



Regular article

## Investigation and analysis of vascular plant resources and diversity in Wuyi Mountain, Fujian Province

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### Abstract

Wuyi Mountain, located in the north of Fujian Province, China, is renowned for its abundant medicinal plant resources. In July 2014, the 8<sup>th</sup> (second team) of Shenyang Pharmaceutical University's Chinese Medicine Resources Scientific Expedition Team conducted field investigation in the area. Through specimen collection and extensive literature review, the team identified and analyzed 223 vascular plant species from 175 genera and 85 families. The most dominant families were Compositae and Rosaceae, and perennial herbs were the predominant species, accounting for 44.39% of the total species identified. Notably, we documented five precious and rare medicinal plants unique to Wuyi Mountain. This study updates the database of plant resources and diversity in the region, providing a valuable reference for future studies. Finally, we put forward some suggestions to enhance the conservation and sustainable utilization of Wuyi Mountain's plant resources.

**Keywords:** plant resources; biodiversity; medicinal; protection and utilization; resource survey; Fujian Province

## 1 Introduction

Plant biodiversity provides humankind with numerous benefits, including food supply, ecosystem

functions, and resilience to climate change [1]. However, natural ecosystems, such as those comprising vascular plants, are under severe threat due to over-exploitation of resources, man-made destruction, and natural disasters. Recognizing the importance of biodiversity, many people worldwide advocate its protection. To support research and sustainable use of plant diversity, essential tools have been developed, including The World Checklist of Vascular Plants (WCVP, <http://wcvp.science.kew>).

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org/) [2]. In order to protect important ecosystems and maintain the number of rare and threatened species, National Parks have been built to strengthen global biodiversity conservation.

Wuyi Mountain Nature Reserve is situated in the core area of the Wuyi mountain range, with an average elevation of over 1,200 m. It was approved by the Fujian Provincial Government in April 1979 and by the State Council in July of the same year, becoming the first national key nature reserve in China. Wuyi Mountain, which has a unique natural landscape and rich cultural heritage, is one of the birthplaces of the Minjiang River. It is also the center for national science education and for youth science and technology education. Huanggang Hill, the highest peak in Wuyi Mountain range and the entire southeastern Chinese mainland, is a significant landmark. Overall, Wuyi National Nature Reserve is one of the most important biological gene banks and is rich in medicinal plant resources.

## 2 Materials and methods

### 2.1 Research area

Wuyi National Nature Reserve has the largest and most intact subtropical forest ecosystem in southeast of China. It is located between latitudes  $27^{\circ}33' - 27^{\circ}54' N$  and longitudes  $117^{\circ}27' - 117^{\circ}51' E$  in the northern Fujian Province in China (Fig. 1). The forest area of the reserve is 56,527 hectares, extending from east to west, spanning a total length

of 52 km and reaching its widest point at 22 km. The elevation within the reserve ranges from 300 m in the lower hills to 2,158 m at the main peak, with an average altitude exceeding 1,200 m. The climate is characterized by semitropical monsoon. The mean annual temperature is  $17.6^{\circ}C$  and the mean annual precipitation is 1,864 mm [3]. The Reserve preserves primitive forests of over 29,000 hectares. Its vegetation types are subtropical evergreen broadleaved forest, coniferous broad-leaved mixed forest, coniferous forest, middle mountain dwarf forest, and mid-mountain meadow from bottom to top.

Wuyi Mountain is the first world cultural and natural heritage reserve in China. It has a variety of flora and fauna and is rich in natural forest resources. There are 6 different rivers originating from Wuyi Mountain in Fujian Provinces and Jiangxi Provinces. In this region of southeast China, latitudinal temperature gradient in winter is much larger than that in summer, largely due to the dominant effect of direct solar radiation on temperature [4]. The relative high peaks in the Wuyi Mountains is a natural barrier, which blocks cold airflow from the west and leaves the moist air brought by spring and summer monsoon. Different temperature structures, large precipitations, high humidity, and long foggy days shape the cloudy and diverse ecology of this region. Because of its rich and comprehensive plant resources, Wuyi Mountain is an ideal place to conduct research on plant resources and diversity.



