巴山蕨类植物区系与分布的研究

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摘 要：在野外调查和已有资料的基础上，对巴山地区蕨类植物的区系和分布进行了系统的分析。结果表明，该区具有蕨类植物 34 科，79 属，289 种(包括变种和变型)。区系地理成分复杂，在属的水平上以热带、亚热带成分为主，约占总属数的 60.87%，温带成分占 39.13%，而在种的水平上，热带、亚热带成分仅占总数的 8.77%，温带成分处于优势地位，为 91.23%，在温带成分中，东亚成分突出，加上中国特有成分共占总数的 86.67%，显然应是东亚区系的一部分，因此巴山蕨类植物区系应属于中国—日本蕨类植物亚区。垂直分布可以划分 3 个带，蕨类植物主要分布在海拔 1 000～1 800 m。

关键词：巴山地区；蕨类植物；区系分析；垂直分布

中图分类号：Q948 **文献标识码**：A **文章编号**：1000-3142(2010)01-0089-06

Notes on flora and distribution of the pteridophytes of Ba Mountains

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Abstract: Based on the field survey and the known data, the flora and distribution of the pteridophytes in Ba Mountains were analyzed. The result were showed that there were about 289 species (including varieties and forms), 79 genera and 34 families of pteridophytes in this region. Floristic and geographic elements are complicated. At genus level, tropical-subtropical distribution types were dominant, accounting for 60.87% of the total genera, and temperate distribution types covered 39.13% of the total. While at the species level, temperate elements were dominant, accounting for 91.23% of the total species, and tropical-subtropical elements covered 8.77% of the total. Of the temperate elements, East Asian element took the largest proportion, including endemic to China, accounting for 86.67% of the total species in the mountains, which indicated that Ba Mountains belonged to China-Japan Sub-zone of pteridophytes. The pteridophytes of Ba Mountains can be divided into 3 altitudinal zones, and their vertical distribution center occured between 1 000—1 800 m above sea level.

Key words: Ba Mountains; pteridophytes; floristic analysis; vertical distribution

1 Introduction

Ba Mountains (including Daba Mountains and Micang Mountains) is located in central China, lying between 106°50′—109°42′ E longitude and 31°40′—32°55′ N latitude, about 400 kilometers from east to west, 40—80 kilometers from south to north. It is bordered

Received date: 2008-11-12 **Accepted date**: 2009-02-23

Foundation item: Supported by the National Natural Sciences Foundation of China(30370117,39899400,30499340); the Special Fund from the Chinese Academy of Sciences for Flora of China(KSXX-SW-122)

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by southern part of Shaanxi Province and Hanshui River on the north, western part of Hubei Province on the east, northern part of Chongqing City on the south, and north-eastern part of Sichuan Province on the west. Ba Mountains geographical position, ancient strata of rock, varied topographical complexity, fertile soil, and humid climate offer a myriad of ecological niches for ferns to grow. The average elevation is more than 2 200 m, and the highest peak, namely "Hualongshan" in Pingli country reaches 2 917 m. In this area, the annual rainfall is 800—1 200 mm and the mean temperature is 14—16 ℃. Therefore, this place is phytogeographically a meeting point for plants of east, west and north China, there are fern groups and a great many species as well.

Since the end of the 19th century, many foreign botanists had made scientific investigations in Ba Mountains, such as A. Henry, E. H. Wilson and R. P. Farges. Similarly, from 1930 to 1990, many Chinese botanists such as Guan-Guang Zhong, Wen-Pei Fang, Bu-Qiu Zhong, Ji-Meng Liu, Tian-Lun Dai, Zhuo-Pin Wang and Pei-Yuan Li made expedition, collections in Ba Mountains. The most famous pteridologist Ren-chang Ching (Ching, 1964; Ching *et al.*, 1985, 1974) and others (Shing, 1965, Kung, 1988) did much work on pteridophytes of the Ba Mountains and published many fern taxa.

However, so far as we know, there is none complete information of the pteridophytic flora and distribution of Ba Mountains. Since 1993, we undertook fourteen years to explore Ba Mountains, systematically and collected 235 fern taxa. The present study is based on collections from Ba Mountains by many professors, which specimen are present in Herbarium of Northwest A & F University (WUK); Herbarium of Institute of Botany, Academia (PE); Herbarium, Department of Biology, Sichuan University (SZ), and literatures (from 1984 to 2006) on the pteridophytes of Ba Mountains are also involved. According to the information mentioned above, we attempt to make a preliminary analysis of the florstic characteristics and geographic distribution of the ferns in Ba Mountains.

