Postprint: Study on the Seed Plant Flora of the Jiuling Mountains, Jiangxi

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Abstract

The flora of the Jiuling Mountains is of ancient origin and is of great significance for studying the evolution of early seed plants, animal and plant migration, and species distribution patterns in China. To investigate the origin of the seed plant flora in the Jiuling Mountains and the conservation and utilization of endangered and protected plants, this study conducted systematic compilation and analysis of the seed plant flora in this mountain range through field investigations, specimen collection and identification, combined with classical phytogeographical research methods. The results indicate: (1) The Jiuling Mountains harbor a total of 2,928 wild seed plant species belonging to 956 genera and 211 families, accounting for 91.5%, 89.8%, and 72.69% respectively of the seed plants in Jiangxi Province (193 families, 1,064 genera, and 4,028 species). (2) Tropical component families in this flora account for 81.35% of the total number of seed plant families in the region (excluding cosmopolitan families), but typical tropical component families are lacking; the numbers of tropical and temperate genera in the flora are comparable, indicating that this flora transitions from a tropical to a temperate nature, which is associated with the Jiuling Mountains being situated in an important climate and ecological transition zone. (3) Chinese endemic plants in this region are distributed across 6 families, 33 genera, and 41 species, with the endemic genera being mainly paleoendemic genera, reflecting the ancient origin of this flora; it is inferred that this mountain range had relatively stable environments during the Quaternary glacial period, providing a "refuge" for numerous plants. (4) Among the seed plants in this region, 109 species belonging to 63 genera and 30 families are nationally protected plants, including 15 National Grade I protected plants, 3 critically endangered species, 11 endangered species, and 20 vulnerable species. The Jiuling Mountain, Guanshan, and Daweishan in this mountain range already have corresponding nature reserves that play an ecological protection role, while effective protection has not been established for the remaining mountainous areas; supervision should be strengthened in areas where relevant endangered plants are located, mea-

sures such as in-situ conservation or ex-situ conservation can be adopted, and relevant germplasm resource banks can be established to ensure the sustainable utilization of endangered and protected plants.

Full Text

Preamble

Spermatophyte Flora of Jiuling Range, Jiangxi

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Abstract

The flora of Jiuling Range has an ancient evolutionary history and plays a crucial role in understanding the early evolution of spermatophytes, as well as the migration patterns and distribution of plant and animal species in China. To investigate the origins of the spermatophyte flora in this region and to inform conservation and utilization strategies for endangered plants, we conducted a systematic inventory and analysis of the seed plant flora based on field surveys, specimen collection and identification, and classical phytogeographical methods. Our results reveal: (1) The Jiuling Range harbors 2,928 species of wild spermatophytes belonging to 956 genera and 211 families, representing 91.5%, 89.8%, and 72.69% of Jiangxi Province's total spermatophyte flora (193 families, 1,064 genera, and 4,028 species), respectively. (2) Tropical families constitute 81.35% of the total families (excluding cosmopolitan families) in this flora, yet typical tropical families are absent. The numbers of tropical and temperate genera are nearly equal, indicating a transitional nature from tropical to temperate characteristics—likely associated with the range' s position at a critical climatic and ecological intersection. (3) The region hosts 41 Chinese endemic species across 33 genera and 6 families, with most endemic genera being paleoendemic, reflecting the ancient origins of this flora. We infer that the Jiuling Range provided stable habitats and served as a "refuge" for numerous plants during the Quaternary glaciations. (4) A total of 109 species across 63 genera and 30 families are listed as nationally protected plants, including 15 first-class protected species, 3 critically endangered, 11 endangered, and 20 vulnerable species. While Jiulingshan, Guanshan, and Daweishan have established nature reserves, other mountainous areas lack effective protection. We recommend enhanced monitoring of regions containing endangered plants, implementation

of in-situ and ex-situ conservation measures, and establishment of germplasm resource banks to ensure sustainable utilization of these protected species.

Keywords: Luoxiao Range; Jiuling Mountain; Guan Mountain; Dawei Mountain; endangered plants

Introduction

Flora represents the sum of all plant species that have evolved over long periods under natural conditions within a given region (Zhang, 1994; Wu et al., 2006). Floristic studies are essential for understanding regional environmental changes and plant diversity. The Jiuling Range, located in central Luoxiao Mountains in eastern mainland China and spanning Jiangxi and Hunan provinces, represents one of five medium-sized mountain ranges within the Luoxiao system, connecting the Mufu Range to the north and the Wugong Range to the south. With its ancient flora and position at a critical climatic and ecological transition zone, the range harbors many rare relict plants and serves as an important region for studying early spermatophyte evolution, species migration, and distribution patterns in China (Zhao, 2017).

