Postprint: Species Diversity and Geographical Distribution of Wild Gesneriaceae in Guizhou Province

Authors: Huangmei, Meijun Li, Huang Hong, Zhang Jinquan, Bai Xinxiang

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Abstract

Based on the establishment of a catalog and geographic distribution database of wild Gesneriaceae plants in Guizhou Province, this study investigates their species diversity and geographic distribution patterns. Through literature review combined with field surveys, analyses were conducted from the aspects of species composition, endemism, horizontal distribution, vertical distribution, and similarity, and finally a screening algorithm was employed to identify hotspot areas for Gesneriaceae distribution in Guizhou. The results show that: Gesneriaceae plants in Guizhou Province comprise a total of 2 tribes 8 subtribes 28 genera 153 species (including infraspecific taxa), distributed across 75 county-level administrative regions, with 128/45 China/Guizhou endemic species, and vertical distribution is most abundant in the 900–1,300 m altitude range. By calculating provincial similarity coefficients, Guizhou was found to have the highest similarity with Guangxi, and finally 10 hotspot counties were screened, collectively representing 75% of Gesneriaceae species. Guizhou Province is a typical karst plateau mountainous region, with rich Gesneriaceae species, particularly in the broad-sense genera Oreocharis, Primulina, Petrocodon, and Paraboea, which exhibit high species diversity and regional endemism. This study can provide theoretical reference for the conservation and sustainable utilization of Gesneriaceae plant resources in Guizhou Province.

Full Text

Species Diversity and Geographic Distribution of Wild Gesneriaceae in Guizhou Province

Mei Huang, Meijun Li, Hong Huang, Jinquan Zhang, Xinxiang Bai*

College of Forestry, Guizhou University, Guiyang 550025, China

Abstract

This study investigates the species diversity and geographic distribution patterns of wild Gesneriaceae in Guizhou Province based on the establishment of a comprehensive species inventory and geographic distribution database. Through literature review and field surveys, we analyzed species composition, endemism, horizontal distribution, vertical distribution, and floristic similarity, and identified hotspot areas for Gesneriaceae distribution in Guizhou using a complementary algorithm. The results show that Guizhou hosts 153 species (including infraspecific taxa) of Gesneriaceae, belonging to 2 tribes, 8 subtribes, and 28 genera, distributed across 75 county-level administrative districts. The province contains 128 Chinese endemic species and 45 Guizhou endemic species, with the richest vertical distribution occurring in the 900–1,300 m elevation band. Provincial similarity coefficient calculations revealed the highest similarity between Guizhou and Guangxi. Finally, ten hotspot counties were identified, representing 75% of Gesneriaceae species in the province. Guizhou' s typical karst plateau mountainous terrain harbors rich Gesneriaceae resources, particularly in the broadly defined genera *Oreocharis*, *Primulina*, *Petrocodon*, and *Paraboea*, which exhibit high species diversity and regional endemism. This study provides a theoretical foundation for the conservation and sustainable utilization of Gesneriaceae resources in Guizhou Province.

Keywords: Gesneriaceae, Guizhou Province, similarity coefficient, hotspot areas, vertical distribution, horizontal distribution

Introduction

The Gesneriaceae family comprises approximately 160 genera and 3,800 species worldwide, primarily distributed across tropical to temperate regions of eastern and southern Asia, Africa, southern Europe, Oceania, and South America to Mexico. China represents one of the major distribution centers of Gesneriaceae. According to Weber' s classification system, as of November 2020, China has recorded 786 species (including infraspecific taxa) in 45 genera, 14 subtribes, and 2 tribes, including 10 endemic genera and 11 monotypic genera. All Chinese Gesneriaceae except *Titanotrichum oldhamii* (Hemsl.) Soler., which belongs to the subfamily Gesnerioideae and forms its own tribe (Titanotricheae T. Yamaz. ex W.T. Wang), are classified under the subfamily Didymocarpoideae. The vast majority of Chinese Gesneriaceae species occur in tropical and subtropical regions of Guangxi, Yunnan, Guizhou, Guangdong, and Sichuan provinces, typically inhabiting exposed rock faces, crevices in karst and Danxia landforms, shaded understories, or cave entrances.

