises roughly 21% of all Gesneriaceae. *Glossoloma* is the sixth most diverse genus (30 spp.) in the Columneinae, after *Columnea* L. (200+ spp.), *Drymonia* Mart. (100+ spp.), *Nautilocalyx* Hanst. (60+ spp.), *Trichodrymonia* Oerst. (50+ spp.) and *Nematanthus* Schrad. (30+ spp.).

Hanstein (1854) initially recognized *Glossoloma* as a genus but later (Hanstein 1865) lumped it with four other genera into *Alloplectus* Mart. The non-monophyly of *Alloplectus* was recognized through phylogenetic studies (Clark and Zimmer 2003; Clark et al. 2006) and resulted in a reclassification of several genera, including most of the currently recognized species in *Glossoloma* (Clark 2005). *Glossoloma* is differentiated from other genera in the Gesneriaceae by the presence of resupinate flowers, a character not mentioned by Hanstein (1854, 1865), but more recently defined as a morphological synapomorphy for the genus (Clark and Zimmer 2003; Clark 2005; Clark et al. 2006). Other characters that define *Glossoloma* include a terrestrial habit of unbranched subshrubs and elongate tubular corollas that are ampliate apically and appear laterally compressed (Clark 2009).

*Glossoloma* ranges from Central America (southern Mexico) to South America (Bolivia). The center of diversity for *Glossoloma* is the western lowland Andean forests of Colombia and Ecuador, where more than 16 species occur. The type locality for *G. magenticristatum* is above 2000 meters on the Cordillera Oriental of the Colombian Andes. This region is characterized by abundant precipitation and high humidity (Ruíz-Hernández et al. 2021), and shares similar climatic conditions with the Cordillera Occidental. The Cordillera Occidental (western Andes) and Cordillera Oriental (eastern Andes) harbor more species of Gesneriaceae relative to the drier inter-Andean valleys (Van der Hammen 2000). For example, Clavijo et al. (2016) cite 66 species of Gesneriaceae in the department of Caquetá. In a forest near the type locality, Alvarez et al. (2019) recorded 21 species of Gesneriaceae, including four new records to the flora of Caquetá.

The type locality of *G. magenticristatum* is along the old highway between Florencia and Guadalupe, an area that is the type locality for several plant discoveries. Examples of species published from this region include *Fuchsia cuatrecasasii* Munz (Munz 1943), *Guzmania cuatrecasasii* L.B.Sm. (Smith 1971), *Juanulloa speciosa* var *glabra* Cuatrec. (Cuatrecasas 1958), *Kohleria longicalyx* L.P.Kvist & L.E.Skog (Kvist and Skog 1992), *Piper resinaense* W.Trujillo (Trujillo and Jaramillo 2021), and *Piper tarquiense* W.Trujillo (Trujillo and Jaramillo 2021).

## Taxonomic treatment

***Glossoloma magenticristatum* J.L.Clark, D.Hoyos & Clavijo, sp. nov.**

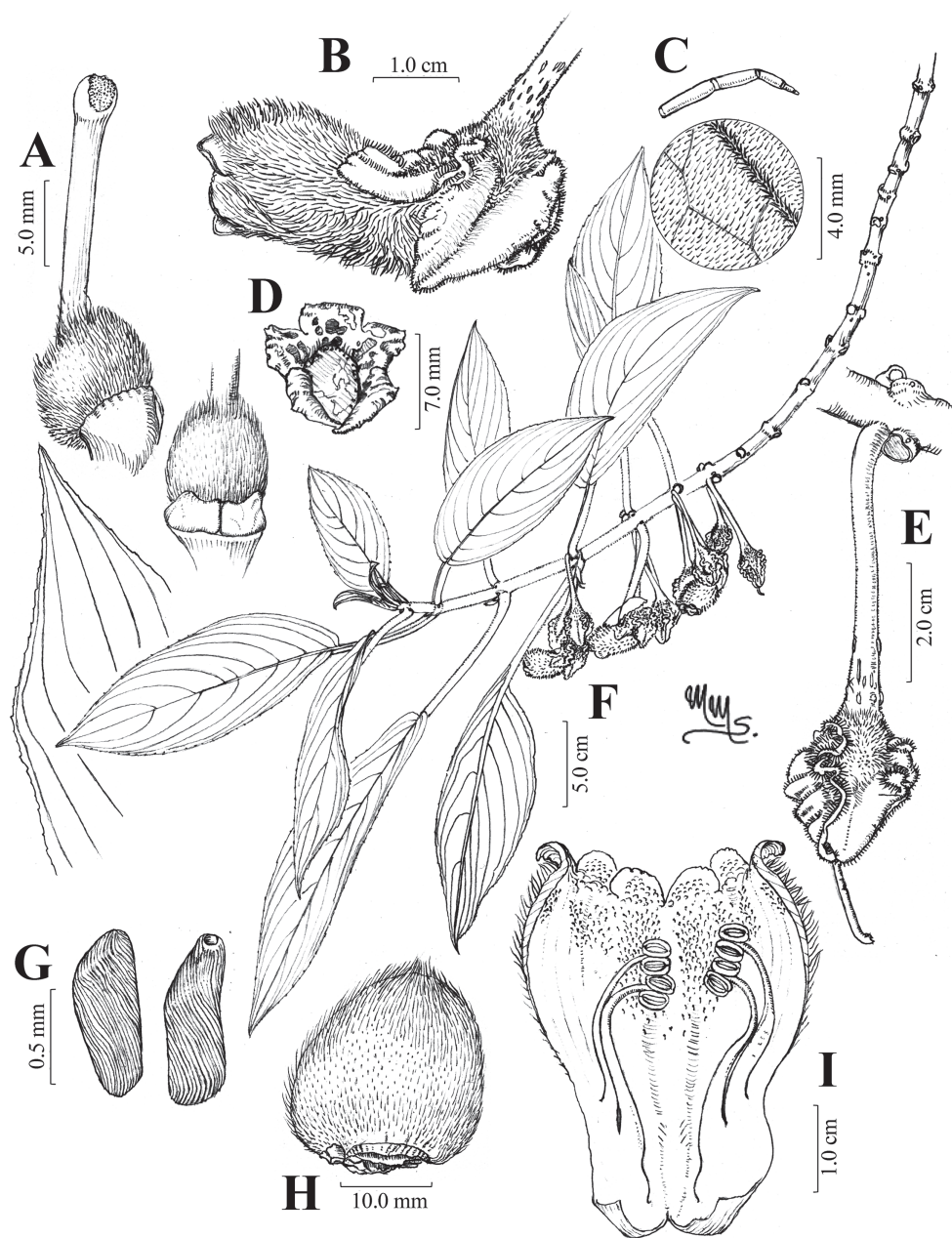
urn:lsid:ipni.org:names:77311680-1

Figs 1, 2

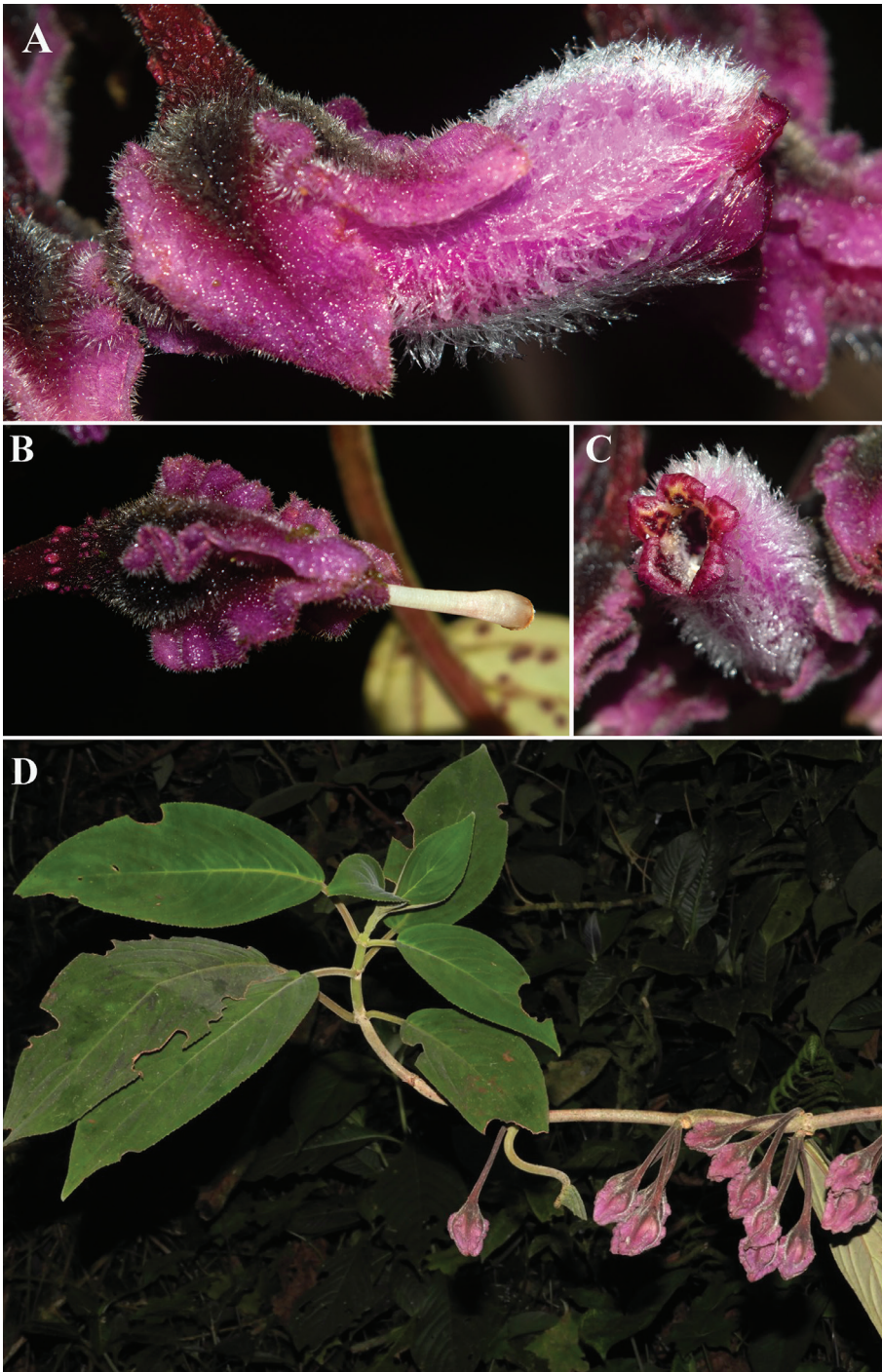
**Diagnosis.** Differs from all other *Glossoloma* by the presence of a magenta corolla tube and a creased calyx formed by tightly appressed adjacent lobes.

**Type.** COLOMBIA. **Caquetá:** Florencia, antigua vía Florencia–Guadalupe, hacia Cerro de Gabinete, 1°51'50"N, 75°40'22"W, 2387 m, 28 June 2021, *D. Hoyos, D. Sanín, A. Pérez & J. Castañeda* 765 (holotype: COL; isotypes: COAH, CUVC, HEAA, HUA, HUAZ).

**Description.** Terrestrial or epiphytic subshrub, branched, with elongate, scandent or horizontal shoots, to 2 m long, 4–8 mm in diameter. **Stems** subwoody, subquadrangular in cross-section, glabrescent proximally, velutinous distally, internodes 1–7 cm long. **Leaves** opposite, decussate, equal to subequal, coriaceous, enations present at the base of petioles, petioles 1–7.3 cm long, velutinous, subterete (flattened adaxially and rounded abaxially) in cross-section, reddish; blade elliptic to ovate, 8–15 × 3–7 cm, base cuneate to obtuse, apex attenuate, margin serrulate, adaxially green, puberulous, trichomes with swollen bases, abaxially light green suffused with pink, drying ferruginous with light brown venation, papillate, puberulent, primary vein velutinous, reddish proximally, lateral veins 6–9 per side, occasionally reddish, more pilose than blade. **Inflorescence** a reduced pair-flowered axillary cyme, with 1–8 flowers per node; peduncles absent or highly reduced (< 2 mm); bracts lanceolate to oblanceolate, 6.2–14.6 × 1.9–4.7 mm, dark purple, the apex acuminate to obtuse, sparsely pilose. **Flowers** resupinate; pedicels 1.2–4.0 cm long, dark vinaceous, velutinous, enations present (more abundant distally). **Calyx** with 5 lobes fused basally, lobes conduplicate with each lobe appressed to adjacent lobe and folded lengthwise with the margins curved outwards and forming a crease, light magenta, dark purple toward the middle and the base, subequal in size and shape, dorsal lobe slightly smaller, 1.4–2.0 × 0.5–1.2 cm, broadly ovate, base truncate, apex acute, margin repand to sinuate, pubescent on both surfaces, more densely pubescent toward the middle. **Corolla** zygomorphic, tubular, 3.8–4.3 cm long, gibbous basally on lower surface, spur absent, tube broadly widened on dorsal surface (not widened on ventral surface), long axis of corolla perpendicular relative to calyx; corolla tube light magenta outside, whitish with dark red to magenta splotches inside, 2.2–2.5 cm long, basal gibbosity 1.2–1.6 cm long, base 9–11 mm in diameter, middle widened, becoming apically ventricose on upper surface, throat slightly constricted, appearing laterally compressed, 4–6 mm in diameter, densely pilose with translucent white trichomes outside, mostly glabrous, with glandular trichomes apically in the inner surface of throat; limb 11–14 mm wide, with 5 reflexed lobes, lobes subequal, 3.2–5.3 × 4.1–6.4 mm, rotund, margin entire, cream yellow with dark red to magenta splotches proximally and light vinaceous splotches distally, glabrous on both surfaces. **Androecium** of 4 stamens; filaments connate at



**Figure 1.** *Glossoloma magenticristatum* J.L.Clark, D.Hoyos & Clavijo **A** gynoecium featuring nectary of two connate glands **B** lateral view of mature flower **C** adaxial leaf surface with inset featuring multicelled trichome **D** face view of flower **E** gynoecium surrounded by cristate calyx lobes **F** habit **G** seeds **H** immature cone-shaped fruit **I** opened corolla featuring mature stamens. Illustration by M. Morales from Hoyos et al. 765.



**Figure 2.** *Glossoloma magenticristatum* J.L.Clark, D.Hoyos & Clavijo **A** lateral view of mature flower **B** lateral view of calyx featuring cristate lobes **C** front view of flower **D** habit (**A, B, C** Hoyos *et al* 765 **D** Hoyos & Castañeda 233). Photos **A, B, C** by D. Sanín and photo **D** by D. Hoyos.

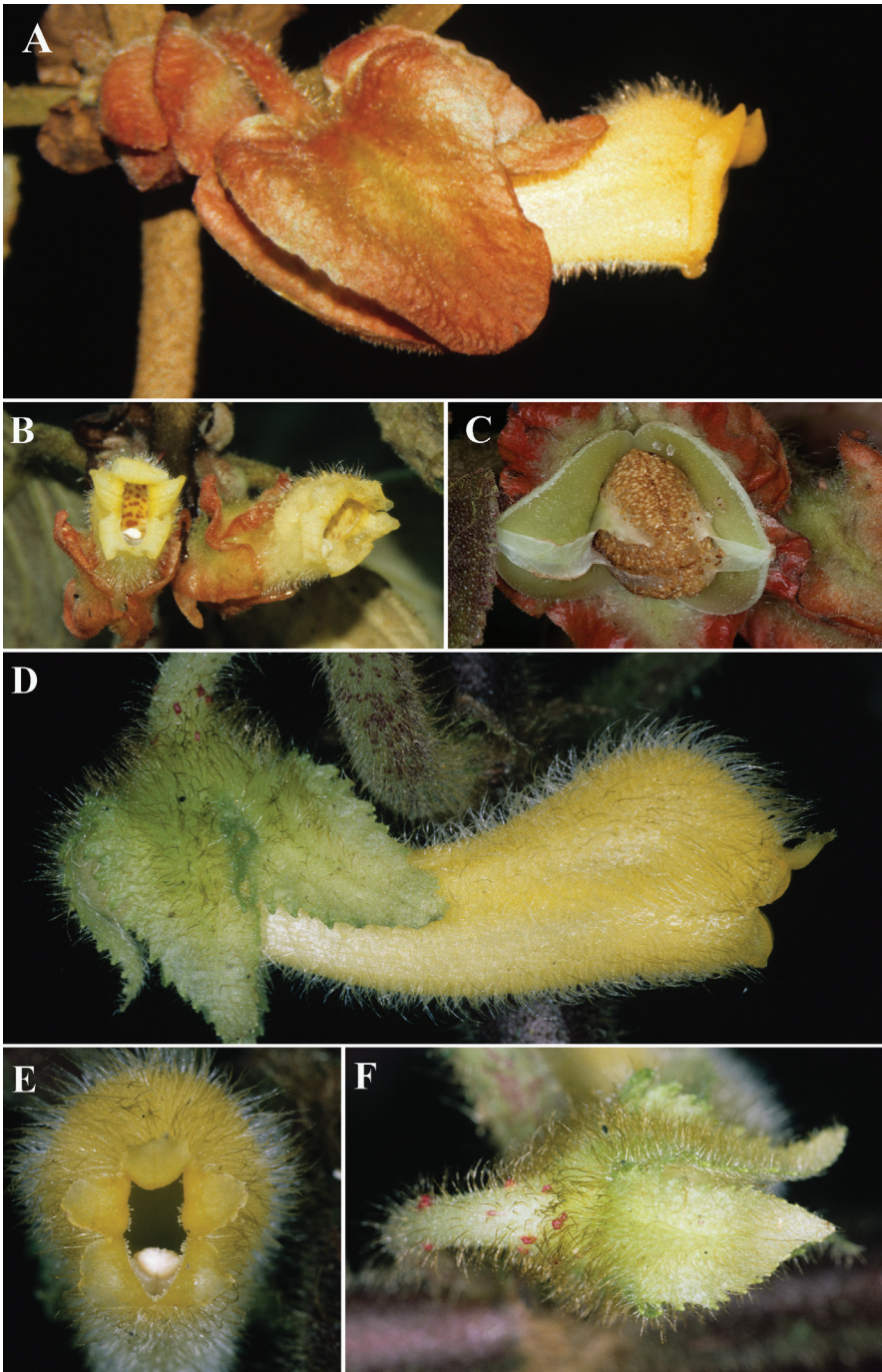
the base forming a filament curtain for 6–9 mm, free portion of filaments 1.5–1.9 cm long, glabrous; anthers rectangular,  $2.9\text{--}3.4 \times 2.7\text{--}2.8$  mm, twice as wide during anthesis, dehiscing by longitudinal slits; staminode absent. **Gynoecium** with two connate glands, each nectary truncate and shallowly bilobed, 2–3 mm long, glabrous; ovary superior, densely pilose,  $8\text{--}10 \times 4\text{--}6$  mm; style ca. 16 mm long, glabrous, stigma stomatomorphic. **Fruit** a bivalved ovoid fleshy capsule, laterally compressed,  $12\text{--}15 \times 13.0\text{--}14.1$  mm, densely pilose, the valves white on both surfaces, valves reflexed to  $180^\circ$  when mature, revealing a central cone of fleshy white funicular tissue covered by an ephemeral thin brown pericarp. **Seeds** numerous, initially covered by the endocarp, but immersed in the central cone of funicular tissue, each seed  $0.9\text{--}1.3 \times 0.3\text{--}0.4$  mm, dark brown, ellipsoid, and longitudinally striate.

**Phenology.** Mature flowers were documented during June and September and immature floral buds during January. Immature fruits were documented during September and October, and mature fruits were observed in October.

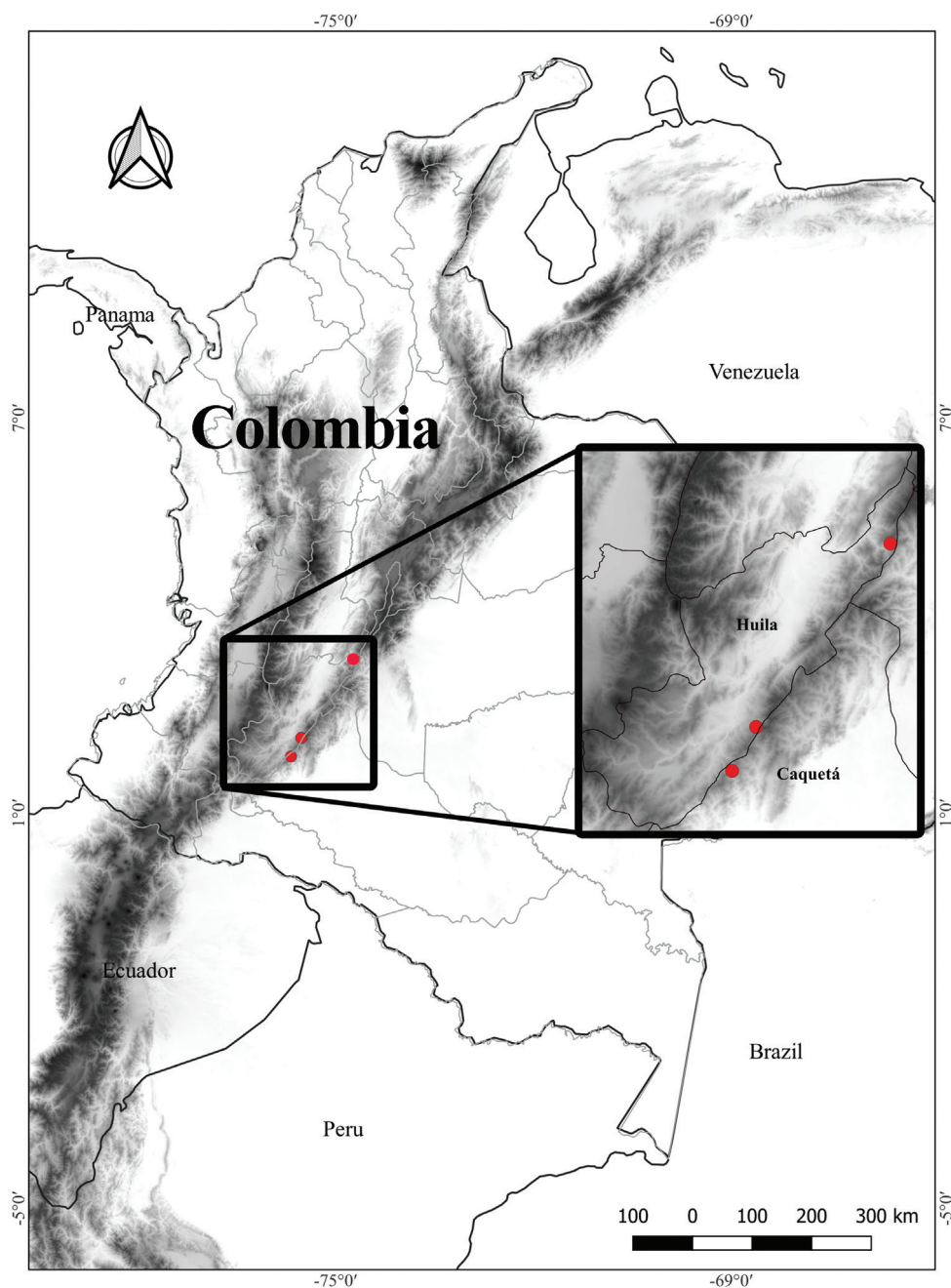
**Etymology.** The specific epithet is derived from two adjectives that reflect the unique characteristics of *Glossoloma magenticristatum*. The corolla is magenta, a color not found in other members of *Glossoloma*. The adjacent calyx lobes are tightly appressed and form a crease that appears winged or crested (Fig. 2B), which reflects the second part of the specific epithet, “cristate.”

**Distribution and preliminary assessment of conservation status.** *Glossoloma magenticristatum* is endemic to the Colombian Cordillera Oriental (Eastern Cordillera) of the northern Andes, between 1900 and 2400 m elevation (Fig. 4). The three known populations of *Glossoloma magenticristatum* were documented growing on roadsides, characterized by shaded secondary forest. Two of the three known populations are documented with collections. A third population in the Huila department ( $3^\circ 19' 3.96''\text{N}$ ,  $74^\circ 39' 42.32''\text{W}$ ) is based on an observation and photograph from April of 2019 on iNaturalist by Jorge Luis Peña. Following the IUCN Red List Categories and Criteria (IUCN 2022) and guidelines of the IUCN Standards and Petitions Committee (IUCN 2022), *Glossoloma magenticristatum* is categorized as Endangered (EN) based on the following criteria: B1ab (III) + 2ab (III), extent of occurrence (EOO) is calculated at  $378.997 \text{ km}^2$  (criterion B1  $< 5000 \text{ km}^2$ ), and area of occupancy (AOO) is calculated at  $12 \text{ km}^2$  (criterion B2  $< 500 \text{ km}^2$ ). The population from the type locality is at risk from periodic disturbance due to the removal of roadside vegetation by maintenance staff on the Florencia–Guadalupe road and globally by the ongoing decline of Andean forests from colonization and agriculture.

**Comments.** Most species of *Glossoloma* share a habit defined as unbranched terrestrial subshrubs. The presence of an epiphytic habit is rare, and it is even more unusual for epiphytic *Glossoloma* to have elongate climbing shoots. Currently known species of *Glossoloma* with an epiphytic habit and elongate shoots include *G. chrysanthum* (Planch. & Linden) J.L.Clark, *G. penduliflorum* (M.Frieberg) J.L.Clark, *G. scandens* J.L.Clark, and *G. wiehleri* J.L.Clark & F.Tobar. The description here of *G. magenticristatum* brings the total number of epiphytic *Glossoloma* with elongate shoots to five species. *Glossoloma magenticristatum* is most similar to *G. serpens* (Fig. 3), but readily distinguished by the presence of a magenta corolla (Fig. 2) (vs. red to yellow corolla in *G. serpens*, Fig.



**Figure 3.** *Glossoloma serpens* J.L.Clark & L.E.Skog (J.L.Clark) and *G. chrysanthum* (Planch. & Linden) J.L. Clark **A** lateral view of mature flower of *G. serpens* **B** front view of mature flower of *G. serpens* **C** mature fruit of *G. serpens* **D** lateral view of mature flower for *G. chrysanthum* **E** front view of mature flower of *G. chrysanthum* **F** calyx of *G. chrysanthum* (**A** J.L.Clark 5627 **B** J.L.Clark 5996 **C** J.L.Clark 9834 **D, E, F** J.L.Clark 6872). All photos by J.L. Clark.



