The Seed Plant Flora of the Mount Jinggangshan Region, Southeastern China

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Abstract

The Mount Jinggangshan region is located between Jiangxi and Hunan provinces in southeastern China in the central section of the Luoxiao Mountains. A detailed investigation of Mount Jinggangshan region shows that the seed plant flora comprises 2,958 species in 1,003 genera and 210 families. Moreover, they can also be sorted into woody plants (350 genera and 1,295 species) and herbaceous plants (653 genera and 1,663 species). The dominant families are mainly Fagaceae, Lauraceae, Theaceae, Hamamelidaceae, Magnoliaceae, Ericaceae, Styracaceae, Aquifoliaceae, Elaeocarpaceae, Aceraceae, Rosaceae, Corylaceae, Daphniphyllaceae, Symplocaceae, Euphorbiaceae, Pinaceae, Taxodiaceae, Cupressaceae and Taxaceae. Ancient and relic taxa include Ginkgo biloba, Fokienia hodginsii, Amentotaxus argotaenia, Disanthus cercidifolia subsp. longipes, Hamamelis mollis, Manglietia fordiana, Magnolia officinalis, Tsoungiodendron odorum, Fortunearia sinensis, Cyclocarya palturus, Eucommia ulmoides, Sargentodoxa cuneata, Bretschneidera sinensis, Camptotheca acumidata, Tapisicia sinensis, etc. The flora of Mount Jinggangshan region includes 79 cosmopolitan genera and 924 non-cosmopolitan genera, which are 7.88% and 92.12% of all genera. The latter includes 452 tropical genera (48.92%) and 472 temperate genera (51.08%). The temperate elements include 44 genera endemic to China, accounting for 4.76% of all genera. Among 1,003 genera, 465 have only a single species and 401 are oligotypic genera (with 2-5 species). These genera account for 86.34% of all genera.

The floristic analysis indicates that the flora of Mount Jinggangshan region is closely related to the flora of Mount Wuyishan region in southeastern China. The flora of Mount Jinggangshan region also contains many elements of central and southern China. Mount Jinggangshan region is an important north-south floristic passageway and is also a boundary between the floras of eastern, central and southern China.

Introduction

The Mount Jinggangshan region is located in the center of the Luoxiao Mountains, an important, large, north-south trending mountain range in southeastern China. Compared with other larger mountain ranges, such as Mount Wuyishan, Nanling Mountains, Wuling Range, Mount Emeishan, Qinling Mountains, Hainan Mountains and Hengduan Mountains, the natural resources and biodiversity of the Luoxiao Mountains have been less well studied.

The Mount Jinggangshan region has four natural reserves: the Mount Jinggangshan National Nature Reserve, the Mount Qixiling National Nature Reserve and the Mount Nanfengmian National Nature Reserve, all of Jiangxi Province, and the Mount Taoyuandong National Natural Reserve of Hunan Province. During 1983-1984, the government of Jiangxi Province organized a comprehensive natural resource survey on the Mount Jinggangshan Nature Reserve [1]. Later, several institutions and scientists developed surveys and research projects on the biodiversity of the other three nature reserves [2-4]. Interestingly, the four reserves have the boundaries which are connected to each other, forming an integrated region. Based on a detailed research, it is stated that the flora of the Mount Jinggangshan region is the core of the Luoxiao Mountains. Therefore, it is significant to comprehensively analyze the flora of the Mount Jinggangshan region.
Based on the field surveys, the specimens collected in the Mount Jinggangshan region from 2009 to 2012 and deposited in herbaria, and relevant literature, we compiled a checklist of the seed plant in the Mount Jinggangshan region [5]. Additionally, we analyzed the composition of the flora of the Mount Jinggangshan region in order to discuss its origin, evolution and floristic status.

**Geography**

**Geographic Limits**

The Mount Jinggangshan region, in the central section of the Luoxiao Mountains, has four, linked, nature reserves. It lies between 26° 13'04″-26°52'30″ N and 113° 56′30″-114°22'00″E and covers an area of 480.05 km² (Figure 1). The Luoxiao Mountains is a large north-south trending mountain range that forms the boundary between Jiangxi and Hunan provinces in southeastern China.

**Topography**

The Mount Jinggangshan region is deeply cut by deep, V-shaped valleys, resulting in a steep topography. There are two main peaks, Nanfengmian (2,120.4 m above sea level) in Jiangxi Province and Lingfeng (2,122 m) in Hunan Province. The lowest point is 200 m above sea level. The Mount Jinggangshan region has more than 300 peaks above 1,000 m. The relative elevation ranges from 500 to 1,300 m.

**Climate**

The Mount Jinggangshan region is under the influence of the monsoon climate and characterized by four distinct seasons and abundant water and heat. Based on the data gathered by

![Figure 1. Map showing the locations of Mount Jinggangshan region and other twelve mounts in China. Notes: JG: Mount Jinggangshan region; QY: Mount Qiyunshan; LS: Mount Lushan; NL: Nanling Mountains; WY: Mount Wuyishan region; WL: Wuling Range; SNJ: Mount Shennongxia; EM: Mount Emeishan; TW: Taiwan Mountains; HN: Hainan Mountains; TB: Mount Taibeishan; XSBN: Mount Xishuangbangna; GLG: Mount Gaoligongshan. doi: 10.1371/journal.pone.0075834.g001](image-url)
the Mount Jinggangshan Weather Bureau from 1971 to 2000, the annual mean temperature is 14.2°C. The hottest month is July, with a mean temperature of 23.9°C and an extreme high temperature of 36.7°C. The coldest month is January, with a mean temperature of 3.4°C and an extreme lowest temperature of −11.0°C. The annual mean sum of radiation ranges from 85 to 105 kcal/cm. The annual cumulative temperature (the sum of daily temperature mean >10°C) is 4,224°C. On average, there are 247.5 fog-free days per year. The annual mean precipitation is 1,889.8 mm with the greatest precipitation of 2,878.8 mm and the lowest precipitation of 1,297.4 mm. The annual mean evaporation capacity is 978.8 mm. The relative humidity is about 85%.

Soils

There are four major soil types in Mount Jinggangshan region: mountain red, yellow, dark yellow-brown and meadow soil. Among them, mountain yellow soil has the largest distribution area, occurring between 800 and 1,200 m. The second most extensive is mountain red soil, which is often at altitudes below 850 m. Mountain dark yellow-brown soil is mainly between 1,200 and 2,100 m. Mountain meadow soil is mainly between 1,600 m and 1,800 m [1].

Vegetation

Based on plot investigations and the Vegetation Classification System of China [6], the natural vegetation of Mount Jinggangshan region is divided into 12 types, 82 association groups and 167 associations [5]. Among them, the warm coniferous and broadleaved mixed forests, including Pinus massoniana mixed forests, Cunninghamia lanceolata mixed forests, Amentotaxus argotaenia mixed forests and Nageia nagi mixed forests, dominate with 28%-30% of the total natural vegetation. Typical evergreen broadleaved forests are also diverse. They include 15 association groups and 39 associations and account for 21.6% of the total natural vegetation, with the main dominant species including Schima superba, Schima argentea, Castanopsis sclerophylla, Castanopsis eyrei, Castanopsis lamontii, Cyclobalanopsis glauca, Cyclobalanopsis sessilifolia, Lithocarpus glaber, Cyclobalanopsis multinervis, Phoebe bourrei, Phoebe hunanensis, Machilus leptophylla, Michelia maudiae, Michelia fovealata, Daphniphyllum glaucescens, Ternstroemia gymnanthera, Sloanea sinensis, etc.

The next largest type is the ravine or lowland monsoon evergreen broadleaved forests, including 12 association groups and 26 associations. The dominant species comprise Castanopsis fargesii, Castanopsis tibetana, Castanopsis fabri, Castanopsis carlesii, Cyclobalanopsis fleuryi, Altingia chinensis, Altingia gracilipes, Elaeocarpus japonicus, Michelia chapsenis, Manglieta fordiana, Machilus thunbergii Exbucklandia tongkinensis, etc. Generally, these forests are evergreen broadleaved forests that include tree ferns, epiphyllous liverworts, vines and lianas, pteridophytes, epiphytic orchids, trees with buttress roots and strangler vines.