2 Number of families, genera and species

On the basis of pteridophytes collected in the wild survey and relevant data, about 289 species (including varieties and forms), 79 genera and 34 families (Ching's system of 1978) are on record in Ba Mountains. The number of families is about 53.9% of 63 families in China, the number of genera 35.1% of 225 genera, and that of species 11.3% of 2 554 species.

In Ba Mountains, large families with over 10 species are as follows: Dryopteridaceae (5 genera/67 species), Polypodiaceae (12/44), Athyriaceae (9/35), Aspleniaceae (1/16), Sinopteridaceae (4/15), Selaginellaceae (1/12), Theylypteridaceae (8/12), Adiantaceae (1/11), and Hemiontidaceae (2/10). The species of the above 9 families account for more then 73% of the total species number of ferns in the Ba Mountainss. they are widely distributed under the broad-leaved forests, making up the main elements of ferns in Ba Mountains. Among these families, Dryopteridaceae and Athyriaceae are mainly distributed in temperate regions and mountainous areas of tropical and subtropical regions. Of the rest, 14 families have 2—8 species, 11 families have only one species. Phytogeographically, Ba Mountains has the complexity of mutual crisscross and the infiltrate transition of tropic, subtropic and temperate elements.

Among the 79 genera of Ba Mountains, the following genera have more than 7 species: *Polystichum* (31 species), *Dryopteris* (19), *Asplenium* (16), *Selaginella* (12), *Adiantum* (11), *Cyrtomium* (11), *Athyrium* (10), *Lepisorus* (10), *Pyrrosia* (9), *Coniogramme* (8), *Pteris* (8), they include 145 species in total, accounting for 50.17% of the total species. 32 genera include 2—7 species, such as *Aleuritopteris* (7 species), *Dryoathyrium* (6), *Lunathyrium* (6), *Neolepisorus* (5), *Phymatopteris* (5), *Ophioglossum* (4), *Huperzia* (4), *Allantodia* (4), *Matteuccia* (4), *Onychium* (4), *Lepidogrammitis* (4), *Loxogramme* (4), *Arachniodes* (3), *Hippochaete* (3), etc., they include 108 species in total, accounting for 37.37% of all species. 36 genera

have only one species.

3 Analysis of the floristic and phytogeographic elements of pteridophytes

3.1 Analysis of the geographical elements of genera

Regarding the 289 species (including varieties and forms) and 79 genera of ferns, which show a more complex phytogeographical nature, they may be subdivided primarily into 15 distribution patterns as follows (Table 1).

Table 1 Distribution-types of genera and species of Pteridophytes in Ba Mountains

Distribution types	No. of genera	Percent of total genera (%)	No. of species	Percent of total species (%)
1. Cosmopolitan	10	—	4	—
Tropics and subtropics	(42)	(60.87)	(25)	(8.77)
2. Pantropic	18	26.08	2	0.70
3. Old World Tropics	4	5.79	2	0.70
4. Tropical Asian-American-African	2	2.90	0	—
5. Tropical Asian-American-Australia	1	1.45	2	0.70
6. Tropical Asian and Tropical American	1	1.45	1	0.35
7. Tropical Asian and Tropical African	5	7.25	3	1.05
8. Tropical Asian and Tropical Australia	3	4.34	2	0.70
9. Tropical and subtropical Asian	8	11.60	13	4.56
Temperate	(27)	(39.13)	(260)	(91.23)
10. North Temperate	13	18.84	10	3.51
11. Old World Temperate	3	4.34	1	0.35
12. E. Asian to N. American disjuncted	1	1.45	1	0.35
13. Temperate Asian	2	2.90	1	0.35
14. Eastern Asian	8	11.60	137	48.07
15. Endemic to China	—	—	110	38.59

Note: Cosmopolitan are not taken into account in computing the percentages in the table.

3.1.1 Cosmopolitan distribution There are 10 genera belonging to this type in Ba Mountains, and almost all of them are distributed in every main locality. The following are those genera: *Polystichum*(31 species), *Selaginella*(12), *Adiantum*(11), *Asplenium*(16), *Huperzia*(4), *Lycopodium*(3), *Equisetum*(2), *Salvinia*(1), *Azolla*(1)and *Marsilea*(1), accounting for 12.66% of the total genera, they include 84 species, accounting for 28.37% of all species in Ba Mountains.