Guizhou Province' s unique geographic location, complex topography, well-developed karst landforms, predominant plateau mountains, high habitat heterogeneity, and warm, humid climate provide diverse habitats for Gesneriaceae. Existing literature indicates that Guizhou possesses relatively rich wild Gesneriaceae resources, with most species being saxicolous and exhibiting unique orna-

mental value, high species diversity, and regional endemism. Previous research on Guizhou' s Gesneriaceae has focused on resource surveys and floristic studies of important taxa at regional scales, with numerous new taxa described in recent years. However, current research remains disproportionate to Guizhou' s status as a resource-rich province. With continuous field surveys and taxonomic developments, particularly revisions to classification systems and descriptions of new taxa, the number of recorded Gesneriaceae species in Guizhou has surged, creating confusion in academic understanding and research. Therefore, systematic compilation and study of Guizhou' s Gesneriaceae resources are urgently needed. Additionally, implementation of Guizhou' s "Great Ecology" strategy has improved environmental conditions, while enhanced transportation infrastructure has increased accessibility for field surveys. Given the narrow distribution ranges characteristic of Gesneriaceae, county-scale literature compilation and field investigation are crucial for establishing baseline data on Guizhou' s Gesneriaceae resources. This study focuses on Guizhou' s Gesneriaceae, incorporating the latest research findings to establish a comprehensive species inventory and analyze species diversity, geographic distribution patterns, and hotspot areas, providing scientific guidance for future field surveys, conservation, and development of these resources.

Materials and Methods

Species Inventory Compilation

We compiled the Guizhou Gesneriaceae species inventory by consulting major floras including *Flora of Guizhou* (Vol. 4), *Flora of China* (Vol. 69), *Flora of China* (Vol. 18), *Plants of Gesneriaceae in China*, *Gesneriaceae of South China*, *Catalogue of Vascular Plants in Guizhou*, and *Plants of Petrocosmea in China*, as well as scientific investigation reports from nature reserves at various levels in Guizhou and the Chinese Virtual Herbarium (CVH). We supplemented this with new taxa reported in master' s and doctoral theses and journal articles published through November 2020. The inventory follows Weber' s classification system, with Chinese and Latin names of genera and species organized, verified, and revised to produce a comprehensive Guizhou Gesneriaceae species list.

Geographic Distribution Data Collection and Correction

We established a geographic distribution database for Guizhou Gesneriaceae by collecting data from: (1) floras including *Flora of Guizhou* (Vol. 4), *Flora of China* (Vol. 69), and *Flora of China* (Vol. 18); (2) academic monographs such as *Plants of Gesneriaceae in China*, *Gesneriaceae of South China*, *Catalogue of Vascular Plants in Guizhou*, and *Plants of Petrocosmea in China*; (3) academic papers published through November 2020 documenting Gesneriaceae distribution; (4) herbarium specimens from the Chinese Virtual Herbarium (http://www.cvh.org.cn); and (5) scientific investigation reports from Guizhou nature reserves. Geographic distribution information was extracted, screened, organized, and compiled. To improve data accuracy, we eliminated duplicate

records and specimens from cultivated areas, corrected geographic data, and converted old and new place names (e.g., Xiaohe District merged into Huaxi District, Shuicheng County changed to Shuicheng District, Qingzhen County changed to Qingzhen City) according to Guizhou' s 2020 administrative divisions. The final database includes attributes such as genus name, species name, endemism, and distribution area, with geographic precision standardized to county-level administrative units.

Based on this database, we used ArcGIS 10.0 to associate species distribution data with Guizhou administrative maps and applied the Natural Breaks (Jenks) classification method to categorize species richness, producing county-scale maps of Gesneriaceae species richness distribution.

Hotspot Area Identification

We employed Dobson' s complementary algorithm to identify hotspot areas for Gesneriaceae distribution in Guizhou based on species richness. The procedure involved: (1) selecting the county with highest species richness, (2) removing those species from the total inventory, (3) selecting the county with highest remaining species richness, and (4) repeating this screening process until all species were eliminated. The resulting set of counties represents hotspot areas containing the highest and most complementary species richness. When counties contained equal numbers of species, we prioritized smaller counties to maximize species representation per unit area.

Results

Species Inventory and Quantitative Changes in Guizhou Gesneriaceae

Our inventory documents 153 species (including infraspecific taxa) of wild Gesneriaceae in Guizhou, belonging to 2 tribes, 8 subtribes, and 28 genera, representing 19.47% of China' s total Gesneriaceae species. This includes 128 Chinese endemic species and 45 Guizhou endemic species (Appendix 1). Recent years have witnessed a surge in newly described Gesneriaceae taxa and significant revisions to tribal and generic classifications within the subfamily. Guizhou' s Gesneriaceae inventory has continuously updated from 82 species in 1988 to 96 in 2005 and 106 in 2015. Reviewing literature through November 2020 revealed numerous new records and new species such as *Oreocharis duyunensis*, *Paraboea dolomitica*, and *Petrocodon luteoflorus*, bringing the total to 153 species.