Geological History

Located in the central section of the Luoxiao Mountains, southeastern Eurasia and southeast of the junction zone of the Yangzi and Cathaysian paleo-plates, Mount Jinggangshan region has experienced a long geological history and undergone complicated evolutionary processes. The region was a basin in the South China Ocean during the Caledonian orogeny of the Neoproterozoic to Eopaleozoic, the margin of the sea during the late Paleozoic, Indosinian orogeny, geological tectonism of Yan mountain and the Himalayan mountain tectonic movement. Cambrian, Ordovician, Devonian and Quaternary strata occur within the Mount Jinggangshan region. The area has been above the sea for more than 20 million years. Through ecological succession, a diversity of life forms have evolved and the distinct vegetation of Mount Jinggangshan region has been formed [1].

Methods

Firstly, a checklist of the seed plant in Mount Jinggangshan region was prepared. We conducted field surveys and collected specimens in Mount Jinggangshan region from 2009 to 2012, with the permissions of four Nature Reserve Administration. No endangered or protected species were involved. Moreover, we consulted the specimens deposited in the herbarium of the Mount Jinggangshan Natural Reserve and the relevant literatures, such as Flora of China [7], Flora of Jiangxi [8,9], List of Jiangxi Seed Plant [10] and Species Checklist of Five Provinces in East China [11].

Secondly, we analyzed the composition and characteristics of the seed plant flora of Mount Jinggangshan region and compared our findings with information from other main mounts in China. Similarity coefficients were calculated according to shared families, genera and species using the formula S = 2c/(a+b) (S is the similarity coefficient between two regions, %; c equals the number of shared taxa; a equals the number of taxa within the region; and b equals the number of taxa within the region). The mounts selected for comparison included Mount Wuyishan region [12-14], Mount Qiyunshan [15], Mount Lushan [16], Wuling Range [17], Mount Emeishan [18], Mount Taiibaishan [19], Nanling Mountains [20], Mount Shennongjia [21], Taiwan Mountains [22], Hainan Mountains [23], Mount Xishuangbanna [24] and Mount Gaoligongshan [25].

The Mount Wuyishan region in this paper includes two natural reserves: the Mount Wuyishan Natural Reserve of Fujian Province and the Mount Wuyishan Natural Reserve of Jiangxi Province. The former is situated between 27°32'36″-27°55'15″ N and 117°24'12″-118°02'50″ E and covers an area of 565.27 km² [12]. It was listed as a World Natural Heritage site in December, 1999. The latter is situated between 27°48'11″-27°59'30″ N and 117°39'30″-117°55'47″ E and covers an area of 656.27 km² [12]. The two natural reserves adjoin each other and share the same main peak, Huanggangshan, therefore, they are regarded as one integrated region. The Mount Wuyishan region is located between 27°32'36″-28°00'35″ N and 117°24'12″-118°02'50″ E and covers an area of 725.34 km². The statistics on the seed
Table 1. Statistics of the seed plants in Mount Jinggangshan region and Mount Wuyishan region.

| Regions/Taxa                  | Families | Genera | Species | Infraspecies* | References |
|-------------------------------|----------|--------|---------|---------------|------------|
| Mount Jinggangshan            | 196      | 951    | 1800    | 1855          | [1]        |
| Mount Qixiling                | 182      | 651    | 1427    | 1464          | [3]        |
| Mount Nanfengmian             | 178      | 676    | 1492    | 1533          | [2]        |
| Mount Taoyuandong             | 187      | 728    | 1566    | 1618          | [4]        |
| Total (Mount Jinggangshan region) | 210    | 1003   | 2958    | 3187          | In this paper |
| Mount Wuyishan in Fujian Province | 189  | 784    | 1806    | 1882          | [11]       |
| Mount Wuyishan in Jiangxi Province | 193  | 805    | 1933    | 2025          | [12]       |
| Total (Mount Wuyishan region) | 201      | 891    | 2331    | 2484          | In this paper |

Notes: The figures in this table may differ from published reports. We have edited the checklists of those mountains to make them uniform at the family, genus and species level based on Zhengyi Wu [26-30]. Infraspecific taxa are considered to be equal to species for statistical purposes.

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Table 2. Composition of the seed plant flora of Mount Jinggangshan region.

| Taxa                  | Mount Jinggangshan region [6] | Jiangxi Province [8-10] | China [31] |
|-----------------------|-------------------------------|-------------------------|------------|
|                       | family | genus | species | family | genus | species | family | genus | species |
| Gymnosperms           | 9      | 17    | 23      | 9      | 23    | 35      | 12     | 34    | 230    |
| Angiosperms           | 201    | 986   | 2935    | 219    | 1309  | 4085    | 325    | 3166  | 26046  |
| Dicotyledoneae        | 170    | 762   | 2399    |        |       |         |        |       |        |
| Monocotyledoneae      | 31     | 224   | 536     |        |       |         |        |       |        |
| Total (Percent%)      | 210    | 1003  | 2958    | 228 (92.1) | 1332 (75.3) | 4120 (71.8) | 337 (62.3) | 3200 (31.3) | 26276 (11.3) |

The Flora of the Mount Jinggangshan Region

Results

Floristic Composition

Table 2 shows the composition of the seed plant flora of Mount Jinggangshan region. Among them, woody plants are from 350 genera and 1295 species, while herbaceous plants are from 653 genera and 1663 species. Table 3, Table 4, Table 5, Table 6 rank all 210 families in Mount Jinggangshan region based on numbers of genera and species, and contain some information of families, such as the numbers of genera and species in Mount Jinggangshan region [5], in China [31] and in the word [32,33], the numbers of endemic general and endemic species, and Areal-types. The families can be divided into 5 grades according to the numbers of species included (Table 7). The seed plant flora of Mount Jinggangshan region is mainly made up of oligotypic families (100 families) and mesotypic families (57), which account for 74.76% of all families, 55.63% of all genera and 62.43% of all species. Compared with other mountains in rich biodiversity, Mount Jinggangshan region has less single-species families (40), such as Mount Emeishan 47 families, Nanling Mountains 59, Mount Dínhghushan 58, Mount Lushan 49, Taiwan Mountain 56, so it goes to show that the flora of Mount Jinggangshan region obtain obvious differentiation.

The typical families in Mount Jinggangshan region are Fagaceae, Lauraceae, Theaceae, Hamamelidaceae, Magnoliaceae, Ericaceae, Styracaceae, Aquifoliaceae, Elaeocarpaceae, Aceraceae, Daphniphyllaceae, Hydrangeaceae, Rosaceae, Symplocaceae, Euphorbiaceae, Pinaceae, Taxodiaceae, Cupressaceae and Taxaceae. Other families with biogeographical implication are Bretschneideraceae, Tapisciaceae, Sargentodoxaceae, Eucommiaceae, Ginkgoaceae, Nyssaceae, Stachyuraceae, Helwingiaceae, Aucubaceae, Berberidaceae, Corylaceae, Cephalotaxaceae, Actinidiaceae and Schisandraceae, etc.

Floristic Geographic Elements

According to the concept of families proposed by Zhengyi Wu [28,29,30], the family areal-types of spermatophyte flora in Mount Jinggangshan region can be divided into 12 types (Table 8, Table 3, Table 4, Table 5, Table 6), which are further grouped into three categories: Cosmopolitan, Tropical and Temperate.