**Figure 4.** Distribution map of *Glossoloma magenticristatum* J.L.Clark, D.Hoyos & Clavijo in Colombia with inset featuring collection localities in the departments of Caquetá and Huila.

3A), ovate calyx lobes (vs. broadly ovate in *G. serpens*, Fig. 3A), and coriaceous leaves (vs. papyraceous in *G. serpens*). The presence of an epiphytic habit with elongate shoots is also found in *G. chrysanthum* from Venezuela. These two species are geographically

isolated, with *G. magenticristatum* endemic to Colombia (Fig. 4) and *G. chrysanthum* endemic to Venezuela. In addition, these species differ by a corolla length 3.8–4.3 cm in *G. magenticristatum* (vs. corolla length to 3.5 cm in *G. chrysanthum*), calyx magenta in *G. magenticristatum* (vs. light green calyx in *G. chrysanthum*, Fig. 3F), and magenta corolla in *G. magenticristatum* (vs. uniformly yellow corolla in *G. chrysanthum*, Fig. 3D).

**Additional specimens examined.** COLOMBIA. **Caquetá:** Florencia, Cerro de Gabinete, Antigua vía Florencia–Guadalupe, 1°52'51.5"N, 75°4'46.5"W, 2000 m, 15 Sep 2018, D. Hoyos & M. Cuellar 103 (COL); Florencia, Cerro de Gabinete, Antigua vía Florencia–Guadalupe, 1°52'51.5"N, 75°4'46.5"W, 2000 m, 22 Sep 2019, D. Hoyos & J. Castañeda 233 (HUAZ, HEAA). **Huila:** Garzón, vereda Las Mercedes, borde de bosque secundario, 2°8'44.5"N, 75°31'9.6"W, 1960 m, 27 Dec 2021, J.L. Peña, E. Rojas & D. Hoyos 924 (HEAA, HUAZ).

## Acknowledgements

We are grateful to David Sanín, Mauricio Cuellar, Juan Castañeda, Alejandro Pérez, Nicolas Bedoya, and Gina Sierra for supporting field expeditions. We thank the Instituto Tecnológico del Putumayo and especially Kiara Chaves, Felipe Moreno, and Kelly Imbachi for the use of their laboratory. We thank Jorge Luis Peña for sharing and alerting us to his iNaturalist observation of *Glossoloma magenticristatum* from the Huila department. We are grateful to D. Sanín for allowing us to use his field images (Fig. 2) and Marcela Morales for the illustration (Fig. 1). We also thank Alain Chautems for helpful comments on an earlier version of the manuscript. We thank Kanchi N. Gandhi for his guidance in selecting an appropriate specific epithet.

## References

- Álvarez C, Castaño D, Hoyos D, Velasco G, Peña JL, Sanín D (2019) Angiospermas no arbóreas de un bosque húmedo tropical en el Piedemonte Andino–Amazónico Colombiano. *Boletín Científico Museo de Historia Natural Universidad de Caldas* 23(2): 62–94. <https://doi.org/10.17151/bccm.2019.23.2.3>
- Clark JL (2005) A monograph of *Alloplectus* (Gesneriaceae). *Selbyana* 25(2): 182–209.
- Clark JL (2009) Systematics of *Glossoloma* (Gesneriaceae). *Systematic Botany Monographs* 89: 1–126.
- Clark JL, Zimmer EA (2003) A preliminary phylogeny of *Alloplectus* (Gesneriaceae): Implications for the evolution of flower resupination. *Systematic Botany* 28: 365–375.
- Clark JL, Herendeen PS, Skog LE, Zimmer EA (2006) Phylogenetic relationships and generic boundaries in the Episcieae (Gesneriaceae) inferred from nuclear, chloroplast, and morphological data. *Taxon* 55(2): 313–336. <https://doi.org/10.2307/25065580>
- Clavijo L, Skog LE, Clark JL (2016) Gesneriaceae. In: Bernal R, Gradstein SR, Celis M (Eds) *Catálogo de plantas y líquenes de Colombia: Volumen I*. Bogotá: Instituto de Ciencias Naturales, Universidad Nacional de Colombia, 1356–1388.

- Cuatrecasas J (1958) The Colombian Species of *Juanulloa*. *Brittonia* 10(3): 146–150. <https://doi.org/10.2307/2804795>
- Hanstein J (1854) Die Gesneraceen des Königlichen Herbariums und der Gärten zu Berlin, nebst Beobachtungen über die Familie im Ganzen I. Abschnitt. *Linnaea* 26: 145–216[, fig. 1–68].
- Hanstein J (1865) Die Gesneraceen des Königlichen Herbariums und der Gärten zu Berlin, nebst monographischer Uebersicht der Familie im Ganzen, II. Abschnitt. Gattungen und Arten. Drittes Stück. Die Eugesnereen, Rhytidophylleen, und Beslerieen. *Linnaea* 34: 225–462.
- IUCN (2022) The IUCN Red List of Threatened Species. Version 2022–1. <https://www.iucn-redlist.org> [Accessed on 26 August 2022]
- IUCN Standards and Petitions Committee (2022) Guidelines for using the IUCN Red List Categories and Criteria. Version 15.1. <https://www.iucnredlist.org/resources/redlistguidelines>
- Kvist LP, Skog LE (1992) Revision of *Kohleria* (Gesneriaceae). *Smithsonian Contributions to Botany* 79(79): 1–83. <https://doi.org/10.5479/si.0081024X.79>
- Munz PA (1943) A revision of the genus *Fuchsia* (Onagraceae). *Proceedings of the California Academy of Sciences* 25(4): 1–138.
- Ogutcen E, Christe D, Nishii K, Salamin N, Möller M, Perret M (2021) Phylogenomics of Gesneriaceae using targeted capture of nuclear genes. *Molecular Phylogenetics and Evolution* 157: 107068. <https://doi.org/10.1016/j.ympev.2021.107068>
- Ruiz-Hernández JC, Condom T, Ribstein P, Le Moine N, Espinoza JC, Junquas C, Villacís M, Vera A, Muñoz T, Maisincho L, Campozano L, Rabatel A, Sicart JE (2021) Spatial variability of diurnal to seasonal cycles of precipitation from a high-altitude equatorial Andean Valley to the Amazon basin. *Journal of Hydrology. Regional Studies* 38: 100924. <https://doi.org/10.1016/j.ejrh.2021.100924>
- Smith LB (1971) Notes on Bromeliaceae, XXXII. *Phytologia* 21(2): 73–96.
- Trujillo W, Jaramillo MA (2021) Taxonomic novelties of *Piper* (Piperaceae) from the Amazonian slopes of the Northern Andes. *Brittonia* 73(1): 67–76. <https://doi.org/10.1007/s12228-020-09638-5>
- Van der Hammen T (2000) Aspectos de historia y ecología de la biodiversidad Norandina y Amazónica. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales* 24(91): 231–245.
- Weber A (2004) Gesneriaceae. In: Kadereit J (Ed.) *The Families and Genera of Vascular Plants*. Vol. 7. Flowering Plants. Dicotyledons. Lamiales (Except Acanthaceae Including Avicenniaceae). Springer, Berlin, 63–158. [https://doi.org/10.1007/978-3-642-18617-2\\_8](https://doi.org/10.1007/978-3-642-18617-2_8)
- Weber A, Clark JL, Möller M (2013) A New Formal Classification of Gesneriaceae. *Selbyana* 31(2): 68–94.
- Weber A, Middleton DJ, Clark JL, Möller M (2020) Keys to the infrafamilial taxa and genera of Gesneriaceae. *Rheedeana* 30: 5–47. <https://doi.org/10.22244/rheedeana.2020.30.01.02>

# *Licaria ramiroi* (Lauraceae), a new species from Western Mexico

Ramón Cuevas Guzmán<sup>1</sup>, Enrique V. Sánchez-Rodríguez<sup>1</sup>,  
José Guadalupe Morales-Arias<sup>1</sup>

<sup>1</sup> *Laboratorio de Botánica, Departamento de Ecología y Recursos Naturales, Centro Universitario de la Costa Sur, Universidad de Guadalajara, Av. Independencia Nacional 151, 48900 Autlán de Navarro, Jalisco, Mexico*

Corresponding author: Ramón Cuevas Guzmán ([rcuevas@cucsur.udg.mx](mailto:rcuevas@cucsur.udg.mx))

---

Academic editor: A. E. Ortiz-Rodríguez | Received 1 September 2022 | Accepted 21 December 2022 | Published 10 January 2023

**Citation:** Cuevas Guzmán R, Sánchez-Rodríguez EV, Morales-Arias JG (2023) *Licaria ramiroi* (Lauraceae), a new species from Western Mexico. PhytoKeys 218: 69–78. <https://doi.org/10.3897/phytokeys.218.94356>

---

## Abstract

*Licaria ramiroi*, a species endemic to western Mexico, is described and illustrated. The ascription of the new species to *Licaria* is analysed. It is classified in the subgen. *Licaria* and is most closely related to *L. triandra* and *L. siphonantha* from which it differs by its glabrous vegetative and floral structures, stamens mainly with free anthers and the inner wall of the receptacle sericeous. According to the IUCN criteria, the species is classified as critically endangered.

## Keywords

cloud forest, endemism, laurel forest, Neotropic, new species, tropical subdeciduous forest

## Introduction

Lauraceae Juss. are a family that is poorly known in terms of the number of taxa and distribution. This is attributed to the fact that many species are large trees with small and inconspicuous flowers, which are difficult to locate and collect (van der Werff and Richter 1996), although these structures are indispensable for the identification of genera and species in the family (van der Werff and Richter 1996; Lorea-Hernández 2002). The family comprises 2,500–3,000 species and is best represented in the trop-

ics of America and Asia (van der Werff and Richter 1996; van der Werff 2009b). The Lauraceae include 120 species in southern Mexico, which are considered to represent between 90 and 93% of the Mexican Lauraceae (Lorea-Hernández 2002).

*Licaria* Aubl. is a Neotropical genus of around 60 species, of which at least 20 have been described in the last 25 years (van der Werff 2009a). Of the total number of *Licaria* species, 17 have been recorded for southern Mexico, eight of which are considered endemic to the country (Lorea-Hernández 2002). Species of *Licaria* are easily recognised by the presence of fertile stamens in whorl III only, bisporangiate anthers and fruits on a well-developed cupule, usually with a double margin (Burger and van der Werff 1990; van der Werff 1991; Lorea-Hernández 1999; Kurz 2000; van der Werff 2009a). The subgenera *Armeniaca*, *Canella* and *Licaria* are recognised by the anther shape and direction of opening and the presence or absence of staminodes in series I and II, with the latter of the three subgen. presenting the greatest species richness and distribution ranges from Florida on the Atlantic side and Mexico (Sinaloa) on the Pacific slope, to southern Brazil and Bolivia (Burger and van der Werff 1990; Kurz 2000; van der Werff 2009a).

As part of a gradient analysis study of the vegetation of the El Tecolote canyon in the Sierra de Manantlán, Jalisco, Mexico (Cuevas 2002), material was collected from a *Licaria* that could not be identified. Initially, only sterile material or material with fruits was available, then material with flowers was collected. However, given the characteristics observed in the flower, particularly the variation in the number of stamens, it was decided to wait until more collections with flowers became available. After making detailed studies of the material from the Sierra de Manantlán, we found no accommodation amongst the known species of *Licaria*, for that reason, this is proposed as a new species.

## Materials and methods

Species morphology was studied and described, based on specimens available in the ZEA Herbarium of the University of Guadalajara and on fresh material collected in the field. Vegetative and reproductive structures were carefully revised under a stereoscopic microscope using the protocol recommended by Radford et al. (1974) in order to elaborate the description. Relevant literature was reviewed, including taxonomic treatments of the genus *Licaria* and descriptions of new species in the genus from the last 25 years (Burger and van der Werff 1990; van der Werff 1991; Gómez-Laurito and Cascante 1999; Lorea-Hernández 1999; Kurz 2000; van der Werff and Vicentini 2000; Lorea-Hernández 2005; van der Werff 2009a). Photographs of type specimens of species that could be related to the *Licaria* species, proposed here as new, were reviewed in the Tropicos (2022) ([www.tropicos.org](http://www.tropicos.org)) and JSTOR (2020) (<http://plants.jstor.org>) databases. Measurements and photographs of the floral structures were taken using fresh or rehydrated material; all other structures were measured in dehydrated specimens. Microphotographs were taken with a SteREO Zeiss Discovery V12 stereoscopic microscope connected to an AxioCam 305 Color Zeiss camera and Zen 3.2 (blue edition) software. Photographs of the species in the field were taken with a Canon

EOS M3 camera. Habitat and phenology data of the new species were obtained from herbarium specimen labels and fieldwork, while information pertaining to the related species was taken from the relevant literature (Kurz 2000; Lorea-Hernández 2005).

## Results

The morphology characteristics of the plant material, collected in the El Tecolote Canyon, supports its allocation in the genus *Licaria* (Fig. 1). All the plants analysed have flowers with fertile stamens only of the whorl III, bisporangiate, lack of staminodes in the first two whorls and the fourth, a deep receptacle surrounding the whole ovary and fruits with double-rimmed cupule. At the same time, the combination found in the specimens of narrow, glabrous leaves, simple cymose-paniculate, glabrous inflorescences, glabrous tepals, stamens fused just by the base of the filaments and receptacle sericeous inside, do not correspond to any *Licaria* species known in Mexico or elsewhere (Table 1); therefore, the recognition of a new species is presented here.

**Table 1.** Morphological differences amongst *Licaria* species and some additional information regarding their phenology and distribution. Information about the species was obtained from Burger & van der Werff (1990) and Kurz (2000) for *L. triandra* and Lorea-Hernández (2005) for *L. siphonantha* and the present study for *L. ramiroi*.

Character	<i>L. ramiroi</i>	<i>L. triandra</i>	<i>L. siphonantha</i>
Leaf blade shape	Lanceolate to oblong	Lanceolate to elliptic	Narrowly elliptical
Leaf blade consistency	Chartaceous	Coriaceous	Chartaceous
Leaf blade surface	Glabrous	Blades when young puberulent on the abaxial part, then glabrous	Glabrous adaxially and appressed puberulent to glabrescent abaxially
Leaf blade size (cm)	7–16 × 1.3–4.7	5–15 × 2–7	(9)13.5–19(-22) × (2-)3.5–5.5
Secondary veins (pairs)	12–23	5–10	12–17
Petiole length (mm)	(4-)7–12 × 1–1.8	8–20 × 1–2	(7-)11–14(-17) × 1–1.8
Inflorescence size (cm)	1–4	1.5–13	3–8(-11.5)
Inflorescence surface	Glabrous, sometimes with few appressed hairs	Sparsely to densely appressed pubescent	Densely puberulent
Pedicle length (mm)	1.2–1.8	1–4	(0.2-)0.7–1.2(-1.5)
Flower length (mm)	2.5–3	1.5–3	2.2–2.5
Receptacle indument	Glabrous outside and sericeous inside	Glabrous to compressed hairy on the outside and occasionally with a few hairs on the inside	Glabrous to appressed puberulent on the outside and glabrous on the inside
Tepal size (mm)	0.8–1.3 × 0.8–0.9	0.7–1	1–1.2 × 0.8–1
Stamens in whorl III	3–5	3	3
Stamen size (mm)	1.2–2.4	1.1–1.7	1.6–1.8
Anther size (mm) and condition	1.1–1.3 × 0.8–0.9, free	Size data unavailable, fused at least for its basal half	1, fused for its basal third
Number and condition of glands	4–8, some free and others fused on their bases	3–6, fused at least for the lower half of their bases, rarely solitary	Number data unavailable, free
Cupule size (mm)	12–14 × 14–18	6–15 × 12–25	8.5–10.5 × 15.5–17.5
Fruit size (mm)	20–28 × 12–15	12–30 × 8–15	16–18 × 11–12.5
Flowering period	July to August	January to December	April to May
Ripe fruit period	February to March	January to December	April to May
Distribution	Jalisco	From Florida, on the Atlantic side and Sinaloa, through the Pacific slope, to Bolivia.	Guerrero

## Taxonomic treatment

### *Licaria ramiroi* Cuevas, sp. nov.

urn:lsid:ipni.org:names:77311681-1

Figs 1, 2

**Diagnosis.** *Licaria ramiroi* is similar to *L. triandra* (Sw.) Kosterm. but differs from the latter by leaves with 12–23 pairs of secondary veins (vs. 5–10); inflorescence surface commonly glabrous (vs. sparsely to densely appressed pubescent); entire hypanthium sericeous inside (vs. glabrous); stamens with free anthers (vs. stamens with anthers fused at least in their basal half).

**Type.** MEXICO. State of Jalisco: Municipality of Casimiro Castillo, cañada El Tecolote, 19 July 2022 (fl), *R. Cuevas G., E.V. Sánchez R. & J.G. Morales A. 14182* (holotype ZEA; isotypes to be distributed).

**Description.** Trees 10–26 m in height, trunk 15–60 cm in diameter; bark flaky and peeling off in irregular layers, the outer reddish-brown, the inner yellow, turning pink as it oxidises. Branchlets cylindrical, 1.5–2 mm thick, brownish-grey, lenticellate and exfoliating, glabrous; axillary buds conical, 1.5–2 mm in length, 1 mm in width, glabrous; terminal buds cylindrical, 7–12 mm in length, 1 mm in width, reddish, glabrous. Leaves alternate, reddish when sprouting, mature leaves lanceolate to oblong, 7–16 × 1.3–4.7 cm, 3–6 times longer than wide, chartaceous, glabrous on both sides; base cuneate, sometimes obtuse; margins entire, sclerotic; apex acuminate; the secondary veins are inconspicuous, but recognisable on both sides, whereas the higher-order venation is not resolved, mid-vein depressed above and protruding below, secondary veins 12–23 pairs; petioles sulcate adaxially (4–) 7–12 × 1–1.8 mm, glabrous. Inflorescences axillary, paniculate-cymose, branched from near the base, rarely solitary, 1–4 cm in length, the terminal flowers often fused at their bases; peduncles 1–2 mm in length; bracts soon deciduous, concave, ovate-lanceolate, 0.7–1.9 × 0.4–0.8 mm, glabrous. Flowers ellipsoid or obovoid, 2.5–3 mm in length; pedicels 1.2–1.8 mm in length, glabrous; hypanthium 1.4–2.1 × 1.9–2 mm, externally glabrous, internally sericeous; tepals 6, fused to 1/4 of their length in the basal part, imbricate, ovate, subequal (inner ones slightly smaller), 0.8–1.3 × 0.8–0.9 mm, concave, inconspicuously fimbriated on their margins; stamen series I and II lacking; androecium with 3–5 stamens, exserted, fused at the filaments only, tomentose on both sides of filaments, 1.2–2.4 mm in length, anthers bisporangiate, ovate to oblong, tomentose at the base on the adaxial face, the rest glabrous, 1.1–1.3 × 0.8–0.9 mm, sporangia on the abaxial side of the anther, each sporangium with an oblique locule covering most of the anther body, sometimes the locule sagittate or irregular i.e. two locules fused, valves extrorse and remaining at the apex of the anther; 4–8 glands observed, at the base of the filaments or slightly above, sometimes contiguous glands fused at their bases, but with clearly separated apices, lanceolate to ovate or irregularly shaped, lamellar, 0.4–0.6 × 0.2–0.4 mm, pubescent at their base; pistil elongate, 2.3–2.7 mm in length, glabrous, ovary 0.8–1 × 0.6–0.7 mm. Fruit ellipsoid, purple with a yellow base when mature, 20–28 × 12–15 mm, glabrous;

cupule lenticellate, 12–14 mm in height, 14–18 mm in diameter at apex, 7–10 mm in depth, double-rimmed, outer margin slightly ascending to spreading, wavy, the inner margin erect, entire, 0.5–1 mm in height; pedicel in fruit turbinate, 3–5 mm in length, 3–4.5 mm in diameter distally, 1.5–2 mm basally.

**Distribution and ecology.** *Licaria ramiroi* is known from only one locality in the Sierra de Manantlán, Jalisco, Mexico. It has been recorded between 1000 and 1600 m in elevation in an ecotone between subdeciduous tropical forest and montane cloud forest. Dominant trees in this habitat correspond to individuals of the Lauraceae family, such as *Beilschmiedia manantlanensis* Cuevas & Cochrane, *Damburneya rudis* (C.K. Allen) Trofimov & Rohwer and *D. salicifolia* (Kunth) Trofimov & Rohwer. Other tree species observed are *Amyris mexicana* Lundell, *Aphananthe monoica* (Hemsl.) J.-F. Leroy, *Calatola laevigata* Standl., *Cedrela odorata* L., *Drypetes gentryi* Monach., *Myrcianthes fragrans* (Sw.) McVaugh, *Prunus cortapico* Kerber ex Koehne, *Sideroxylon brucebenzii* Cuevas & A. Vázquez, *S. portoricense* Urb. and *Trophis mexicana* (Liebm.) Bureau. Hemi-epiphytes are represented by *Balmea stormiae* Martínez, *Ficus aurea* Nutt., *Oreopanax echinops* (Schltdl. & Cham.) Decne. & Planch. and *Oreopanax sanderianus* Hemsl. and vines by *Solandra maxima* (Sessé & Moc.) P.S. Green.

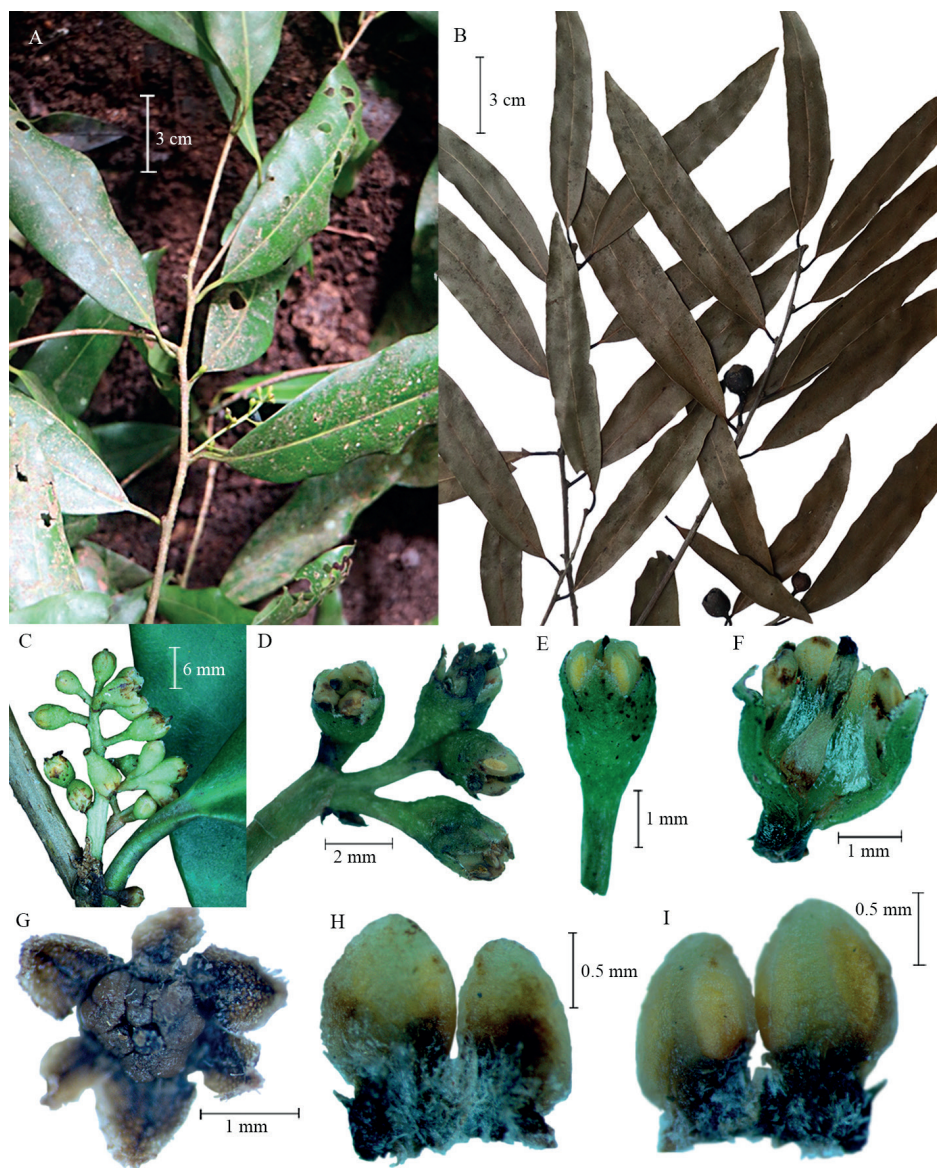
Field observations were carried out for three years; as we found no flowers or fruits during the different seasons of the year, nor observed any seedlings, in this period, this leads us to suggest that this species could have supra-annual flowering and fruiting periods.

The locality from where the new species of *Licaria* is described is an area that has been prominent for records of new species, such as *Beilschmiedia manantlanensis* (Cuevas & Cochrane, 1999), *Sideroxylon brucebenzii* (Cuevas & Vázquez-García, 2021) or disjunct distributions, such as those of *Desmopsis trunciflora* (Schltdl. & Cham.) G.E. Schatz (Cuevas et al. 2002) and *Nectandra rudis* C.K. Allen (Cuevas et al. 2008), amongst others. Fortunately, the area forms part of the Sierra de Manantlán Biosphere Reserve, ensuring a certain degree of conservation of the flora of this area, which is notable in the region for its uniqueness and the distribution of some of its species (Cuevas 2002).

The species has been recorded in flower in the months of July–August and with ripe fruits from February to March.

**Etymology.** The species honours the memory of Ramiro Cuevas Guzmán, dear brother of the first author, a person who loved the countryside and who collected plants for more than 30 years together with the author of the species, in various regions of the southern coast of Jalisco. Several of these collections are deposited in national herbaria and some have resulted in scientific novelties.

**Preliminary conservation status.** According to the Categories and Criteria of the IUCN Red List (IUCN 2012), *L. ramiroi* is assigned a preliminary status of “Critically Endangered” CR B2a C2a(ii). The known and estimated geographical distribution of this species is less than 10 km<sup>2</sup> in area and it has been recorded at only one locality, with a population size estimated at fewer than 250 mature individuals. Moreover, it should be noted that there is little natural regeneration of the species and few juvenile individuals present.