Species Diversity Analysis

Taxonomic Diversity and Endemism Guizhou' s Gesneriaceae are predominantly epiphytic, with most species occurring in karst and Danxia landforms, growing on humus layers on rock surfaces or in rock crevices, while a few inhabit humus-rich forest understories. The family exhibits high diversity at tribal, subtribal, generic, and specific levels, comprising 2 tribes (Epithe-

mateae and Trichosporeae), 8 subtribes (Monophyllaeinae, Loxotidinae, Epithematinae, Litostigmatinae, Corallodiscinae, Leptobaeinae, Didymocarpinae, and Loxocarpinae), 28 genera, and 153 species—accounting for 62.22% of China' s total genera and 19.47% of total species. Two Chinese monotypic genera occur in Guizhou: *Briggsiopsis* and *Middletonia*. Endemism is pronounced, with Chinese endemic species comprising 83.66% of the provincial total and Guizhou endemics comprising 29.41%. Seven genera contain more than 10 species each, totaling 114 species and representing 74.51% of Guizhou' s Gesneriaceae flora (Table 1).

Floristic Similarity Analysis We calculated similarity coefficients between Guizhou and other provinces using the formula: Similarity coefficient = 2w/(a+b), where a and b represent total species numbers in each region and w represents shared species. This metric serves as a fundamental quantitative indicator of floristic affinity in biogeographic comparisons. Based on shared species statistics with other provinces ($ $30 species), similarity coefficients were calculated (Table 2). Guizhou shows highest similarity with Guangxi (25.37%), likely because Guizhou represents a transitional zone from the Yunnan-Guizhou Plateau to the Hunan-Guangxi hills, with the adjacent Hongshui River basin sharing similar karst limestone landforms and climate types, and both regions maintaining relatively high species richness.

Geographic Distribution Patterns in Guizhou

Horizontal Distribution Field surveys and literature data reveal widespread distribution of Gesneriaceae across Guizhou, with all prefecture-level cities hosting species. The richest distributions occur in Qiannan Buyi and Miao Autonomous Prefecture (74 species), followed by Qianxinan Buyi and Miao Autonomous Prefecture (58 species), Zunyi City (46 species), Qiandongnan Miao and Dong Autonomous Prefecture (33 species), Tongren City (30 species), Guiyang City (24 species), Bijie City (28 species), while Anshun and Liupanshui cities have relatively fewer species (17 and 14, respectively).

At the county scale, 75 county-level administrative districts host Gesneriaceae. Ten counties have $ $15 species: Libo, Chishui, Xingyi, Daozhen, Guiding, Zhenfeng, Anlong, Jiangkou, Luodian, and Xingren (Figure 1 [Figure 1: see original paper]a). Guizhou endemic species occur in 37 counties, with high endemism areas showing a discrete distribution pattern across the province (Figure 1b,c). Floristic differentiation intensity, expressed as the species/genus ratio, varies regionally. Some areas with high species richness have low genus diversity, resulting in low differentiation rates, particularly in Libo and Daozhen counties (Figure 1d).

Vertical Distribution Wild Gesneriaceae in Guizhou show distinct vertical distribution patterns. We divided the elevation range into seven 400-m bands: H1 (148–500 m), H2 (500–900 m), H3 (900–1,300 m), H4 (1,300–1,700 m), H5

(1,700–2,100 m), H6 (2,100–2,500 m), and H7 (2,500–2,900 m) (Table 3 , Figure 2 [Figure 2: see original paper], Figure 3 [Figure 3: see original paper]).

The H3 elevation band (900–1,300 m) contains the most genera and species (24 genera, 99 species), representing 64.71% of the provincial total. Overall, lower elevation bands show relatively high generic and specific diversity, peaking at H3 and declining thereafter. Different genera show varying elevational distributions: *Oreocharis* species increase from H1 to H3 then decrease, while *Primulina* and *Hemiboea* predominantly occur at lower elevations (<900 m) and decline with increasing altitude.

We calculated Jaccard similarity coefficients between elevation bands using the formula Cj = j/(a+b-j), where a and b represent species numbers in each band and j represents shared species. The mean similarity across 21 pairwise comparisons was 0.2127 (range: 0–0.5278). Greater elevational distance corresponds to larger environmental differences and lower similarity coefficients. H1 and H7 share no species (coefficient = 0), reflecting distinct environmental adaptations. Although mid-low elevations host the most species, high endemism results in few shared species and moderate similarity coefficients.

Hotspot Areas

Applying Dobson's complementary algorithm, we identified ten hotspot counties containing 111 species (75% of the provincial total): Libo, Chishui, Xingyi, Zhenfeng, Weining, Jiangkou, Guiding, Daozhen, Panzhou, and Yanhe. Libo County hosts the greatest richness with 51 species. Nine counties contain only two species each, while remaining counties host single species found nowhere else, such as *Oreocharis wentsaii*, *O. wanshanensis*, and *Petrocosmea qiruniae*. When the cumulative species total reaches 100%, 39 hotspot counties are identified, encompassing all 153 species (Figure 4 [Figure 4: see original paper]).