The genera can be divided into 5 categories according to size (Table 9). Based on the generic distribution concept proposed by Zhengyi Wu [26,27], the 1,003 seed plant genera can be divided into 14 types and 17 sub-types (Table 10). Those types and sub-types can be further sorted into three groups: cosmopolitan, 79 genera (7.88% of total, including 456 species); tropical, 452 genera (48.92% of non-cosmopolitan genera, including 1168 species); and temperate, 472 genera (51.08% of non-cosmopolitan genera, including 1278 species). Temperate genera contain 44 genera endemics to China (4.76% of non-cosmopolitan genera, including 56 species). The larger cosmopolitan genera include Cyperus (including 48 species), Rubus (45), Carex (42), Polygonum (37), Viola (26), Lysimachia (19), Clematis (24), Polygala (14), Salvia (11), Rhamnus (10) and Ranunculus (9). Among no-cosmopolitan genera, 51 genera with more than 10 species include 971 species, accounting for 32.83% of all species. For example, Ilex has 47 species, Rhododendron 31, Acer 31, Symplecos
Table 3. Ranking of families (with >10 species) in Mount Jinggangshan region based on numbers of genera and species [5,32,33].

| Families                  | Number of genera1 | GE2 Number of species3 | SE4 A5 | Families                  | Number of genera | GE Number of species | SE A |
|---------------------------|-------------------|------------------------|--------|---------------------------|------------------|----------------------|------|
| Poaceae                   | 99/244/268        | 5/19/1175/1022         | 31     | 1/1                        | Asclepiadaceae   | 6/4/180              | 1/2  |
| Compositae                | 73/239/1620       | 1/189/2477/2250        | 29     | 1/1                        | Hamamelidaceae   | 12/19/30             | 2/16 |
| Rosaceae                  | 20/56/95          | 147/1119/2830          | 70     | 1/1                        | Malastomatinae   | 8/26/188             | 2/16 |
| Cyperaceae                | 15/37/98          | 141/673/4350           | 9      | 1/1                        | Caesalpininae    | 7/17/165             | 2/6  |
| Papilionaceae             | 46/127/480        | 131/1190/12000         | 34     | 2/1                        | Symphoaceae      | 1/1/1                | 2/4  |
| Labiatae                  | 33/97/236         | 88/758/7175            | 37     | 1/1                        | Cupulariaceae    | 10/31/11             | 2/6  |
| Orchidaceae               | 35/177/880        | 1/84/1037/21950        | 14     | 2/1                        | Solanaceae       | 8/19/102             | 2/6  |
| Lauraceae                 | 9/25/50           | 83/437/2500            | 50     | 2/1                        | Primulaceae      | 3/13/20              | 2/14 |
| Rubiaceae                 | 20/80/600         | 7/1602/1000            | 19     | 2/1                        | Simulaceae       | 2/2/2                | 2/6  |
| Theaceae                  | 10/15/22          | 1/60/373/610           | 43     | 2/1                        | Gesneriaceae     | 6/57/147             | 1/17 |
| Fagaceae                  | 6/6/7             | 58/324/670             | 30     | 2/1                        | Magnoliaceae     | 6/11/15              | 1/11 |
| Rarurnculaceae            | 10/40/62          | 55/739/2525            | 25     | 8/1                        | Ulmaceae         | 7/8/16               | 1/10 |
| Scrophulariaceae          | 20/61/65          | 54/669/1700            | 13     | 1/1                        | Acanthaceae      | 14/63/229            | 2/18 |
| Polygonaceae              | 6/16/43           | 50/229/1100            | 6      | 8/1                        | Hydrangeaceae    | 7/11/17              | 2/11 |
| Liliaceae                 | 23/50/175         | 1/48/335/2000          | 10     | 1/1                        | Styraceae        | 6/10/11              | 2/17 |
| Apiaceae                  | 24/101/434        | 47/522/3780            | 13     | 8/1                        | Crassulaceae     | 3/12/34              | 1/16 |
| Euphorbiaceae             | 13/66/222         | 47/366/5970            | 11     | 2/1                        | Crassulaceae     | 16/247/1370          | 4/1  |
| Aquifoliaceae             | 17/1/1            | 47/118/405             | 27     | 2/1                        | Polygalaceae     | 2/4/18               | 6/1  |
| Ericaceae                 | 5/14/126          | 43/720/3995            | 30     | 8/1                        | Araceae          | 6/28/106             | 2/5  |
| Urticaceae                | 11/25/54          | 42/238/2625            | 7      | 2/1                        | Amaranthaceae    | 4/14/174             | 0/1  |
| Caprifoliaceae            | 4/12/15           | 42/195/420             | 3      | 8/1                        | Menispermaceae   | 8/19/70              | 4/5  |
| Vitaceae                  | 7/8/14            | 39/143/850             | 21     | 2/1                        | Apocynaceae      | 6/38/415             | 0/1  |
| Celastraceae              | 5/13/69           | 38/213/1300            | 21     | 2/1                        | Malvaceae        | 6/17/243             | 0/1  |
| Rhuaceae                  | 12/28/161         | 34/134/1815            | 11     | 2/1                        | Aristolochiaceae | 3/5/7                | 1/12 |
| Verbenaceae               | 7/18/30           | 34/170/1100            | 13     | 2/1                        | Onagraceae       | 3/15/24              | 0/8  |
| Araliaceae                | 11/25/43          | 32/181/1450            | 16     | 2/1                        | Elaeagnaceae     | 1/2/3                | 9/8  |
| Aceraceae                 | 1/23              | 31/152/200             | 18     | 8/1                        | Lardizalaceae    | 4/7/9                | 3/6  |
| Cruciferae                | 15/102/321        | 29/417/3400            | 1      | 8/1                        | Thymelaceae      | 3/11/48              | 0/1  |
| Rhamnaceae                | 6/16/50           | 29/137/900             | 17     | 1/1                        | Melosniaceae     | 1/1/1                | 7/3  |
| Myrsinaceae               | 5/6/41            | 28/129/1435            | 6      | 4/1                        | Gentianaceae     | 3/15/50              | 0/1  |
| Moraceae                  | 6/39              | 27/161/1100            | 5      | 2/1                        | Dioscoraceae     | 1/1/3                | 8/3  |
| Violaceae                 | 1/42              | 26/125/800             | 8      | 1/1                        | Boragineae       | 7/47/148             | 3/5  |
| Caryophyllaceae           | 13/28/66          | 24/294/2200            | 2      | 1/1                        | Loranthaceae     | 6/8/8                | 0/1  |
| Oleaceae                  | 7/13/24           | 24/180/615             | 18     | 2/1                        | Capnanulaceae    | 5/15/64              | 0/1  |
| Actinidiaceae             | 2/23              | 24/53/355              | 15     | 14/1                        | Saxifragaceae    | 4/13/29              | 5/6  |

Notes: 1 Number of genera in Mount Jinggangshan region/number in China/number in the world; 2 Number of genera endemic to China; 3 Number of species in Mount Jinggangshan region/number in China/number in the world; 4 Number of species endemic to China; 5 Areal-types of families of the seed plants in Mount Jinggangshan region.

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22. Euonymus 21, Camellia 20, Eurya 19, Litsea 17, Cinnamomum 14, Machilus 13, Neolitsea 11, Lithocarpus 15, Cyclobalanopsis 14, Castanopsis 13, Ficus 16, Callicarpa 15, Photinia 14, Meliosma 13 and Styrax 11. The genera including the dominant species in arboreous layer, in shrub layer and in herbaceous layer in Mount Jinggangshan region are listed in Table 11.

Comparison with Other Twelve Main Mounts in China

Table 12 shows similarity coefficients between Mount Jinggangshan region and other twelve main mounts in China. Among them, the flora of Mount Jinggangshan region is most similar to Mount Wuyishan region’s, as one would expect from their close proximity. The similarities at family, genus and species level are 93.4%, 85.1% and 71.6%, respectively. Next are Mount Qiyunshan (family 89.8% /genus 81.4% /species 67.5%) and Mount Lushan (92.5%/81.3%/63.3%). The above mountains are all in eastern China. The third most similar regions are the Nanling Mountains (south of Mount Jinggangshan region) (90.4%/77.6%/61.6%) and the Wuling Range (west of Mount Jinggangshan) (93.1%/81.0%/57.6%).

