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Morphological Details Confirm the Synonymization of *Polygala barbellata* within *P. tonkinensis* (Polygalaceae) in China and Vietnam

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Abstract

The current classification status of *Polygala barbellata* S.K.Chen and *P. tonkinensis* Chodat is unclear. In Flora of Cambodia, Laos and Vietnam, *P.* is treated as a synonym for *P. tonkinensis*. However, the synonymization did not provide detailed evidence, so this treatment may not be convincing, which requires more research to verify whether this treatment is valid. Here, we examined all the available specimens and observed the wild plants of the above two species, confirming no obvious morphological difference between them. Our result shows that the synonymization of *Polygala barbellata* within *P. tonkinensis* is convinced and accepted.

Keyword: Border, Plant taxonomy, synonym

Introduction

The phenomenon of the same plant bearing more than one scientific name is relatively common, especially in the border areas of two countries. There are some examples occurring between China and Vietnam. For example, *Lysimachia gesnerioides* Y. M. Shui & M. D. Zhang in China was recognized as a synonym of *L. baviensis* C. M. Hu in Vietnam (Tong et al. 2017). Similarly, *Begonia sonlaensis* Aver. in Vietnam was identified as a synonym of *B. pseudodryadis* C. Y. Wu in China (Chen et al. 2018). The above taxonomic treatment of the above species was unexceptionally revised based on examination of morphological details from specimens and field observation.

However, in some local floras, the synonymization of species is sometimes casual, and although most of these treatments are correct, there are also some errors. For example, *Euonymus mengtzeanus* (Loes.) Sprague was treated as a synonym of *E. balansae* Spraguein in Flora of China (Ma et al. 2008), but the examination of leaf surface characteristics, specimens and the plant in the wild reveals that the above two species are still two independent species (Zheng et al. 2012; Du et al. 2013). Nevertheless, there are also some other cases worth learning from. For example, the taxonomic status of *Allomorphia eupteroton* Guillaumin var. *teretipetiolata* C. Y. Wu & C. Chen was annoated by the existing taxonomic problems lacking sufficient evidence in the FOC (Chen and Renner 2007) , and then Chen et al. (2007) delimited the morphology of *Allomorphia eupteroton* under the genus *Oxyspora* DC. and revised *A. eupteroton* var. *teretipetiolata*as an independent

species, viz. *Oxyspora teretipetiolata* (C. Y. Wu & C. Chen) W. H. Chen & Y. M. Shui. So, The decision of taxonomic revision should be based on the careful and comprehensive examination of specimens and wild plants.

Polygalaceae is widely distributed in the world, comprising 1354 species belonging to 28 genera. The genus *Polygala*, with 465 species, is the largest genus in Polygalaceae and is also widely distributed in the world (COL, 2024; POWO, 2024). Plants of *Polygala* are either herbs or shrubs, with papery or nearly leathery leaves, entire margins, racemes, unequal sepals, keel petals surrounding stamens and styles, persistent or absent flower discs, winged capsules, and caruncle (Chen et al. 2008).In 1893, Chodat described a new species of *Polygala* based on the specimen (collection number *Balansa 3784*) collected by Balansa in Bavi mountain, Tonkin, Vietnam, and named it *Polygala tonkinensis* Chodat (Chodat 1893). In 1980, Chen described *P. barbellata* S.K.Chen, a new species of *Polygala*, based on the specimen (collection number *Pin I Mao 02805*) collected by Pin I Mao in Pingbian County (now Hekou County), China (Wu and Chen. 1980). In 1988, Meijden revised the taxonomic treatments of some *Polygala* species, in which *Chamaebuxus arillata* Hassk., *P. tonkinensis* and *Crotalaria duboisii* R.Wilczek were treated as synonyms of *Polygala arillata* Buch.-Ham. ex D.Don (Meijden 1998). When writing the Polygalaceae part of Flora of China (FOC) in 2008, Chen, Ma and Parnell had different views on the taxonomic status of *P. barbellata*. Parnell suggested that *P. barbellata* might be a synonym of *P. tonkinensis*, but Chen and Ma argued that *P. barbellata* and *P. tonkinensis* were two completely different species, so finally *P. barbellata* remained as an independent species in FOC (Chen et al. 2008). In 2014, Pendry revised Polygalaceae for *Flora of Cambodia, Laos and Vietnam* and treated *P. barbellata* as a synonym of *P. tonkinensis*, but did not present detailed evidence for this synonymization and did not provide the comparison of their morphological characteristics (Pendry 2014). Therefore, this synonymization may be not convincing. Up to now, this synonymization is not yet updated to the database of POWO (2024), IPNI (2024) and GBIF (2024). In summary, the classification status of *P. barbellata* and *P. tonkinensis* is still unclear, which requires further in-depth research to clarify