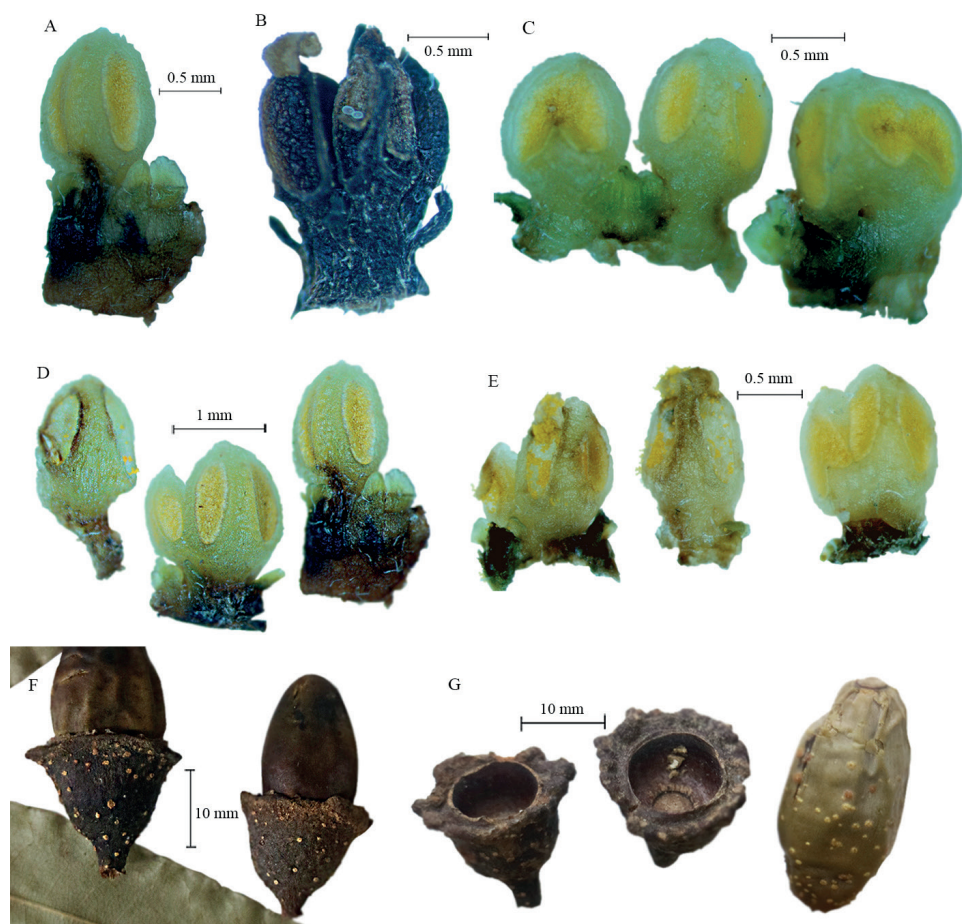
**Figure 1.** *Licaria ramiroi* Cuevas sp. nov. **A** branchlets with inflorescences **B** branchlets with immature fruit **C** close-up image of an inflorescence **D** inflorescence with flowers in top and side view, with the two terminal flowers fused at their bases **E** side view of flower **F** flower in tangential section showing pistil and sericeous internal surface of hypanthium **G** upper frontal view of a flower with stamens the tepals opened artificially **H** Pair of stamens in adaxial view **I** Pair of stamens in abaxial view.

**Additional specimens examined.** MEXICO: State of Jalisco: Municipality of Casimiro Castillo: cañada El Tecolote, 19°36'55"N, 104°18'27"W, 13 December 1998 (st), R. Cuevas, L. Guzmán & J. Aragón 6374 (ZEA); R. Cuevas, L. Guzmán &

*J. Aragón* 6367 (ZEA); cañada El Tecolote, 19°37'06"N, 104°19'29"W, 14 December 1998 (st), *R. Cuevas*, *L. Guzmán* & *J. Aragón* 6413 (ZEA); cañada de La Naranjera, 19°37'20"N, 104°20'38"W, 23 February 1999 (ripe fr), *R. Cuevas*, *L. Guzmán* & *J. Aragón* 6571 (ZEA); cañada de La Naranjera, 19°37'21"N, 104°20'33"W, 24 February 1999 (ripe fr), *R. Cuevas*, *L. Guzmán* & *J. Aragón* 6591 (ZEA); barranca de La Naranjera, 19°36'55"N, 104°18'27"W, 11 July 1999 (immature fr), *R. Cuevas*, *L. Guzmán*, *C. Palomera* & *J. Aragón* 6819 (ZEA); 19°36'55"N, 104°18'27"W, 11 July 1999 (fl), *R. Cuevas*, *L. Guzmán*, *C. Palomera* & *J. Aragón* 6820 (ZEA).

**Notes.** Due to its erect tepals, the exserted stamens with their filaments fused at the base, the anthers with large locules orientated in the longitudinal axis of the flower, with the valves opening upwards, *Licaria ramiroi* is classified in the subgen. *Licaria*, within the group of species with exserted stamens and with the locules on the external surface of the anthers (Kurz 2000). Morphological characters with narrow leaves with 12 or more secondary veins, the shape and size of the flowers, exserted stamens and the large sporangia covering most of the anther body and running lengthwise to the flower axis, relate *Licaria ramiroi* to *L. siphonantha* Lorea-Hern. but separates from this species by its fused tepals at its base, generally shorter and glabrous inflorescences, free anthers and the hypanthium internally sericeous (see Table 1). The shape and size of the flowers, the tepals fused at their bases, the glands often fused at their bases with free apices, the size of the cupules in the fruit with strongly undulating margins, as well as the shape and size of the fruit, relate *L. ramiroi* with the variable *L. triandra* (sensu Kurz (2000), including *L. cervantesii* (Kunth) Kosterm. and *Misanteca nayaritensis* Lundell), the only species of *Licaria* recorded for western Mexico (Kurz 2000), from which it is separated by the presence of stamens fused only in the filaments, while the anthers are generally free, an internally sericeous hypanthium and other characters that are presented in Table 1.

A review of 60 flowers from two individuals (20 from one and 40 from the other) collected 23 years apart, suggests that the proportion of flowers with 3, 4 and 5 stamens in whorl III is more or less equal. This phenomenon observed in *L. ramiroi* is something previously not recorded in the genus *Licaria*. The evidence supporting the notion that they are all stamens of whorl III is that all of the anthers are extrorse and there is incomplete separation of stamen primordia and, when this occurs, some of these stamens can show a certain degree of fusion at the base of the anthers (see Fig. 2). Gradation is also observed in the locules that show an incomplete separation during development, sagittate locules and others with an irregular shape. Between four and eight glands were observed in *L. ramiroi*, some of them free and others fused at their bases, but always with clearly separated apices (Fig. 2). In *L. ramiroi*, the development of more than three fertile stamens in whorl III, with the corresponding increase in glands, could be a teratological condition due to an environmental response, possibly to the infection of Diptera larvae, which were observed parasitising some of the dissected flowers. To determine if the aberrations observed in the flowers of the species are due to the presence of the indicated parasites, further research will be required.



**Figure 2.** *Licaria ramiroi* Cuevas sp. nov. **A** stamen with two pairs of glands **B** ring of stamens, with the anthers showing locules and valves and three glands in the base **C** three stamens of a flower, one showing a sagittate locule (left), the other with an irregular locule (right) and several glands **D** four stamens of a flower with several glands **E** five stamens of a flower **F** fruits with their cupules **G** one fruit and two cupules, showing the outer and inner margins.

*Licaria* has been a well-defined genus by its three bisporangiate fertile stamens in whorl III, the presence or absence of staminodes in whorls I and II and the lack of staminodes in whorl IV, a deep receptacle and a double-margined cupule (Kurz 2000). Recent molecular studies have recovered a clade within the *Ocotea* complex called “*Licaria* group and allies”, which includes, in addition to *Licaria*, other genera with deep receptacles and a double-margined cupule, including species of *Ocotea* Aubl., *Aniba* Aubl., *Dicypellium* Nees & Mart., *Kubitzkia* van der Werff, *Paraia* Rohwer, H.G. Richt. & van der Werff and *Urbanodendron* Mez (Trofimov et al. 2019).

The double-margined cupule in *L. ramiroi* suggests a morphological connection to species in genera such as *Aiouea* Aubl., *Damburneya* Raf. and *Mespilodaphne* Nees & Mart., especially with those with bisporangiate anthers. However, the species of these

genera present other characteristics that are not recorded in *L. ramiroi*, such as the fact that, in *Aiouea*, there are staminodes in the fourth androecial whorl that show a large glandular head, generally chordate to sagittate (Rohde et al. 2017); in *Damburneya*, the tepals are adaxially pubescent at the base and generally papillose towards the tips (Trofimov et al. 2016) and both genera have nine fertile stamens, occasionally six or three in *Aiouea*. *Mespilodaphne*, on the other hand, is a recently reinstated genus, it presents flowers with spreading tepals, tongue-shaped stamens, heavily papillose and tetrasporangiate (Trofimov et al. 2019). *Mocinnodaphne* Lorea-Hern., recently included in *Aiouea*, meets most of the characters of *Licaria*, with the exception of having well-developed staminodes in whorl IV (Lorea-Hernández 1995). Due to a set of characters present in *L. ramiroi*, such as its deep receptacle, fertile stamens in the III whorl, bisporangiate, cupule with double margin, lack of staminodes in the first two whorls and the fourth, we consider that the best inclusion of the species is in *Licaria*.

Understanding the morphological complexity of the “*Licaria* group and allies” within the *Ocotea* complex and taking into account the androecial morphology recorded in *L. ramiroi*, considering that it is a genetic condition, then the species could be relocated to another genus within the *Ocotea* complex, but it would be necessary to wait for the species to be included in some molecular study to better define its phylogenetic relationships.

## Acknowledgements

We thank Dr. Holger Kurz for kindly sending his doctoral thesis on the genus *Licaria*, Keith MacMillan for reviewing and correcting the English text and Francisco Lorea-Hernández and two anonymous reviewers who made very substantial contributions to improve the work. We also gratefully acknowledge the economic support of Universidad de Guadalajara and the Mexican National Council of Science and Technology, through the programme of members of the National System of Researchers.

## References

- Burger WC, van der Werff H (1990) Family #80 Lauraceae. In: Burger WC (Ed.) Flora Costaricensis. Fieldiana, Botany, new series 23: 1–138. <https://doi.org/10.5962/bhl.title.2586>
- Cuevas GR (2002) Análisis de gradientes de la vegetación de la cañada El Tecolote, en la sierra de Manantlán, Jalisco, México (Tesis doctoral). Colegio de Posgraduados, Montecillo, Texcoco, México.
- Cuevas GR, Cochrane TS (1999) *Beilschmiedia manantlanensis* (Lauraceae), una nueva especie de Jalisco, México. Novon 9(1): 18–21. <https://doi.org/10.2307/3392109>
- Cuevas GR, Vázquez-García JA (2021) Nueva especie de *Sideroxylon* de pétalos indivisos (Sapotaceae) para Jalisco, México. Revista Mexicana de Biodiversidad 92(0): e923535. <https://doi.org/10.22201/ib.20078706e.2021.92.3535>
- Cuevas GR, López-Mata L, García-Moya E (2002) Primer registro de *Desmopsis trunciflora* (Schlecht. & Cham) G.E. Schatz (Annonaceae) para el occidente de México y análisis de

- su población en la sierra de Manantlán, Jalisco. *Acta Botánica Mexicana* 58(58): 7–18. <https://doi.org/10.21829/abm58.2002.887>
- Cuevas GR, García-Moya E, Vázquez-García JA, Núñez-López NM (2008) Estructura poblacional y relaciones ambientales del árbol tropical *Nectandra rudis* (Lauraceae), una especie rara en el occidente de México. *Revista de Biología Tropical* 56: 247–256. <https://doi.org/10.15517/rbt.v56i1.5521>
- Gómez-Laurito J, Cascante A (1999) *Licaria caribaea* (Lauraceae); A new species from the Caribbean Lowlands of Costa Rica. *Novon* 9(2): 199–201. <https://doi.org/10.2307/3391798>
- IUCN (2012) IUCN red list categories and criteria, version 3.1. 2<sup>nd</sup> edn. IUCN, Gland, Switzerland and Cambridge U.K., [iv +] 32 pp. <https://portals.iucn.org/library/node/10315>
- JSTOR (2020) Global Plants. ITHAKA, New York. <http://plants.jstor.org>
- Kurz H (2000) Revision der Gattung *Licaria* (Lauraceae). *Mitteilungen aus dem Institut für allgemeine Botanik in Hamburg* 28/29: 89–221.
- Lorea-Hernández FG (1995) *Mocinnodaphne*, un género nuevo de la familia Lauraceae en la flora de México. *Acta Botánica Mexicana* 32(32): 25–32. <https://doi.org/10.21829/abm32.1995.743>
- Lorea-Hernández FG (1999) Una nueva especie de *Licaria* (Lauraceae) del sur de México. *Polibotánica* 10: 105–110. <http://www.redalyc.org/articulo.oa?id=62101006>
- Lorea-Hernández FG (2002) La familia Lauraceae en el sur de México: Diversidad, distribución y estado de conservación. *Botanical Sciences* 71(71): 59–70. <https://doi.org/10.17129/botsci.1663>
- Lorea-Hernández FG (2005) Nuevas especies de *Licaria*, *Ocotea* y *Persea* (Lauraceae) de México. *Acta Botánica Mexicana* 71(71): 61–87. <https://doi.org/10.21829/abm71.2005.995>
- Radford AE, Dickison WC, Massey JR, Bell CR (1974) *Vascular plant systematics*. Harper and Row Publishers. Nueva York, U.S.A.
- Rohde R, Rudolph B, Ruthe K, Lorea-Hernández FG, Rodríguez de Moraes PL, Li J, Rohwer JG (2017) Neither *Phoebe* nor *Cinnamomum* – the tetrasporangiate species of *Aiouea* (Lauraceae). *Taxon* 66(5): 1085–1111. <https://doi.org/10.12705/665.6>
- Trofimov D, Rudolph B, Rohwer JG (2016) Phylogenetic study of the genus *Nectandra* (Lauraceae), and reinstatement of *Damburneya*. *Taxon* 65(5): 980–996. <https://doi.org/10.12705/655.3>
- Trofimov D, Rodríguez de Moraes PL, Rohwer JG (2019) Towards a phylogenetic classification of the *Ocotea* complex (Lauraceae): Classification principles and reinstatement of *Mespilodaphne*. *Botanical Journal of the Linnean Society* 190(1): 25–50. <https://doi.org/10.1093/botlinnean/boz010>
- Tropicos (2022) Tropicos.org. Missouri Botanical Garden. <http://www.tropicos.org>
- van der Werff H (1991) A key to the genera of Lauraceae in the New World. *Annals of the Missouri Botanical Garden* 78(2): 377–387. <https://doi.org/10.2307/2399567>
- van der Werff H (2009a) Nine new species of *Licaria* (Lauraceae) from tropical America. *Harvard Papers in Botany* 14(2): 145–159. <https://doi.org/10.3100/025.014.0206>
- van der Werff H (2009b) Lauraceae (in part). *Flora Mesoamericana* 2(1): 1–248. <http://legacy.tropicos.org/Name/42000016?projectid=3&langid=66>
- van der Werff H, Richter HG (1996) Toward an improved classification of Lauraceae. *Annals of the Missouri Botanical Garden* 83(3): 409–418. <https://doi.org/10.2307/2399870>
- van der Werff H, Vicentini A (2000) New species of Lauraceae from Central Amazonia, Brazil. *Novon* 10(3): 264–297. <https://doi.org/10.2307/3393111>

# *Sinosenecio minshanicus* (Asteraceae, Senecioneae), a new species from south-eastern Gansu and northern Sichuan, China

Xiu-Jiang Su<sup>1,2\*</sup>, Wen-Qun Fei<sup>1,3\*</sup>, Ding Zhao<sup>4</sup>, Ying Liu<sup>5</sup>, Qin-Er Yang<sup>1,6</sup>

**1** Key Laboratory of Plant Resources Conservation and Sustainable Utilization, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510655, Guangdong, China **2** Administration Bureau of Baiyunshan Nature Reserve, Baojing 416500, Hunan, China **3** University of Chinese Academy of Sciences, Beijing 100049, China **4** Administration Bureau of Xuebaoding National Nature Reserve, Pingwu 622550, Sichuan, China **5** State Key Laboratory of Biocontrol and Guangdong Key Laboratory of Plant Resources, School of Life Sciences, Sun Yat-sen University, No. 135, Xin-Gang-Xi Road, Guangzhou 510275, Guangdong, China **6** Center of Conservation Biology, Core Botanical Gardens, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510655, Guangdong, China

Corresponding author: Qin-Er Yang ([qeyang@scib.ac.cn](mailto:qeyang@scib.ac.cn))

Academic editor: Peter de Lange | Received 12 November 2022 | Accepted 15 December 2022 | Published 10 January 2023

**Citation:** Su X-J, Fei W-Q, Zhao D, Liu Y, Yang Q-E (2023) *Sinosenecio minshanicus* (Asteraceae, Senecioneae), a new species from south-eastern Gansu and northern Sichuan, China. *PhytoKeys* 218: 79–91. <https://doi.org/10.3897/phytokeys.218.97475>

## Abstract

*Sinosenecio minshanicus* (Asteraceae, Senecioneae), a new species from south-eastern Gansu (Wenxian and Zhugu counties) and northern Sichuan (Pingwu county), China, is described and illustrated. This species is similar to *S. rotundifolius*, a species locally endemic to Songpan county in northern Sichuan, in having a scapigerous habit, orbicular leaves and solitary capitula, but differs by the presence (vs. absence) of stolons and by having thinner rhizomes (ca. 2 mm vs. more than 5 mm in diameter), stems proximally sparsely fulvous arachnoid or glabrescent (vs. densely sericeous-villous) and obscure (vs. conspicuous) main veins on adaxial surface of leaves. The chromosome number of the new species is reported to be  $2n = 60$ . Colour photographs of living plants in the wild and a distribution map are provided for the new species and *S. rotundifolius*. The geographical distribution of *S. rotundifolius* is also corrected, with the previous record of this species from south-eastern Gansu (Wenxian county) actually referring to *S. minshanicus*.

## Keywords

chromosome number, Compositae, floral micromorphology, *Sinosenecio rotundifolius*, taxonomy

\* These authors contributed equally to this work.

## Introduction

During a botanical trip in 2016 in connection with the biodiversity survey of the Xuebaoding National Nature Reserve in Pingwu county in northern Sichuan province, China, we discovered an unusual population of *Sinosenecio* B. Nord. (Asteraceae, Senecioneae) (Figs 1–3). At first glance, the plants most closely resemble those of *S. rotundifolius* Y.L. Chen in having a scapigerous habit, orbicular leaves and solitary capitula, but are distinguishable immediately by having long and slender stolons (Figs 1E, 2A, B and 3). Closer examination revealed that the population in question is distinct from *S. rotundifolius* also by having thinner rhizomes (ca. 2 mm vs. more than 5 mm in diameter), stems proximally sparsely fulvous arachnoid or glabrescent (vs. densely sericeous-villous) and obscure (vs. conspicuous) main veins on adaxial surface of leaves (Figs 1E, 2D, 4, 5E and F). Moreover, the plants of the population prefer shaded and moist habitats on rocky cliffs and slopes along stream sides (Fig. 1A–D), while *S. rotundifolius* has been found only amongst *Betula* or *Rosa* bushes on arid slopes (Fig. 5A). During a botanical trip to Zhugqu county in south-eastern Gansu province in 2022, we discovered a population of *Sinosenecio* with the same morphological characters and habitats (Figs 6–7) as the population in northern Sichuan. We therefore determined that these two populations represent a hitherto undescribed species. Our re-examination of two collections identified on the determination slips or cited as *S. rotundifolius* by Liu (2010), *Baishuijiang Exped. 0320* (PE; <http://www.cvh.ac.cn/spms/detail.php?id=eaffdad4>) and *Baishuijiang Exped. 0800* (PE; <http://www.cvh.ac.cn/spms/detail.php?id=eaffdb62>), from Wenxian county in south-eastern Gansu revealed that they also belong to this new species. This species is described below and its somatic chromosome number ( $2n$ ) is also reported.

## Taxonomic treatment

***Sinosenecio minshanicus* XiuJ.Su, W.Q.Fei, YingLiu & Q.E.Yang, sp. nov.**

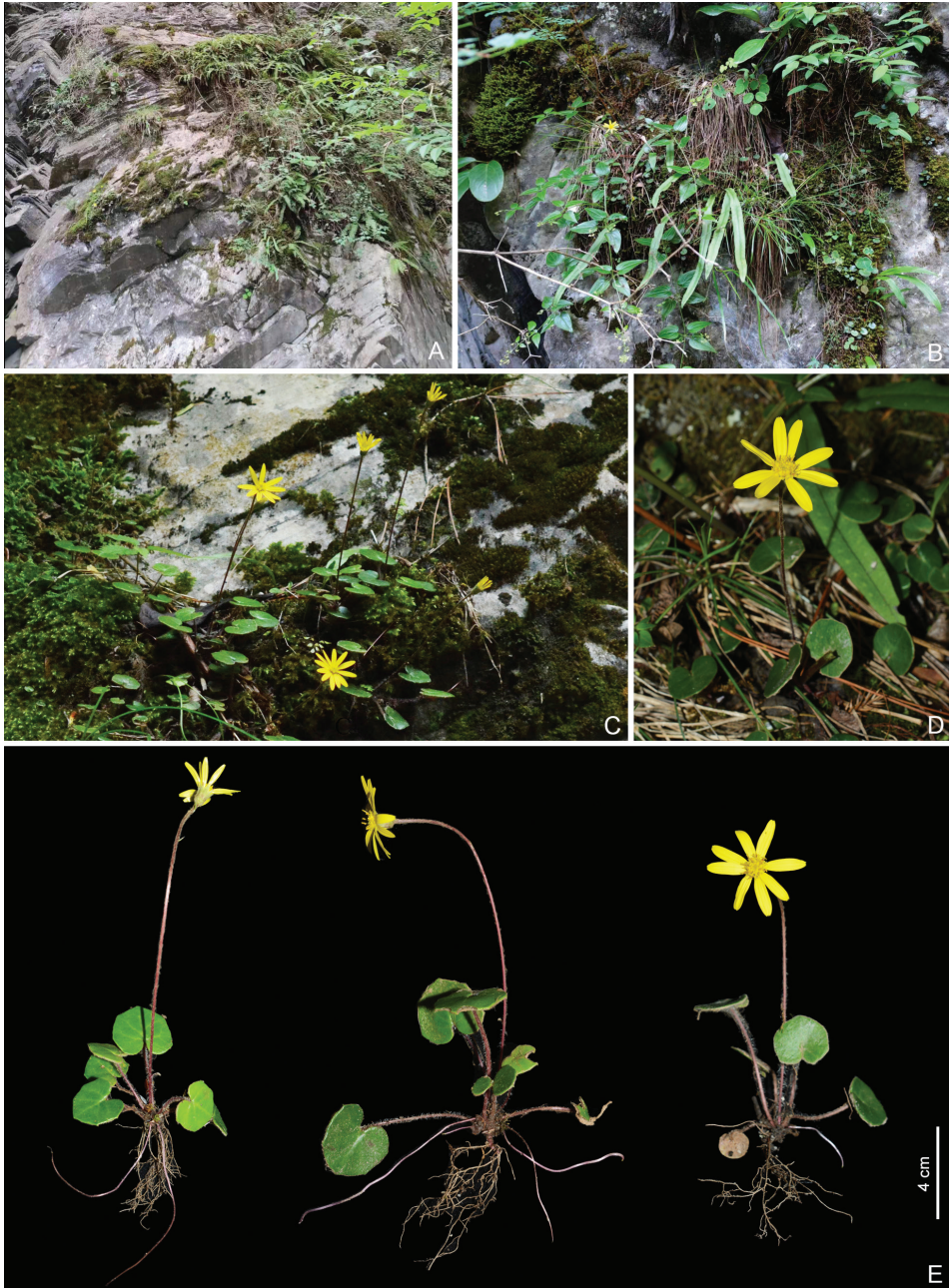
urn:lsid:ipni.org:names:77311682-1

Figs 1–3, 6 and 7

**Type.** CHINA. Sichuan province: Pingwu county, Huya town, Xuebaoding National Nature Reserve, on moist rocky cliff in valley, alt. ca. 2240 m, 6 June 2022, *W.Q. Fei & J. Li 563* (holotype: IBSC; isotypes: CDBI, PE, SYS). Fig. 3.

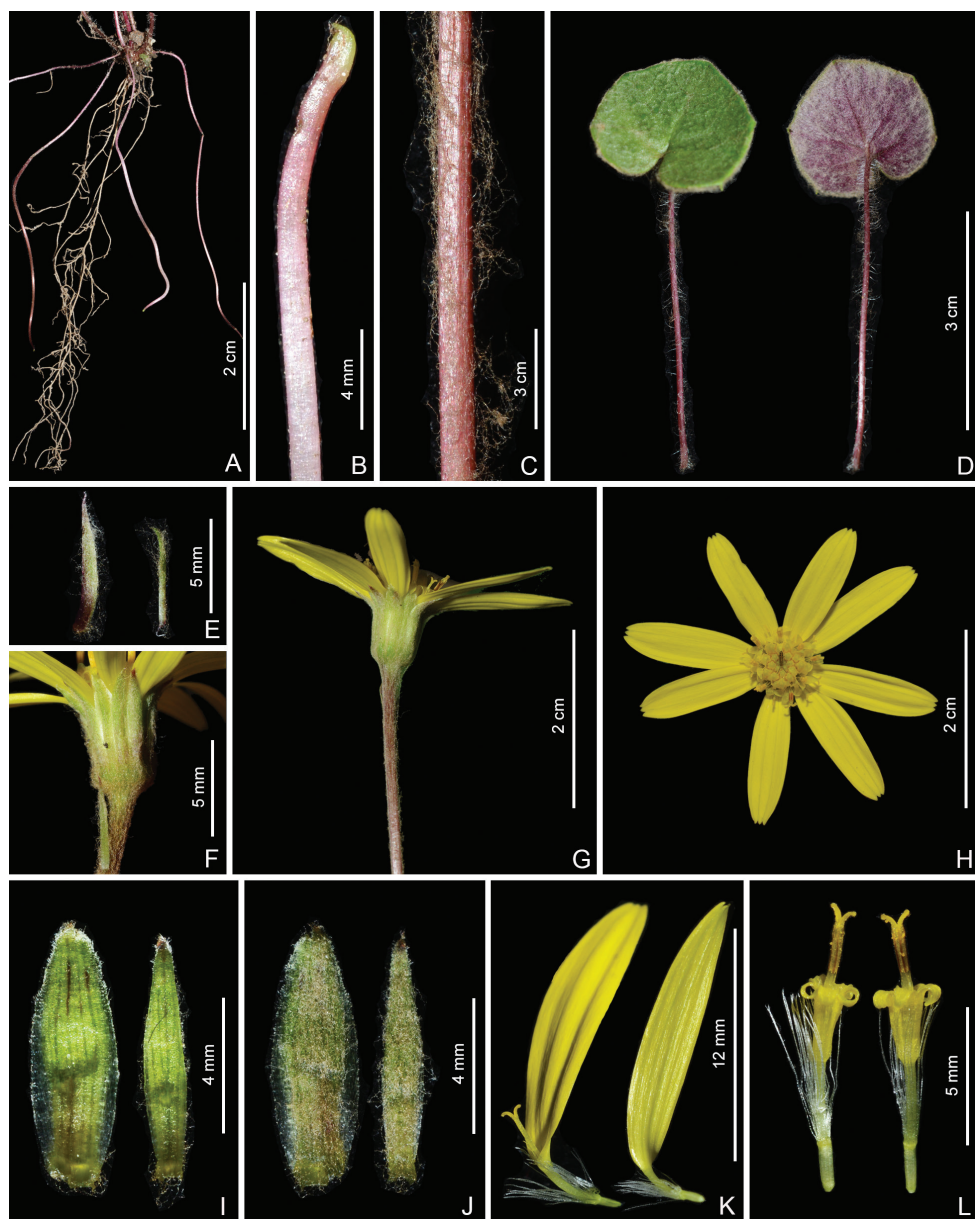
**Diagnosis.** *Sinosenecio minshanicus* most closely resembles *S. rotundifolius* in having a scapigerous habit, orbicular leaves and solitary capitula, but differs by the presence (vs. absence) of stolons and by having thinner rhizomes (ca. 2 mm vs. more than 5 mm in diameter), stems proximally sparsely fulvous arachnoid or glabrescent (vs. densely sericeous-villous) and obscure (vs. conspicuous) main veins on adaxial surface of leaves.