Mount Jinggangshan region is at the northern distribution limit of Gnetaceae and Samydaceae. They occur in Mount Jinggangshan region and Nanling Mountains, but not in Mount Wuyishan region, Wuling Range or Mount Lushan. The
Table 4. Ranking of families (with 5-10 species) in Mount Jinggangshan region based on numbers of genera and species.

| Families                | Number of genera | Number of species | SE A | Number of genera | Number of species | SE A |
|-------------------------|------------------|------------------|------|------------------|------------------|------|
| Convolvulaceae          | 7/2/157          | 10/115/1600      | 0/1  | 1/2/3            | 7/19/320        | 1/1  |
| Lythraceae              | 4/1/25           | 10/48/550        | 1/1  | 1/9/18           | 6/22/116        | 0/2  |
| Anacardiaceae           | 3/15/70          | 10/51/985        | 2/3  | 2/5/7            | 1/27/50         | 2/8  |
| Buxaceae                | 3/3/4            | 10/22/70         | 8/2  | 1/4/20           | 6/80/1100       | 1/2  |
| Cornaceae               | 3/3/5            | 10/51/100        | 6/8  | 3/10/80          | 1/21/500        | 1/2  |
| Coriaceae               | 2/4/4            | 10/30/89         | 5/8  | 2/49/100         | 6/198/1400      | 0/1  |
| Schisandraceae          | 2/2/3            | 10/29/92         | 7/9  | 2/2/7            | 6/68/305        | 0/1  |
| Balsaminaceae           | 1/2/2            | 10/191/1000      | 8/2  | 1/4/10           | 6/87/210        | 5/8  |
| Hypericaceae            | 1/4/10           | 10/54/300        | 2/1  | 2/2/2            | 6/77/5          | 5/9  |
| Commelinaceae           | 6/13/40          | 9/53/652         | 0/2  | 2/2/4            | 6/10/50         | 1/9  |
| Berberidaceae           | 2/2/14           | 9/245/701        | 9/9  | 1/1/10           | 6/45/1160       | 1/2  |
| Begoniaceae             | 1/1/2            | 9/90/1401        | 8/2  | 1/1/2            | 6/30/102        | 0/1  |
| Fumariaceae             | 1/7/16           | 9/215/450        | 1/8  | 4/4/6            | 5/13/23         | 2/8  |
| Chloranthaceae          | 2/3/4            | 8/16/75          | 4/2  | 3/3/6            | 5/7/30          | 0/1  |
| Ebenaceae               | 1/1/4            | 8/58/548         | 4/2  | 3/6/52           | 5/10/261        | 1/2  |
| Saliaceae               | 1/1/3            | 8/26/100         | 7/7  | 3/3/3            | 5/15/45         | 2/3  |
| Vacciniaceae            | 1/2/22           | 8/87/400         | 7/1  | 3/20/49          | 5/145/1188      | 1/7  |
| Naucleaceae             | 5/8/11           | 7/28/143         | 0/4  | 2/3/20           | 5/24/600        | 1/2  |
| Alismatraceae           | 2/5/12           | 7/12/81          | 0/1  | 2/4/17           | 5/40/315        | 1/8  |
| Elaeocarpaceae          | 2/2/12           | 7/52/625         | 1/2  | 1/1/1            | 5/8/17          | 2/2  |
| Juncaceae               | 2/2/7            | 7/80/430         | 0/1  | 1/1/2            | 5/16/76         | 1/3  |
| Salicaceae              | 2/2/55           | 7/228/1010       | 7/8  | 1/2/6            | 5/13/770        | 0/1  |
| Pittosporaceae          | 1/1/9            | 7/34/200         | 2/4  | 1/4/5            | 5/54/3600       | 3/2  |

Notes: 1 Number of genera in Mount Jinggangshan region/number in China/number in the world; 2 Number of genera endemic to China; 3 Number of species in Mount Jinggangshan region/number in China /number in the world; 4 Number of species endemic to China; 5 Areal-types of families of the seed plants in Mount Jinggangshan region.

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Nageiaceae, Capparaceae and Erythroxylaceae, mainly in southern China, are also in Mount Jinggangshan region and Mount Wuyishan region, but not Mount Lushan and Wuling Range. The Zygophyllaceae, mainly in northern dry areas, is in Mount Jinggangshan, but not Mount Qiyunshan, Nanling Mountains or Mount Wuyishan region. Mount Jinggangshan region marks the southernmost distribution of Zygophyllaceae.

Some important tropical or southern tropical genera such as Tsoongiodendron, Exubicklandia, Allingia, Disanthus, Semiliquidambar, Cryptocarya, Anneslea, Garcinia, Pithecellobium, Heteropanax, Psychotria, Passiflora, Blastus and Bredia are mainly in southern China. They occur in Mount Jinggangshan region, but not Mount Lushan or Wuling Range.

Some typical genera in central China, such as Saruma, Clermatoclethra and Dickinsia [34], occur in Mount Jinggangshan region, but not Mount Wuyishan region, Mount Qiyunshan or Nanling Mountains. Some genera endemic to central and eastern China, including Eucommia, Bretschneidera, Sargentodoxa, Pseudotaxus, Cyclocarya, Changnienia, Eomecon, Changium, Fortunearia, Shearea, are also in Mount Jinggangshan. The following genera are mainly in Mount Jinggangshan region and eastern China: Ginkgo, Cunninghamia, Bretschneidera, Monimopetalum, Hiliella, Gelidocalamus, Speiranthus.

From Figure 1 and Figure 2, it can be seen that tropical genera (Tr) increase and temperate genera (Tm) decrease from north to south and from west to east. The rate of change is expressed by Tr/Tm value. For example, Mount Jinggangshan region has 452 tropical genera and slightly less than 472 temperate genera, so Tr/Tm=0.94. The Mount Wuyishan region has 400 tropical genera and slight less than 425 temperate genera, so Tr/Tm=0.94.

**Discussion and Conclusions**

The flora of the Mount Jinggangshan region includes abundant primitive gymnosperms and angiosperms. Among them are 9 families of gymnosperms with 17 genera and 23 species. They account for 75.0%, 50.0% and 10.0% of wild gymnosperms (12 families, 34 genera and 230 species) in China respectively, and 69.2%, 23.9% and 2.9% of all gymnosperms (13 families, 71 genera and 800 species) in the world. Ginkgo biloba can be traced back to the Permian. Amentotaxus argotaenia, Fokienia hodginsii and Podocarpus macrophyllus were widely distributed in Cretaceous. Abies beshanzuensis var. ziuyuensis, endemic to China and critically endangered (<500 individuals in 2013), is looked as an evidence that Abies migrated from north to south and from high elevation to low elevation during the Quaternary ice age and withdraw to north and to higher elevation in post glacial [35]. The Mount Jinggangshan region is the largest distribution area of Abies beshanzuensis var. ziuyuensis (<350 individuals in...
2013) and the lowest distribution area of Abies at the same latitude in the world.

To angiosperms, there are plentiful primitive representatives of the ancient families, such as *Tsengiodendron odorum*, *Manglieta fordiana* and *Magnolia officinalis*, belonging to Magnoliaceae, and *Exbucklandia tonkinensis*, *Hamamelis mollis* and *Fortunearia sinensis*, belonging to Hamamelidaceae. The fossils of *Exbucklandia* (in the Paleocene in North America and China), *Fortunearia* (in the Oligocene in German and Pliocene in Japan), and *Hamamelis* (in Cretaceous in Sweden and Eocene in China) have been discovered [32,36-38]. Other primitive taxa include *Disanthus cercidifolia* subsp. *longipes*, *Eucomitia ulmoides*, *Cyclocarya paliurus*, *Sargentodoxa cuneata*, *Bretschniederia sinensis*, *Camptotheca acuminata*, and *Euryoilymus carvalkeri*.

As a refugium, there are many communities consisting of relic species as the dominant species, such as *Amentotaxus argotaenia*, *Cunninghamhia lanceolata*, *Fokienia hodginsii*, *Nageia nagi*, *Pseudotaxus chienii*, *Taxus wallichiana* var. *mairei*, *Tsuga chinensis*, *Exbucklandia tonkinensis* and *Disanthus cercidifolia* subsp. *longipes*.

The seed plant flora of Mount Jinggangshan region includes many endemics genera and species. There are 44 genera endemics to China and 1146 species endemics to China (in 424 genera and 131 families), accounting for 17.53% and 39.52% of all in China respectively. The number of endemics genera are equivalent to other mounts in rich biodiversity, such as Mount Shennongjia (43 endemic genera), Mount Wuyishan region (38), Wuling Range (37) and Mount Emeishan (39). The important families with more endemic species include Rosaceae, Lauraceae, Theaceae, Labiatae, Papilionaceae, Fagaceae and Ericaceae.