In order to clarify the above issues and verify whether this synonymization is tenable, we examined all available materials of the above species in herbaria and in the field, and compared their morphological characteristics. Our results show that there is no obvious morphological difference between them. In a word, morphological details support synonymization of *Polygala barbellata* within *P. tonkinensis* in Polygalaceae. Here, we present our study in details in the following.

Material and methods

The type specimens of *P. barbellata* and *P. tonkinensis* in G, HITBC, K, KUN, LE, P, PE and WUK were collected, and the morphological characteristics of all specimens were examined. Bedsides, we observed the wild plants of *P. barbellata*, took photos and collected specimens in the Gulinqing plot (Huang et al.; Liu et al. 2024), the *P. barbellata*'s locality. In addition, we observed the wild plants of *P. tonkinensis* in Bawei mountain, the locality of *P. tonkinensis*, and took photos. Among shrubs of the same genus, *P. karensium* Kurz with erect inflorescences was similar to *P. barbellata* and *P. tonkinensis* in morphological characteristics, so it was also selected for comparison of morphological characteristics. The morphological characteristics were compared based on the photos of specimens and wild plants, focusing on the characteristics of flower structure, inflorescence and leaves (Table 1). Specimens and high-definition electronic photographs were collected by the Chinese Virtual Herbarium (CVH, https://www.cvh.ac.cn/index.php), G (http://www.ville-ge.ch/musinfo/bd/cjb/chg/index.php?lang=en), JSTOR Global Plants

(https://plants.jstor.org/), P (https://science.mnhn.fr/institution/mnhn/search) and the Global Biodiversity Information Facility (GBIF, https://www.gbif.org/).We conducted a comprehensive examination on 17 specimens of *P. barbellata*, including 11 samples collected from the Gulinqing plot, and 14 specimens of *P. tonkinensis*. The length of the physical specimen was measured with a ruler. Based on the specimen photos, IMAGEJ 1.54 software was used to measure the length of leaf, flower and other structures of the specimen. Other information is obtained by consulting relevant literature (Chen 1983, 1991, 1997; Shui et al. 2006; Chen et al. 2008; Nguyen et al. 2013).

TABLE 1. Morphological characteristics of *Polygala barbellata*, *P. tonkinensis* and *P. karensium*, the three species in Polygalaceae distinctive being shrubs with erect inflorescences.

Characters	*P. barbellata*	*P. tonkinensis*	*P. karensium*
Leaf shape	elliptic or nearly elliptic-obovate	elliptic or nearly elliptic-obovate	linear-lanceolate to elliptic-lanceolate
Leaf tip	acute	acute	acuminate
Leaf length*	19.7.2–35.5 cm	15.0–25.0 cm	5.9–16.5 cm
Leaf width*	6.5–14.9 cm	5.3–8.8 cm	1.7–4.2 cm
Inflorescence length*	4.6.1–11.7 cm	4.3–8.8 cm	2.5–4.9 cm
Inflorescence axis diameter*	1.7–3.2 mm	1.6–2.6 mm	0.6–1.0 mm
Arrangement of flowers	tightly	tightly	sparsely
Color of flowers	yellow or orange	yellow or red	purple or white
Apex appendages	with stalk	with stalk	sessile
Keel	hooded	hooded	cucullate
Fruit	broadly ovoid	broadly ovoid	quadrangular-ellipsoidal or obcordate
Seed	globose	globose	ovoid

Note: * Indicates that the data are from specimen measurement; Other data sources are specimen observation and literature. *P. barbellata* data were obtained from Chen (1980); *P. tonkinensis* data were derived from Chodat (1893); *P. karensium* data were derived from Kurz (1872).