Fig. 1 Geographic location of the study area and the survey site



## 2.2 Methods

The 8<sup>th</sup> (second team) Shenyang Pharmaceutical University Chinese Medicine Resources Scientific Expedition Team carried out field expeditions in Wuyi National Nature Reserve in July 2014. The line survey method was adopted in five representative fields, including Huanggang Hill, Paradise Valley, and Tongmuguan. Plant species flourish during this period, which makes it easy to observe and record. Sampling plots were located along the trekking trail up the mountain, and the samples were collected along the way. The collection number, collection location, plant species, morphology and time were carefully documented, and digital photos of medicinal plants were carefully taken during each expedition. The latitude and longitude of the process were recorded using a GPS logger.

We took the specimens back to the camp since identification was difficult during the field trip. Species identification of the vascular plants was carried out according to *Flora Republicae Popularis Sinicae* (<http://www.iplant.cn/frps>) and Information System of Chinese Rare and Endangered Plants (<http://www.iplant.cn/rep>). The list of vascular plant resources was established, with a total of 223 species. Based on the list, a number of vascular plants that can be used as medicine was screened out according to the National Chinese herbal medicine compilation, Dictionary of Chinese ethnic medicine [5],

Chinese Herbal Medicines: Comparisons and Characteristics (2nd Edition) [6] and other sources. With reference to the above literature, 215 species were identified as medicinal plants, belonging to 83 families and 173 genera. The identified specimens were deposited in the library of Shenyang Pharmaceutical University. The diversity of plant resources in Wuyi Mountain was analyzed and evaluated in detail, and suggestions were put forward on the development, utilization, and protection of plant resources.

## 3 Results and discussion

### 3.1 Vascular plants species composition in Wuyi Mountain

Statistical analysis was conducted on all field data acquired during field expeditions. In total, we collected 85 plant families from Wuyi Mountain. It can be seen from Table 1 that there were 201 species of angiosperms, including 73 families and 160 genus. Dicotyledons were the most evolved, diverse, and adaptable taxon of angiosperms. Angiosperms were the most abundant at all three levels of family, genus, and species. In contrast, pteridophytes and gymnosperms had relatively few species. The results showed that angiosperms had few ecological niche limitations and were highly adaptable to the environment of Wuyi Mountain.

Table 1 Vascular plant species in Wuyi Mountain

Growth form	No. families	Ratio/%	No. genera	Ratio/%	No. species	Ratio/%
Pteridophytes	9	10.59	11	6.29	18	8.07
Gymnosperms	3	3.53	4	2.29	4	1.79
Dicotyledons	65	76.47	143	81.71	181	81.17
Monocotyledons	8	9.41	17	9.71	20	8.97
Total	85	100	175	100	223	100



3.2 Vascular plant families and genera composition in Wuyi Mountain

It can be seen from Fig. 2 that 38 families, which accounted for 44.71% of the total number of families, contain 1 species. Most of the families (45.88%) had 2-5 species in Wuyi Mountain, and the number of species (51.57%) also accounted for the most. Besides, 6 families had 6-10 species,

accounting for 7.06% of the total number of families. Only Compositae and Rosaceae contained more than 10 species. Even though the two represented only 2.35% of the total number of families, the species they included represented 12.56% of the total number of species. This result was related to the ecological habits of the plants, the environmental conditions, and the conservation management of the nature reserve.