There are 17 local endemic species in Mount Jinggangshan region, a number similar to Mount of Wuyishan region (20 species), such as *Rhododendron jinggangshanicum*, *Rhododendron strigosum*, *Rhododendron xiaoxidongense*, *Nellia jinggangshansensis*, *Rubus glandulosocarpus*, *Actinidia chinensis* var. *jinggangshansensis*, Acer cordatum var. *jinggangshanensis*, *Vitis jinggangensis*, *Trichosanthes jinggangshanica*, *Impatiens jinggangensis*, *Impatiens jinggangensis* var. *pauicifora*, *Hemiboea subacaulis* var. *jiangxiensis*, which are restricted to the Mount Jinggangshan region. *Rhododendron kiangsiense*, *Rhododendron*

### Table 5. Ranking of families (with 2-4 species) in Mount Jinggangshan region based on numbers of genera and species.

| Families           | Number of genera | Number of species | SE | A | Families           | Number of genera | Number of species | SE | A |
|--------------------|------------------|-------------------|----|---|--------------------|------------------|-------------------|----|---|
| Cupressaceae       | 4/9/29           | 4/31/140          | 2  | 8 | Iteaceae           | 1/1/2            | 3/12/18           | 1  | 9 |
| Papaveraceae       | 3/11/41          | 1/4/58/760        | 2  | 8 | Myrtaceae          | 1/10/131         | 3/0/14/625        | 2  | 2 |
| Haloragaceae       | 2/2/8            | 4/7/145           | 0  | 1 | Pyroloaceae        | 1/4/14           | 3/3/140           | 1  | 8 |
| Iridaceae          | 2/5/87           | 4/44/1800         | 1  | 2 | Stilaginaceae      | 1/1/1            | 3/17/170          | 1  | 4 |
| Loganiaceae        | 2/5/13           | 4/15/420          | 2  | 2 | Trapaceae          | 1/1/1            | 3/5/30            | 0  | 10|
| Amonaceae          | 1/22/129         | 4/122/2220        | 2  | 4 | Gutiferae          | 2/5/27           | 2/20/450          | 0  | 2 |
| Aucubaceae         | 1/1/11           | 1/14/11           | 2  | 14| Hypoxidaceae       | 2/3/8            | 2/8/160           | 0  | 2 |
| Balanophoraceae    | 1/2/7            | 4/18/50           | 1  | 2 | Nyssaceae          | 2/2/5            | 1/27/22           | 1  | 9 |
| Cephalotaxaceae    | 1/1/1            | 4/7/28            | 3  | 14| Portulacaceae      | 2/3/36           | 2/7/395           | 0  | 1 |
| Droseraceae        | 1/2/3            | 4/7/115           | 0  | 1 | Santalaceae        | 2/7/44           | 2/3/2/95          | 0  | 2 |
| Illiciaceae        | 1/1/1            | 4/26/50           | 4  | 9 | Sauraraceae        | 2/3/4            | 2/4/8             | 0  | 9 |
| Philadelphaceae    | 1/1/1            | 4/15/75           | 4  | 9 | Azoraceae          | 1/1/1            | 2/4/4             | 0  | 8 |
| Phytolaccaceae     | 1/2/18           | 4/7/65            | 1  | 2 | Amaryllidaceae     | 1/5/59           | 2/23/600          | 0  | 2 |
| Plantaginaceae     | 1/1/47           | 4/13/1350         | 0  | 1 | Callirhizaceae     | 1/1/1            | 2/4/25            | 1  | 1 |
| Viaceae            | 1/1/2            | 4/11/70           | 1  | 1 | Ceratophyllaceae   | 1/1/1            | 2/5/7             | 0  | 1 |
| Sapindaceae        | 3/25/135         | 3/51/1580         | 2  | 2 | Cleomaceae         | 1/1/10           | 2/3/300           | 0  | 2 |
| Simarubaceae       | 3/4/19           | 3/12/95           | 1  | 2 | Dipsacaceae        | 1/4/11           | 2/20/290          | 0  | 10|
| Betulaceae         | 2/2/6            | 3/37/145          | 1  | 8 | Myrtaceae          | 1/1/3            | 2/4/57            | 0  | 1 |
| Mimosaceae         | 2/11/56          | 3/65/2800         | 0  | 2 | Oleaceae           | 1/4/14           | 2/8/103           | 1  | 2 |
| Monotropaceae      | 2/4/12           | 3/5/21            | 0  | 8 | Orobancheaceae     | 1/10/99          | 2/40/2060         | 0  | 8 |
| Pontiederaceae     | 2/2/9            | 3/5/33            | 0  | 2 | Parnassiaceae      | 1/1/2            | 2/36/61           | 0  | 8 |
| Buddlejaceae       | 1/1/7            | 3/29/100          | 1  | 2 | Podocarpaceae      | 1/4/17           | 2/20/125          | 0  | 8 |
| Calycanthaceae     | 1/2/5            | 3/4/11            | 2  | 9 | Proteaceae         | 1/2/80           | 2/21/1600         | 1  | 2 |
| Cuscutaceae        | 1/1/1            | 3/10/170          | 0  | 1 | Sambucaceae        | 1/1/1            | 2/5/20            | 1  | 8 |
| Daphniphyllaceae   | 1/1/1            | 3/12/25           | 0  | 7 | Stachyuraceae      | 1/1/1            | 2/8/10            | 1  | 14|
| Ehrhadiaceae       | 1/1/1            | 3/12/50           | 0  | 2 | Stemonaceae        | 1/1/4            | 2/6/27            | 1  | 5 |
| Helwingiaceae      | 1/1/1            | 3/5/8             | 0  | 14| Typhaceae          | 1/1/1            | 2/10/11           | 0  | 1 |

Notes: 1 Number of genera in Mount Jinggangshan region/number in China /number in the world; 2 Number of genera endemic to China; 3 Number of species in Mount Jinggangshan region/number in China /number in the world; 4 Number of species endemic to China; 5 Areal-types of families of the seed plants in Mount Jinggangshan region.

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The Flora of the Mount Jinggangshan Region
Table 6. Ranking of families (with 1 species) in Mount Jinggangshan region based on numbers of genera and species.

| Families            | Number of genera | GE | Number of species | SE | A | Families | Number of genera | GE | Number of species | SE | A |
|---------------------|------------------|----|-------------------|----|---|----------|------------------|----|-------------------|----|---|
| Alliaceae           | 1/3/13           | 1/112/795 | 0 | 1 | Nageiaceae | 1/1/1          | 1/5/5 | 0 | 7 |
| Asparagaceae        | 1/1/1           | 1/24/300  | 0 | 5 | Najadaceae | 1/1/1          | 1/4/50 | 0 | 1 |
| Bignoniaceae        | 1/4/110         | 1/43/800   | 0 | 4 | Nandinaece | 1/1/1          | 1/1/1 | 0 | 14 |
| Bischofiaceae       | 1/1/1           | 1/2/2     | 1 | 7 | Nelumbonace | 1/1/1          | 1/1/2 | 0 | 9 |
| Bretschneideraceae  | 1/1/1           | 1/1/1     | 1 | 15| Nymphaceae | 1/2/5          | 1/8/48 | 0 | 1 |
| Cabombaceae         | 1/2/2           | 1/3/3     | 0 | 8 | Passiflorace | 1/2/16         | 1/22/605 | 1 | 2 |
| Capparaceae         | 1/4/16          | 1/30/480  | 0 | 2 | Penthorace | 1/1/1          | 1/1/2 | 0 | 9 |
| Erythroxylaceae     | 1/1/4           | 1/3/240   | 0 | 2 | Phrymaceae | 1/1/1          | 1/1/1 | 0 | 0 |
| Eucommiaceae        | 1/1/1           | 1/1/1     | 1 | 15| Pistaicace | 1/1/1          | 1/3/10 | 1 | 12 |
| Euryalaceae         | 1/1/5           | 1/1/85    | 0 | 14| Samyacace | 1/2/17         | 1/18/400 | 0 | 2 |
| Ginkgoaceae         | 1/1/1           | 1/1/11    | 1 | 15| Sargendoxace | 1/1/1          | 1/1/1 | 1 | 15 |
| Gnetaceae           | 1/1/1           | 1/7/30    | 0 | 2 | Sparganiace | 1/1/1          | 1/5/14 | 0 | 8 |
| Grossulariaceae     | 1/1/1           | 1/45/150  | 0 | 8 | Spigeliace | 1/2/2          | 1/6/8 | 0 | 2 |
| Hippocastanaceae    | 1/1/2           | 1/8/32    | 1 | 8 | Taccaceae | 1/2/2          | 1/4/12 | 0 | 2 |
| Hydrocotylaceae     | 1/1/1           | 1/2/2     | 0 | 2 | Tapsicace | 1/1/2          | 1/2/5 | 1 | 15 |
| Menyanthaceae       | 1/2/5           | 1/4/58    | 0 | 1 | Taxacaceae | 1/5/30         | 1/7/130 | 0 | 9 |
| Molluginaceae       | 1/2/9           | 1/6/87    | 0 | 2 | Zannichellace | 1/1/6          | 1/1/20 | 0 | 1 |
| Musaceae            | 1/3/3           | 1/7/35    | 0 | 4 | Zygothyllace | 1/5/26         | 1/27/285 | 0 | 1 |