**Description.** Scapigerous herbs with axillary slender stolons. Rhizomes short, ca. 2 mm in diameter, with few fibrous roots. Stems solitary, erect, purplish, scapiform, 7.5–17 cm tall, simple, proximally sparsely fulvous arachnoid or glabrescent, distally



**Figure 1.** *Sinosenecio minshanicus* sp. nov. in the wild (China, Sichuan province, Pingwu county, the type locality) **A, B** habitat **C, D** habitat and habit **E** habit. Photographed by W.Q. Fei.

fulvous pubescent with uniseriate hairs or glabrescent. Leaves radical, rosulate; petioles 0.5–5 cm long, slender, basally expanded, pubescent with uniseriate hairs; blades orbicular or reniform-orbicular,  $0.5\text{--}1.7 \times 0.7\text{--}2.3$  cm, subleathery, abaxially purplish,



**Figure 2.** *Sinosenecio minshanicus* sp. nov. in the wild (China, Sichuan province, Pingwu county, the type locality) **A** stolons and roots **B** close-up of stolon **C** middle portion of scape **D** leaf (left: adaxial side; right: abaxial side) **E** bracts on the scape **F** close-up of capitulum (lateral view) **G** capitulum (lateral view) and distal portion of scape **H** capitulum (top view) **I** phyllaries (adaxial side) **J** phyllaries (abaxial side) **K** ray florets **L** disc florets. Photographed by W.Q. Fei.



**Figure 3.** Holotype sheet of *Sinosenecio minshanicus* sp. nov.



Figure 4. Holotype sheet of *Sinosenecio rotundifolius*.

fulvous arachnoid, adaxially green, glabrous, palmately 5-veined, veins obscure adaxially and slightly raised abaxially, margin subentire or repand and mucronulate, base cordate, apex acute or rounded. Capitula terminal, solitary, radiating, 2.5–3.4 cm in



**Figure 5.** *Sinosenecio rotundifolius* in the wild (China, Sichuan province, Songpan county, the type locality) **A** habitat **B–D** habit **E** basal part of an individual with rhizome and roots, showing the densely sericeous-villous collar, stout rhizome and absence of stolons **F** leaves (adaxial side; inset: abaxial side) **G** capitula (left: top view; right: lateral view). Photographed by Ying Liu.

diameter, scape with 1–3 linear bracts 2–5 mm long in middle or upper parts. Involucres long-campanulate, ca. 5 × 7–10 mm, ecalyculate, fulvous pubescent; phyllaries 10–14, oblong-lanceolate, 1–2 mm wide, margin narrowly scarious, apically purplish, fulvous pubescent. Ray florets 8–12; tube 3–3.5 mm long; lamina yellow, oblong, 10–14 × 2–3 mm, 4-veined, apically denticulate. Disc florets 15–32; corolla yellow, ca. 6 mm long, with ca. 2.5 mm long tube and funnel-form campanulate limb; lobes ovate-lanceolate, apically acuminate. Anthers oblong, 2.5 mm long, basally obtuse to rounded, appendages ovate-lanceolate; anther-collar cells uniform (Fig. 8A and B); endothelial cell wall thickenings strictly polar (Fig. 8C and D). Style branches 0.7 mm

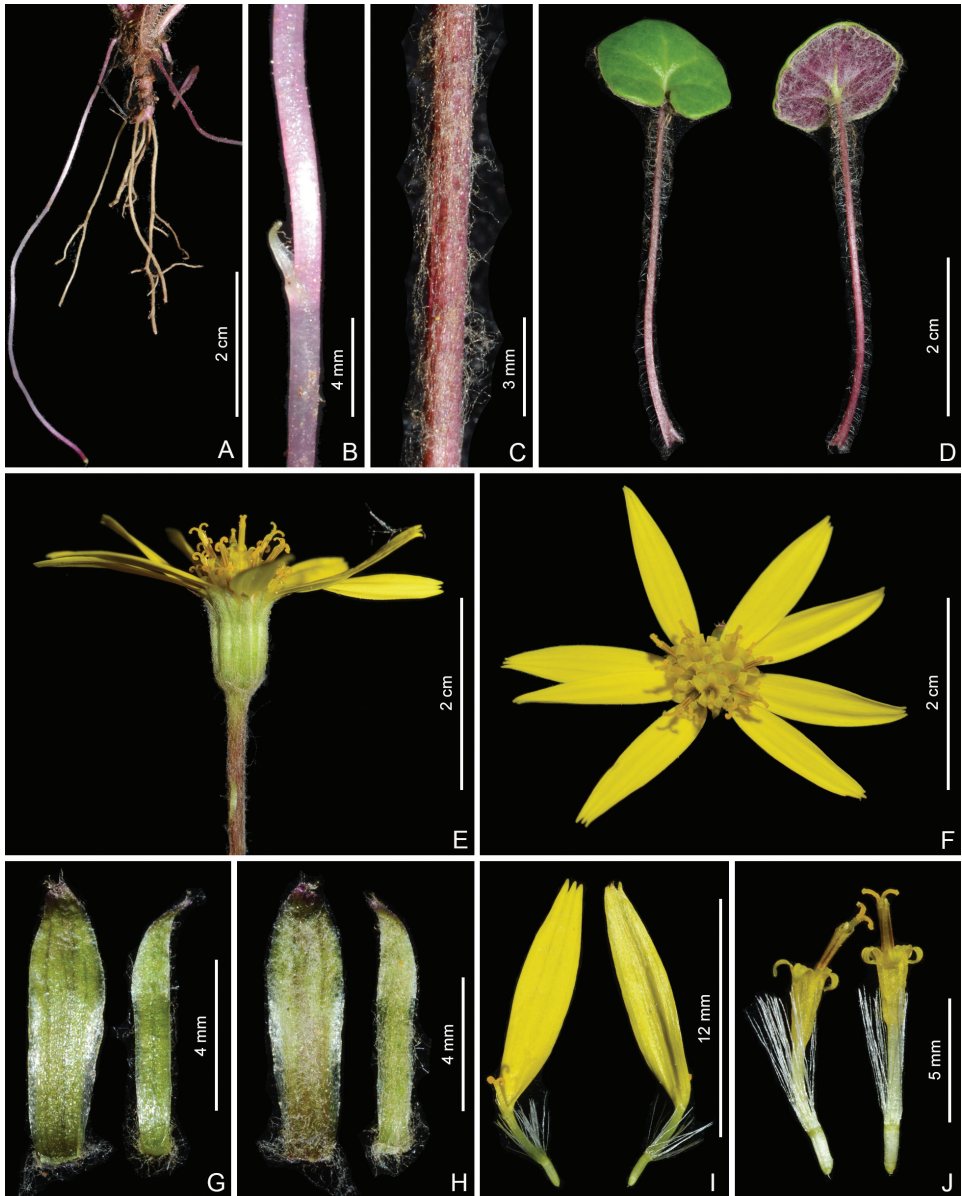


**Figure 6.** *Sinosenecio minshanicus* sp. nov. in the wild (China, Gansu province, Zhugqu county) **A** habitat **B** habitat and habit **C** habit. Photographed by W.Q. Fei.

long, recurved, apically truncate, papillose. Achenes (immature) cylindrical, ca. 2 mm long, glabrous, smooth, ribbed (Fig. 8E and F). Pappus white, 4–6 mm long.  $2n = 60$  (Fig. 9A and B).

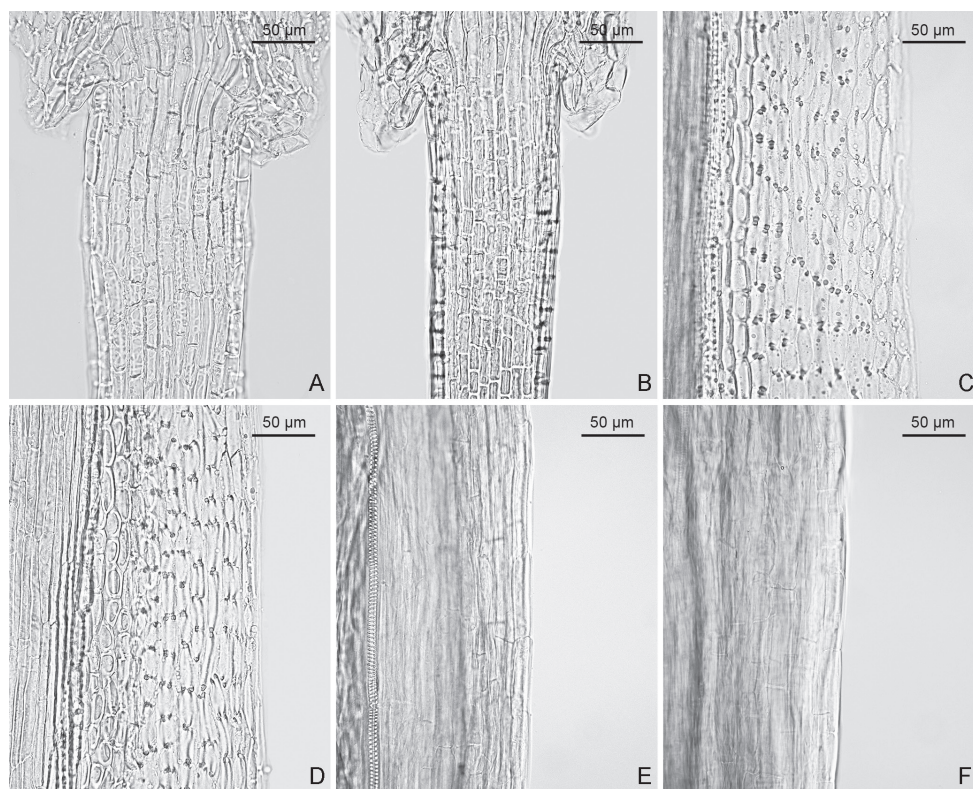
**Phenology.** Flowering in June; fruiting in July.

**Etymology.** The specific epithet, “*minshanicus*”, is derived from Min Shan, a chain of mountains extending from south-western Gansu to northern Sichuan, China. The currently known localities of the new species are all situated in the Minshan Mountains region.

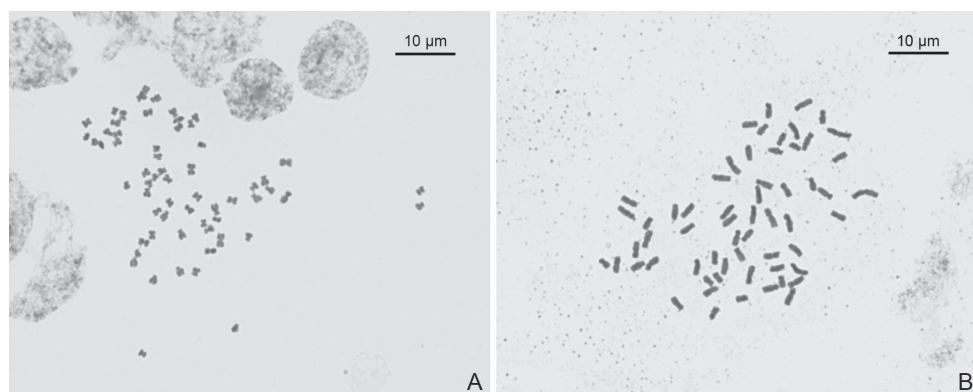


**Figure 7.** *Sinosenecio minshanicus* sp. nov. in the wild (China, Gansu province, Zhugqu county) **A** stolons and roots **B** close-up of stolon **C** middle portion of scape **D** leaf (left: adaxial side; right: abaxial side) **E** capitulum (lateral view) and distal portion of scape **F** capitulum (top view) **G** phyllaries (adaxial side) **H** phyllaries (abaxial side) **I** ray florets **J** disc florets. Photographed by W.Q. Fei.

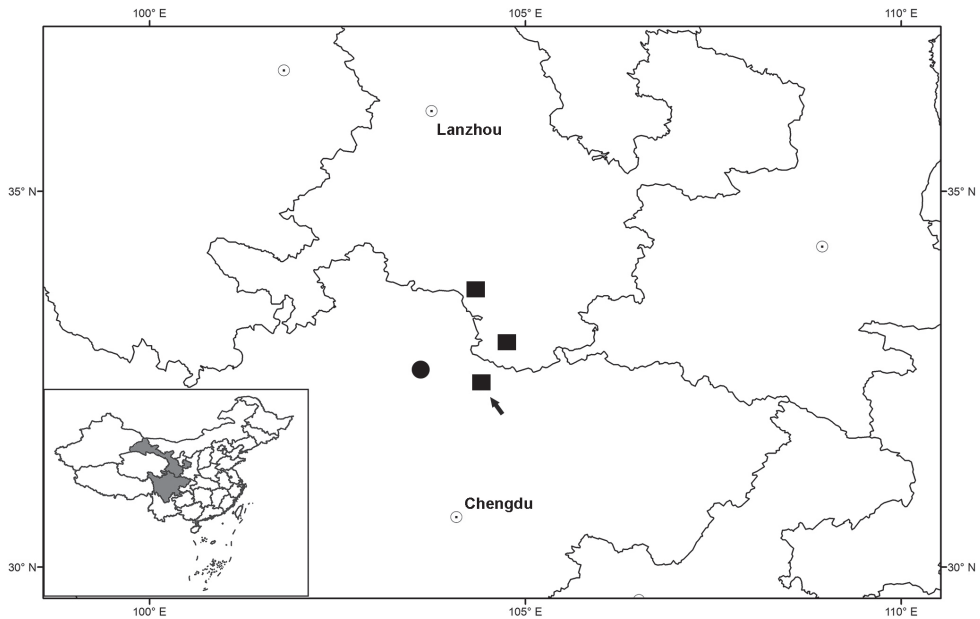
**Distribution.** *Sinosenecio minshanicus* is currently known from south-eastern Gansu (Wenxian and Zhugqu counties) and northern Sichuan (Pingwu county), China (Fig. 10). It grows on shaded and moist places in forests or on rocky cliffs and slopes along stream sides at altitudes of 2200–3000 m above sea level.



**Figure 8.** Two floral micromorphological characters (**A–D**) and achene surface (**E, F**) of two populations of *Sinosenecio minshanicus* sp. nov. **A, B** uniformly-sized cells of filament collar of stamens **C, D** strictly polar endothelial cell wall thickenings **E, F** smooth achene surface. Voucher: **A, C, E** from W.Q. Fei & J. Li 598 (IBSC, SYS) from Zhugqu county in south-eastern Gansu, China **B, D, F** from W.Q. Fei & J. Li 563 (CDBI, IBSC, PE, SYS) from Pingwu county in northern Sichuan province, China.



**Figure 9.** Mitotic metaphase chromosomes ( $2n = 60$ ) of two populations of *Sinosenecio minshanicus* sp. nov. **A** population from Zhugqu county in south-eastern Gansu province, China; voucher: W. Q. Fei & J. Li 598 (IBSC, SYS) **B** population from Pingwu county in northern Sichuan province, China; voucher: W.Q. Fei & J. Li 563 (CDBI, IBSC, PE, SYS).



**Figure 10.** Distribution of *Sinosenecio minshanicus* sp. nov. (■) and *S. rotundifolius* (●). The arrow indicates the type locality, i.e. Pingwu county in Sichuan province, China.

**Additional specimens examined.** CHINA. Gansu province: Wenxian county, Baishuijiang Nature Reserve, Qiujiaba, on slope in forest, alt. 2500 m, 26 June 2006, *Baishuijiang Exped. 0320* (PE); Wenxian county, Baishuijiang Nature Reserve, in *Abies* and *Rhododendron* forests, alt. 3000 m, 30 June 2006, *Baishuijiang Exped. 0800* (PE); Zhugqu county, Chagang forestry station, in grasses and mosses on shaded rocky slopes, alt. ca. 2400 m, 21 June 2022, *W. Q. Fei & J. Li 598* (IBSC, SYS).

**Conservation status.** *Sinosenecio minshanicus* is currently known from Wenxian and Zhugqu counties in south-eastern Gansu and Pingwu county in northern Sichuan, China. Only approximately 30 to 50 mature individuals were discovered each in the Pingwu and Zhugqu populations. They are scattered within ca. 1 km along a valley. Data of the size of the two Wenxian populations are not available. Although the known populations of *S. minshanicus* are all located within national nature reserves, some human activities, road building in particular, may destroy their habitats and, thus, severely affect the survival of this species. According to the IUCN Red List Categories and Criteria (IUCN 2012), *S. minshanicus* may better be categorised as Endangered (EN).

**Notes.** The genus *Sinosenecio* as defined by Chen et al. (2011) encompasses two major groups of species, with one having strictly polar anther endothelial cell wall thickenings and base chromosome number of  $x = 30$  and occurring in mountainous areas largely surrounding the Sichuan basin in south-western China and the other having polar and radial thickenings and base chromosome number of  $x = 24$  (rarely 13) and largely occurring in mountainous areas in central and southern China (Liu 2010;

Chen et al. 2011; Liu and Yang 2011a, b, 2012; Liu et al. 2019; Zou et al. 2020; Chen et al. 2022; Peng et al. 2022; Su et al. 2023). Obviously, *S. minshanicus* belongs to the first group, in which 15 species are currently recognised, including *S. homogyniphyllus* (Cumm.) B. Nord., the type species of *Sinosenecio* and *S. rotundifolius*, the putative closest ally of *S. minshanicus* (Liu 2010; Chen et al. 2011; Chen et al. 2022; Su et al. 2023). In this group, *S. minshanicus* is the only species hitherto known to have slender stolons.

*Sinosenecio rotundifolius* was described on the basis of a single collection, *Inst. Biol. Sichuan Exped. 702* (Fig. 4), from Songpan county in northern Sichuan, China (Chen 1988). It was recorded to be locally endemic to Songpan in the account of *Sinosenecio* in the “Flora Reipublicae Popularis Sinicae” (Chen 1999). The results of our observation of living plants of this species from the type locality are shown in Fig. 5. As mentioned earlier, Liu (2010) cited two collections, *Baishuijiang Exped. 0320* (PE) and *Baishuijiang Exped. 0800* (PE), from Wenxian county in south-eastern Gansu under *S. rotundifolius*, thus extending the distributional range of this species. This treatment was adopted by Chen et al. (2011) in the account of *Sinosenecio* in the “Flora of China”. We re-examined these two collections and found that they have slender stolons and match *S. minshanicus* well also in other characters and thus belong to this species. The previous record of *S. rotundifolius* from south-eastern Gansu actually refers to *S. minshanicus*. Currently *S. rotundifolius* is indeed known only from its type locality in Songpan county in northern Sichuan, not occurring in south-eastern Gansu. As pointed out by Jeffrey and Chen (1984), *Sinosenecio* is noteworthy for the narrow endemism of many of its species.

*Sinosenecio minshanicus* occurs in the same valley together with another species of the same group in the genus, i.e. *S. pingwuensis* Xiu J. Su et al. (Su et al. 2023). Both of them prefer shaded and moist microhabitat and share the same flowering time (June). However, we did not observe any morphologically putative hybrids between them, which is probably due to isolation via intrinsic post-zygotic barriers.

## Acknowledgements

We are grateful to Dr. Peter de Lange, Dr. Peter Pelser and Dr. Tony Bean for their valuable comments on the manuscript. We thank Yong Shen with the Xuebaoding National Nature Reserve in Pingwu County, Sichuan, China, for his help in our field work. This work was financially supported by the National Natural Science Foundation of China (grant nos. 32070238, 31770216).

## References

- Chen YL (1988) Eight new species of the tribe Senecioneae (Compositae) from China. *Zhiwu Fenlei Xuebao* 26(1): 50–57.
- Chen YL (1999) Compositae-Senecioneae. In: Chen YL (Ed.) *Flora Reipublicae Popularis Sinicae* Vol. 77 (1). Science Press, Beijing, 1–358.

- Chen YL, Liu Y, Yang QE, Nordenstam B, Jeffrey C (2011) *Sinosenecio* B. Nordenstam. In: Wu ZY, Raven PH, Hong DY (Eds) Flora of China Vol. 20–21. Science Press, Beijing, 464–481.
- Chen B, Liu Y, Luo JX, Wang Q, Yang QE (2022) *Sinosenecio jiuzhaigouensis* (Asteraceae, Senecioneae), a new species from Sichuan, China. Phytotaxa 544(3): 289–294. <https://doi.org/10.11646/phytotaxa.544.3.3>
- IUCN (2012) IUCN Red List Categories and Criteria: Version 3.1. 2<sup>nd</sup> edn. Gland, Switzerland and Cambridge, UK, 1–32.
- Jeffrey C, Chen YL (1984) Taxonomic studies on the tribe Senecioneae (Compositae) of Eastern Asia. Kew Bulletin 39(2): 205–446. <https://doi.org/10.2307/4110124>
- Liu Y (2010) Systematics of the genus *Sinosenecio* B. Nord. (Asteraceae). Ph.D. thesis, Institute of Botany, Chinese Academy of Sciences, Beijing, 1–277.
- Liu Y, Yang QE (2011a) Cytology and its systematic implications in *Sinosenecio* (Senecioneae-Asteraceae) and two closely related genera. Plant Systematics and Evolution 291(1–2): 7–24. <https://doi.org/10.1007/s00606-010-0365-3>
- Liu Y, Yang QE (2011b) Floral micromorphology and its systematic implications in the genus *Sinosenecio* (Senecioneae-Asteraceae). Plant Systematics and Evolution 291(3–4): 243–256. <https://doi.org/10.1007/s00606-010-0385-z>
- Liu Y, Yang QE (2012) *Sinosenecio jiangxiensis* (Asteraceae), a new species from Jiangxi, China. Botanical Studies (Taipei, Taiwan) 53(3): 401–414.
- Liu Y, Xu Y, Yang QE (2019) *Sinosenecio peltatus* (Asteraceae, Senecioneae), a remarkably distinctive new species from Guangdong, China. Phytotaxa 406(3): 206–212. <https://doi.org/10.11646/phytotaxa.406.3.7>
- Peng JY, Zhang DG, Deng T, Huang XH, Chen JT, Meng Y, Wang Y, Zhou Q (2022) *Sinosenecio yangii* (Asteraceae), a new species from Guizhou, China. PhytoKeys 210(34): 1–13. <https://doi.org/10.3897/phytokeys.5555.89480>
- Su XJ, Fei WQ, Liu Y, Yang QE (2023) (in press) *Sinosenecio pingwuensis* (Asteraceae, Senecioneae), a new species from northern Sichuan, China. PhytoKeys.
- Zou CY, Liu Y, Liu Y (2020) *Sinosenecio ovatifolius* (Asteraceae), a new species from Guangxi, China. Phytotaxa 460(2): 149–159. <https://doi.org/10.11646/phytotaxa.460.2.5>



# Three new species of *Mitrephora* (Annonaceae) from Thailand

Charan Leeratiwong<sup>1</sup>, Piya Chalermglin<sup>2</sup>, Richard M. K. Saunders<sup>3</sup>

**1** Division of Biological Science, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, 90112, Thailand **2** Agricultural Technology Department, Thailand Institute of Scientific & Technological Research, 35 Technopolis, Liap Khlong Ha Road, Khlong Luang District, Pathum Thani Province 12120, Thailand **3** Division of Ecology & Biodiversity, School of Biological Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong, China

Corresponding author: Richard M. K. Saunders ([saunders@hku.hk](mailto:saunders@hku.hk))

Academic editor: T. L. P. Couvreur | Received 12 August 2022 | Accepted 12 December 2022 | Published 12 January 2023

**Citation:** Leeratiwong C, Chalermglin P, Saunders RMK (2023) Three new species of *Mitrephora* (Annonaceae) from Thailand. *PhytoKeys* 218: 93–107. <https://doi.org/10.3897/phytokeys.218.91582>

## Abstract

Three new *Mitrephora* species (Annonaceae), *M. langsuanensis* **sp. nov.**, *M. sirindhorniae* **sp. nov.** and *M. sukhothaiensis* **sp. nov.**, are described from Thailand. *Mitrephora langsuanensis* resembles *M. macclurei*, but its leaves have more secondary veins, and its flowers have more carpels, with yellow-and-pink striped outer petals with a margin that becomes undulate with age. *Mitrephora sirindhorniae* resembles *M. tomentosa*, but has larger sepals and petals, longer flowering pedicels, and shorter monocarp stipes, with monocarps that have a longitudinal ridge. *Mitrephora sukhothaiensis* is distinct from its Thai congeners in having outer petals that reflex at maturity and inner petals with a pair of appendages on the margin adaxially. The addition of these three new taxa raises the total number of *Mitrephora* species in Thailand to 14. An identification key for Thai species is provided.