Results

The examination of all specimens of *P. barbellata* and *P. tonkinensis* reveal that they both have short, golden tower-like inflorescences, tightly spirally arranged flowers on the inflorescence axis, thick inflorescence axes that remain erect during both flowering and fruiting periods (Fig. 1B, 1E, 1H), elliptic or nearly elliptic-obovate leaves, apex acuminate leaf tip, adaxially impressed main and lateral veins, and similar number of vein pairs (Fig. 1A, 1C, 1D, 1F, 1G, 1I). The photographic documentations of wild plants further substantiate the morphological consistency of *P. barbellata* and *P. tonkinensis* among various features, such as the plant, leaves, inflorescence, apex appendages of flowers, and fruit (Fig. 2).

Furthermore, the morphological comparative analysis on *P. barbellata*, *P. tonkinensis*, and other closely related species within the genus indicate that *P. karensium* can be distinguished from *P. barbellata* and *P. tonkinensis* by several features, such as the acuminate leaf tip (as opposed to the acute leaf tip of *P. barbellata* and *P. tonkinensis*), the thinner inflorescence (as opposed to the thicker inflorescence), the sparsely arranged flowers along the inflorescence axis (as opposed to the tightly arranged flowers), the primarily purple or white flower (as opposed to the yellow or red flowers), and the upper petals that remain unreflexed (as opposed to the strongly reflexed upper petals) (Table 1). Based on the observations above, we conclude that *P. barbellata* should thus be considered a new synonym of *P. tonkinensis*.