Notes: 1 Number of genera in Mount Jinggangshan region/number in China/number in the world; 2 Number of genera endemic to China; 3 Number of species in Mount Jinggangshan region/number in China/number in the world; 4 Number of species endemic to China; 5 Areal-types of families of the seed plants in Mount Jinggangshan region.

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Table 7. Statistics of the family size from the seed plant flora of Mount Jinggangshan region.

| Taxa                | Single-species families (1 species) | Oligotypic families (2-10 species) | Mesotypic families (11-50 species) | Pluritypic families (51-100 species) | Macrotypic families (>100 species) |
|---------------------|-----------------------------------|-----------------------------------|-----------------------------------|-------------------------------------|-----------------------------------|
| Gymnosperms         | 4 (4-4)1                          | 5 (14:21)                         |                                   |                                     |                                   |
| Angiosperms         | 36 (36:36)                        | 95 (173:462)                      | 57 (371:1361)                     | 8 (143:553)                         | 5 (262:806)                       |
| Total               | 40 (40:40)                        | 100 (187:483)                     | 57 (371:1361)                     | 8 (143:553)                         | 5 (262:806)                       |
| Percent of total (%)| 19.05/3.99/1.352                   | 47.62/18.64/16.33                 | 27.14/36.99/46.01                 | 3.81/14.26/18.70                    | 2.38/26.12/27.25                 |

Notes: 1 Number of families (number of genera included in the families : number of species included in the families); 2 Percent of all 210 families (percent of all 1003 genera : percent of all 2958 species).

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Table 9. Statistics of the genus size from the seed plant flora of Mount Jinggangshan region.

| Taxa                | Single-species genera (1 species) | Oligotypic genera (2-5 species) | Mesotypic genera (6-10 species) | Pluritypic genera (11-20 species) | Macrotypic genera (>21 species) |
|---------------------|----------------------------------|---------------------------------|---------------------------------|-----------------------------------|---------------------------------|
| Gymnosperms         | 13 (13)2                         | 5 (12)                          |                                 |                                    |                                 |
| Angiosperms         | 452 (452)                        | 396 (1155)                      | 86 (640)                        | 37 (529)                          | 14 (442)                        |
| Total               | 465 (465)                        | 401 (1167)                      | 86 (640)                        | 37 (529)                          | 14 (442)                        |

Notes: 1 Single-species genera include monotypic genus containing only one species in the world. There are 63 monotypic genera in the Mount Jinggangshan region; 2 Number of genera (number of species included in the genera).

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**hypoblematosum**, *Rhododendron crassistylum*, *Elaeagnus jiangxiensis* and *Gelidocalamus stellatus* are centered in the Mount Jinggangshan region, but also occur in the Luoxiao Mountains.
The greater part of the Chinese flora was usually considered to belong to the Holarctic Kingdom, with a small part in the south belonging to the Paleotropic kingdom in the early days [39]. Hungta Chang [40] and Zhengyi Wu [41] successively proposed that the Chinese flora should be a separate floristic kingdom, the East Asian Kingdom, based on its primitiveness, origin and integrity. Based on Wu’s concept, the flora of Mount Jinggangshan region belongs to the East Asian Kingdom, the Sino-Japanese subkingdom, east China Region and south Jiangxi-east Hunan sub-region. As discussed above, the flora of Mount Jinggangshan region is closely related to the flora of Mount Wuyishan region. They share endemic genera and other elements, therefore both of them should be typical of the flora of eastern China.

However, the flora of Mount Jinggangshan region has obvious transitional properties. Many endemic genera are characteristic of either eastern or central China. The Mount Jinggangshan region is also the southeastern boundary for some typical genera of central China. Furthermore, the Mount Jinggangshan region is a corridor between northern and southern China. Renlin Liu implied that the Mount Jinggangshan region has many tropical elements, especially characterized by Fagaceae, Lauraceae, Theaceae, Hamamelidaceae, and Magnoliaceae [42]. These families make up the dominant elements of the evergreen broadleaved forests as in Nanling Mountains.

In conclusion, Mount Jinggangshan region is one of the richest regions in biodiversity in southeastern China and an important refugium for Tertiary relicts. The region in the central section of the Luoxiao Mountains is an important north-south floristic passageway and is also a boundary between the floras of eastern, central and south China.

| Areal-types of families | Number of families in JGR / in China | Percent of total non-cosmopolitan families in JGR (%) |
|------------------------|------------------------------------|---------------------------------------------------|
| 1. Cosmopolitan        | 42/50                              | —                                                 |
| 2. Pantropic           | 81/120                             | 48.21                                             |
| 3. Tropical Asian and tropical American disjunct | 5/11 | 2.98 |
| 4. Old World Tropic    | 7/17                               | 4.17                                              |
| 5. Tropical Asia to Tropical Australia | 2/10 | 1.19 |
| 6. Tropical Asia to tropical Africa | 0 / 7 | 0 |
| 7. Tropical Asia (Indo-Malaysia) | 6/20 | 3.57 |
| 8. North temperate     | 38/47                              | 22.62                                             |
| 9. East Asian and North American disjunct | 14/17 | 8.33 |
| 10. Old World temperate| 2/6                                | 1.19                                              |
| 11. Temperate Asia     | 0 / 0                              | 0                                                 |
| 12. Mediterranean region, western to central Asia | 1/8 | 0.60 |
| 13. Central Asia       | 0 / 1                              | 0                                                 |
| 14. East Asia          | 7/18                               | 4.17                                              |
| 15. Endemic to China   | 5/8                                | 2.98                                              |
| Total                  | 210/337                            | 100                                               |

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## Table 10. Areal-types of genera from the seed plant flora of Mount Jinggangshan region (JGR).