Discussion

Species Diversity of Gesneriaceae in Guizhou

Located on the Yunnan-Guizhou Plateau and representing a core karst region in southern China with typical subtropical monsoon climate, Guizhou provides diverse habitats for Gesneriaceae. The province hosts 2 tribes, 8 subtribes, 28 genera, and 153 species, representing 62.22% of China' s total genera and 19.47% of total species, establishing Guizhou as a major distribution center for Chinese Gesneriaceae. Chinese and Guizhou endemics are particularly abundant. Dominant genera include *Oreocharis*, *Primulina*, *Hemiboea*, *Petrocosmea*, *Petrocodon*, *Paraboea*, and *Lysionotus*, totaling 114 species. While Guangxi and Yunnan rank first and second in species numbers, their proportions of China' s total species (40.71% and 35.88%, respectively) far exceed Guizhou's, suggesting that field surveys and research on Guizhou' s Gesneriaceae remain insufficient and many new taxa await discovery. Improved transportation infrastructure

and tourism development have facilitated fieldwork. Future priorities should include intensified field surveys and systematic studies, particularly in suitable microhabitats such as evergreen broad-leaved forest understories, limestone cliffs, caves, tiankengs, canyons, and riparian zones.

Geographic Distribution Patterns

Gesneriaceae are widely distributed across 75 county-level districts in Guizhou, concentrated in Qiannan, Qianxinan, and Zunyi, with 128 Chinese endemics and 45 Guizhou endemics. Due to their specialized habitat requirements, Gesneriaceae diversity patterns indirectly reflect regional biodiversity richness. Analysis of endemic proportions reveals discrete distribution patterns of high-priority conservation areas across the province. Some regions with low species richness exhibit high endemism, matching the 100% species hotspot identification. Although these areas have lower diversity, they harbor regional endemics with high irreplaceability and complementary contribution, warranting elevated conservation priority.

At the county scale, Libo, Xingyi, and Chishui represent concentration centers, with Libo being the richest. Vertically, species primarily occur at 500–1,700 m, peaking at 900–1,300 m. *Primulina* and *Hemiboea* mostly occur below 900 m, *Petrocodon* at 500–1,000 m, while *Oreocharis* spans 300–2,600 m.

Highest similarity with Guangxi likely reflects Guizhou' s southern distribution, adjacent geography, and similar karst landforms and climate. However, overall similarity coefficients remain low, possibly due to incomplete surveys, numerous undiscovered taxa, or high regional endemism fostered by unique environments. Alpine valleys may promote speciation and maintenance through habitat isolation, as evidenced by species like *Oreocharis panzhouensis*, *O. pankaiyuae* var. *weiningense*, and *O. ovatilobata* restricted to elevations above 1,700 m. Systematic surveys should target hotspots, high-endemism areas, and literature gaps.

Conservation and Utilization of Gesneriaceae Resources in Guizhou

Gesneriaceae conservation is urgent. Field observations reveal that while some species form large populations, others are declining due to destruction of specialized habitats (caves, limestone cliffs, canyons) and over-collection of medicinally valuable species. Environmental protection is therefore critical.

We recommend: (1) improving distribution and population status information; (2) strengthening resource surveys and scientific research to accurately assess distribution, abundance, and growth status; (3) identifying priority taxa and areas to prevent extinction; (4) understanding threats to develop targeted conservation measures; (5) conducting public education in hotspot areas; and (6) implementing in-situ conservation as primary strategy with ex-situ conservation as supplement to reduce human disturbance and enhance protection effectiveness.

Gesneriaceae exhibit diverse growth forms, brilliant floral colors, and intricate structures, offering high ornamental value. Guizhou' s rich Gesneriaceae flora, with multiple adaptive types and nearly year-round flowering, shows extensive morphological variation and exceptional ornamental potential, yet remains largely wild and underutilized. Most species thrive on moist limestone cliffs and crevices or in shaded forest understories, making them ideal for rock gardens, container cultivation, and shade plantings. Large-leaved, showy species like *Hemiboea subcapitata*, *Primulina liboensis*, and *P. eburnea* can enrich forest understory and shade garden plantings. Gesneriaceae represent excellent materials for rockeries, potted plants, and specialized landscapes with significant development potential. We recommend in-depth germplasm research and domestication of high-value ornamental species to bring these beautiful wild plants into horticultural applications.

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Appendix 1: List of Gesneriaceae Plants in Guizhou Province

Note: Those marked with are newly increased distribution areas found in field surveys; those marked with # are to be published; those marked with + are new records for Guizhou Province, currently being published.*

[The appendix continues with the detailed species list in tabular format as provided in the original]

Note: Figure translations are in progress. See original paper for figures.