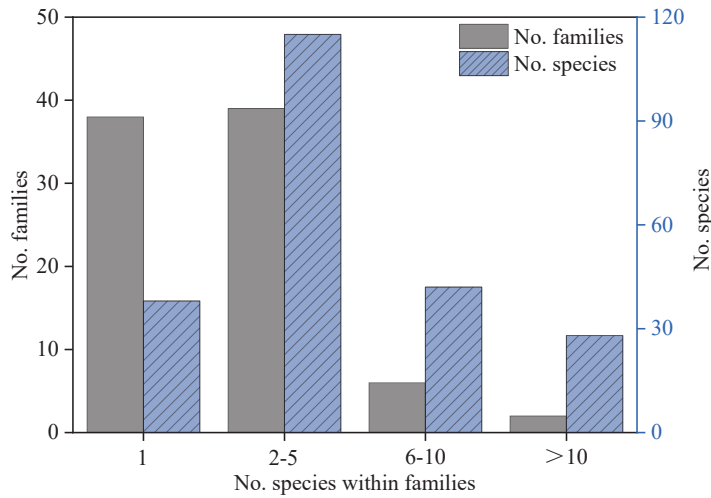


Fig. 2 Species in different families of vascular plants in Wuyi Mountain

There are 175 genera of plants collected in total. The genera were not evenly distributed and showed clear dominance. Statistical results indicated that 139 genera containing only 1 species accounted for the highest proportion of the total genera (79.43%), and

their species accounted for the highest portion of the total species (62.33%) (Fig. 3). Only 1 genus (Rubus) contained 6 species. Though accounting for 0.57% of the genus in the total collected plants, it has 2.69% abundance in the total species.

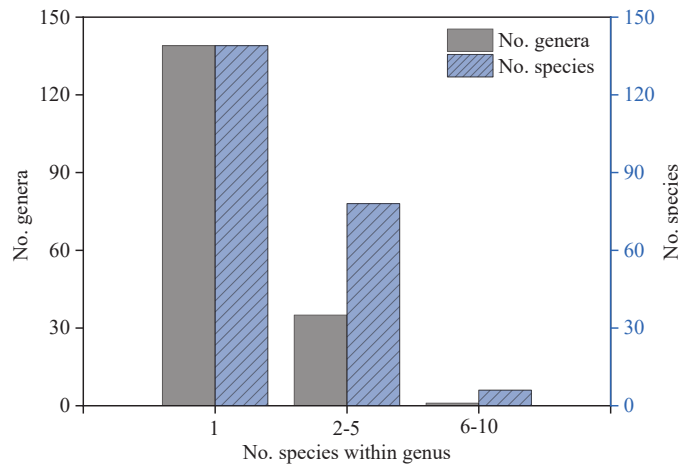


Fig. 3 Species in different genus of vascular plants in Wuyi Mountain



### 3.3 Vascular plants growth forms in Wuyi Mountain

According to Table 2, the dominant species was perennial herb, with 99 species, accounting for 44.39% of the total number of species. The proportion of the species of shrubs is 21.08%. Species of arbors and vines species followed, with 30 species each, accounting for 26.92% of the total.

In general, perennial herb and shrubs were the main vascular plants in Wuyi Mountain. In order to survive, plants optimize the allocation of limited natural resources, such as light, water, and nutrients, thus exhibiting a “fast-slow” strategy [7]. Most of perennial herbs and shrubs grow under arbors, which has high resource utilization efficiency and can ensure their growth and survival.

Table 2 Different growth forms of vascular plants in Wuyi Mountain

Growth form	No. species	Ratio/%
Perennial herbs	99	44.39
Therophyte/Biennial	17	7.62
Shrubs	47	21.08
Arbors	30	13.46
Vines	30	13.46