## Keywords

Annonaceae, *Mitrephora langsuanensis*, *Mitrephora sirindhorniae*, *Mitrephora sukhothaiensis*, new species, Thailand

## Introduction

*Mitrephora* Hook.f. & Thomson (Annonaceae subfam. Malmeeoideae tribe Miliuseae: Chatrou et al. 2012; Guo et al. 2017) is a horticulturally important genus of small tropical and subtropical trees that often bear attractive, flamboyant flowers. The only

comprehensive taxonomic revision of the genus (Weerasooriya and Saunders 2010) recognised 47 species, although three additional species have since been described (Okada 2014; Damthongdee et al. 2019; Saunders and Chalermglin 2019).

The flowers are pendent and have two petal whorls, each of three parts. The inner whorl forms a mitriform dome ('type III' sensu Saunders 2010) that forms a floral chamber that is likely to function in secondary pollen presentation, capturing pollen that is released from the anthers and retained by hairs on the inner surface of the floral chamber (Saunders 2020). As with most Annonaceae species, the flowers are bisexual: although *Mitrephora* species are self-compatible, self-fertilisation is largely avoided by protogyny (Weerasooriya and Saunders 2010; Pang and Saunders 2014). *Mitrephora* species are likely to be pollinated by small beetles (Weerasooriya and Saunders 2010). The flowers are apocarpous and give rise to fruits comprising separate 'monocarps' that are derived from individual fertilised carpels.

Eleven *Mitrephora* species are currently recognised from Thailand (Weerasooriya and Saunders 2010; Damthongdee et al. 2019; Saunders and Chalermglin 2019; Weerasooriya et al. 2022), viz. *M. alba* Ridl., *M. chulabhorniana* Damth., Aongyong & Chaowasku, *M. keithii* Ridl., *M. macclurei* Weeras. & R.M.K.Saunders, *M. monocarpa* R.M.K.Saunders & Chalermglin, *M. sirikitiae* Weeras., Chalermglin & R.M.K.Saunders, *M. teysmannii* Scheff., *M. tomentosa* Hook.f. & Thomson, *M. vulpina* C.E.C.Fisch., *M. wangii* Hu, and *M. winitii* Craib. We describe three new species here, viz. *M. langsuanensis* Leerat., Chalermglin & R.M.K.Saunders, *M. sirindhorniae* Chalermglin, Leerat. & R.M.K.Saunders and *M. sukhothaiensis* Leerat., Chalermglin & R.M.K.Saunders.

The species descriptions provided here are based on observations from living plants (cultivated) and herbarium material (from BKF, HKU, KKU, PSU, QBG and SING herbaria). Taxonomic conclusions were based on comparisons with the extensive dataset generated by Weerasooriya and Saunders (2010). Data obtained from living plants (such as overall height) were obtained during the third growing season from four cultivated individuals of each species, grafted from top shoots. They were grown in full sunlight and irrigated.

## New species descriptions

### *Mitrephora langsuanensis* Leerat., Chalermglin & R.M.K.Saunders, sp. nov.

urn:lsid:ipni.org:names:77311807-1

Figs 1, 2

**Diagnosis.** *Mitrephora langsuanensis* is similar to *M. macclurei* Weerasooriya & R.M.K.Saunders, but differs in having: leaves with more secondary veins (7–14 pairs), sometimes with domatia abaxially; yellow outer petals with pink stripes, densely hairy abaxially, and with a margin that becomes undulate with age; more carpels per flower (10–12); and longer fruiting pedicels (20–25 mm).

**Types.** **THAILAND:** TISTR Annonaceae collection plot, Khlong Luang District, Pathum Thani Province, Central Thailand, ca. 5 m alt., 3 May 2021, *P. Chalermglin*

640503 (originally from Phu Muang temple, Lang Suan District, Chumphon Province, Peninsular Thailand, ca. 100 m alt.) (holotype PSU; isotypes BKF, KKU, QBG).

**Description (from cultivated material).** Small trees, to 4 m (in cultivation). Young branches densely pubescent. Leaf laminas coriaceous, (elliptic-)lanceolate, (5.5–)8–22 by 3–5 cm, base obtuse or rounded, apex acute to acuminate, glossy, glabrous adaxially, sparsely to moderately pubescent (sometimes pilose) abaxially, secondary veins 7–14 pairs per leaf, sometimes with domatia at axils of secondary veins abaxially; petioles 6–12 mm long, moderately pubescent. Inflorescence rachides simple, with rachis internodes remaining short, 2–4 mm long, 2–3-flowered, densely pubescent; pedicels 23–30 mm long. Sepals free, broadly ovate, not imbricate, 4–6 by 5.5–6.5 mm, densely pubescent abaxially, glabrous to sparsely pubescent, denser at margin adaxially. Outer petals creamy white, turning yellow with pink stripes, ovate, 20–27 by 15–17 mm, not clawed, margin undulate with age, acute, densely pubescent ab- and adaxially. Inner petals with greenish-yellow claw, purple towards apex with a yellow stripe, 13–15 by 9–11 mm, claw incurved, densely pubescent ab- and adaxially. Stamens 1.2–1.3 mm long, connective truncate, glabrous. Carpels 10–12 per flower, 2–2.7 mm long; ovary oblong, 1.3–1.6 mm long, moderately pubescent; stigma subglobose, 0.4–0.6 mm long, hairy; ovules 4–8 per carpel. Fruits with up to 12 monocarps, borne on a pedicel 20–25 mm long, 3–5 mm wide, densely pubescent. Monocarps yellow when ripe, ellipsoid, ovoid to oblong-ellipsoid, 20–40 by 17–20 mm, smooth, with longitudinal ridge, sparsely pubescent; stipes 16–20 mm long, moderately pubescent. Seeds 2–6 per monocarp, semi-lenticular (lowermost and uppermost within monocarp) or discoid (others), 10–13 by 5–8 mm, glabrous, pitted.

**Phenology (in cultivation).** Flowering between May and June; fruiting in May.

**Distribution and habitat.** Endemic to Chumphon Province, Peninsular Thailand (Fig. 3). Growing on limestone hill in tropical rain forest; ca. 100 m alt.

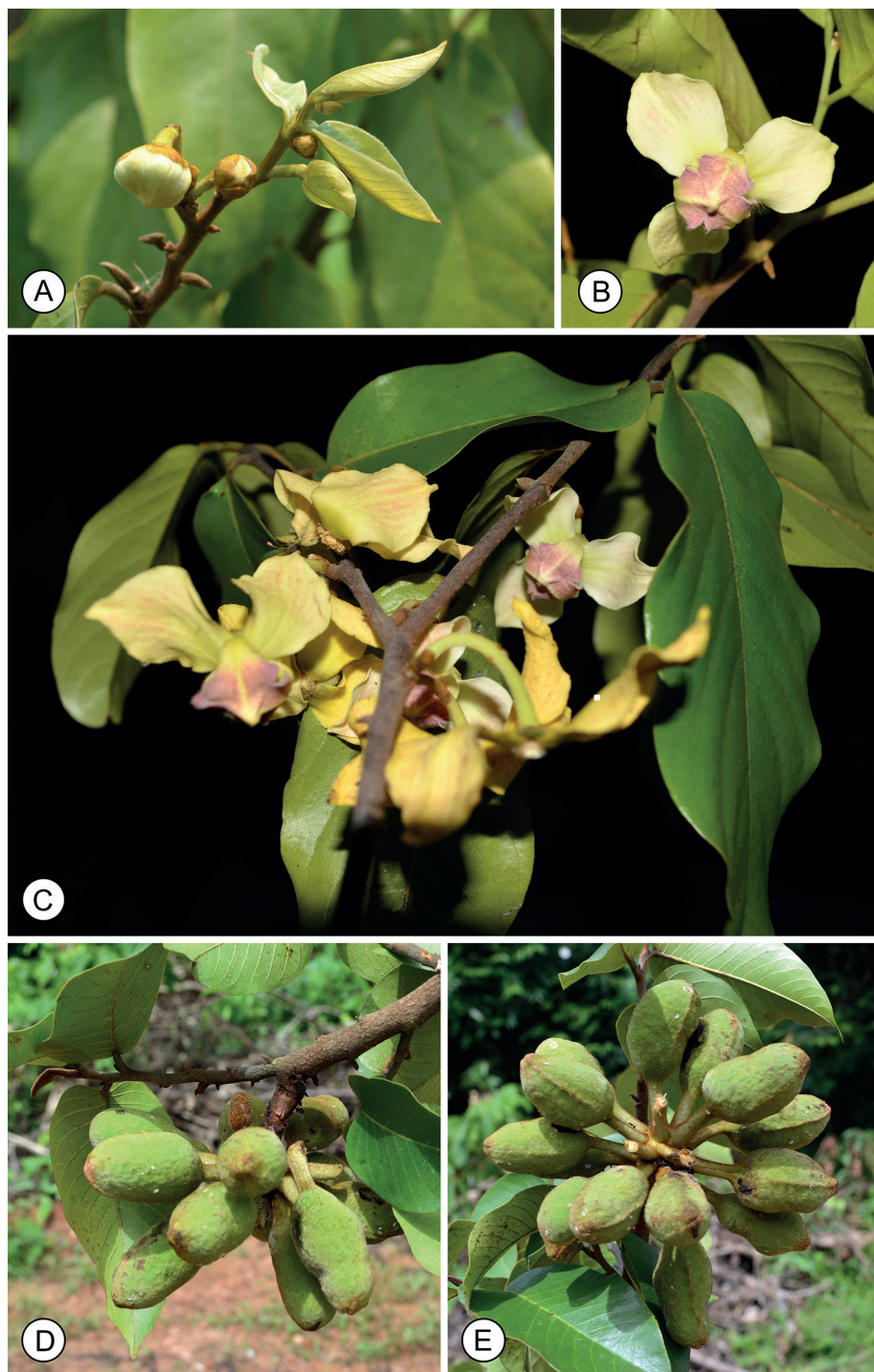
**Etymology.** From the name Lang Suan district, Chumphon Province.

**Local name.** Phrom lang suan (พรมหลังสวน) (Chumphon).

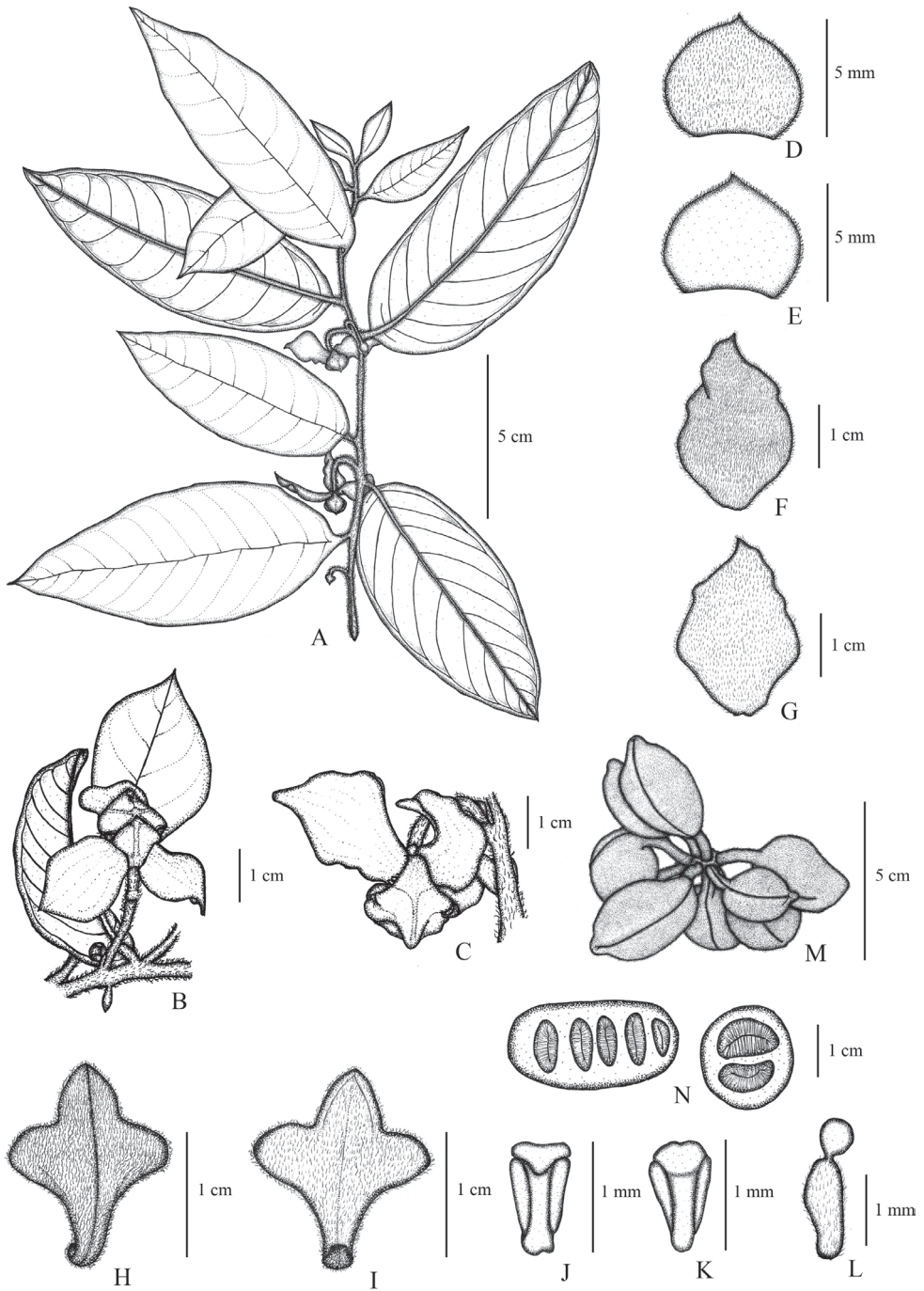
**Additional specimens examined (paratypes).** THAILAND: Pathum Thani Province, Khlong Luang District, TISTR Annonaceae collection plot, ca. 5 m alt., 23 June 2022, *P. Chalermglin* 650623/1 (originally from Phu Muang temple, Lang Suan District, Chumphon Province, Peninsular Thailand, ca. 100 m alt.) (PSU).

**Discussion.** *Mitrephora langsuanensis* resembles *M. macclurei* Weerasooriya & R.M.K.Saunders, but differs in having leaves with or without domatia on abaxial leaf surface (absent in *M. macclurei*), and a densely hairy indument abaxially (*vs* sparsely hairy). The flowers of *Mitrephora langsuanensis* have yellow outer petals with pink stripes (*vs* yellow petals without pink stripes in *M. macclurei*), margins that undulate with age (not undulate in *M. macclurei*), densely hairy indument abaxially (*vs* sparsely hairy), more carpels (10–12 *vs* 7–8) and longer fruiting pedicels (20–25 mm *vs* ca. 13 mm).

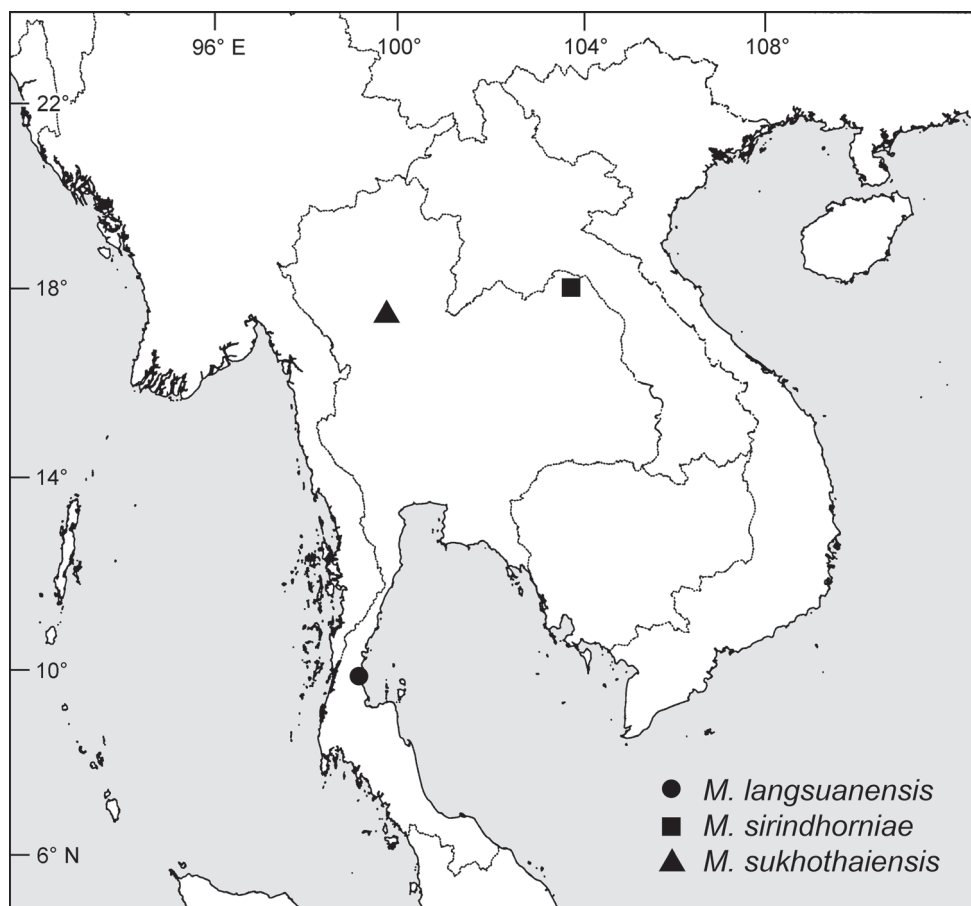
*Mitrephora langsuanensis* also resembles *M. wangii* Hu from China (Weerasooriya and Saunders 2010), but differs in its leaf laminas that are densely pubescent (sparsely hairy in *M. wangii*), sometimes with domatia at axils of secondary veins abaxially (absent in *M. wangii*), outer petals with pink stripes (absent in *M. wangii*), longer fruiting pedicels (10–16 mm in *M. wangii*) and longer monocarp stipes (9–13 mm in *M. wangii*).



**Figure 1.** *Mitrephora langsuanensis* sp. nov. **A** flower buds **B** flower **C** flowering branch **D, E** fruits (slightly immature). Photos by P. Chalermglin.



**Figure 2.** *Mitrephora langsuanensis* sp. nov. **A, B** flowering branches **C** flower **D, E** Sepals (ab- and adaxial) **F, G** outer petals (ab- and adaxial) **H, I** inner petals (ab- and adaxial) **J, K** stamens (ab- and adaxial) **L** carpel **M** fruit, composed of separate monocarps **N** seeds (longitudinal and transverse sections). Drawn by A. Somphrom, from P. Chalermglin 640503 (PSU).



**Figure 3.** Distributions of *Mitrephora langsuanensis*, *M. sirindhorniae* and *M. sukhothaiensis*.

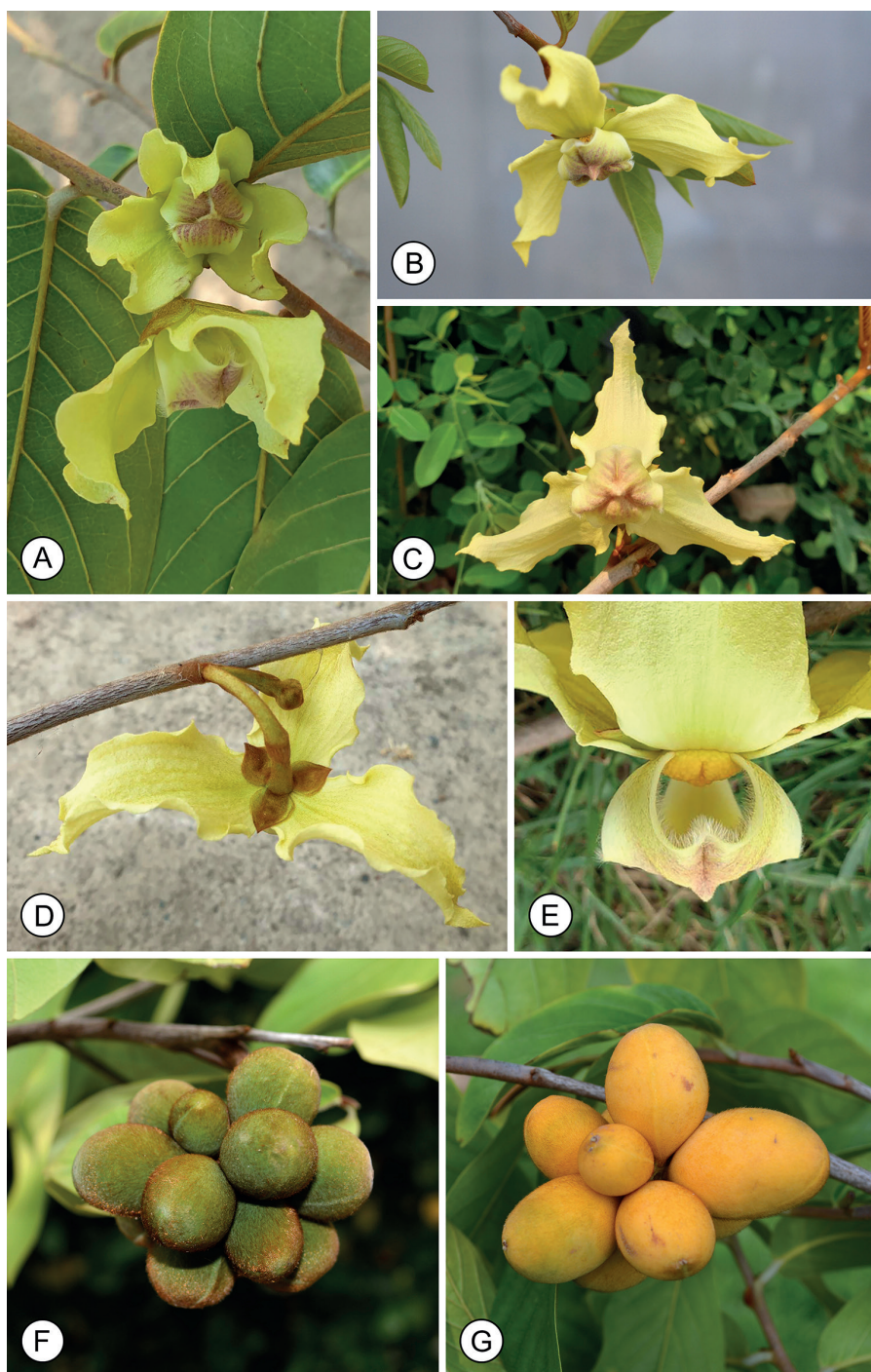
***Mitrephora sirindhorniae* Chalermglin, Leerat. & R.M.K.Saunders, sp. nov.**

urn:lsid:ipni.org:names:77311808-1

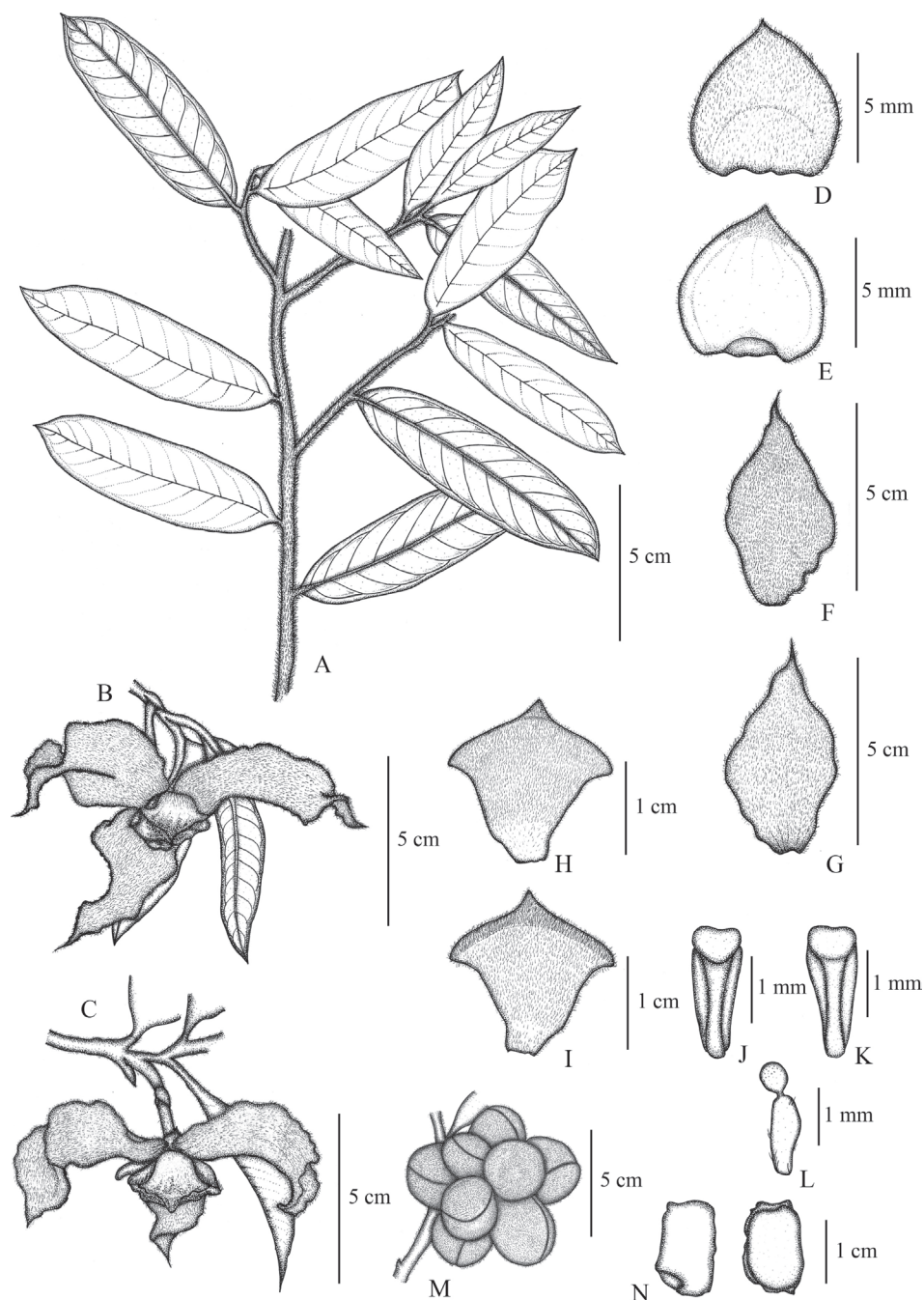
Figs 4, 5

**Diagnosis.** *Mitrephora sirindhorniae* resembles *M. tomentosa* Hook.f. & Thomson, but is distinguished by its leaves that are sparsely hairy abaxially, larger sepals (8–10 by 10–12 mm), larger outer petals (40–60 by 22–35 mm), larger inner petals (14–16 by 14.5–15 mm), longer flowering pedicels (25–27 mm), shorter monocarp stipes (2.5–8 mm) and monocarps with a longitudinal ridge.