Previous research on plant resources in the Jiuling Range has been limited in scope. Wan et al. (1986) investigated plant resources in the Wumei Mountain section, analyzing vegetation types, flora, and edible and medicinal resources. Tao (1998) documented woody plants in Tonggu County, while Liu and Wu (2005) conducted systematic surveys of the northeastern Guanshan section. Li et al. (2009) performed comprehensive scientific investigations of the Jiulingshan National Nature Reserve. Using literature data, Tu et al. (2014) compared seed plant flora across 12 national nature reserves in Jiangxi (including Guanshan and Jiulingshan), finding complex floristic components in both areas. Additional studies have examined plant communities and vegetation in Guanshan and Daweishan (Sun & Liu, 1986; Liu et al., 2015; Wang et al., 2018; Xu et al., 2018). However, these investigations were geographically restricted and incomplete, hindering comprehensive understanding of the Jiuling Range flora and effective biodiversity conservation. This study addresses these gaps through extensive field surveys, specimen collection and identification, and application of classical phytogeographical methods to systematically document and analyze the seed plant flora, characterize its composition and features, and discuss its origins and conservation strategies for endangered species, thereby providing a scientific foundation for understanding floristic evolution and sustainable resource utilization.

1. Study Area Overview

The Jiuling Range extends between 114°02 -115°24 E and 28°21 -29°03 N, oriented northeast-southwest across Anyi, Fengxin, Jing' an, Yifeng, Wanzai, and Tonggu counties in Jiangxi Province, as well as Daweishan in Liuyang City and Lianyunshan in Pingjiang County, Hunan Province. The region en-

compasses numerous nature reserves and forest farms, with major components including Daweishan, Guanshan, and Jiulingshan. The northeastern section (Guanshan and Jiulingshan) lies in Jiangxi Province, while the southwestern section (Daweishan) extends into northeastern Hunan, covering a vast area. The region experiences a mid-subtropical monsoon humid climate with mean annual temperatures of 11.4–17°C and annual precipitation of 1,653–2,100 mm. The highest peak is Jiulingjian at 1,794 m elevation (Li et al., 2009; Liu et al., 2015; Wang et al., 2018). Geologically, the Jiuling Range belongs to the Yangtze Plate in the northern Luoxiao Mountains (Zhang et al., 2003). While Daweishan and Guanshan are dominated by temperate genera, Jiulingshan contains slightly more tropical than temperate genera. The prevalence of mid-low elevation mountains and significant influence of warm-humid southeastern air currents contribute to extensive evergreen broad-leaved forests in Jiulingshan (Zhao, 2017).

3.1 Species Composition

The Jiuling Range exhibits rich plant diversity with dense, relatively intact vegetation. Through systematic field surveys and specimen identification, we documented 2,928 wild spermatophyte species (including infraspecific taxa) belonging to 956 genera and 211 families. This represents 91.5%, 89.8%, and 72.69% of Jiangxi Province' s total spermatophyte flora (193 families, 1,064 genera, and 4,028 species), respectively (Deng et al., 2012). The flora comprises 24 gymnosperm species in 15 genera and 8 families, 2,306 dicotyledonous species in 734 genera and 172 families, and 598 monocotyledonous species in 207 genera and 31 families . Gymnosperms account for 0.82% of total spermatophyte species, while angiosperms represent 99.18%. Notably, *Anoectochilus zhejiangensis* Z. Wei et Y. B. Chang and *Chrysosplenium delavayi* Franch. represent new records for Jiangxi Province.

3.2.1 Family Analysis

3.2.1.1 Family Composition Among the 211 families, 39 contain more than 20 species , including Poaceae (87 genera, 216 species), Compositae (75 genera, 183 species), Rosaceae (28 genera, 133 species), Lauraceae (8 genera, 57 species), and Fagaceae (6 genera, 50 species). These 39 families represent 18.48% of total families but contain 578 genera and 1,990 species (67.96% of total species), indicating their dominant role in the flora. Seventy families contain 5–19 species (33.18% of total families), including Ulmaceae (6 genera, 19 species), Magnoliaceae (6 genera, 18 species), Araceae (6 genera, 17 species), Acanthaceae (10 genera, 16 species), Balsaminaceae (1 genus, 9 species), Polygalaceae (2 genera, 8 species), and Lythraceae (3 genera, 7 species). These comprise 336 genera and 896 species (30.60% of total species). Sixty families contain 2–4 species (28.44% of total families) with 82 genera and 172 species, including Nyssaceae (4 genera, 12 species), Taxodiaceae (2 genera, 7 species), Cephalotaxaceae (3 genera, 4 species), and Saururaceae (3 genera, 4 species). Forty-two families are

monotypic (19.91% of total families). Families with 1–4 species thus account for 48.35% of total families.