3.1.2 Tropical-subtropical distribution This distribution type is the most common in Ba Mountains, these genera can extend their distribution up to the southern part of Qinling Mountain or only extend their distribution up to the Ba Mountains, such as *Microlepia*, *Lepidomicrosorium*, *Colysis*, *Parathelypteris*, *Psilotum*, *Mecodium*, *Gonocormus*, *Sphenomeris*, *Macrothelypteris*, *Loxogramme*, *Lygodium* and so on, it is obvious to indicate Ba Mountains is on the edge of subtropical flora of Asia. In the pteridophytic flora about 42 genera may be classified in this types, which cover 60.87% of the total genera. Pantropical genera are high-proportioned (26.08% of the total, excluding the cosmopolitan genera), including 18 genera i. e. *Vittaria*, *Pellaea*, *Allantodia*, *Pteris*, *Parathelypteris*, *Loxogramme*, *Ctenitis*, *Trichomanes*, *Lygodium* and so on. 8 Tropical and Subtropical Asian genera are distributing in the mountain (11.60% of the total), they are *Polypodiodes*, *Metathelypteris*, *Pseudophegopteris*, *Anisocampium*, *Cyclogramma*, *Microlepia*, *Arthromeris* and so on, the results show clearly that Ba Mountains flora is only partly related to tropical Asia flora. There are other tropical genera, 23.18% of the total genera, e. g. Old World Tropics (5.79%), such as *Drynari*, *Gonocormus*, *Pyrrosia*, *Colysis*; Tropical Asian-American-African(2.90%), such as *Coniogramme*, *Aleuritopteris*; Tropical Asian-American-Australia (1.45%), such as *Cheilosoria*; Tropical Asian and Tropical American (1.45%), such as *Gymnopteris*; Tropical Asian and Tropical African (7.25%), such as the genera *Lepisorus*, *Dryoathyrium*, *Crepidomanes*, *Microsorium*, *Pseudopegopteris*; Tropical Asian and Tropical Australia(4.34%), such as *Athyriopsis*, *Macrothelypteris*, *Pronephrium* and so on.

3.1.3 Temperate distribution There are 27 genera belonging to this type, and almost all of them are distributing in temperate Asia or northern Hemisphere, accounting for 39.13% of the total genera in Ba Mountains. 13 North Temperate genera (18.84%), they are *Dryopteris*, *Athyrium*, *Sceptridium*, *Woodsia*, *Ophioglossum*, *Gymnocarpium*, *Matteuccia*, *Phegopteris*, *Struthiopteris* and so on; 3 Old World Temperate

genera(4.34%), such as *Botrypus*, *Osmunda*, *Cystopteris*; *E. Asian* to N. American disjunct distribution only one genera(1.45%), *Lunathyrium*; 2 Temperate Asian genera(2.90%), *Pseudocystopteris*, *Cyrtomium*; East Asian distribution type contains 8 genera(11.60%), *Pleurosoiopsis*, *Lepidogrammitis*, *Drymotaenium*, *Saxiglossum*, *Leptorumohra*, *Neolepisorus* and so on, of which *Pleurosoiopsis*, *Neolepisorus* and *Lepidogrammitis* are China-Himalayas type, while others China-Japan type.

As mentioned above, at genus level, the geographical elements of the genera are mainly composed of tropical and subtropical types, which cover 60.87% of the total genera in the mountains, and the temperate types of the genera cover 39.13% of the total. There are no endemic genera, but many tropical and subtropical genera have only one species, such as *Phlegmariurus*, *Drymotaenium*, *Stenoloma*, *Macrothlypteris*, *Trichomanes*, *Pronephrium*, *Microsorum*, *Ctenitis*, *Gonocormus*, *Crepidomanes*, *Mecodium*, which are chiefly distributed in the warm and moist parts in Ba Mountains, where they reach their northern limit. This fully shows Ba Mountains must be the northern margin of the distribution of tropical and subtropical ferns, thus, the fern flora also have close relations with tropical and subtropical elements.

3.2 Analysis of the geographical elements of species

Of the 289 fern species in Ba Mountains, there are 14 distribution patterns(Table 1). Among these distribution types, Eastern Asian and Endemic to China are relatively important.