| Areal-types of genera | Number of genera in JGR / in China | Percent of the total non-cosmopolitan genera in JGR (%) |
|-----------------------|-----------------------------------|--------------------------------------------------------|
| 1. Cosmopolitan       | 79/107                            | ——                                                     |
| 2. Pantropic          | 164/304                           | 17.75                                                  |
| 2-1. Tropical Asia, Australasia (to New Zealand) and Central to South America (or Mexico) disjunct | 10/21 | 1.08 |
| 2-2. Tropical Asia, Africa and Central to South America disjunct | 8/32 | 0.87 |
| 3. Tropical Asian and tropical American disjunct | 17/78 | 1.84 |
| 4. Old World Tropical | 54/150                            | 5.84                                                   |
| 4-1. Tropical Asia, Africa (or East Africa, Madagascar) and Australasia disjunct | 12/27 | 1.30 |
| 5. Tropical Asia to Tropical Australia | 42/154 | 4.55 |
| 5-1. Chinese (southwest) Subtropical and New Zealand disjunct | 1/2 | 0.11 |
| 6. Tropical Asia to tropical Africa | 29/145 | 3.14 |
| 6-2. Tropical Asia and East Africa or Madagascar disjunct | 3/8 | 0.32 |
| 7. Tropical Asia (Indo-Malaysia) | 80/460 | 8.66 |
| 7-1. Java (or Sumatra), Himalaya to south and southwest China disjunct or dispersed | 12/31 | 1.30 |
| 7-2. Tropical India to south China (particularly southern Yunnan) | 6/53 | 0.65 |
| 7-3. Burma, Thailand to southwest China | 4/36 | 0.43 |
| 7-4. Vietnam (or Indochina) to south China (or southwest China) | 10/66 | 1.08 |
| 8. North temperate | 113/193                           | 12.23                                                  |
| 8-4. North Temperate and south temperate disjunct | 31/78 | 3.35 |
| 8-5. Eurasia and South America temperate disjunct | 1/8 | 0.11 |
| 9. East Asia and North America disjunct | 75/122 | 8.12 |
| 9-1. East Asia and Mexico disjunct | 1/2 | 0.11 |
| 10. Old World temperate | 41/119                            | 4.44                                                   |
| 10-1. Mediterranean, western Asia (or central Asia) and East Asia disjunct | 9/30 | 0.97 |
| 10-2. Mediterranean and Himalayan disjunct | 1/7 | 0.11 |
| 10-3. Eurasia and southern Africa (sometimes Australasia also) disjunct | 4/18 | 0.43 |
| 11. Temperate Asia | 14/64                             | 1.52                                                   |
| 12. Mediterranean region, western to central Asia | 3/133 | 0.32 |
| 12-3. Mediterraneen to temperate-tropical Asia, Australasia and South America disjunct | 2/7 | 0.22 |
| 13. Central Asia | 1/73                              | 0.11                                                   |
| 14. East Asia | 60/75                             | 6.49                                                   |
| 14-1. Sino-Himalayan (SH) | 21/142                           | 2.27                                                   |
| 14-2. Sino-Japanese (SJ) | 51/100                           | 5.52                                                   |
| 15. Endemic to China* | 44/251                           | 4.76                                                   |
| Total | 1003/3200 | 100 |

Notes: * The genera endemic to China include Ginkgo, Cunninghamia, Pseudolarix, Parakmeria, Tsogiodendron, Sargentodoxa, Saruma, Eomencon, Yinshania, Poliothyrsis, Tutcheria, Clematoclethra, Speranskia, Chimonanthus, Fortunearia, Semiliquidambar, Eucommia, Pteroceltis, Moninopetalum, Poncirus, Eurycorymbus, Bretschneidera, Tapisciaca, Cyclocarya, Camptotheca, Metapanax, Tetrapanax, Changium, Dickinsia, Meliodendron, Biondia, Shearera, Sinojohnstonia, Thyrocarpus, Schnabelia, Bostysthanchera, Hanceola, Speirantha, Changnienia, Indocalamus, Gelidocalamus, Oligostachyum, Omphalotrigonitis, Emmenopterys.

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| genera                | arborous layer                                                                 | shrub layer                        | herbaceous layer                                                                 |
|-----------------------|-------------------------------------------------------------------------------|-----------------------------------|--------------------------------------------------------------------------------|
| **Tropical**          | Cyclobalanopsis, Lithocarpus, Ternstroemia, Cleyaera, Schima, Camellia, Cinramomum, Machilus, Phoebe, Neolitsea, Exbucklandia, Sycopeis, Distylicum, Michella, Mangleia, Styax, Alniphyllum, Elaeocarpus, Symplocos, Ficus, Dendropanax, Sapium, Fokienia, Amentotaxus | Eurya, Maesa, Ardisia, Turpinia, Sageestia, Tarenna, Smailax, Clethra, Lasianthus, Psychotria, Bambusa, Helicteres, Mallotus, Embelia, Gardenia, Smithia, Melastoma, Myrsine, Adina, Toddalia, Lindera, Kadsura | Impatiens, Osbeckia, Phyllagathis, Elatostema, Pallonia, Ditymocarpus, Opiorrhiza, Elephantopus, Sesbania, Eupatorium, Pollia, Lycianthes, Alpinia, Paraphollmis, Filescapa, Brachiaria, Cyrtococcum, Heteropogon, Ichnarthus, Miscanthus, Thysanolaena, Pennisetum, Sporobolus, Coelogyne, Bulbostylis, Neyraudia, Fimbristyli |
| **Temperate**         | Quercus, Fagus, Castanopsils, Castanea, Rhododendron, Lyonia, Cerasus, Sorbus, Carpinus, Dendrothamnus, Comus, Acer, Alnus, Osmanthus, Magnolia, Illicium, Halesia, Stewartia, Liquidambar, Phrocarys, Pinus, Abies, Taxus, Tsuga | Viburnum, Elaeagnus, Rosa, Berberis, Fagopus, Vaccinium, Sambucus, Hydrangea, Toxicodendron, Lyonia, Pieris, Azonida, Bredia, Deutzia, Enkiantheus, Holboelia, Pleioblastus | Cimicfuga, Eomecon, Draca, Sodium, Saxifraga, Fagopyrum, Circaea, Bredia, Geum, Habernaria, Oerobaster, Valeriana, Artemisia, Inula, Kalimeris, Swertia, Trigonolis, Balthrospermum, Pedicularis, Hosta, Veronicastrum, Oreocharis, Prunella, Aspidistra, Uriope, Acorus, Arundinella, Aster, Deyeuxia, Spodobagon, Triarthra |
Table 12. Similarity coefficients at family, genus and species between Mount Jinggangshan region and other twelve main mounts in China.

| Mount     | JG  | WY  | QY  | LS  | NL  | WL  | SNJ  | EM  | TW  | HN  | TB  | XSBN | GLG |
|-----------|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|------|-----|
| Area (km²)| 480 | 725 | 110 | 292 | 563 | 10000 | 705  | 154 | 35990 | 33000 | 563 | 2418 | 4046 |
| F¹        | 210 | 201 | 182 | 192 | 219 | 213  | 181  | 202 | 246  | 244   | 156  | 236  | 215  |
| G²        | 1003 | 891 | 790 | 757 | 996 | 964  | 780  | 869 | 1251  | 1247   | 633  | 1217 | 1025 |
| S³        | 2958 | 2331 | 2152 | 1732 | 2713 | 3040  | 2155 | 2411 | 3378  | 3369   | 1759 | 3767 | 3798 |
| WY        | F⁴  | 192/93.4 |  |  |  |  |  |  |  |  |  |  |  |
| G⁵        | 809/85.4 |  |  |  |  |  |  |  |  |  |  |  |  |
| S⁶        | 1814/68.6 |  |  |  |  |  |  |  |  |  |  |  |  |
| QY        | F⁷  | 176/89.8 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 730/81.4 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 1724/67.5 |  |  |  |  |  |  |  |  |  |  |  |  |
| LS        | F⁸  | 186/92.5 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 715/81.3 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 1484/63.3 |  |  |  |  |  |  |  |  |  |  |  |  |
| NL        | F⁹  | 194/90.4 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 776/77.6 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 1746/61.6 |  |  |  |  |  |  |  |  |  |  |  |  |
| WL        | F¹⁰ | 197/93.1 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 797/81.0 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 1726/65.7 |  |  |  |  |  |  |  |  |  |  |  |  |
| SNJ       | F¹¹ | 168/85.9 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 618/69.3 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 1079/42.2 |  |  |  |  |  |  |  |  |  |  |  |  |
| EM        | F¹² | 182/88.4 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 677/72.3 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 1073/40.0 |  |  |  |  |  |  |  |  |  |  |  |  |
| TW        | F¹³ | 196/86.0 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 752/66.7 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 949/30.0 |  |  |  |  |  |  |  |  |  |  |  |  |
| HN        | F¹⁴ | 175/77.1 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 600/53.3 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 905/26.8 |  |  |  |  |  |  |  |  |  |  |  |  |
| TB        | F¹⁵ | 142/77.6 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 468/57.2 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 653/27.7 |  |  |  |  |  |  |  |  |  |  |  |  |
| XSBN      | F¹⁶ | 183/82.1 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 611/55.0 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 804/23.9 |  |  |  |  |  |  |  |  |  |  |  |  |
| GLG       | F¹⁷ | 185/87.1 |  |  |  |  |  |  |  |  |  |  |  |
| G        | 649/94.0 |  |  |  |  |  |  |  |  |  |  |  |  |
| S        | 741/21.9 |  |  |  |  |  |  |  |  |  |  |  |  |

Notes: ¹ Number of families in the mount; ² Number of genera in the mount; ³ Number of species in the mount; ⁴ Number of shared families/coefficient of similarity (%); ⁵ Number of shared genera/coefficient of similarity (%); ⁶ Number of shared species/coefficient of similarity (%); JG: Mount Jinggangshan region; WY: Mount Wuyishan region; QY: Mount Qiyunshan; LS: Mount Lushan; NL: Nanling Mountains; WL: Wuling Range; SNJ: Mount Shennongxia; EM, Mount Emeishan; TW: Taiwan Mountains; HN: Hainan Mountains; TB: Mount Taibeishan; XSBN: Mount Xishuangbanna; GLG: Mount Gaoligongshan.