### 3.4 Medicinal vascular plants diversity in Wuyi Mountain

To analyze the diversity of medicinal vascular plants, literature review and information review were conducted in Wuyi Mountain in 2014, and 83 families, 173 genera and 215 species were recorded (Table 3). They accounted for 97.65% of the total number of families, 98.86% of the total number of genera, and 96.41% of the total number of species, respectively. The main families included Rosaceae (16), Asteraceae (11), Lamiaceae (8), Polypodiaceae (7), Saxifragaceae (7), Liliaceae (7) in the medicinal vascular plant, which occupied 19.28%, 13.25%, 9.64%, 8.43%, 8.43%, and 8.43% of the total number of families, respectively. The main genera

were Rubus (6), which accounted for 3.47% of the total number of genera, followed by Lysimachia (3), Hydrangea (3), Viola (3), Actinidia (3), Lonicera (3), and Pyrrosia (3) each accounting for 1.73%. Additionally, the main living form of medicinal plants was herbs, with 113 species, accounting for 52.56% of the total number of species of medicinal vascular plants.

Vascular plants were common as medicinal plants because of their location and convenience of collection. Meanwhile, they were regenerative resources, characterized by long development cycle, wide geographical distribution, and high reserve dynamics. However, vascular plants were susceptible to changes in species and reserves due to human factors and natural forces.

Table 3 Diversity of medicinal vascular plants in Wuyi Mountain

Composition/%	83 families (97.65%)	173 genera (98.86%)	215 species (96.41%)
Main families and genera (No. species)	Rosaceae (16) Asteraceae (11) Lamiaceae (8) Polypodiaceae (7) Saxifragaceae (7) Liliaceae (7)		Rubus (6) Lysimachia (3) Hydrangea (3) Viola (3) Actinidia (3) Lonicera (3) Pyrrosia (3)

(to be continued)



Continued table 3

Composition/%	83 families (97.65%)	173 genera (98.86%)	215 species (96.41%)
Growth form (No. species)	Herbs		113 (52.56%)
	Shrubs		44 (20.47%)
	Arbors		30 (13.95%)
	Vines		28 (13.02%)

Medicinal vascular plants in Wuyi Mountain can be categorized into whole plants, flowers, fruits, and seeds. The results suggested that the whole plant or root of more than 80 species of medicinal plants were used as medicinal parts, accounting for 79.18% of the total number of species of medicinal vascular plants (Table 4). The natural environment of Wuyi

Mountain provides favorable conditions for the whole plant. Plants are the richest source of different bioactive molecules. Most of the bioactive molecules originate from the roots because many bioactive plant secondary metabolites accumulate there [8]. Ever since the primitive societies, people have often used whole plants or plant roots to treat diseases.

Table 4 Different medicinal parts of medicinal vascular plants in Wuyi Mountain

Part used*	No. species	Ratio/% <sup>†</sup>
Whole plants	89	40.27
Roots	86	38.91
Rhizomes	46	20.81
Flowers	7	3.17
Branchs and leaves	37	16.74
Fruits	17	7.69
Seeds	5	2.26

Note: \* Some plant species had multiple medicinal parts, all of which were counted.

† Ratio is equal to the number of species divided by the total species number of medicinal vascular plants.

### 3.5 Precious and endangered medical plants in Wuyi Mountain

There are some endangered, unique, and rare plant species in Wuyi Mountain. For example, the *semiliquidambar cathayensis* distributed fragmentarily in Wuyi is on the verge of extinction. In addition to *Semiliquidambar cathayensis* H. T. Chang, the genus *Semiliquidambar*, endemic to southern and eastern China, also includes two species, *Semiliquidambar caudata* H. T. Chang and

*Semiliquidambar chingii* (F. P. Metcalf) H. T. Chang [9]. *S. cathayensis* has comprehensive morphological features between genus *Liquidambar* and *Mushroom* [10]. *S. cathayensis* grows in forests below 950 m above sea level or next to streams. Its dried stems and leaves have antirheumatic, activating blood, and eliminating stasis effects, and are used as medicine to treat rheumatism, lumbar muscle strain, traumatic-injury, osteoarthritis, bleeding, and oedema [11]. The ethyl acetate soluble fraction of the rhizome of *S. cathayensis* showed significant anti-inflammatory



activity [12]. At different growth stages, it needs different amounts of water, light, and heat. Ye et al. pointed out that ambient temperature and annual precipitation restricted the geographical distribution pattern of *S. cathayensis*, and its concentrated distribution was rarely found [13]. With the increase of climate change and human activities, *S. cathayensis* with a small population becomes more endangered and has the highest possibility of

extinction, so it enjoys the priority of protection. In China, *S. cathayensis* belongs to the vulnerable (UV) category as a second-grade protected wild plant on the China Biodiversity Red List.