3.2.1 Eastern Asian distribution There are 137 species belonging to this type, accounting for 48.07% of the total species(excluding the cosmopolitan species) in Ba Mountains. It can be broken down into 4 subtypes: Asia-wide distribution, 23 species, accounting for 8.07% of the total species, such as *Lycopodium japonicum*, *Selaginella involvens*, *Hippochaete debilis*, *Allantodia squamigera*, *Asplenium varians*, *Polystichum neolobatum*, *P. makinoi*, *Woodwardia unigemmata*, *Pseudocystopteris atkinsonii*, etc.; Sino-Himalayan distribution, 33 species, account for 11.58% of the total species, such as *Crepidomanes lateatum*, *Onychium japonicum*, *Pellaea nitidula*, *Aleuritopteris gresia*, *Athyrium mackinnonii*, *Lepisorus variabilis*, *Pseudopegopteris pyrrhorachis*, *Polystichum stenophyllum*, *P. brachypterum*, *Dryopteris komarovii*, *D. peninsulae*, etc.; Eastern Asian-Vietnam distribution, 21 species, account for 7.36% of the total species, such as *Coniogramme rosthornii*, *Anisocampium sheareri*, *Phegopteris decursive-pinnata*, *Polystichum dielsii*, *Loxogramme duclouxii*, etc.; Sino-Japanese distribution, 60 species, account for 21.05% of the total species, such as *Selaginella tamariscina*, *Ophioglossum thermale*, *Botrypus strictus*, *Dennstaedtia wilfordii*, *Onychium japonicum*, *Athyrium wardii*, *A. fallaciosum*, *Allantodia okudairai*, *Asplenium incisum*, *Woodia unigemmata*, *Arachniodes pseudo-aristata*, *Polystichum tripteron*, *Pyrrosia periolosa*, *Saxiglossum angustissimu*, *Microrum fortunei*, *Drgnaria roosii*, etc.

3.2.2 Endemic to China distribution There are 110 species belonging to this type, accounting for 38.59% of the total species. Endemic to Ba Mountains, such as *Cheilosoria insignis*, *Polystichum longiarstatum*, *Asplenium chengkouense*, *A. humistratum*, *Coniogramme ankangensis*, account for 2.11% of the total species; Other species endemic to China, account for 36.49% of the total species, such as *Huperzia emeiensis*, *Aleuritopteris duclouxii*, *Lunathyrium sichuanense*, *Polystichum baoxingense*, *Neolepisorus ovatus*, *Dryopteris pycnopteroides*, *D. rosthornii*, *Gymnopteris bipinnata*, *Dryoathyrium henryi*, *Arachniodes simulans*, *Polystichum acutipinnulum*, *Lepisorus oligolepidu*, *Drymotaenium miyoshianum*, *Phymatopteris majoensis*, *Mecodium corrugatum*, *Dryoathyrium setigerum*, *Aleuritopteris shensiensis*, *Lunathgrium giraldii*, *Woodia shensiensis*, *Dryopteris sericea*, *Hypodematium gracile*, *Pyrrosia davidii*, *Aleuritopteris niphobola*, *Adiantum davidii*, *Woodia rosthorniana*, *Pyrrosia periolosa*, *Selaginella uncinata*, *Adiantum roborowskii*, *Coniogramme wilsonii*, *Struthiopteris eburuea*, etc. Those species are distributing in other regions of China, for example, West China, East China, Central China, North China, Northwest China, Qinling, etc.

3.2.3 Tropical and subtropical Asian distribution

There are 13 species belonging to this type, accounting for 4. 56% of the total species, such as *Psilotum nudum*, *Selaginella nipponica*, *S. moellendorffii*, *S. vaginata*, *Lygodiaum japonicum*, *Microlepia pseudostrigosa*, *Stenoloma chusanum*, *Pteris multifida*, *Microrum fortune*, *Colysis ellptica* var. *flexiboba*, etc. Other Tropical distribution, 12 species, account for 4. 21% of the total species.

3. 2. 4 North Temperate distribution There are 10 species belonging to this type, accounting for 3. 51% of the total species, such as *Polystichum braunii*, *Ophioglossum vulgatum*, *Equisetum arvense*, *Hippochaete hyemale*, *Lycopodium annotianum*, etc. Other Temperate distribution, 3 species, accounting for 1. 05% of the total species.

As mentioned above, at species level, the tropical and subtropical elements only cover 8. 77% of the total species in the mountain, and temperate elements are in a dominant position, accounting for 91. 23% of the total. Of the temperate elements, East Asia elements and Endemic to China elements significantly dominate, accounting for 86. 67% of the total species in the mountain. With regard to the element of the pteridophytic flora of the Ba Mountains, the temperate element is dominant, the East Asia elements are the most important and the Endemic to China, the tropical and subtropical and North Temperate are also abundant there. Ba Mountains range may be a region transitional from tropical and subtropical to temperate, being considered phytogeographically as a focus for tropical, subtropical and temperate ferns, and as a center of the ferns of East, West and North China.

4 Vertical distribution of pteridophytes

The pteridophytes of the Ba Mountainss can be divided into 3 altitudinal zones(Fig. 1).