Comparing major families (those with >50 species) in the Jiuling Range with their Chinese counterparts reveals that Poaceae, Fagaceae, Lauraceae, Rosaceae, Cyperaceae, Lamiaceae, and Papilionaceae represent substantial proportions of China' s total species in these families . While Poaceae, Cyperaceae, and Lamiaceae are herbaceous and not dominant in the flora, Fagaceae, Lauraceae, and Rosaceae are both numerous and structurally important, representing characteristic families of this flora. Dominant species include *Castanopsis fargesii*, *C. tibetana*, *Lithocarpus glaber*, *Castanea henryi* (Fagaceae), *Acer wilsonii*, *Liquidambar formosana*, and *Manglietia decidua*.

3.2.1.2 Family Distribution Types The 211 families can be classified into 13 areal types and 9 variants , comprising three major categories: cosmopolitan, tropical, and temperate families.

Cosmopolitan families (38 families, 18.01% of total) include species-rich families such as Poaceae, Compositae, Rosaceae, and Papilionaceae. However, based on life forms, these are predominantly herbs and shrubs and not major components of the flora.

Tropical families (Types 2–7) number 106 families, accounting for 81.35% of non-cosmopolitan families and dominating the flora. Pantropical distribution (including 2 variants, 58 families) is most prominent, representing 33.53% of non-cosmopolitan families.

Temperate families (Types 8–14) comprise 61 families (18.18% of non-cosmopolitan families). Though proportionally small, they enrich the flora' s composition, containing 101 genera and 305 species (10.56% of total genera and 10.42% of total species). North Temperate and its variants are most common, with 31 families representing 6.17% of the total.

3.2.2 Genus Analysis

3.2.2.1 Genus Composition Among 956 genera, 51 are large genera containing >10 species , including *Rubus* (42 species), *Ilex* (36 species), *Symplocos* (22 species), *Smilax* (20 species), *Ficus* (19 species), *Euonymus* (18 species), and *Callicarpa* (10 species). These 51 genera contain 814 species (27.80% of total species). Genera with 1–9 species number 901, representing 94.67% of total genera and including medium-sized genera such as *Lonicera* (9 species), *Rumex* (8 species), *Ranunculus* (7 species), *Callerya* (6 species), and *Eriocaulon* (5 species), as well as monotypic and oligotypic genera like *Youngia* (1 species). Monotypic and oligotypic genera total 834, representing 87.24% of total genera.

3.2.2.2 Genus Distribution Types The 956 genera can be divided into 14 areal types and 11 variants . Cosmopolitan genera (88 genera, 450 species)

include *Rubus* (42 species) and *Polygonum* (6 species), but are mostly herbaceous and shrubby with limited community significance. As they are widely distributed and cannot reflect floristic characteristics, they are excluded from other distribution type statistics.

Tropical genera (Types 2–7) comprise 422 genera and 982 species, representing 48.62% of non-cosmopolitan genera and 33.54% of species. Pantropical distribution (including 3 variants, 191 genera) is most abundant, accounting for 22.00% of non-cosmopolitan genera. Important community components include *Ficus*, *Ardisia*, *Symplocos*, and *Schefflera*. Tropical Asia and its variants contain 89 genera (10.25%), with *Cyclobalanopsis* dominating the tree layer and *Blastus* and *Diploclisia* common in understory and forest gaps.

Temperate genera (Types 8–14) number 413 genera and 1,145 species, representing 47.58% of non-cosmopolitan genera and 39.11% of species. North Temperate and its subtypes are most common, comprising 166 genera (19.12% of non-cosmopolitan genera). Only 11 genera show Mediterranean, West Asian (or Central Asian) and East Asian disjunct distribution, with no Central Asian type (T13) genera, indicating weak connections with the ancient Tethys flora. Only 13 temperate Asian distribution genera (T11) occur, suggesting minimal influence from ancient Mediterranean elements.