**Types.** **THAILAND:** TISTR Annonaceae collection plot, Khlong Luang district, Pathum Thani Province, Central Thailand, ca. 5 m alt., 30 April 2021, *P. Chalermglin* 640430 (originally from small sandstone hill in Bueng Kan Province, North-Eastern Thailand, ca. 200 m alt.) (holotype PSU; isotypes BKF, KGU, QBG).



**Figure 4.** *Mitrephora sirindhorniae* sp. nov. **A** flowering branch **B, C** flowers **D** flower, showing calyx **E** flower, showing indument on adaxial surface of inner petals **F** fruit (slightly immature) **G** fruit (mature). Photos by P. Chalermglin.



**Figure 5.** *Mitrephora sirindhorniae* sp. nov. **A** vegetative branch **B, C** flowers **D, E** sepals (ab- and adaxial) **F, G** outer petals (ab- and adaxial) **H, I** inner petals (ab- and adaxial) **J, K** stamens (ab- and adaxial) **L** carpel **M** fruit, composed of separate monocarp **N** seeds. Drawn by A. Somphrom, **A–L** from *P. Chalermglin* 640430 (PSU), **M–N** from *P. Chalermglin* 630723 (PSU).

**Description (from cultivated material).** Small trees, to 4 m (in cultivation). Young branches densely pubescent. Leaf laminae subcoriaceous, (oblong-)lanceolate, 7–15 by 1.5–6 cm, base slightly oblique, broadly cuneate to slightly rounded, apex acute to rarely acuminate, glossy, glabrous adaxially, sparsely pubescent (denser on midrib) abaxially, secondary veins 8–12 pairs per leaf, without domatia; petioles 4–7 mm long, densely pubescent. Inflorescence rachides simple, with rachis internodes remaining short, 3–5 mm long, 2–3-flowered, densely pubescent; pedicels 25–27 mm long. Sepals free, ovate, not imbricate, 8–10 by 10–12 mm, densely pubescent abaxially, glabrous except densely pubescent at margin adaxially. Outer petals greenish-yellow, turning yellow, (broadly) oblanceolate, 40–60 by 22–35 mm, not clawed, margin undulate with age, apex acute, sparsely pubescent ab- and adaxially. Inner petals pale yellow with purple stripes apically, 14–16 by 14.5–15 mm, claw slightly incurved, densely pubescent ab- and adaxially. Stamens 1–1.5 mm long, connective truncate, glabrous. Carpels 15–20 per flower, 2–2.5 mm long; ovary oblong 1.2–1.5 mm long, sparsely pubescent, stigma club-shaped, 0.5–0.8 mm long, hairy; ovules 8–10 per carpel. Fruits with 7–14 monocarps, borne on a pedicel 20–30 mm long, 3–5 mm wide, densely pubescent. Monocarps yellow when ripe, (ellipsoid-)obovoid to ovoid, 15–30 by 10–25 mm, smooth, with longitudinal ridge, densely pubescent; stipes 2.5–8 mm long, densely pubescent. Seeds 1–10 per monocarp, semi-lenticular (lowermost and uppermost within monocarp) or discoid (others), 9–16 by 8–9.5 mm, surface glabrous, pitted.

**Phenology (in cultivation).** Flowering in April and fruiting in July.

**Distribution and habitat.** Endemic to Bueng Kan Province, North-Eastern Thailand (Fig. 3). Growing on sandstone hill in dry dipterocarp forest; ca. 200 m alt.

**Etymology.** Named after Her Royal Highness Maha Chakri Sirindhorn, in honour of her project on plant germplasm conservation in Thailand.

**Local name.** Maha phrom sirinthon (มหาพรหมสิรินธร) (general).

**Additional specimens examined (paratypes).** THAILAND: Pathum Thani Province, Khlong Luang District, TISTR Annonaceae collection plot, ca. 5 m alt., 23 July 2020, *P. Chalermglin* 630723 (originally from small sandstone hill in Bueng Kan Province, North-Eastern Thailand, ca. 200 m alt.) (PSU).

**Discussion.** *Mitrephora sirindhorniae* is characterised by its sparsely hairy abaxial leaf surface, flowers with long outer petals (40–60 mm) that are broadly oblanceolate, and by its densely pubescent fruits with a longitudinal ridge. The species is morphologically most similar to *M. tomentosa* Hook.f. & Thomson, from which it differs as its leaves are sparsely hairy abaxially (*vs* densely hairy), with flowers with larger sepals (8–10 by 10–12 mm *vs* 5–9 by 5–9 mm), outer petals (40–60 by 22–35 mm *vs* 16–19[–34] by 7.5–18 mm), inner petals (14–16 by 14.5–15 mm *vs* 8.5–16.5 by 7–12.5 mm), and longer flowering pedicels (25–27 mm *vs* 11–23 mm). The monocarp stipes are shorter (2.5–8 mm *vs* 16.5–29[–39] mm), and the monocarps have a longitudinal ridge.

***Mitrephora sukhothaiensis* Leerat., Chalermglin & R.M.K.Saunders, sp. nov.**

urn:lsid:ipni.org:names:77311809-1

Figs 6, 7

**Diagnosis.** *Mitrephora sukhothaiensis* is distinct from all other species in having a combination of outer petals that reflex at maturity as well as inner petals that have inwardly folded marginal protrusions at the midpoint adaxially.

**Types.** **THAILAND:** CENTRAL: TISTR Annonaceae collection plot, Khlong Luang district, Pathum Thani Province, Central Thailand, ca. 5 m alt., 10 December 2021, *P. Chalermglin* 641210 (originally from Si Satchanalai District, Sukhothai Province, Northern Thailand, ca. 360 m alt.) (holotype PSU; isotypes BKF, KKU).

**Description (from cultivated material).** Shrubs, to 2 m (in cultivation). Young branches densely pubescent. Leaf laminae coriaceous, (elliptic-)lanceolate or rarely ovate-lanceolate, 6–22 by 2.5–8 cm, base rounded to slightly cordate, apex acute to acuminate, glossy, glabrous (except midrib pubescent) adaxially, moderately to sparsely pubescent abaxially, secondary veins 6–14 pairs per leaf, with domatia; petioles 3–8 mm long, moderately pubescent. Inflorescence rachides simple, with rachis internodes remaining short, 1–3 mm long, 2–3-flowered, densely pubescent; pedicels 8–17 mm long. Sepals united at base, broadly ovate, not imbricate, 4–5.5 by 4–5.5 mm, densely pubescent ab- and adaxially. Outer petals creamy white to yellow, ovate, 12–17 by 9–12 mm, reflexing when mature, not clawed, margin not undulate, apex obtuse, densely pubescent ab- and adaxially. Inner petals greenish-yellow with purple spot towards apex, 10–12 by 5–6 mm, claw incurved, densely pubescent abaxially, densely hairy with long hairs towards apex adaxially, with inwardly folded marginal protrusions at the midpoint adaxially. Stamens 0.8–1.3 mm long, connective truncate, glabrous. Carpels 12–20 per flower, 1.6–2 mm long; ovary ellipsoid to oblong-ellipsoid, 1.3–1.5 mm long, moderately hairy; stigma globose, 0.3–0.5 mm long, hairy; ovules 6–10 per carpel. Fruits with up to 16 monocarps, borne on a pedicel 15–25 mm long, 4–6 mm wide, densely pubescent. Monocarps yellow when ripe, (ellipsoid-)ovoid to subglobose, 13–20 by 10–16 mm, smooth, without longitudinal ridge, densely pubescent; stipes 15–22 mm long, densely pubescent. Seeds 2–6 per monocarp, semi-lenticular (lowermost and uppermost within monocarp) or discoid (others), 5–10 by 5–6 mm, glabrous, pitted.

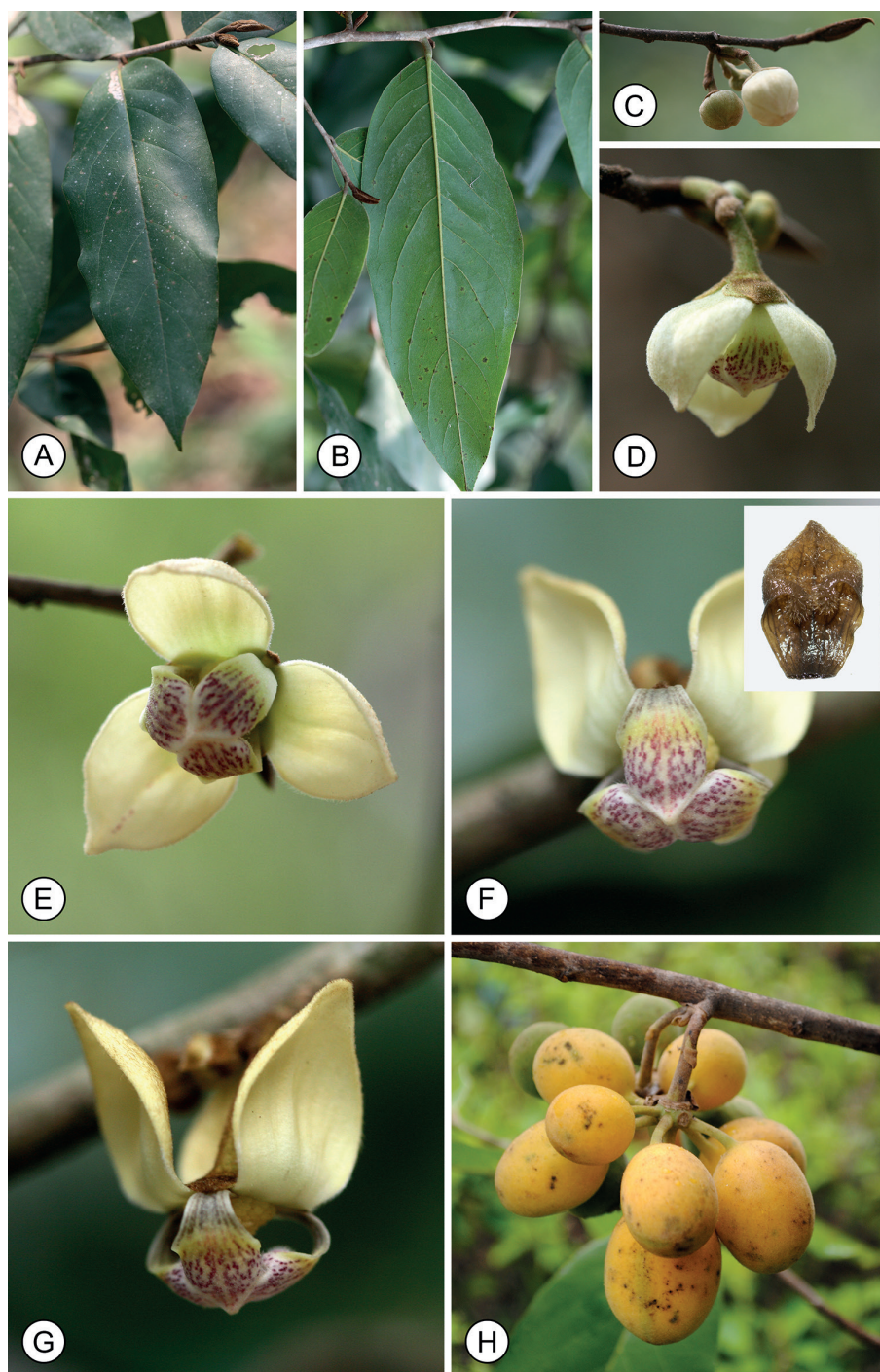
**Phenology (in cultivation).** Flowering between December and March to June; fruiting between May and July.

**Distribution and habitat.** Endemic to Sukhothai Province, Northern Thailand (Fig. 3). Growing in mixed deciduous forest; ca. 360 m alt.

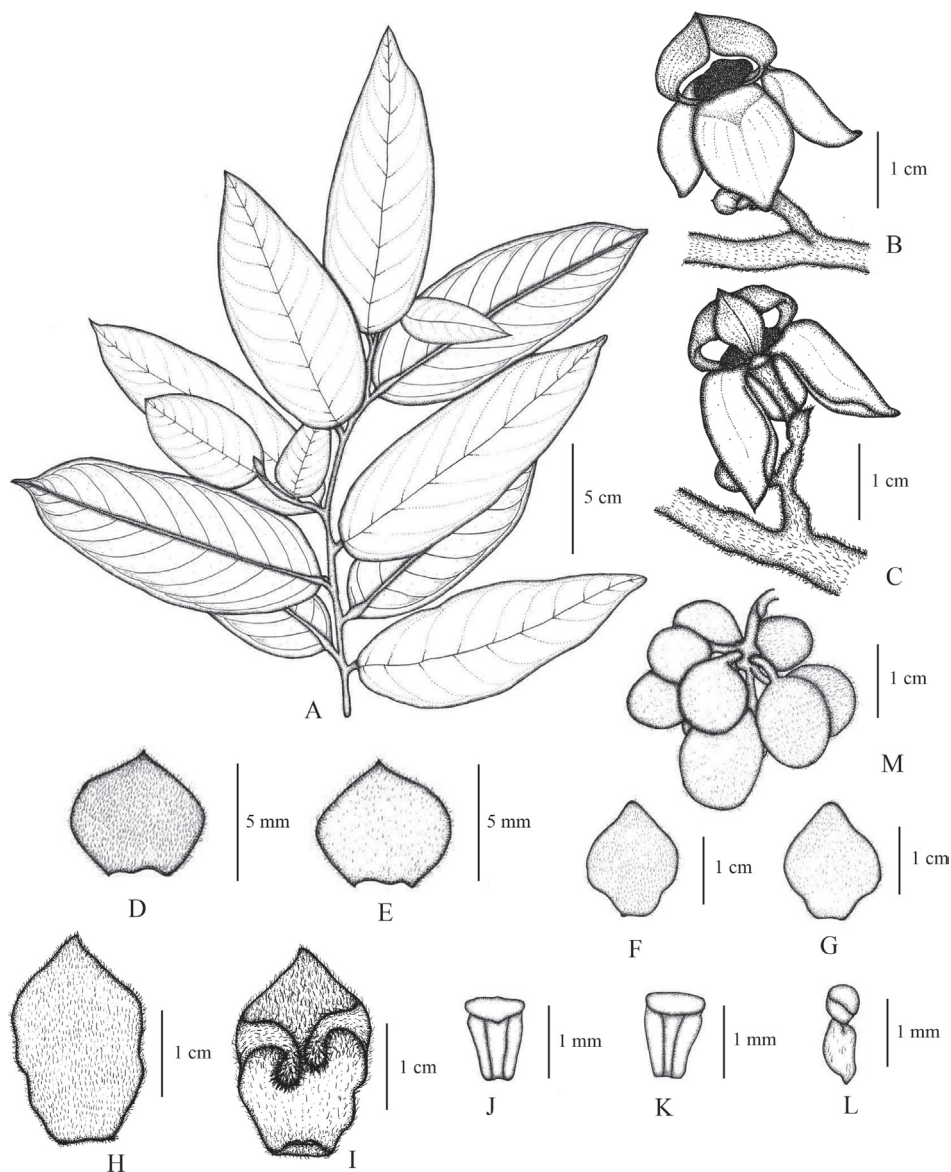
**Etymology.** From the name Sukhothai province.

**Local name.** Phrom sukho (พรมสุโข) (general).

**Additional specimens examined (paratypes).** **THAILAND:** Pathum Thani Province, Khlong Luang District, TISTR Annonaceae collection plot, ca. 5 m alt., 20 November 2020, *P. Chalermglin* 631120 (originally from Si Satchanalai District, Sukhothai Province, Northern Thailand, ca. 360 m alt.) (SING); *ibid.* 1 May 2022, *P. Chalermglin* 650501 (KKU, PSU); *ibid.*, 23 June 2022, *P. Chalermglin* 650623/2 (PSU).



**Figure 6.** *Mitrephora sukhothaiensis* sp. nov. **A, B** leaves (ad- and abaxial) **C** flower buds **D** flower (slightly immature) **E–G** flowers, **F, G** showing the outer petals reflexed when mature, with insert in **F** showing adaxial surface of inner petal with inwardly folded marginal protrusions **H** fruit (mature). Photos by P. Chalermglin.



**Figure 7.** *Mitrephora sukhothaiensis* sp. nov. **A** vegetative branch **B, C** flowers **D, E** sepals (ab- and adaxial) **F, G** outer petals (ab- and adaxial) **H, I** inner petals (ab- and adaxial, showing marginal protrusions) **J, K** stamens (ab- and adaxial) **L** carpel **M** fruit, composed of separate monocarps. Drawn by A. Somphrom, **A–L** from *P. Chalermglin* 641210 (PSU), **M** from *P. Chalermglin* 650501 (PSU).

**Discussion.** *Mitrephora sukhothaiensis* is easily distinguished from all other species in two key characters: its outer petals that reflex at maturity, and its inner petals that have inwardly folded marginal protrusions at the midpoint adaxially.

*Mitrephora sukhothaiensis* also resembles *M. tomentosa* in the appearance of the fruit (monocarp shape and surface) and seeds, but differs in its shrubby habit, growing to 2 m in height (*vs* small to medium trees to ca. 20 m), sparsely to moderately hairy leaf indument abaxially (*vs* densely hairy), outer petals that reflex at maturity and without undulate margins), inner petals with inwardly folded marginal protrusions, and narrower seeds (5–6 mm *vs* ca. 8 mm).

### Key to *Mitrephora* species in Thailand

- 1a Outer petals 37.5–60 × 22–53 mm; inner petals 14.5–41 mm wide ..... **2a**
- 2a Outer petals (broadly) oblanceolate, sparsely pubescent abaxially; monocarps 15–30 mm long, with 1–10 seeds .....  
***Mitrephora sirindhorniae** Chalermglin, Leerat. & R.M.K.Saunders, sp. nov.*
- 2b Outer petals ovate to broadly ovate, densely pubescent abaxially; monocarps 50–58(–68) mm long, with 13–21 seeds ..... **3a**
- 3a Leaf laminas glossy adaxially, with 8–11 pairs of secondary veins; flower pedicels 18–27 mm long; sepals 13.5–15.5 × 14–19.5 mm; outer petals 44–53.5 × 41–53 mm; inner petals 37–43 × 36.5–41 mm .....  
***Mitrephora sirikitiae** Weeras., Chalermglin & R.M.K.Saunders*
- 3b Leaf laminas matt adaxially, with 11–13 pairs of secondary veins; flower pedicels 10–15.5 mm long; sepals 7.5–10.5 × 7.5–11 mm; outer petals 37.5–40 × 22–29.5 mm; inner petals 28–32 × 22–24.5 mm .....  
***Mitrephora winitii** Craib*
- 1b Outer petals 4.5–34.5 × 3.5–19 mm; inner petals 3–15 mm wide ..... **4a**
- 4a Outer petals 4.5–5 × ca 3.5 mm; inner petals 5–5.5 × 4–6 mm; monocarps 9.5–10 mm long, with solitary seed .....  
***Mitrephora chulabhorniana** Damth., Aongyong & Chaowasku*
- 4b Outer petals 9.5–34.5 × 6.5–20 mm; inner petals 6–19 × 3–12.5 mm; monocarps 11–38 mm long, with 4–10 seeds ..... **5a**
- 5a Young branches sparsely pubescent ..... **6a**
- 6a Flowers and fruits with a solitary carpel; monocarp sessile .....  
***Mitrephora monocarpa** R.M.K.Saunders & Chalermglin*
- 6b Flowers and fruits with 12–16 carpels; monocarps stipitate ..... **7a**
- 7a Flower pedicels 10–16 mm long; sepals 1.5–2.5 mm long; outer petals white, 10.5–15.5 mm wide; inner petals white with pink/purple margins, 9–14.5 × 5.5–11 mm; monocarps warty, with longitudinal ridge; stipes 6–15 mm long .....  
***Mitrephora alba** Ridl*
- 7b Flower pedicels 4.5–9 mm long; sepals 3–4 mm long; outer petals yellow, 6.5–9.5 mm wide; inner petals yellow with pink margins, 7.5–9.5 × 4.5–6 mm; monocarps smooth, without longitudinal ridge; stipes 3–3.5 mm long .....  
***Mitrephora keithii** Ridl*
- 5b Young branches densely pubescent ..... **8a**

- 8a Shrubs to ca. 2 m; outer petals reflexing when mature; inner petals with inwardly folded marginal protrusions at midpoint adaxially ..... ***Mitrephora sukhothaiensis* Leerat., Chalermglin & R.M.K.Saunders, sp. nov.**
- 8b Trees to 4–30 m; outer petals not reflexing when mature; inner petals without inwardly folded marginal protrusions at midpoint adaxially ..... **9a**
- 9a Inflorescence rachides with internodes that elongate, bearing > 3 flowers; 36–40 carpels per flower; monocarps not glaucous..... ***Mitrephora vulpina* C.E.C.Fisch.**
- 9b Inflorescence rachides with internodes that do not elongate, bearing < 3 flowers; 7–17 carpels per flower; monocarps glaucous..... **10a**
- 10a Leaf laminas densely pubescent abaxially; sepals 5–9 × 5–9 mm; monocarps globose..... ***Mitrephora tomentosa* Hook.f. & Thomson**
- 10b Leaf laminas subglabrous to sparsely pubescent abaxially; sepals 1.5–6 × 2–6.5 mm; monocarps obovoid, ellipsoid or oblong ..... **11a**
- 11a Leaf laminas matt adaxially, inner petals cream, 6–12.5 mm long; monocarps without longitudinal ridge, densely pubescent ..... ***Mitrephora teysmannii* Scheff.**
- 11b Leaf laminas glossy adaxially; inner petals purplish, 11–19 mm long; monocarps with longitudinal ridge, sparsely pubescent ..... **12a**
- 12a Leaf laminas densely pubescent, sometimes with domatia at axils of secondary veins abaxially; outer petals with pink stripes; fruit pedicels 20–25 mm long..... ***Mitrephora langsuanensis* Leerat., Chalermglin & R.M.K.Saunders, sp. nov.**
- 12b Leaf laminas sparsely pubescent, without domatia at axils of secondary veins abaxially; outer petals without pink stripes; fruit pedicels 10–16 mm long ..... **13a**
- 13a Leaves with 7–9 pairs of secondary veins; margin of outer petals not undulate with age; petals and fruit pedicels sparsely pubescent abaxially; stipes 14–18 mm long ..... ***Mitrephora macclurei* Weeras. & R.M.K.Saunders**
- 13b Leaves with 10–14 pairs of secondary veins; margin of outer petals ± undulate with age; petals and fruit pedicels densely hairy abaxially; stipes 9–13 mm long ..... ***Mitrephora wangii* Hu**

## Acknowledgements

The authors are grateful to the curators and staff of herbaria cited for access to plant specimens. We also thank Ms Arisa Somphrom for the line drawings and David Johnson, Pasakorn Bunchalee and Thomas Couvreur for their invaluable input. The first author would like to thank the Plant Genetic Conservation Project under the Royal Initiation of Her Royal Highness Princess Maha Chakri Sirindhorn (RSPG) for financial support.

## References

Chatrou LW, Pirie MD, Erkens RHJ, Couvreur TLP, Neubig KM, Abbott JR, Mols JB, Maas JW, Saunders RMK, Chase MW (2012) A new subfamilial and tribal classification of

- the pantropical flowering plant family Annonaceae informed by molecular phylogenetics. *Botanical Journal of the Linnean Society* 169(1): 5–40. <https://doi.org/10.1111/j.1095-8339.2012.01235.x>
- Damthongdee A, Aongyang K, Chaowasku T (2019) *Mitrephora chulabhorniana* (Annonaceae), an extraordinary new species from southern Thailand. *Brittonia* 71(4): 381–388. <https://doi.org/10.1007/s12228-019-09573-0>
- Guo X, Tang CC, Thomas DC, Couvreur TLP, Saunders RMK (2017) A mega-phylogeny of the Annonaceae: Taxonomic placement of five enigmatic genera and recognition of a new tribe, Phoeniciantheae. *Scientific Reports* 7(1): 7323. <https://doi.org/10.1038/s41598-017-07252-2>
- Okada H (2014) Three new species of Annonaceae from West Kalimantan, Indonesian Borneo. *Acta Phytotaxonomica et Geobotanica* 65: 17–24.
- Pang CC, Saunders RMK (2014) The evolution of alternative mechanisms that promote outcrossing in Annonaceae, a self-compatible family of early-divergent angiosperms. *Botanical Journal of the Linnean Society* 174(1): 93–109. <https://doi.org/10.1111/boj.12118>
- Saunders RMK (2010) Floral evolution in the Annonaceae: Hypotheses of homeotic mutations and functional convergence. *Biological Reviews of the Cambridge Philosophical Society* 85: 571–591. <https://doi.org/10.1111/j.1469-185X.2009.00116.x>
- Saunders RMK (2020) The evolution of key functional floral traits in the early divergent angiosperm family Annonaceae. *Journal of Systematics and Evolution* 58(4): 369–392. <https://doi.org/10.1111/jse.12645>
- Saunders RMK, Chalermglin P (2019) *Mitrephora monocarpa* (Annonaceae): a new species from Surat Thani Province, Peninsular Thailand. *PhytoKeys* 121: 73–80. <https://doi.org/10.3897/phytokeys.121.34271>
- Weerasooriya AD, Saunders RMK (2010) Monograph of *Mitrephora* (Annonaceae). *Systematic Botany Monographs* 90: 1–167 [+ pl. 1–4].
- Weerasooriya AD, Chalermglin P, Saunders RMK, Chaowasku T (2022). *Mitrephora*. In: Johnson DM, Murray NA (Eds) *Annonaceae. Flora of Thailand* 16(1): 189–198.



