

A General Study on the Forest Vegetation of the Wuyi Mountains in Southeastern China

by

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八田洋章*・秦 祥坤**・郝 思軍** : 無夷山自然保護区の樹木相とその概観

Lying at the eastern edge of the Asian continent, the Wuyi Mountains are one of the nearest mountain ranges to Japan. Compared with the southwestern part of China, which includes the Himalayan areas known as Yunnan and Sichuan Provinces, the Wuyi Mountains are little known by the world. There have been a few investigative reports about its flora made by Japanese botanists, nevertheless, the laurel forests in the Wuyi Mountains have been considered to represent one of the original types of forest in Japan and constitute an important location in the Sino-Japanese Flora, especially in the warm temperate zone from Japan to the Himalayan Mountains.

It was a good experience for us to be a part of the Sino-Japanese Botanical Expedition Team, which investigated around the Wuyi Mountains Natural Reserves in Southeastern China for a 20-day period in 1994. This report is based on the results of our investigation at that time, the many experiences of our Chinese collaborators, and related references (Chang 1981, Cheng *et al.* 1982, Huang 1991, Huang *et al.* 1981, 1984, Lin and Ye 1984, Ling *et al.* 1981, Ji 1991a, 1991b, Nong 1991, Wang 1991).

The Survey of Nature in the Wuyi Mountains

The Wuyi Mountains Natural Reserve is located in the northern part of the Wuyi Mountain range, which lies at the boundary of Fujian and Jiangxi Provinces (Fig. 1). The Reserve, located in the region of 27° 33' ~ 54' north latitude and 117° 27' ~ 51' east longitude, has an area of about 610 km²; and its highest peak, Huang-gang-shan, rises to a height of 2,158 m above sea level. Its basic rock is composed of granite and volcanic rock and the forest soil appears weakly acidic. The annual mean rainfall reaches 2000 mm at an altitude of 900 m, and the region gets most of the rain in the summer due to the influence of the seasonal winds from the southeastern ocean. In winter, the mountain areas are foggy. The annual relative humidity is more than 80%. The annual mean temperature is 13°C, and the monthly mean is 3°C in January and 23~24°C in July. Resulting from the varied climate and complex topography, a variety of vegetation is recognized there.

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Fig. 1. Map showing the location of Wuyi Mountains and Yakushima Island.

The General Survey of the Forest Vegetation

The Wuyi Natural Reserve has preserved plenty of primary vegetation, as this region has been less disturbed by humans compared with other places. The natural forests are found seldom at low altitude area, where the artificial forests of *Pinus massoniana* and *Cunninghamia lanceolata* are the main forests, together with many bamboo forests. But, on the slopes of deep valleys, the subtropical evergreen broad-leafed forest seems well-developed. At the upper part of these slopes, there are warm-temperate evergreens, mainly composed of Fagaceae, Theaceae, and Lauraceae, mixed with the deciduous trees. At above 1,500 m alt., the natural warm coniferous forests of *Tsuga chinensis* var. *tchekiangensis*, *Pinus taiwanensis*, and *Crypromeria fortunei* are preserved.

The Wuyi Mountains are blessed with plenty of botanical resources. Statistical figures show there to be 1,487 species and 90 varieties of seed plants belonging to 668 genera and 152 families, in which gymnosperms of 7 families, 14 genera, 12 species, and 2 varieties are included (Ling *et al.* 1981). There are woody plants comprising about 650 species on the northern slope of the Wuyi Mountains (Ji 1991b). Otherwise, many species are rare and in danger, such as *Bretschneidera sinensis*, *Ginkgo biloba*, *Halesia macgregorii*, *Liriodendron chinensis*, *Magnolia officinalis* ssp. *biloba*, *Semiliquidambar chingii*, *Tsuga chinensis* var. *tchekiangensis*, etc. (Huang *et al.* 1981).

A. The Evergreen Broad-leafed Forest

The evergreen broad-leafed forests are scattered under 1,700 m, and there are several kinds of different communities with the change of altitude and habitat. The plants of Fagaceae (6 genera and 31 species), as the main part of the broad-leafed forests, bear small/middle-sized coriaceous leaves, and the umbrella-shaped crown of these trees is wavy (Fig. 2.). The communities are composed of various kinds of species, and there are no pure forests except for those of bamboo. Some tropical or

subtropical montane deciduous trees, such as *Betula*, *Quercus*, *Prunus*, and *Liquidambar*, which are usually 12~20 m high, are scattered in the evergreen forests. As the forest canopy is so densely covered, the herbs in the forest floor are not so developed.