(1)540—1 000 m. This region corresponds to the deciduous-evergreen broad-leaved mixed forest and the evergreen coniferous forest zone of *Cunninghamia lanceolata*, where 44 species of ferns are found, accounting for 15. 3% of all species in the Ba Mountains. This zone is dominated by small and drought-resistant saxicolous species of the *Selaginella*, *Aleuritopteris*, *Asplenium*, *Pyrrosia*, *Equisetum* and *Pteris* growing by streamlets or in dampish places.

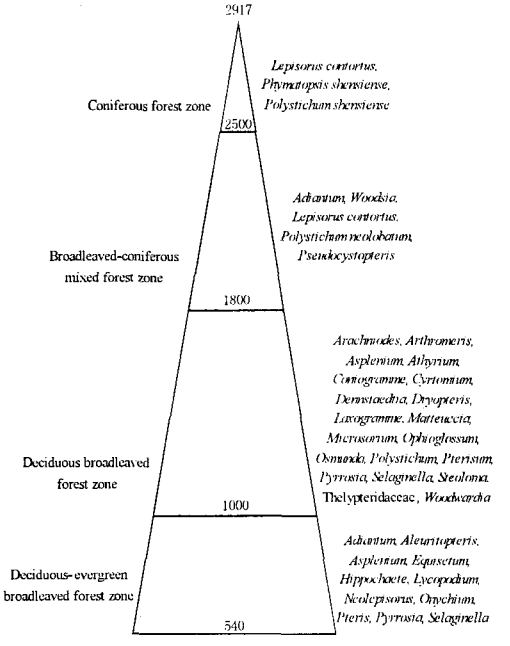

Fig. 1　Vertical distribution of pteridophytes in Ba Mountains

(2)1 000—1 800 m. This region corresponds to the deciduous broad-leaved forest zone, and mainly consists of the lower mountain(between 1 000—1 800 m) Quercus forest. This region is the richest in fern species. There are 228 species of ferns known in this region, which comprise 78. 9% of all species in the Ba Mountains, among which representative families are Dryopteridaceae, Athyriaceae, Hemionitidaceae, Aspleniaceae, Dennstaedtiaceae, Thelypteridaceae, Osmundaceae, Onocleaceae and others. These ferns grow under the forests.

(3)1 800—2 917 m. This region corresponds to the deciduous broad-leaved and evergreen coniferous forest zone, and mainly consists of the middle mountain (between 1 800—2 500 m) *Betula* and(between 2 500—2 917 m) *Abies fargesii* forest. The ferns known from this region consist of 17 species which comprise 5. 8% of all species in the Ba Mountains. The number of large ferns is reduced in this region, dominated by cold-resistant medium to small-sized species belonging to genera *Pseudocystopteris* and *Polystichum* growing

under the forest and alpine species of *Woodsia*, *Lepisorus*, *Phymatopsis* distributed on drier faces of rock.

5 Conclusions

Through statistic analysis of the pteridophytic flora at the level of family, genus and species in Ba Mountains, some conclusions are as follows: (1) The species of pteridophytes in this region are rich. There are 289 species(including varieties and forms), 79 genera, 34 families of pteridophytes in this region. The representative families are Dryopteridaceae, Polypodiaceae, Athyriaceae and Aspleniaceae. The main genera are *Polystichum*, *Dryopteris*, *Asplenium*, *Selaginella*, *Adiantum*, *Cyrtomium*, *Athyrium*, *Lepisorus*, *Pyrrosia*, *Coniogramme*, *Pteris*.

(2) Floristic and geographic elements are complicated. At genus level, tropical-subtropical distribution types are dominant, covering 60.87% of the total genera in the mountains, and the temperate types of the genera cover 39.13% of the total. This fully shows that Ba Mountains must be the northern margin of the distribution of tropical and subtropical ferns, thus, the fern flora also has close relations with tropical and subtropical elements. While at the species level, temperate and mountainous areas of tropical and subtropical species are the dominant, East Asian element takes the largest proportion, including endemic to Chinese elements, accounting for 86.67% of the total species in the mountain. It's indicated that Ba Mountains fern flora is characterized by temperate feature on the level of species. The Ba Mountains range may be a transitional region from tropical and subtropical to temperate, being considered phytogeographically as a focus for tropical, subtropical and temperate ferns, and as a center of the ferns of East, West and North China. However, this also indicates that Ba Mountains belongs to China-Japan Sub-zone of peridophytes.

(3) Vertical distribution of ferns is also notable. The pteridophytes of the Ba Mountains can be divided into 3 altitudinal zones, their vertical distribution center occurring between 1 000—1 800 m above sea level.

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