3.2.3 Endemism in the Jiuling Range Flora

3.2.3.1 Chinese Endemic Families The Jiuling Range hosts six Chinese endemic families: Bretschneideraceae, Calycanthaceae, Eucommiaceae, Ginkgoaceae, Sargentodoxaceae, and Tapisciaceae. Ginkgoaceae, a "famous living fossil" originating in the Permian with broad historical distribution (Willis & McElwain, 2002; Zhou et al., 2005), is monotypic. Bretschneideraceae is monotypic with scattered distribution of deciduous trees in subtropical mountains. Sargentodoxaceae is monotypic, occurring as associated lianas in the forest understory. Tapisciaceae is oligotypic with one species in the range. Eucommiaceae is monotypic with rare wild individuals. Calycanthaceae contains a single genus with three species in the range.

3.2.3.2 Chinese Endemic Genera Thirty-three genera with 41 species are endemic to China, predominantly monotypic and oligotypic, including 20 monotypic and 9 oligotypic genera . Most have ancient origins, such as *Sargentodoxa*, *Camptotheca*, and *Bretschneidera*.

3.3 Endangered and Protected Plants in the Jiuling Range

The flora includes 109 nationally protected species across 63 genera and 30 families , comprising 15 first-class protected species (e.g., *Cypripedium japonicum*, *Dendrobium findlayanum*, *D. moniliforme*, *Metasequoia glyptostroboides*, *Taxus wallichiana* var. *chinensis*) and 94 second-class protected species (e.g., *Amitostigma gracile*, *Anoectochilus roxburghii*, *A. zhejiangensis*). Forty-one species

appear in the *Red List of China' s Biodiversity—Higher Plants* (Ministry of Environmental Protection & Chinese Academy of Sciences, 2013), including 3 critically endangered (*Metasequoia glyptostroboides*, *Ginkgo biloba*, *Brasenia schreberi*), 11 endangered (e.g., *Anoectochilus roxburghii*, *A. zhejiangensis*, *Bletilla striata*, *Changnienia amoena*), 20 vulnerable (e.g., *Actinidia trichogyna*, *Cephalotaxus oliveri*, *Cinnamomum japonicum*), and 7 near-threatened species (e.g., *Actinidia valvata*, *Goodyera schlechtendaliana*, *Michelia chapensis*). These species primarily inhabit valleys, streamsides, trees, sparse or dense forests at 180–1,450 m elevation, where favorable habitats provide critical conditions for their survival and reproduction.

4.1 Transitional Nature of the Jiuling Range Spermatophyte Flora

The Jiuling Range contains 211 families, with 106 tropical and 61 temperate families. While tropical families dominate numerically, most are broadly distributed and lack typical tropical characteristics. At the genus level, 422 tropical and 413 temperate genera occur in nearly equal numbers, reflecting a clear transition from tropical to temperate nature. Situated in eastern mainland China at a critical climatic and ecological transition zone with northeast-southwest orientation, the range facilitates effective species migration, allowing coexistence of tropical and temperate elements and creating a transitional flora.

4.2 Ancient Characteristics of the Jiuling Range Flora

The flora exhibits pronounced mono- and oligotypic families and genera, most of which emerged during the early Tertiary as isolated taxa, indicating ancient origins. The range contains six Chinese endemic families, 33 endemic genera, and 41 endemic species (including infraspecific taxa). The endemic genera are predominantly paleo-endemic and monotypic. These ancient genera historically had broad distributions but became endemic to China following Quaternary glaciations and geological changes, representing relicts of the Tertiary paleotropical flora (Jin et al., 2003; Zhao, 2017). The rich paleo-endemic flora suggests that the Jiuling Range maintained stable environments during the Quaternary, serving as a "refuge" that preserved numerous ancient species and providing valuable material for studying early distribution patterns.

4.3 Conservation and Utilization of the Jiuling Range Flora

The flora includes 109 nationally protected species, with 41 listed in the *Red List of China' s Biodiversity—Higher Plants* (Ministry of Environmental Protection & Chinese Academy of Sciences, 2013). Many have high medicinal value, such as *Schisandra chinensis*, *Paris fargesii*, *Liparis nervosa*, *Dysosma versipellis*, and *Coptis chinensis* var. *brevisepala*. Unsustainable exploitation could severely damage these endangered species. While Jiulingshan, Guanshan, and

Daweishan have established nature reserves, other mountainous areas lack effective protection and monitoring (Nie, 2014). Sustainable utilization of plant resources in these regions faces serious challenges. We recommend enhanced supervision of areas containing endangered plants, implementation of in-situ and ex-situ conservation measures, and establishment of germplasm resource banks to ensure sustainable utilization of protected species.

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