The following genera are common in the forests: *Castanopsis*, *Lithocarpus*, *Cyclobalanopsis*, *Schima*, *Eurya*, *Photinia*, *Machilus*, *Symplocos*, *Rhododendron*, and *Phyllostachys*.

According to the altitude, the vegetation is described as follows:



Fig. 2. Typical feature of an evergreen broad-leaved forest dominated by Fagaceae, Theaceae, and Lauraceae in the Wuyi Mountains Natural Reserve.

1. Below 500 m

In the hilly areas, the trees are mainly *Castanopsis fagesii* and *C. carlesii* (15~20 m high), and the shrub layer (2~4 m high) is usually composed of *Rhododendron henryi*, *Machilus grijsii*, and *Eurya nitida*.

In the river valley at a similar altitude, otherwise, the combinations of *Castanopsis tibetana* + *Loropetalum chinensis* and *Castanopsis eyrei* + *Schima superba* are common. Trees are 10~13 m high, and their crown is yellowish dark-green with middle-sized leaves.

2. 500~800 m

The tall trees of 12~18 m are *Cyclobalanopsis glauca* + *Castanopsis eyrei* + *Schima superba*, whereas the shrub layer is mainly composed of *Rhododendron latoucheae* and *Itea chinensis* var. *oblonga* and is often mixed with some invading *Phyllostachys heterocyclus*. The areas with better water and soil conditions are usually populated with communities of *Pinus massoniana* + *Phyllostachys heterocyclus* + *Castanopsis fargesii*. There are some big trees of *Pinus massoniana*, which are thought to be the remainders of the transition from the pine forest to the broad-leaved forest.

Sometimes, the following combination is also found in this altitude: *Castanopsis eyrei* and *Schima superba* as the main trees, with *Indosasa* sp. below (Fig. 3).



Fig. 3. Common tree species in the lower elevation of the Natural Reserve: *Castanopsis eyrei*.

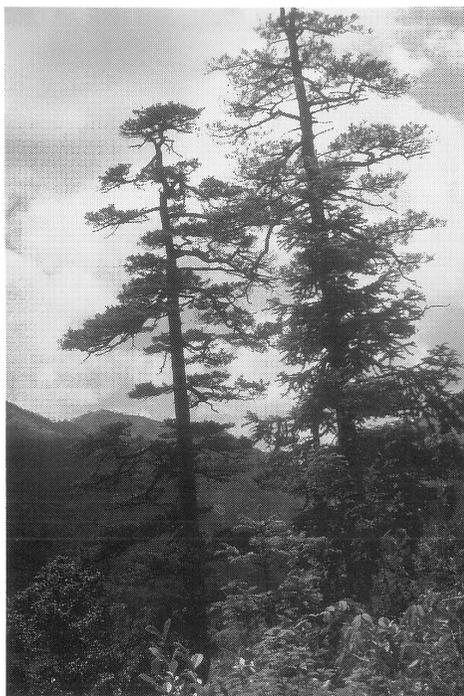


Fig. 4. *Pinus taiwanensis*, one of the main coniferous tree species in the higher elevation.



Fig. 5. Remarkable stand of *Tsuga chinensis* var. *tchekiangensis* growing at the bottom of a valley.



Fig. 6. Common features of a dwarf forest on the slope of Huang-gang-shan.

3. 1,200~1,400 m

The tree layer (8~12 m high) seems to be quite stable with *Schima superba*, *Cyclobalanopsis glauca*, and *C. multinervis* in residence, and its natural regeneration is in good condition.

The upper areas are needle- and broad-leafed mixed forests, which are described below.

B. Needle- and Broad-leafed Mixed Forest

1. The forest of *Pinus massoniana* can be recognized as the natural secondary forest when the evergreen broad-leafed forest is disturbed. They are usually grow up in regions about 1000 m alt. As *P. massoniana* is resistant to drought and poor soil, and its seeds can propagate well in acid soil, it becomes the main tree of afforestation on barren hills.



Fig. 7. Subtropical mountain grassland at the top of Huang-gang-shan.

The following combinations of a) to d) can be thought of as the representative associations of which *Pinus massoniana* is the main component. In some places with better natural conditions, after forests of *Phyllostachys heterocyclus* or *Cunninghamia lanceolata* have been cut, the semi-natural forest of *Pinus massoniana* is formed as a transition to the evergreen broad-leaved forest.