# *Sinosenecio pingwuensis* (Asteraceae, Senecioneae), a new species from northern Sichuan, China

Xiu-Jiang Su<sup>1,2\*</sup>, Wen-Qun Fei<sup>1,3\*</sup>, Ding Zhao<sup>4</sup>, Ying Liu<sup>5</sup>, Qin-Er Yang<sup>1,6</sup>

**1** Key Laboratory of Plant Resources Conservation and Sustainable Utilization, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510655, Guangdong, China **2** Administration Bureau of Baiyunshan Nature Reserve, Baojing 416500, Hunan, China **3** University of Chinese Academy of Sciences, Beijing 100049, China **4** Administration Bureau of Xuebaoding National Nature Reserve, Pingwu 622550, Sichuan, China **5** State Key Laboratory of Biocontrol and Guangdong Key Laboratory of Plant Resources, School of Life Sciences, Sun Yat-sen University, No. 135, Xin-Gang-Xi Road, Guangzhou 510275, Guangdong, China **6** Center of Conservation Biology, Core Botanical Gardens, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510655, Guangdong, China

Corresponding author: Qin-Er Yang ([qeyang@scib.ac.cn](mailto:qeyang@scib.ac.cn))

Academic editor: Peter de Lange | Received 12 November 2022 | Accepted 21 December 2022 | Published 12 January 2023

**Citation:** Su X-J, Fei W-Q, Zhao D, Liu Y, Yang Q-E (2023) *Sinosenecio pingwuensis* (Asteraceae, Senecioneae), a new species from northern Sichuan, China. *PhytoKeys* 218: 109–116. <https://doi.org/10.3897/phytokeys.218.97485>

## Abstract

*Sinosenecio pingwuensis* (Asteraceae, Senecioneae), a new species from Pingwu county in northern Sichuan, China, is described and illustrated. This species is distinguished in *Sinosenecio* by having leathery, glabrous, ovate or ovate-oblong leaves often pinnately-veined and solitary capitula 2.3–4.3 cm in diameter, a unique character combination hitherto never recorded in the genus. Two floral micromorphological characters (configuration of filament collar of stamens and anther endothelial cell wall thickenings) and achene surface features of the new species are reported. Color photographs of living plants and a distribution map are also provided for the new species.

## Keywords

Compositae, floral micromorphology, taxonomy, Xuebaoding National Nature Reserve

\* These two authors contributed equally to this paper.

## Introduction

During a botanical trip in 2016 in connection with the biodiversity survey of the Xuebaoding National Nature Reserve in Pingwu county in northern Sichuan, China, we discovered an unusual population of *Sinosenecio* B. Nord. (Asteraceae, Senecioneae) (Figs 1–3). The plants are distinguished in *Sinosenecio* by having leathery, glabrous, ovate or ovate-oblong leaves often pinnately-veined, and solitary capitula 2.3–4.3 cm in diameter, a unique character combination hitherto never recorded in the genus. We therefore determined that the population in question represents a new species, which we describe below.

## Taxonomic treatment

*Sinosenecio pingwuensis* Xiu J.Su, W.Q.Fei, Ying Liu & Q.E.Yang, sp. nov.

urn:lsid:ipni.org:names:77311810-1

Figs 1–3

**Type.** CHINA. Sichuan province: Pingwu county, Huya town, Xuebaoding National Nature Reserve, on moist rocky cliffs in valley, alt. ca. 2300 m, 6 June 2022, *W. Q. Fei & J. Li* 562 (holotype: IBSC; isotypes: CDBI, PE, SYS). Fig. 3.

**Diagnosis.** *Sinosenecio pingwuensis* is distinguished in the genus by having leathery, glabrous, ovate or ovate-oblong leaves often pinnately-veined and solitary capitula 2.3–4.3 cm in diameter.

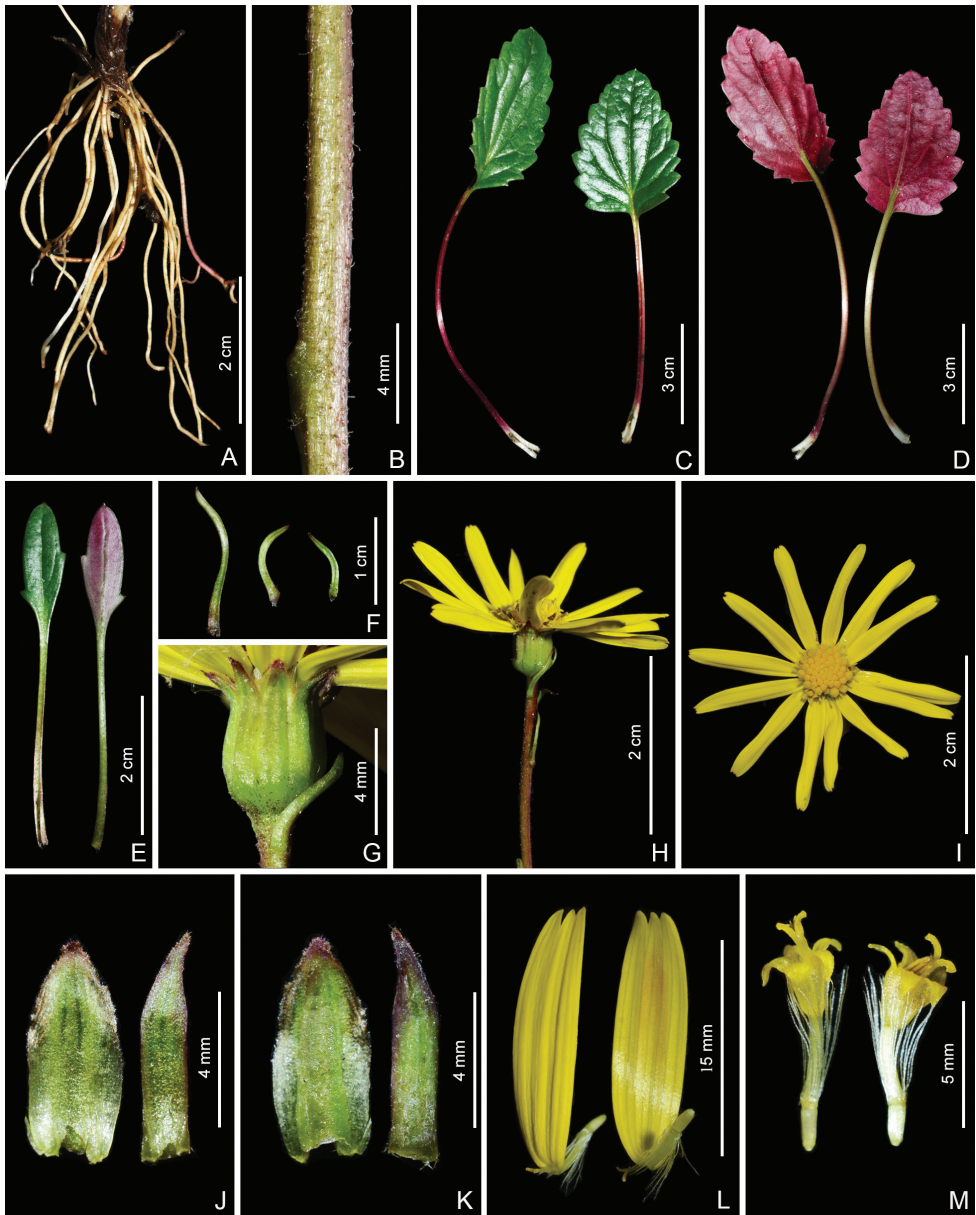
**Description.** Scapigerous herbs. Rhizomes 2–5 mm in diameter, clad in persistent petiole bases; collar densely sericeous-villous. Stems 1 or 2, erect, scapiform, 11–20 cm tall, simple, purplish, sparsely pubescent, more densely so at base and in upper part below the capitulum, sometimes glabrescent in the middle part. Leaves radical, rosulate, long petiolate; petioles 3.3–10 cm long, basally expanded, sparsely villous or pubescent, densely so at base, often glabrescent in the middle and upper parts; blades ovate or ovate-oblong, rarely broadly ovate, 1–4.5 × 0.9–3 cm, leathery, abaxially purplish, adaxially green or dark green, glabrous on both sides, palmately 5–7-veined or pinnately-veined due to some of the main veins arising from the midrib above the base, veins conspicuous adaxially, ± raised abaxially, margin dentate, rarely mucronulate, base truncate, rounded or cuneate, apex acute or obtuse. Capitula terminal, solitary, radiating, 2.3–4.3 cm in diameter; scape often bearing 2–6 sessile, linear bracts 4–16 mm long in the middle and upper parts, rarely the lowest one with petiole 1–3 cm long. Involucres campanulate, 7–9 × 5.5–7.5 mm, ecalyculate; phyllaries 8–13, ovate-oblong to linear-oblong, 1.5–3.5 mm wide, herbaceous, sparsely pubescent with blackish purple hairs in the middle and at base, sometimes glabrescent, margin scarious, apically purplish, ciliate, acuminate. Ray florets 11–13; corolla tube 2–3 mm long, glabrous; lamina yellow, oblong, 14–17 × 2–3 mm, 4–7-veined, apically 3-denticulate. Disc florets 33–55; corolla yellow, ca. 6 mm long, with ca. 3 mm long tube and funnellform campanulate limb; lobes ovate-oblong, ca. 1 mm long, apically acuminate. Anthers oblong, ca. 2 mm long, basally obtuse. Style branches 0.5 mm



**Figure 1.** *Sinosenecio pingwuensis* sp. nov. in the wild (China, Sichuan province, Pingwu county, the type locality) **A, B** habitat **C–E** habitat and habit **F** habit. Photographed by W.Q. Fei.

long, recurved, apically truncate, papillose. Achenes cylindrical, ca. 2.5 mm long (immature), smooth, glabrous, ribbed. Pappus white, 5–6 mm long.

**Floral micromorphological characters and achene surface features.** The filament collar of stamens in *Sinosenecio pingwuensis* consists of uniformly-sized cells



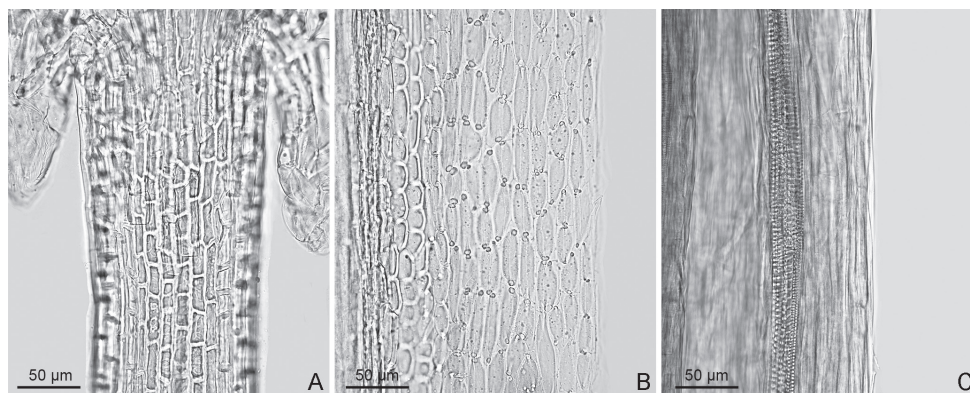
**Figure 2.** *Sinosenecio pingwuensis* sp. nov. in the wild (China, Sichuan province, Pingwu county, the type locality) **A** roots **B** portion of stem **C** radical leaves (adaxial side) **D** radical leaves (abaxial side) **E** radical leaf (left: adaxial side; right: abaxial side) **F** bracts on the scape **G** close-up of capitulum **H** capitulum (lateral view) and portion of scape **I** capitulum (top view) **J** phyllaries (adaxial side) **K** phyllaries (abaxial side) **L** ray florets **M** disc florets. Photographed by W.Q. Fei.

(Fig. 4A) and the anther endothelial cell wall thickenings are strictly polar (Fig. 4B). The achene is glabrous and smooth (Fig. 4C).

**Phenology.** Flowering in June; fruiting in July.



**Figure 3.** Holotype sheet of *Sinosenecio pingwuensis* sp. nov.



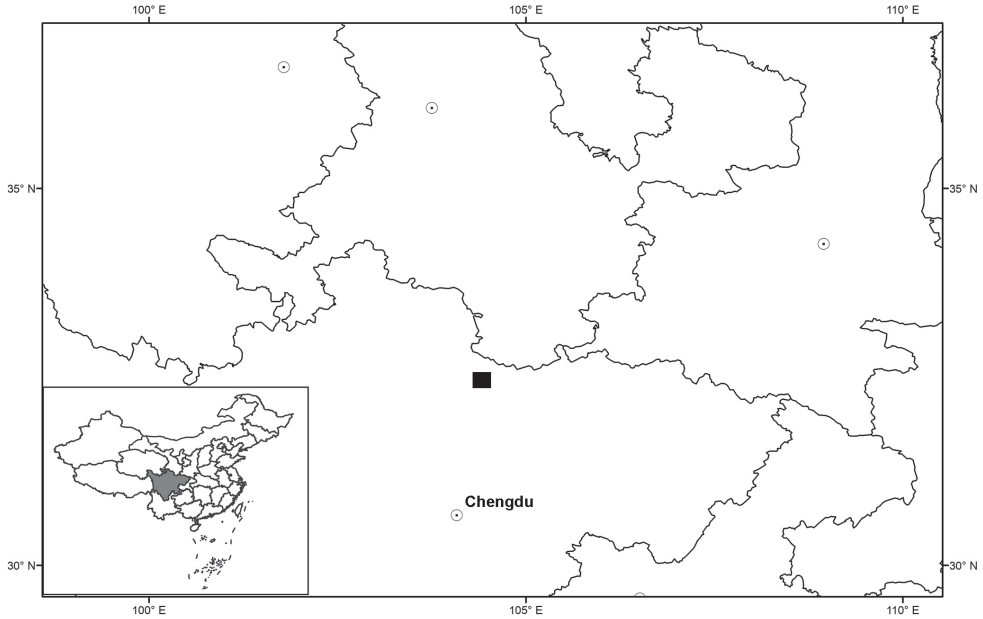
**Figure 4.** Two floral micromorphological characters (**A**, **B**) and achene surface feature (**C**) of *Sinosenecio pingwuensis* sp. nov. **A** uniformly-sized cells of filament collar of stamens **B** strictly polar anther endothelial cell wall thickenings **C** smooth achene surface. All from W.Q. Fei & J. Li 562 (IBSC, SYS) from Pingwu county in northern Sichuan province, China.

**Etymology.** The specific epithet, “*pingwuensis*”, refers to the type locality of the new species, i.e. Pingwu county in northern Sichuan, China.

**Distribution and habitat.** *Sinosenecio pingwuensis* is currently known only from its type locality, i.e. Pingwu county in northern Sichuan, China (Fig. 5). It grows on moist rocky cliffs along stream sides in a valley at an altitude of ca. 2300 m above sea level.

**Conservation status.** The currently only known population of *Sinosenecio pingwuensis* at the type locality comprises ca. 80 individuals growing on rocky cliffs. They are scattered within ca. 1 km along a valley. Although the population is located in the Xuebaoding National Nature Reserve, some human activities, road building in particular, may destroy the habitat of the population and, thus, severely affect the survival of this species. According to the IUCN Red List Categories and Criteria (IUCN 2012), the new species should be categorised as Critically Endangered (CR).

**Notes.** The genus *Sinosenecio*, as defined by Chen et al. (2011), comprises two major species assemblages with different configurations of anther endothelial cell wall thickenings (polar and radial vs. strictly polar), different base chromosome numbers ( $x = 24$ , rarely 13 vs.  $x = 30$ ) and different geographical distributions (central and southern China vs. areas largely surrounding the Sichuan basin in south-western China) (Liu 2010; Liu and Yang 2011a, b, 2012; Liu et al. 2019; Zou et al. 2020; Chen et al. 2022; Peng et al. 2022). Judging from its strictly polar anther endothelial cell wall thickenings and its occurrence only in Pingwu county at the northern margin of the Sichuan basin, *S. pingwuensis* should belong to the latter assemblage, in which 14 species are currently recognised, including *S. homogyniphyllus* (Cumm.) B. Nord., the type species of *Sinosenecio* (Liu 2010; Chen et al. 2011; Chen et al. 2022). Regrettably, we have been unable to check the chromosome number of *S. pingwuensis* due to our failure in transplanting living plants to obtain actively growing roots for squashing. From its configuration of strictly polar anther endothelial cell wall thickenings,



**Figure 5.** Distribution of *Sinosenecio pingwuensis* sp. nov. (black square).

*S. pingwuensis* should have a somatic chromosome number ( $2n$ ), based on  $x = 30$ , very likely  $2n = 60$ , the commonest somatic chromosome number in this assemblage (Liu and Yang 2011a). In *Sinosenecio*, the strictly polar anther endothelial cell wall thickenings correlate well with the base chromosome number of  $x = 30$  (Liu 2010; Liu and Yang 2011a, b).

In the same valley where *Sinosenecio pingwuensis* occurs, we discovered another hitherto undescribed species of *Sinosenecio*. This species and *S. pingwuensis* should belong to the same species assemblage of the genus. Both prefer shaded and moist microhabitat and grow on rocky cliffs. Although they do not grow strictly in the same community, some individuals of them are less than 100 m away from each other and they begin to flower at the same time (in June). We did not observe, however, any morphologically putative hybrids between them. This is probably due to isolation via intrinsic post-zygotic barriers. We will report this undescribed species elsewhere.

## Acknowledgements

We are grateful to Dr. Christina Flann, Dr. Peter de Lange and Tony Bean for their valuable comments on the manuscript. We thank Yong Shen with the Xuebaoding National Nature Reserve in Pingwu county, Sichuan, China, for his help in our field work. This work was financially supported by the National Natural Science Foundation of China (grant nos. 32070238, 31770216).

## References

- Chen YL, Liu Y, Yang QE, Nordenstam B, Jeffrey C (2011) *Sinosenecio* B. Nordenstam. In: Wu ZY, Raven PH, Hong DY (Eds) Flora of China Vol. 20–21. Science Press, Beijing, 464–481.
- Chen B, Liu Y, Luo JX, Wang Q, Yang QE (2022) *Sinosenecio jiuzhaigouensis* (Asteraceae, Senecioneae), a new species from Sichuan, China. *Phytotaxa* 544(3): 289–294. <https://doi.org/10.11646/phytotaxa.544.3.3>
- IUCN (2012) IUCN Red List Categories and Criteria: Version 3.1. 2<sup>nd</sup> edn. Gland, Switzerland and Cambridge, UK, 1–32.
- Liu Y (2010) Systematics of the genus *Sinosenecio* B. Nord. (Asteraceae). Ph.D. thesis, Institute of Botany, Chinese Academy of Sciences, Beijing, 1–277.
- Liu Y, Yang QE (2011a) Cytology and its systematic implications in *Sinosenecio* (Senecioneae-Asteraceae) and two closely related genera. *Plant Systematics and Evolution* 291(1): 7–24. <https://doi.org/10.1007/s00606-010-0365-3>
- Liu Y, Yang QE (2011b) Floral micromorphology and its systematic implications in the genus *Sinosenecio* (Senecioneae-Asteraceae). *Plant Systematics and Evolution* 291(3–4): 243–256. <https://doi.org/10.1007/s00606-010-0385-z>
- Liu Y, Yang QE (2012) *Sinosenecio jiangxiensis* (Asteraceae), a new species from Jiangxi, China. *Botanical Studies (Taipei, Taiwan)* 53(3): 401–414.
- Liu Y, Xu Y, Yang QE (2019) *Sinosenecio peltatus* (Asteraceae, Senecioneae), a remarkably distinctive new species from Guangdong, China. *Phytotaxa* 406(3): 206–212. <https://doi.org/10.11646/phytotaxa.406.3.7>
- Peng JY, Zhang DG, Deng T, Huang XH, Chen JT, Meng Y, Wang Y, Zhou Q (2022) *Sinosenecio yangii* (Asteraceae), a new species from Guizhou, China. *PhytoKeys* 210(34): 1–13. <https://doi.org/10.3897/phytokeys.5555.89480>
- Zou CY, Liu Y, Liu Y (2020) *Sinosenecio ovatifolius* (Asteraceae), a new species from Guangxi, China. *Phytotaxa* 460(2): 149–159. <https://doi.org/10.11646/phytotaxa.460.2.5>

# *Commelina danxiaensis* (Commelinaceae), a new species from Guangdong, China

Long-Yuan Wang<sup>1</sup>, Wan-Yi Zhao<sup>2</sup>, Zai-Xiong Chen<sup>3</sup>, Wei-Cheng Huang<sup>1</sup>,  
Ming-Yan Ding<sup>4</sup>, Jin-Chu Luo<sup>1</sup>, Wen-Bo Liao<sup>2</sup>, Wei Guo<sup>1</sup>, Qiang Fan<sup>2</sup>

**1** Department of Horticulture and Landscape Architecture, Zhongkai University of Agriculture and Engineering, Guangzhou, Guangdong, China **2** State Key Laboratory of Biocontrol and Guangdong Provincial Key Laboratory of Plant Resources, School of Life Sciences, Sun Yat-sen University, Guangzhou, Guangdong, China **3** Administrative Commission of Danxiashan National Park, Shaoguan, Guangdong, China **4** Shunde Polytechnic, Foshan, Guangdong, China

Corresponding authors: Wei Guo ([gwei717@163.com](mailto:gwei717@163.com)), Qiang Fan ([fanqiang@mail.sysu.edu.cn](mailto:fanqiang@mail.sysu.edu.cn))

Academic editor: Peter Boyce | Received 4 August 2022 | Accepted 16 December 2022 | Published 13 January 2023

**Citation:** Wang L-Y, Zhao W-Y, Chen Z-X, Huang W-C, Ding M-Y, Luo J-C, Liao W-B, Guo W, Fan Q (2023) *Commelina danxiaensis* (Commelinaceae), a new species from Guangdong, China. *PhytoKeys* 218: 117–126. <https://doi.org/10.3897/phytokeys.218.91199>

## Abstract

*Commelina danxiaensis* (Commelinaceae), a remarkable new species from Mount Danxia, Guangdong Province, China, is described and illustrated. This species is similar to *C. communis* in inflorescences and flowers but readily distinguishable in its nearly erect stems, larger flowers, and different petal colouration.

## Keywords

Commelinales, morphology, Mount Danxia, phylogeny, taxonomy

## Introduction

*Commelina* L. is the largest genus of Commelinaceae, consisting of about 170 species distributed in tropical and subtropical regions (Faden 1998, 2012), with eight species recorded for China (Hong 1997; Hong and DeFilipps 2000). The genus is most diverse in tropical Africa, where an estimated 100 species occur (Faden 2001), with a wide range of variation in habit, inflorescence, flower colour, capsule dehiscence, seed number, testa ornamentation, and chromosome number (Faden 2012). Most of its species occur in open environments or as weeds along roadsides or in cultivation fields, but a few of them

are restricted or exclusively known from forest habitats (Faden 2012; Nandikar 2013; Nandikar and Gurav 2014). *Commelina* is easily differentiated from the remaining genera in the tribe by its inflorescences which are subtended by spathaceous basal bracts and reduced to (1–)2 fasciculate cincinni, zygomorphic flowers, petals clawed, unequal and mostly blue (but sometimes white or lilac, rarely yellow, apricot or orange), three posterior staminodes with 6-lobed cruciform antherodes, three anterior stamens, and 2-locular or unequally 3-locular and 2-valved capsules (Faden 1998; Pellegrini and Forzza 2017).

During our botanical investigation of Mount Danxia of Guangdong Province in 2019–2020, we found an unusual population of *Commelina*. The plants are most closely similar to *C. communis* L., a species widely distributed in Asia, but differ mainly by the ascending stems (vs. creeping), petals sky-blue with a white basal third (vs. evenly dark blue).

## Materials and methods

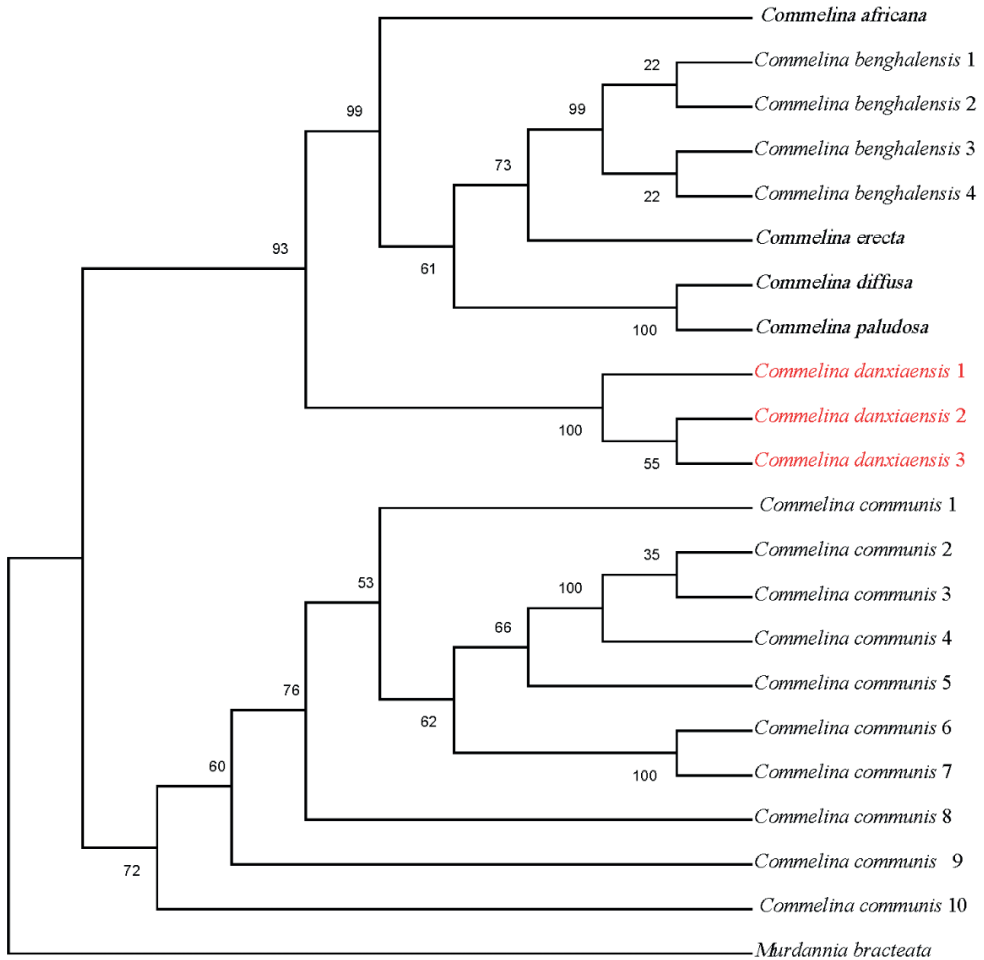
Morphological observations of the putative new species and its close relatives were carried out based on living plants in the field, as well as on dried specimens. The voucher specimens were deposited in the Herbarium of Sun Yat-sen University (SYS). Leaf samples for the putative new species were collected and stored in silica gel. Total DNA was extracted from dried leaves using the modified CTAB method following the protocol of Doyle and Doyle (1990). In order to clarify the taxonomic delimitations of the putative new species and its relative species, sequences from one nuclear gene (nrITS) and three chloroplast DNA regions (*matK*, *rbcL* and *trnH-psbA*) were used respectively to estimate a Maximum Likelihood phylogeny tree. Some species belonging to genera of tribe *Commelineae*, which were related to *Commelina* (Faden, 1991), have been chosen as outgroups, such as *Floscopa scandens* Lour., *Murdannia edulis* (Stokes) Faden, and *M. bracteata* (C.B.Clarke) Kuntze ex J.K.Morton, sequences of which were downloaded from Genbank. Details of sequence data are given in Appendix 1.