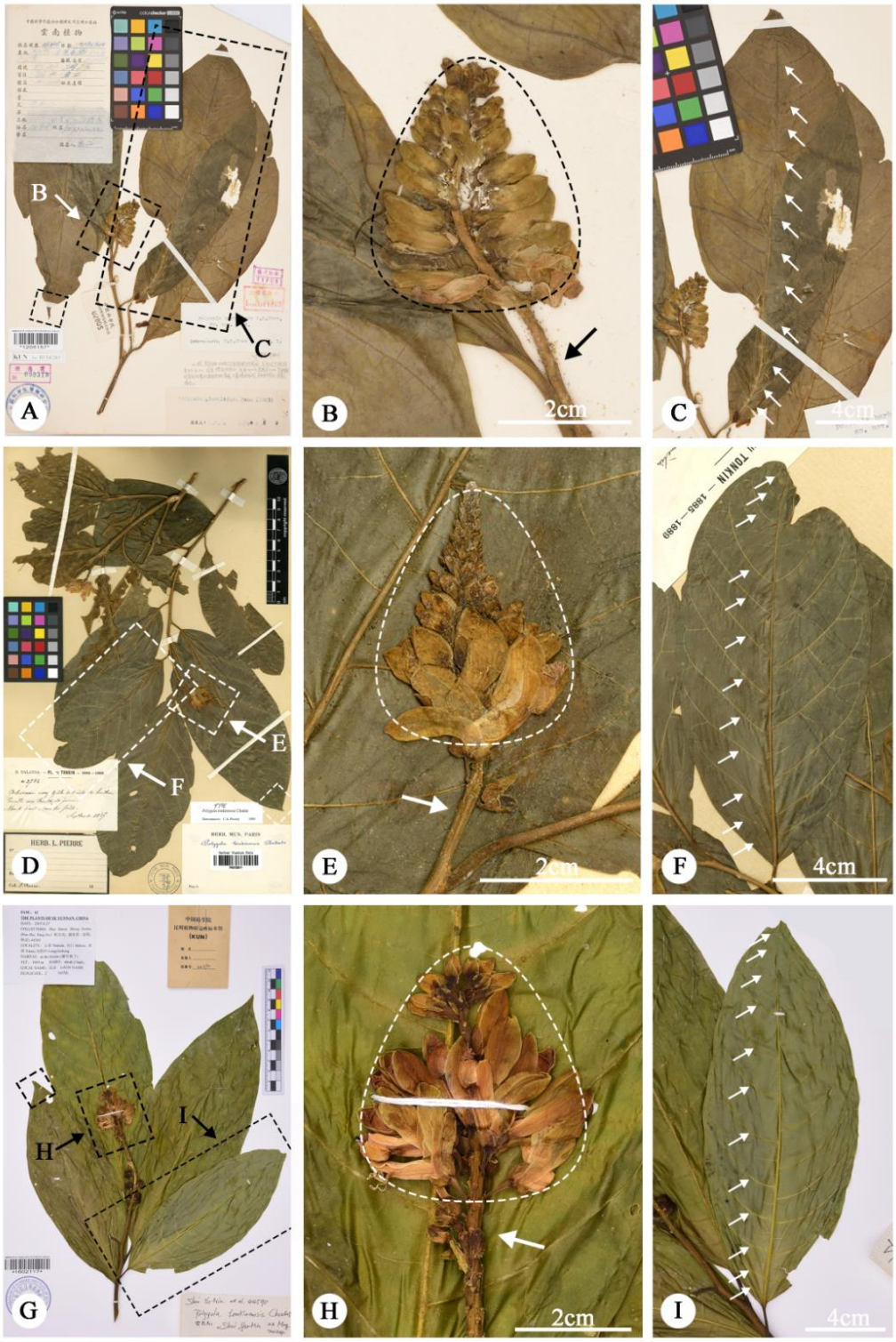


Figure 1. Type specimens of *Polygala barbellata* (A–C) and *P. tonkinensis* (D–F), as well as *P. barbellata* specimens from the Gulinqing plot (G–I) **A** *Pin I Mao 02805* (holotype of *P. barbellata*, KUN!), Hekou (previously Pingbian), SE Yunnan, China **B** Short golden tower-like inflorescence (the arrow indicates thick inflorescence axis) **C** Leaf (the arrow indicates lateral vein) **D** *Balansa B 3784* (syntype of *P. tonkinensis*, P!), Ba Vi Mountain, Vietnam **E** Short golden tower-like inflorescence (the arrow indicates thick inflorescence axis) **F** Leaf (the arrow indicates lateral vein). **G.** *Y. M. Shui, J. S. Sheng, R. Zhao, J. Yang 44590* (KUN!), Gulinqing plot, Maguan, SE Yunnan, China **H** Short golden tower-like inflorescence (the arrow indicates thick inflorescence axis) **I** Leaf (the arrow indicates lateral vein).

Taxonomic treatment

***Polygala tonkinensis* Chodat**
urn:lsid:ipni.org:names:692470-1

Polygala tonkinensis Chodat, Mém. Soc. Phys. Genève 31(2): 97–98. 1893. Type: Vietnam. Ba Vi Mountain, in the forest, September 1887, *Balansa B 3784* (syntype: P![P00733316, P00733317, P00733318, P00733320, P00733321], K![K000592315], G![G00076243, G00076244])
=*Polygala barbellata* S. K. Chen, Acta Bot. Yunnan. 2(1): 83. 1980. syn. nov. Type: CHINA. Yunnan: Hekou County (previously Pingbian), open forests, damp places on mountain slopes, alt. 1100 m, 8 August 1953, *Pin I Mao 02805* (holotype: KUN![KUN1205157], isotype: KUN![KUN0569164]).