By the way, in East China, *Cunninghamia lanceolata* has been planted widely in the hilly areas below 1,000 m alt. But in this natural reserve the mixed forests of *Cunninghamia* with *Phyllostachys heterocyclus* or *Pinus massoniana* can be commonly found.

- a) *Pinus massoniana* + *Phyllostachys heterocyclus* + *Castanopsis fargesii*
- b) *Pinus massoniana* + *Cunninghamia lanceolata* + *Phyllostachys heterocyclus*
- c) *Pinus massoniana* + *Loropetalum chinensis* + *Rhododendron ovatum*
- d) *Pinus massoniana* + *Cunninghamia lanceolata* + *Loropetalum chinensis*

2. *Pinus taiwanensis* is usually about 10 m high and grows in areas above 1,200 m alt. It often grows as a natural forest on the ridge or at the peak of a mountain, and forms a temperate coniferous forest in these subtropical mountainous areas (Fig. 4). Sometimes, it is mixed with *Pinus massoniana* at 1,000~1,100 m alt., or with *Tsuga chinensis* var. *tchekiangensis* on occasion.

a) *Pinus taiwanensis* + *Clethra cavaleriei*: this combination exists above 1,200 m alt., and is conspicuous at the north side of the highest peak, Huang-gang-shan.

b) *Pinus taiwanensis* + *Rhododendron simsii* + *Clethra cavaleriei* + *Photinia beauverdiana*

c) *Pinus taiwanensis* + *Stranvaesia davidiana* var. *undulata*: these are scattered in the places of 1,800~1,850 m alt. where it is cold and windy, so that the crowns become lower and wider.

d) *Pinus taiwanensis* + *Tsuga chinensis* var. *tchekiangensis* + *Carpinus londoniana* + *Cyclobalanopsis multinervis* + *Lithocarpus cleistocarpus* + *Rhododendron kiangsiense* + *Euonymus carnosus* + *Styrax japonicus*

3. At 1,500~1,800 m alt., there are *Tsuga chinensis* var. *tchekiangensis* mixed with broad-leaved trees

or *Pinus taiwanensis*. The trees grow straight and reach 20~23 m in height. As they grow at the bottom of valleys or on slopes where soil is somewhat thick and less disturbed by human beings, these trees are estimated to be more than 100 years old (Fig. 5).

a) *Tsuga chinensis* var. *tchekiangensis* + *Betula luminifera* + *Lithocarpus cleistocarpus* + *Rhododendron kiangsiense* + *Enkianthus chinensis*

b) *Tsuga chinensis* var. *tchekiangensis* + *Cyclobalanopsis multinervis* + *Lithocarpus cleistocarpus* + *Eurya saxicola*

4. There is a natural forest of *Cryptomeria fortunei*, having a limited range on the northeastern slope of Huang-gang-shan, 1,600 m alt.

C. Subtropical Montane Dwarf Forest

This kind of forest is mainly located at the top of the peak, Huang-gang-shan (1,700~1,900 m alt.), just above the forest of *Tsuga chinensis* var. *tchekiangensis* or the evergreen broad-leaved forest. The trees are 3.5~5.5 m high (Fig. 6).

a) *Clethra cavaleriei* + *Symplocos phyllocalyx* + *Buxus sinica* var. *parvifolia*

b) *Clethra cavaleriei* + *Rhododendron kiangsiense* + *Eurya saxicola*

D. Subtropical Montane Grassland

On the top of mountains over 1,800 m alt., the montane grassland appears with *Calamagrostis arundinacea*, *Meliniopsis hai*, *Miscanthus sinensis*, etc. and species of trees which are cushion-like in shape (Fig. 7).

Discussion and Conclusions

The evergreen broad-leaved forest in China is much developed in the middle subtropical area of East China including the area of the Wuyi Mountains. The tall trees of *Castanopsis carlesii*, *C. fargesii*, etc. have come to be the main constructive species of these forests. Sometimes, trees of the southern subtropics, such as *C. fordii* and *C. fabri*, also appear here.

The vertical distribution of the main plants that comprise the evergreen broad-leaved and coniferous forests in this natural reserve is shown in Fig. 8.

Based on the ecological investigation (Huang *et al.* 1984), 128 species (78% of the trees are evergreen and 22% are deciduous) in the evergreen broad-leaved forest have been recorded, which belong to 7 associations from 420 to 1,300 m alt. The species that appear in all 7 associations are *Schima superba* and *Rhododendron henryi*; *Cyclobalanopsis glauca*, *Castanopsis eyrei* and *Rhododendron ovatum* exist in 5 associations.