The multiple sequences of each gene were aligned with Clustal X (Thompson et al. 1997) and then manually adjusted in Sequence Alignment Editor (Rambaut 2002). Gaps within the sequence were treated as missing data. The whole dataset was analysed with Maximum Likelihood (ML) methods. Clade support was estimated using 1,000 bootstrap replicates (BS) with the same heuristic search conditions. The ML analyses were performed with RAXML v.8.2.4 (Stamatakis 2014).

## Results

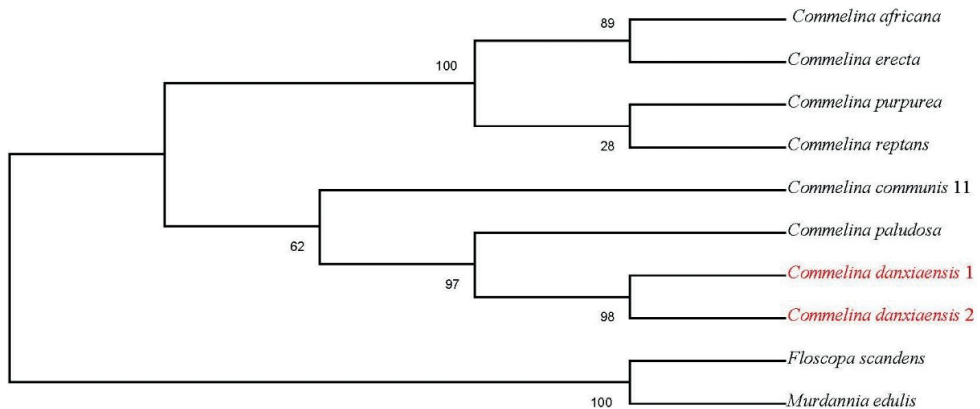
### Molecular analyses

The ML phylogenetic tree based on nrITS (Fig. 1) showed that all seven *Commelina* species were clustered into one lineage. Three individuals of *Commelina danxiaensis*



**Figure 1.** Maximum Likelihood consensus tree of the new species and related species based on nrITS sequence. Numbers beside nodes represent ML bootstrap values. The accessions for the new species are shown in red colour.

were recovered in a clade sister to a clade composed of *C. africana*, *C. benghalensis*, *C. erecta*, *C. diffusa*, and *C. paludosa*. Ten individuals of *C. communis* are recovered in a poorly supported clade, distantly related to *C. danxiaensis*. The ML phylogenetic tree based on three chloroplast DNA regions (*matK*, *rbcL*, and *trnH-psbA*) (Fig. 2) showed that all seven *Commelina* species were clustered into one lineage, and the outgroups were clustered into another one. And the two individuals of *C. danxiaensis* clustered into one lineage and were sistered to the lineage clustered with *C. communis* and *C. paludosa*. Although the phylogenetic trees based on nrITS and chloroplast DNA were in conformity, the individuals of *C. danxiaensis* formed one lineage, which partly supported it as a distinct species.



**Figure 2.** Maximum Likelihood consensus tree of the new species and related species based on three chloroplast sequences (*matK*, *rbcL*, and *trnH-psbA*). Numbers beside nodes represent ML bootstrap values. The accessions for the new species are shown in red colour.

## Taxonomic treatment

### *Commelina danxiaensis* Q.Fan, Long Y.Wang & W.Guo, sp. nov.

urn:lsid:ipni.org:names:77311811-1

Figs 3, 4

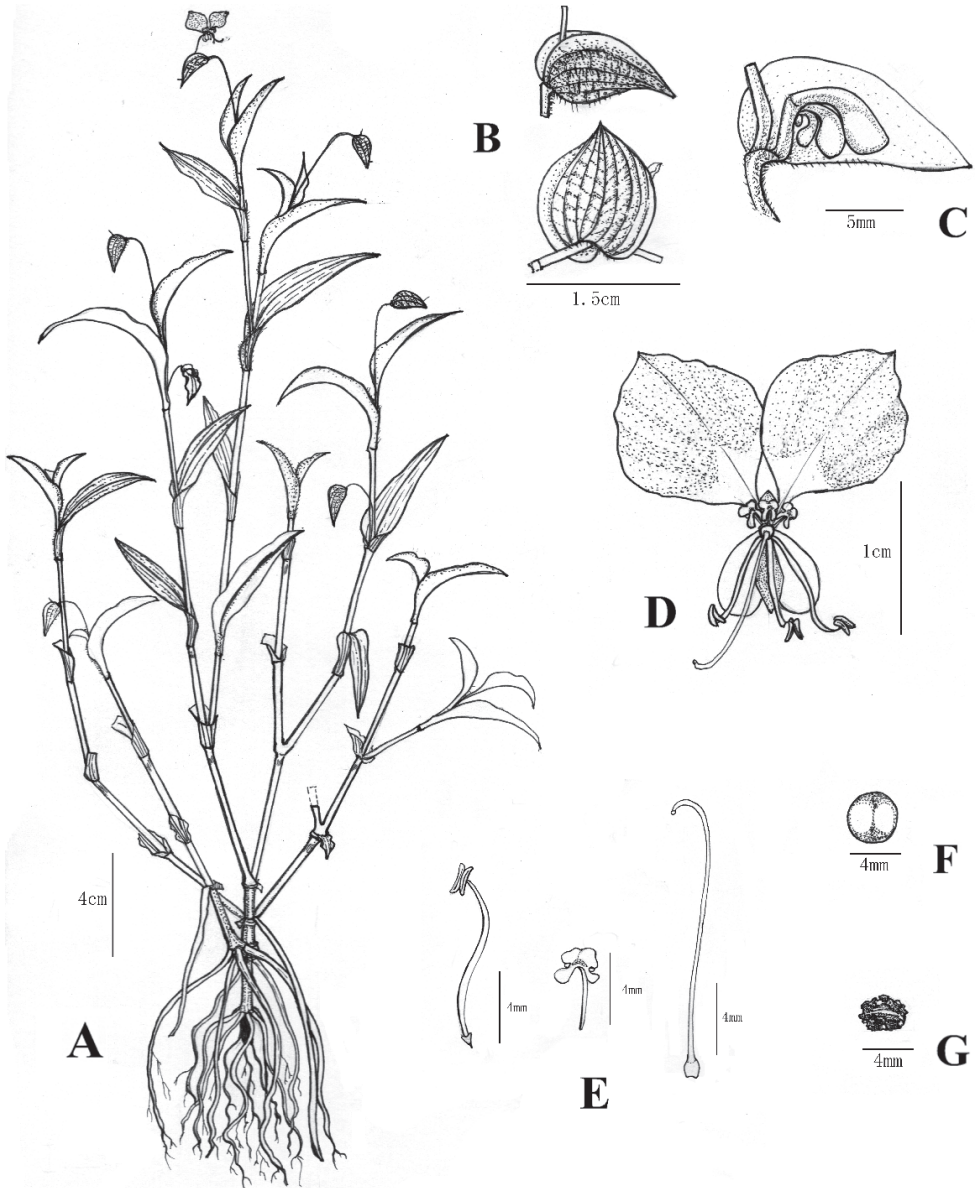
Chinese name. 丹霞鸭跖草 [dān xiá yā zhǐ cǎo]

**Type.** CHINA. Guangdong: Shaoguan City, Renhua County, Mount Danxia, 24°56'29.73"N, 113°45'21.96"E, dry mountaintop, ca. 350 m elev., 23 May 2020, Q. Fan 17910 (holotype: SYS!; isotypes: SYS!, IBSC!).

**Diagnosis.** *Commelina danxiaensis* is morphologically similar to *C. communis* due to their diffuse stems, lanceolate leaf-blades and approximate floral forms. However, it differs in its ascending stems (Fig. 4B), tomentose leaf-blades and sheaths (Fig. 4C–F), and sky-blue lateral petals with a white basal third (Fig. 4G).

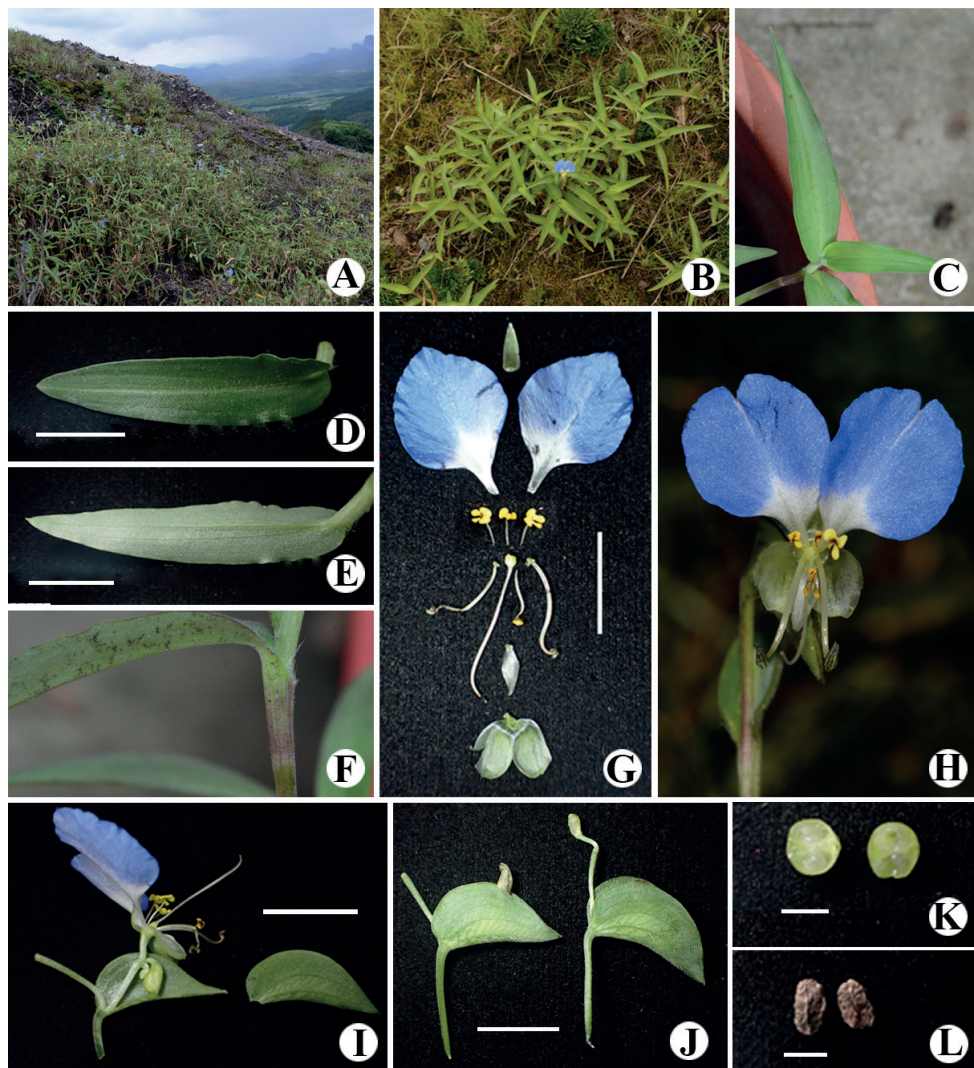
**Description.** *Herbs* over 30 cm tall, annual. *Roots* thin, fibrous. *Stems* ascending, many-branched; young shoots tomentose, becoming glabrous when old, hairs hyaline. *Leaves* spirally-alternate, evenly distributed along the stems; sheaths tomentose, hairs hyaline, margin ciliate, hairs setose, white; blades 3–9 × 1.5–2.0 cm, lanceolate to ovate-lanceolate, tomentose on both sides, evenly, hairs hyaline, base obtuse, margin glabrous, green to light-purple, apex lanceolate. *Inflorescences* leaf-opposite, restricted to the apex of the stems; peduncle 1.5–4.0 cm long, tomentose, hairs hyaline; spathe 1.2–2.5 × 1.0–2.2 cm, cordate, 6–8 veined, adaxially tomentose, long pilose hairs sometimes along the veins, hairs hyaline, abaxially glabrous, base cordate, free, margin green, apex acute; upper cincinnus developed, 1-flowered, flower staminate, peduncle ca. 8 mm long, exserted, sparsely tomentose to nearly glabrous, hairs hyaline; lateral cincinnus 2–3-flowered, flowers bisexual, peduncle 5–8 mm long, nearly included, tomentose to nearly glabrous, hairs hyaline. *Flowers* chasmogamous, bisexual or staminate,

strongly zygomorphic; pedicels c. 3 mm long at anthesis, less than 6 mm long in fruit, reflected, nearly glabrous, hairs hyaline; sepals green, membranous, glabrous, dorsal sepal c.  $5 \times 2$  mm, triangular-lanceolate, apex lanceolate, lateral sepals c.  $5 \text{ mm} \times 3 \text{ mm}$ , widely oblique-elliptic, connate for 3.6–4.2 mm, apex obtuse to round; paired petals short-clawed, claw c. 2–3 mm long, limb c.  $1 \text{ cm} \times 1 \text{ cm}$ , orbicular to sub-orbicular,



**Figure 3.** *Commelina danxiaensis* sp. nov. **A** habitat **B** involucral bract **C** inflorescence **D** flower **E** fertile, sterile stamens and pistil **F** fruit in transverse section **G** seed.

sky-blue with a white basal third, medial petal c.  $5 \times 2$  mm, narrowly rhombic, white, nearly hyaline; staminodes 3, subequal, the medial slightly shorter, filaments c. 3 mm long, antherodes X-shaped, distinctly four-lobed, upper lobes c. 1/2 to the lower ones, yellow, with a dark maroon at centre; lateral stamen filaments ca. 1 cm long, curved, anthers  $1.8\text{--}2.2 \times 1.2\text{--}1.4$  mm, elliptic; medial stamen filament ca. 5 mm long, anther  $2.2\text{--}2.4 \times 1.8\text{--}2.2$  mm, saddle-shaped; ovary c.  $1 \times 1$  mm, ovoid, glabrous, 2-locular, ovules 2 per locule, style c. 1.2 cm long, strongly curved at apex, stigma trilobate,



**Figure 4.** *Commelina danxiaensis* sp. nov. **A** habitat, growing on top of the Danxia landform **B** habit, plants ascending **C–E** leaf-blade, lanceolate to ovate-lanceolate **F** leaf-sheaths, with pubescence **G–H** flower **I** inflorescence **J** spathe **K** fruit in transverse section, 2 seeds per valve **L** seed. Scale bars: 1 cm (**D, E, G, I, J**); 3 mm (**K, L**).

white. **Capsule** c. 5 × 3 mm, ellipsoid, glabrous, equally 2-valved. **Seeds** 2 per valve, 3–4 × 2–2.5 mm, elliptic, ventrally flattened, testa brown, irregularly pitted.

**Phenology.** *Commelina danxiaensis* flowers from April to July and fruits from June to September.

**Distribution and habitat.** *Commelina danxiaensis* is only known from the type locality, Mount Danxia, Renhua County, Guangdong Province, China. Only two populations have been found, with several hundred individuals. It grows on dry mountain-tops of the Danxia formation at elevations of 100–350 m.

**Conservation assessment.** *Commelina danxiaensis* has only been found in Mount Danxia within an area of less than 20 km<sup>2</sup>, making it putatively ‘Vulnerable’ (VU D2) according to the guidelines of the IUCN Red List Categories and Criteria (IUCN 2022). However, the threat risk seems low because it is not economically valuable, and the area’s conservation is good.

**Additional specimens examined (paratypes).** CHINA. Guangdong: Shaoguan City, Renhua County, Mount Danxia, fl., 3 July 2020, *Q. Fan 18026* (SYS); loc. cit., fr., 29 August 2020, *Q. Fan 18231* (SYS); loc. cit., fr., 29 August 2020, *Q. Fan 18232* (SYS).

**Discussion.** The new species *Commelina danxiaensis* is similar to *C. communis* and *C. diffusa* in some of its morphological characters, such as lanceolate leaf-blades, cordate spathes free at base, and blue paired petals. Morphological comparisons among them have been listed in Table 1.

Additionally, we found the name *Commelina bicolor* D.Q.Wang & M.E.Cheng described by Wang et al. (2019), which is a later homonym of *C. bicolor* Poepp. ex Kunth (1843). Therefore, it is illegitimate under Art. 53.1 of ICN (Turland et al. 2018). This species is documented in Anhui and Hubei Provinces, and the type speci-

**Table 1.** Morphological comparison amongst *Commelina danxiaensis*, *C. communis*, *C. diffusa* and *C. bicolor* D.Q. Wang & M.E. Cheng.

Character	<i>C. danxiaensis</i>	<i>C. communis</i>	<i>C. diffusa</i>	<i>C. bicolor</i> D.Q. Wang & M.E. Cheng
Stem	ascending	creeping	creeping	unknown
Phyllotaxy	spirally-alternate	distichously-alternate	distichously-alternate	unknown
Leaf-blades	tomentose	glabrous	glabrous or hispid	unknown
Leaf-sheaths	tomentose	glabrous	hispid or hispid-ciliate	glabrous
Flower size	2.5 × 2 cm	2 × 1.5 cm	2 × 1.5 cm	unknown
Lateral sepals connation	connate	connate	free	unknown
Lateral petals colour	sky blue, basal third white	dark blue, sometimes lilac or white	light blue, sometimes lilac	upper most part deep-blue, basal part with claws (3 mm long) white
Medial petal colour	white	white	light blue	white
Medial petal claw	absent	absent	present	absent
Medial petal shape	narrowly rhombic	obtrullate	rhombic	oribicular-ovata or broadly ovata
Medial staminode development	developed	developed	not developed	developed
Stigma colour	white	white	white	unknown
Capsule valve number	equally 2-valved	equally 2-valved	unequally 2-valved	2-valved
Seed number per valve	2-seeded	2-seeded	dorsal valved 1-seeded, ventral valve 2-seeded	2-seeded
Seed testa ornamentation	irregularly pitted	irregularly pitted	Double-reticulate	irregularly foveolate

Up to the present time, four species of *Commelina* have been documented in Danxia-shan National Nature Reserve, including the new species *Commelina danxiaensis*. In order to facilitate identification, we here provide a key and checklist for the *Commelina* species in Mount Danxia.

1	Spathe margin connate at base, base truncate.....	<i>C. benghalensis</i>
–	Spathe margin free at base, base cordate or rounded.....	2
2	Spathe narrowly cordate, veins concolourous to the spathe and inconspicuous; medial petal subequal to the laterals; capsules unequally 2-valved .....	<i>C. diffusa</i>
–	Spathe cordate, veins dark green and conspicuous; medial petal unequal to the laterals; capsules equally 2-valved .....	3
3	Stem ascending; lateral petals sky blue, basal third white.....	<i>C. danxiaensis</i>
–	Stem prostrate; lateral petals evenly dark blue, sometimes lilac or white .....	<i>C. communis</i>

We are deeply grateful to Ms Rong-En Wu for her excellent illustration of the new species. This study was supported by Guangdong Provincial Special Research Grant for the Creation of National Parks (2021GJGY034), Science and Technology Program of Guangzhou (201803020013; 201903010076), Foundation of Administrative Committee of Danxiashan National Park (20163300071021059) and the Project for Educational Commission of Guangdong Province of China (2020KTSCX368).

Dai JM, Huang YS, Sun YY, Guo JQ, Chen ZX, Liao WB, Fan Q (2021) New records of plants from Guangdong Province II. Subtropical Plant Science 50(6): 495–499.

- Doyle JJ, Doyle JL (1990) Isolation of plant DNA from fresh tissue. *Focus* 12: 13–15.
- Faden RB (1998) Commelinaceae. In: Kubitzki K (Ed.) *The Families and Genera of Vascular Plants*, Vol. 4, Flowering Plants, Monocotyledons, Alismatanae and Commelinanae. Springer-Verlag, Berlin Heidelberg, 109–128. [https://doi.org/10.1007/978-3-662-03531-3\\_12](https://doi.org/10.1007/978-3-662-03531-3_12)
- Faden RB (2001) New or misunderstood species of *Commelina* (Commelinaceae) from the Flora of Tropical East Africa and Flora Zambesiaca areas. *Novon* 11(4): 298–309. <https://doi.org/10.2307/3393151>
- Faden RB (2012) Commelinaceae. In: Beentje H (Ed.) *Flora of Tropical East Africa*. Royal Botanic Gardens, Kew, 203–204.
- Hong DY (1997) Commelinaceae. In: Wu GF (Ed.) *Flora Reipublicae Popularis Sinicae*, vol. 13(3). Science Press, Beijing, 69–133.
- Hong DY, DeFilipps RA (2000) Commelinaceae R. Brown. In: Wu ZY, Raven PH, Hong DY (Eds) *Flora of China*, vol. 24. Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, 19–39.
- IUCN (2022) Guidelines for using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Subcommittee of the IUCN Species Survival Commission. [https://nc.iucnredlist.org/redlist/content/attachment\\_files/RedListGuidelines.pdf](https://nc.iucnredlist.org/redlist/content/attachment_files/RedListGuidelines.pdf) [Accessed 14 June 2022]
- Kunth K (1843) *Enumeratio Plantarum Omnium Hucusque Cognitarum* 4: 89.
- Nandikar MD (2013) A taxonomic revision of Indian Spiderwort (Commelinaceae) [Unpublished doctoral thesis]. Shivaji University, Kolhapur.
- Nandikar MD, Gurav RV (2014) A revision of the genus *Cyanotis* D. Don (Commelinaceae) in India. *Taiwania* 59(4): 292–314.
- Pellegrini MOO, Forzza RC (2017) Synopsis of *Commelina* L. (Commelinaceae) in the state of Rio de Janeiro, reveals a new white-flowered species endemic to Brazil. *PhytoKeys* 78: 59–81. <https://doi.org/10.3897/phytokeys.78.11932>
- Rambaut A (2002) *Se-Al Sequence Alignment Editor v.2.0a11*. University of Oxford, Oxford.
- Stamatakis A (2014) RAxML Version 8: A tool for phylogenetic analysis and Post-analysis of large phylogenies. *Bioinformatics* 30(9): 1312–1313. <https://doi.org/10.1093/bioinformatics/btu033>
- Thompson JD, Gibson TJ, Plewniak F (1997) The Clustal X Windows interface: Flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic Acids Research* 25(24): 4876–4882. <https://doi.org/10.1093/nar/25.24.4876>
- Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber WH, Li D-Z, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ, Smith GF [Eds] (2018) International Code of Nomenclature for algae, fungi and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. *Regnum Vegetabile* 159. Koeltz Botanical Books, Glashütten. <https://doi.org/10.12705/Code.2018>
- Wang DQ, Qing Z, Xie J, Cheng ME, Zhang L (2019) Four new species of flowering plants from Anhui. *Journal of West Anhui University* 35(5): 67–73.

Appendix I

**Table A1.** Details of sequence data and taxa arranged for phylogeny research.

Species sequenced	GenBank accessions				Voucher information
	nrlTS	matK	rbcL	trnH-psbA	
<i>Commelina africana</i>	KR733806.1	KR734981.1	KR737249.1	KR736019.1	/
<i>Commelina benghalensis</i> 1	OQ189896	OQ164772	OQ164778	OQ164784	L. Y. Wang 1833 (SYS), Guangzhou
<i>Commelina benghalensis</i> 2	MH768093.1	/	/	/	/
<i>Commelina benghalensis</i> 3	MH768094.1	/	/	/	/
<i>Commelina benghalensis</i> 4	ON908416.1	/	/	/	/
<i>Commelina communis</i> 1	OM934863.1	/	/	/	/
<i>Commelina communis</i> 2	MZ489676.1	/	/	/	/
<i>Commelina communis</i> 3	OM934871.1	/	/	/	/
<i>Commelina communis</i> 4	MH703263.1	/	/	/	/
<i>Commelina communis</i> 5	OM934864.1	/	/	/	/
<i>Commelina communis</i> 6	OM934865.1	/	/	/	/
<i>Commelina communis</i> 7	OM934867.1	/	/	/	/
<i>Commelina communis</i> 8	OM934870.1	/	/	/	/
<i>Commelina communis</i> 9	MH710676.1	/	/	/	/
<i>Commelina communis</i> 10	OM934869.1	/	/	/	/
<i>Commelina communis</i> 11	/	OQ164773	OQ164779	OQ164785	Q. Fan 18145 (SYS), Renhua
<i>Commelina danxiaensis</i> 1	OQ189892	OQ164774	OQ164780	OQ164786	Q. Fan 17910 (SYS), Renhua
<i>Commelina danxiaensis</i> 2	OQ189893	OQ164775	OQ164781	OQ164787	Q. Fan 18026 (SYS), Renhua
<i>Commelina danxiaensis</i> 3	OQ189895	/	/	/	Q. Fan 18232 (SYS), Renhua
<i>Commelina diffusa</i>	OQ189891	OQ164776	OQ164782	OQ164788	L. Y. Wang 1831 (SYS), Guangzhou
<i>Commelina erecta</i>	MG639917.1	KJ772671.1	KR737134.1	KR735729.1	/
<i>Commelina paludosa</i>	OQ189894	OQ164777	OQ164783	OQ164789	Q. Fan 18247 (SYS), Renhua
<i>Commelina reptans</i>	KR733954.1	KR735150.1	KR736643.1	KR735386.1	/
<i>Commelina purpurea</i>	/	GQ248103.1	EF590514.1	GQ248272.1	/
<i>Floscopa scandens</i>	/	LC540553.1	AF312255.1	KY018930.1	/
<i>Murdannia edulis</i>	/	MW617988.1	MW617988.1	MW617988.1	/
<i>Murdannia bracteata</i>	MT358291.1	/	/	/	/