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Figure 2. Numbers and ratios of the tropical genera and the temperate genera in Mount Jinggangshan region and other twelve mounts in China.

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Author Contributions

Conceived and designed the experiments: WL. Performed the experiments: LW. Analyzed the data: WL. Contributed reagents/materials/analysis tools: QF CC. Wrote the manuscript: LW. Field works: LW WL CC QF.

References

1. Lin Y (1990) Scientific survey and research on Jinggangshan Natural Reserve. Beijing: Xinhua Publishing House. pp. 1-103.
2. Huang XF, Shan JH, Liu RL (2008) Jiangxi Nanfengmian Nature Reserve scientific survey report. Printed by Nanfengmian. Nature Reserve: 1-133.
3. He LZ, Liu RL (2010) Scientific survey and study of biodiversity on the Goxing Nature Reserve in Jiangxi Province. Nanchang: Jiangxi Science and Technology Press.
4. Hou BQ (1993) The comprehensive investigation reports of natural resource in Taoyuan Dong, Ling County, Hunan Province. Changsha: National University of Defense Technology Press. pp. 1-178.
5. Liao WB, Wang YY, Li ZB, Chen QQ et al. (2013) A comprehensive scientific survey of biodiversity from Mount Jinggangshan Region, China. Beijing: Science Press. pp. 1-514. In press.
6. Wu ZY (1980) The vegetation of China. Beijing: Science Press. pp. 1-1375.
7. Wu ZY, Raven PH, Hong DY (1995-2001) Flora of China (Vol.1-25). Beijing: Science Press, and St. Louis: Missouri : Botanical Garden Press.
8. Lin Y, Lai SK, Ding JH, Zhou XY, Cheng JF (1993) Flora of Jiangxi Volume 1. Nanchang: Jiangxi Science & Technology Press. pp. 1-541.
9. Lin Y, Lai SK, Ding JH, Zhou XY, Cheng JF (2004) Flora of Jiangxi Volume 2. Nanchang: Jiangxi Science & Technology Press. pp. 1-1112.
10. Liu RL, Zhang ZX, Liao WM (2010) List of Jiangxi seed plant. Beijing: China : Forestry Publishing House. pp. 1-365.
11. Zhang MZ, Lai MZ (1993) Species checklist of five provinces in East China. Shanghai: Shanghai : Popular Science Press. pp. 1-491.
12. He JY (1994) Wuyishan research series (natural resources). Xiamen: Xiamen University Press. pp. 222-262.
13. Ling LK, Ling YR, Chang YT (1981) A list of vascular plants from Wuyishan, north Fujian. Journal of Wu Juyi Science 12: 17-49.
14. Liu XZ, Fang FS (2001) Scientific survey of Wuyishan Nature Reserve in Jiangxi. Beijing: China : Forestry Press. pp. 1-204.
15. Liu XM, Guo YG, Liu RL (2010) The collection of scientific exploration of Jiangxi Qiyunshan Nature Reserve. Beijing: China : Forestry Press. pp. 1-381.
16. Liu XZ, Wang L (2010) The collection of scientific exploration of the Lushan Nature Reserve in Jiangxi Province. Beijing: China : Forestry Press. pp. 539-567.
17. Zhang MZ, Lai MZ (1993) Species checklist of five provinces in East China. Shanghai: Shanghai : Popular Science Press. pp. 1-491.
18. Li ZY, Shi L (2007) Plants of Mount Emei. Beijing: Beijing Science and Technology Press. pp. 225-483.
19. Ren Y (2006) Biodiversity, conservation and management of Taiibaishan Nature Reserve. Beijing: China : Forestry Press. pp. 157-158.
20. Xing FW, Chen HF, Wang FG, Chen ZM, Zeng QW (2011) Inventory of plant species diversity in Nanling Mountains. Wuhan: Huazhong University of Science and Technology Press. pp. 1-272.
21. Zhu ZQ, Song CS (1999) Scientific survey of Shennongia Nature Reserve. Beijing: China : Forestry Press. pp. 1-249.
22. Haileh CF (2002) Composition, endemism and phytogeographical affinities of the taiwan flora. Taiwan 47: 298-310.
23. Wu DL (1994) A checklist of flowering plants of islands and reefs of Hainan and Guangdong province. Beijing: Science Press. pp. 1-334.
24. Zhu H, Yan LC (2012) Native seed plants in Xishuangbanna of Yunnan. Beijing: Science Press. pp. 1-565.
25. Li H, Guo HJ, Dac ZL (2000) Flora of Gaoligong Mountains. Beijing: Science Press. pp. 1-1344.
26. Wu ZY (1991) The areal-types of Chinese genera of seed plants. Acta BotanicaBot Yunnanica Suppl. IV: 1-139.
27. Wu ZY (1993) Addenda et Corrigenda ad Arealorum Generorum Spermatophytorum. Acta BotanicaBot Yunnanica Suppl. IV: 141-178.
28. Wu ZY, Zhou ZK, Li DZ, Peng H, Sun H (2003) The areal-types of the world families of seed plants. Acta BotanicaBot Yunnanica 25: 245-257.
29. Wu ZY (2003) The revision of The areal-types of the world families of seed plants'. Acta BotanicaBot Yunnanica 25: 535-538.
30. Wu ZY, Zhou ZK, Sun H, Li DZ, Peng H (2006) The areal-types of seed plants and their origin and differentiation. Kunming: Yunnan Science and Technology Press. pp. 1-566.
31. Li XW (1996) Floristic Statistics and Analyses of Seed Plants from China. Acta BotanicaBot Yunnanica 18: 363-384.
32. Wu ZY, Lu AM, Tang YC, Chen ZD, Li DZ (2003) The families and genera of angiosperms in China: A comprehensive analysis. Beijing: Science Press. pp. 1-1210.
33. Mabberley DJ (2008) The plant-book: a portable dictionary of the vascular plants. London: Cambridge University Press. pp. 1-858.
34. Wu ZY, Sun H, Zhou ZK, Li DZ, Peng H (2011) Floristics of seed plants from China. Beijing: Science Press. pp. 74-79.
35. Xiang QP (2001) A preliminary survey on the distribution of rare and endangered plants of Abies in China. Guahaia 21: 113-117.
36. Zhang ZY, Lu AM (1995) Hamamelidaceae: geographic distribution, fossil history and origin. Acta Phytotaxonomica SinicaSin 33: 313-339.
37. Manchester SR (1999) Biogeographical relationships of North American Tertiary floras. Annals Ann of Mo the Missouri Botanical Bot 73: 394-416. doi:10.2307/2666183.
38. Tiffney BH (1986) Fruit and seed dispersal and the evolution of the Hamamelidae. Annals Ann of Mo the Missouri Botanical Bot Garden 86: 472-522. doi:10.2307/2666183.
39. Wu DL (1994) A checklist of flowering plants of islands and reefs of Hainan and Guangdong province. Beijing: Science Press. pp. 1-334.
40. Chang HT (1994) A review on the origin of Cathaysian flora. Acta Scientiarum Naturalium Universitatis Sunyatseni, 33: 1-9.
41. Wu ZY, Wu SG (1996) A proposal for a new floristic kingdom (realm)—the East Asiatic Kingdom, its delineation and characteristics. In: AL Tahktajan AL Translated by (1978) Translated by Huang GC (1988) The regionalization of the flora in the World. Beijing: Science Press. pp. 1-331.
42. Chang HT (1994) A review on the origin of Cathaysian flora. Acta Scientiarum Naturalium Universitatis Sunyatseni, 33: 1-9.