The flora of this region is rich and include plants thought to be primitive. As gymnosperms, there are *Ginkgo biloba* (?), *Pinus massoniana*, *P. taiwanensis*, *Cunninghamia lanceolata*, *Podocarpus nagi*, *Cephalotaxus sinensis*, *Torreya grandis*, *Cryptomeria fortunei*, *Tsuga chinensis* var. *tchekiangensis*, and *Taxus chinensis* var. *mairei*, which grow naturally. On the other hand, 56 species of 29 genera are apocarpous and 115 species of 42 genera are amentiferous (Lin *et al.* 1981). We would like to make a comparison of the above with that of Yakushima Island and Japan (Masamune 1929, Ohwi 1972).

Yakushima Island, with an area of 500 km² and Mt. Miyanoura, 1,935 m high, is quite similar

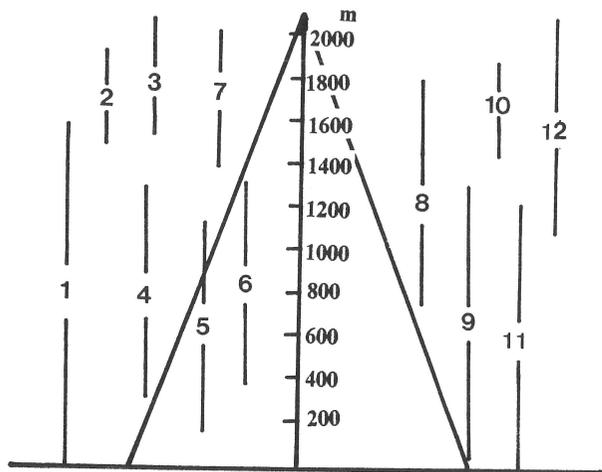


Fig. 8. A diagram of Wuyi Mountains showing the altitudinal distribution of vegetation/main trees composing the evergreen broad-leafed and coniferous forests (after Lin *et al.*).

1: Evergreen broad-leafed forest composed of Fagaceae, Magnoliaceae, Theaceae, Lauraceae and Hamamelidaceae. 2: Dwarf montane mossy forest, 3: Montane grassland, 4: *Schima superba*, 5: Cultivated *Phyllostachys heterocyclus*, 6: Cultivated *Camellia sinensis*, 7: *Quercus*, *Betula*, *Salix*, *Acer*, *Prunus*, *Clethra*, 8: *Cryptomeria fortunei*, 9: *Pinus massoniana*, 10: *Tsuga chinensis* var. *tchekiangensis*, 11: *Cunninghamia lanceolata* and 12: *Pinus taiwanensis*.

to the Wuyi Mountains National Reserve (610 km² and the main peak of Huang-gang-shan, 2,158 m high). Although 90% area of the island is covered by the mountain, the forest at the foot of mountain has been seriously damaged, as that in the Wuyi Mountains. A similar evergreen broad-leafed forest can be found on the slopes along the rivers and in the forests belonging to shrines. There are big trees of *Cryptomeria japonica*, *Abies firma*, and *Tsuga sieboldii* in the middle of the island, whereas some dwarf communities such as *Rhododendron metternichii* var. *yakushmanum* and bamboo grass grow at upper altitudes. In the zone of needle and broad-leafed mixed forests, the forest of *Cryptomeria japonica* is developed incomparably. Other conifers such as Pinaceae, Cephalotaxaceae, Taxaceae, etc. are mixed with broad-leafed trees such as *Acer sieboldianum*, *Stewartia monadelphica*, *Lindera erythrocarpa*, *Quercus acuta*, *Trichodendron aralioides*, *Ilex pedunculosa*, *Machilus thunbergii*, and *Cornus kousa*. Although the needle- and broad-leafed mixed forests of *Pinus taiwanensis*, *Tsuga chinensis* var. *tchekiangensis* in the Wuyi Mountains are comparable to those of Yakushima Island, the ratio of the laurel forest to total forest of the two areas is different; and, unlike the Wuyi Mountains, Yakushima Island has no big community of *Phyllostachys heterocyclus*.

As seen in Table 1, the genera and species numbers of gymnosperms in the Wuyi Mountains and Yakushima Island are similar; and most of the genera are common to both areas. In the Wuyi Mountains, *Ginkgo biloba* is found in the wild, but we can not sure whether it is native or not.