Additional selected specimens examined. CHINA. Yunnan: Pingbian, 27 October 1954, *K. M. Feng 5195* (paratype: PE![PE 00630372]). Hekou, Nanxi, Longyinchong, 27 August 2005, *Y. M. Shui, J. S. Sheng, R. Zhao, J. Yang 44590* (KUN![KUN1602117], PE!). Maguan, Gulinqing, *Y. M. Shui GLQ0107-127* (KUN!); Maguan, Gulinqing, 16 July 2022, *Y. M. Shui GLQ0513-073* (KUN!); Maguan, Gulinqing, 24 September 2022, *Y. M. Shui GLQ0714-077* (KUN!); Maguan, Gulinqing, 27 September 2022, *Y. M. Shui GLQ0717-147* (KUN!); Maguan, Gulinqing, 27 September 2022, *Y. M. Shui GLQ0717-312* (KUN!); Maguan, Gulinqing, 25 October 2022, *Y. M. Shui GLQ0925-001* (KUN!); Maguan, Gulinqing, 31 October 2023, *Y. M. Shui GLQ1117-136* (KUN!); Maguan, Gulinqing, 23 December 2022, *Y. M. Shui GLQ1313-037* (KUN!); Maguan, Gulinqing, 23 December 2022, *Y. M. Shui GLQ1313-031* (KUN!); Maguan, Gulinqing, 23 December 2022, *Y. M. Shui GLQ1313-036* (KUN!). **VIETNAM**. Annam, 21 November 1923, *M. Poilane 7104* (P!); Kon Tum: Kon Plong District, Kon Chu Rang Nature Reserve near Mang Den Town, 1200 m, 14° 36.13′ N, 108° 17.90′ E, 22 November 2023, *L. Averyanov, Nguyen Van Canh, T. Maisak AL2760* (LE![LE01254122]); Ninh Binh: Cuc Phuong National park, 520 m, 20° 21.70′ N, 105° 35.10′ E, 19 July 2000, *P.K. Loc, D.T. Kien, M.V. Sinh P10383* (P!); Quang Tri: Dakrong Dist, Dakrong Forest, 450 m, 16° 29.60′ N, 107° 0.56′ E, 09 July 2008, *D. D. Soejarto DDS14194* (P![P06803354]); Tien Yen: Ho Yung Shan and vicinity, 13 October 1940, *W. T. Tsang 30743* (P![P02556693]); 26 April 1939, *E. Poilane 27756* (P![P02556681]); 29 December 1925, *M. Poilane 12219* (P![P02556683]); 29 December 1925, *M. Poilane 12298* (P![P02556682]).

Distribution. —China (Yunnan), Vietnam (Kon Tum, Ninh Binh, Quang Tri, Tien Yen)

Habitat and phenology. It grows in the humid areas of forests at altitudes from 450 to 1200 meters, such as the bottom of pits. Flowers in July–August, fruits in September–October.

Note. Based on the species description (Wu and Chen 1980) and Flora Reipublicae Popularis Sinicae (Chen 1997), *P. barbellata* is similar to *P. globulifera* Dunn, but differs in the thick and upright inflorescence axis (*vs.* thinner and drooping inflorescence axis), and the tightly arranged flowers (*vs.* sparsely arranged flowers). After examination on the herbaria specimens, we found that some specimens of *P. barbellata* in CVH had been incorrectly identified as *P. globulifera*, such as the specific specimens (PE00630371, PE00630372, and PE00630373). Similarly, some specimens of *P. barbellata* were incorrectly identified as *P. fallax* Hemsl, such as the specific specimens (KUN0569273, and WUK0206804). In addition, some specimens of *P. fallax* were incorrectly identified as *P. barbellata*, such as the specific specimens (HITBC005546, HITBC005552, HITBC005554, and HITBC005555).