In our study, 5 different precious and rare medicinal plants were collected in Wuyi Mountain (Table 5). Their families, genus, scientific name, part used, and medicinal use were listed below in Table 5.

Table 5 Endangered medicine plants in Wuyi Mountain

Families	Genus	Scientific name	Part used	Medicinal use
Magnoliaceae	Houpoea	<i>Houpoea officinalis</i> (Rehder & E. H. Wilson) N. H. Xia & C. Y. Wu	Bark (mainly) / flowers / seeds	Gynaecopathia, resolve phlegm, brighten the eyes
Magnoliaceae	Illicium	<i>Illicium henryi</i> Diels in Bot. Jahrb.	Leaves / roots	Traumatic-injury, bleeding, remove dampness, back pain
Magnoliaceae	Liriodendron	<i>Liriodendron chinense</i> (Hemsl.) Sarg.	Bark / leaves	Rheumatism, cough, cold, remove dampness
Juglandaceae	Cyclocarya	<i>Cyclocarya paliurus</i> (Batal.) Iljinsk.	Bark / leaves / roots	Heat cleaning, pain relief, reduce blood sugar
Hamamelidaceae	Semiliquidambar	<i>Semiliquidambar cathayensis</i> H. T. Chang	Roots / stem tuber	Rheumatism, lumbar muscle strain, bruises, osteoarthritis, bleeding, oedema

#### 4 Conclusion

Situated in the north of Fujian Province, China, Wuyi Mountain is renowned for its abundant medicinal plant resources and serves as the source of numerous rivers in both Fujian and Jiangxi Provinces. Our expedition yielded a wealth of first-hand information, specimens, photographs, and video files. Our research team collected 223 medicinal plant species, spanning 85 families and 175 genera. Notably, two families, Compositae and Rosaceae, each comprised over 10 species. Angiosperms were predominant in terms of families, genera, and species, underscoring their high adaptability in Wuyi Mountain. Among 175 genera

of vascular plant, the genus containing only 1 species had distinct advantages. In addition, perennial herb and shrubs were the main vascular plants in Wuyi Mountain. The results showed that the whole plants of 89 species were used as medicinal parts. Rosaceae, Asteraceae, Lamiaceae, Polypodiaceae, Saxifragaceae, and Liliaceae were the major medicinal families. The expedition counted clearly vascular plant resources, medical plant resources, key protected wild medical plants, their part used and medicinal use. Further research is needed.

Although Wuyi Mountain is rich in plant resources, its development, utilization, and protection have not yet reached the best level. To solve these problems, nature reserves have been



established in various locations, focusing on the protection of biological diversity as well as natural and cultural resources, and managed by legal or other effective means. However, these efforts are often insufficient, resulting in some plant species facing unnoticed threats. Therefore, it is important to update plant resource inventories and enhance the conservation and utilization of plant diversity of Wuyi Mountain.

On this basis, the following suggestions are put forward. Firstly, scientific research on Wuyi Mountain's plant resources should be strengthened by increasing support for researchers. It is imperative to conduct basic research in disciplines such as chemistry and biology. A comprehensive plan should be made to evaluate the development potential and utilization values of these plant resources. Secondly, biodiversity conservation mechanisms should be enhanced. This may include bolstering the operational capacity of nature reserves, strictly enforcing legal punishments against biodiversity crimes, and raising public awareness of plant protection and ethnobotany knowledge.

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