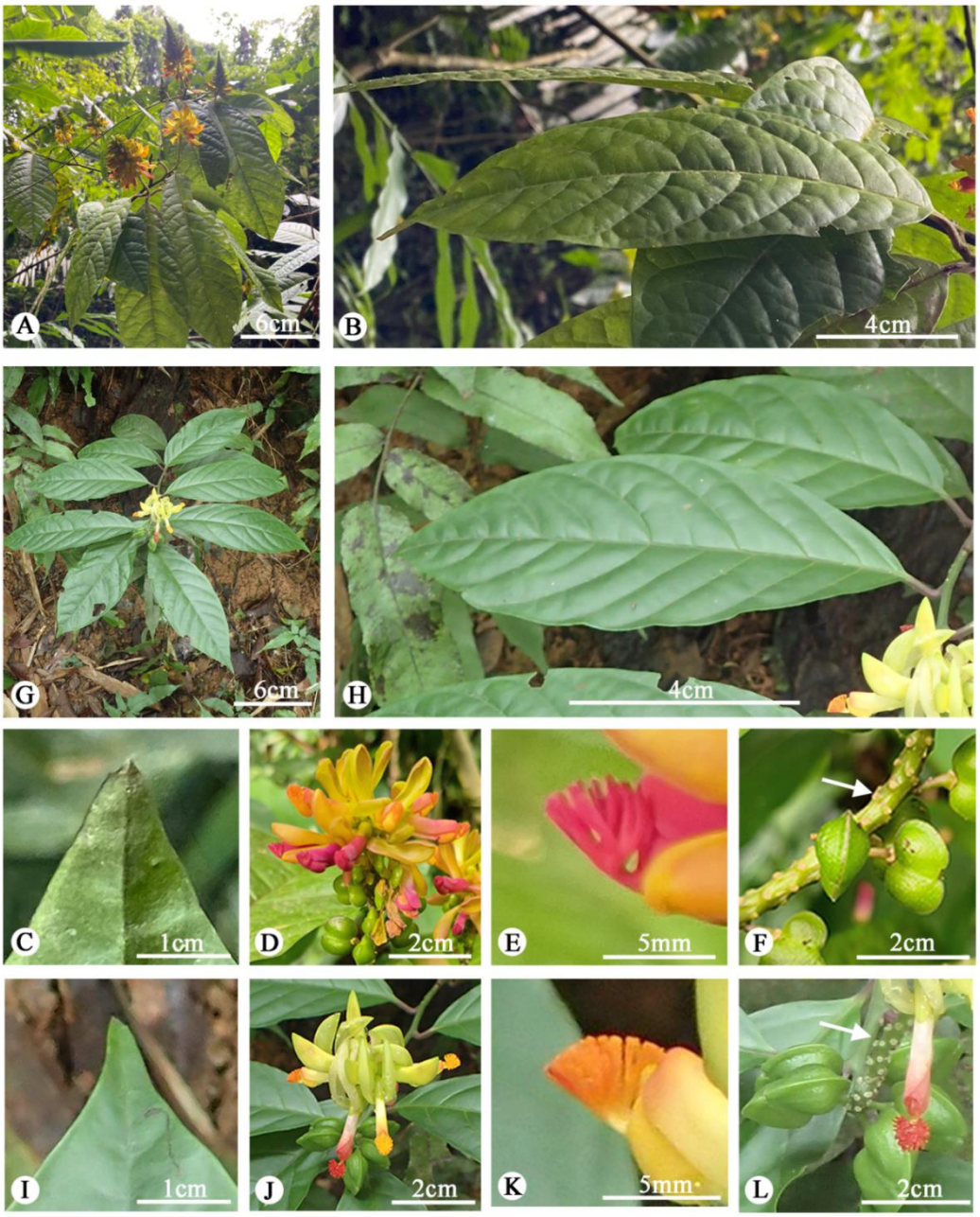


Figure 2. Images of *Polygala barbellata* (A–F) and *P. tonkinensis* (G–L) in the field **A** Plant **B** Leaves **C.** Leaf tip **D** The top of the inflorescence **E** Apex appendages of flowers **F** Fruit (the arrow indicates dense and obvious flower shedding trace) **G** Plant **H** Leaves **I** Leaf tip **J** The top of the inflorescence **K** Apex appendages of flowers **L** Fruit (the arrow indicates dense and obvious flower shedding trace) (A and B, photographed by Yu Min Shui; C–F, by Qing Huang; G–L, by Khang Sinh Nguyen).

Acknowledgements

We would like to give our sincere gratitude to Changli Fan from the research group for her assistance in examining the herbaria specimens.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

This work was financially supported by the Yunnan Provincial Science and Technology Talent and Platform Plan (202305AM070005), the Monitoring Program of the Hekou Field Station of Tropical Karst Ecosystem (2024-YN-06), and the Second Integrated Scientific Surveys of Daweishan National Nature Reserve of Yunnan, China.

Author contributions

Conceptualization: QH, LL, WHC, VTP, KSN, YMS. Data curation: QH, LL, WHC, VTP, KSN, YMS. Formal analysis: QH, LL, WHC, VTP, KSN, YMS. Funding acquisition: WHC, YMS. Investigation: QH, LL, WHC, VTP, KSN, YMS. Methodology: QH, LL, WHC, YMS. Project administration: WHC, YMS. Resources: QH, LL, WHC, VTP, KSN, YMS. Supervision: WHC, YMS. Validation: QH, LL, WHC, YMS. Writing - original draft: QH, LL, WHC, YMS. Writing - review and editing: QH, LL, WHC, VTP, KSN, YMS.

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Data availability

All of the data that support the findings of this study are available in the main text.

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