Compared with their number in Yakushima Island, the number of amentiferous plants in the Wuyi Mountains is greater: the number of genera is 10 greater and that of species is double (Table 2).

The ratio of genera in the Wuyi Mountains to those in Japan is 42: 47, and the number of species is similar except in the case of Salicaceae and Betulaceae, which are mainly distributed in the temperate zone.

As to the apocarpous families (Table 3), the genera and species in the Wuyi Mountains are more numerous than those in Japan if the Ranunculaceae are excluded. In Japan, there are no Annonaceae, Calycanthaceae and Sargentodoxaceae in nature. According to Tables 2 and 3, the Wuyi Mountains have preserved many plants of ancient origin.

The splendid evergreen broad-leaved forests have come to be the character of the Wuyi Mountains Natural Reserve. As seen in Table 4, the Fagaceae, comprising 6 genera and 31 species, are the main component forming the crown. *Castanopsis eyrei*, *C. fargesii*, *C. fabri*, *C. tibetana*, *C. fordii*, *C. lamontii*, *C. sclerophylla*, *C. carlesii*, *Cyclobalanopsis glauca*, *Lithocarpus harlandii*, and *L. hancei* often appear in the evergreen broad-leaved forests below 1,300 m alt.; *Cyclobalanopsis nubium*, *C. myrsinaefolia* and *Quercus phillyraeoides* are usually in the range of 800~1,500 m alt.; *Cyclobalanopsis*

Table 1. Comparison of the genera and species number in the families of gymnosperms

	Wuyi Mountains	Yakushima Island	Japan
Cycadaceae	—	—	1(1)*
Ginkgoaceae	1(1)?	—	—
Pinaceae	3(4)	3(5)	6(23)
Taxodiaceae	2(2)	1(1)	1(1)
Cupressaceae	2(2)	1(1)	4(9)
Podocarpaceae	1(1)	1(2)	1(2)
Cephalotaxaceae	1(2)	1(1)	1(1)
Taxaceae	2(2)	1(1)	2(2)
Sciadopityaceae	—	—	1(1)
Total	12(14)	8(11)	17(40)

*genera (species)

Table 2. Comparison of the genera and species number in the amentiferous families

	Wuyi Mountains	Yakushima Island	Japan
Saururaceae	2(2)	2(2)	2(2)*
Piperaceae	2(2)	2(2)	2(2)
Chloranthaceae	2(4)	1(2)	1(5)
Salicaceae	2(7)	1(3)	4(44)
Myricaceae	1(1)	1(1)	1(2)
Juglandaceae	4(5)	1(1)	3(3)
Betulaceae	3(4)	2(2)	5(28)
Fagaceae	6(34)	5(13)	6(21)
Ulmaceae	5(10)	3(3)	5(10)
Moraceae	5(19)	6(13)	6(16)
Urticaceae	10(27)	8(12)	12(44)
Total	42(115)	32(54)	47(177)

*genera (species)

Table 3. Comparison of the genera and species number in the apocarpous families

	Wuyi Mountains	Yakushima Island	Japan
Magnoliaceae	5(8)	2(2)	2(10)*
Illiciaceae	1(2)	1(1)	1(1)
Schisandraceae	2(4)	—	2(2)
Annonaceae	1(1)	—	—
Calycanthaceae	1(2)	—	—
Ranunculaceae	6(18)	4(11)	20(143)
Berberidaceae	5(8)	1(1)	7(15)
Lardizabalaceae	4(9)	2(2)	2(3)
Sargentodoxaceae	1(1)	—	—
Menispermaceae	3(3)	3(4)	5(6)
Total	29(56)	13(21)	39(180)

*genera (species)

Table 4. Comparison of the species number of Fagaceae

	Wuyi Mountains	Yakushima Island	Japan
<i>Fagus</i>	2	—	2
<i>Castanea</i>	3	1	1
<i>Castanopsis</i>	9	2	2
<i>Lithocarpus</i>	5	2	2
<i>Chyclobaranopsis</i>	8	7	7
<i>Quercus</i>	4	2	7
Total	31	14	21

multinervis and *Lithocarpus cleistocarpus* and the main trees in the forest of 1,500~2,000 m alt. In Japan, the species of Fagaceae such as *Castanopsis sieboldii* and *Lithocarpus edulis* seem to be common in the forests but are far less noticeable than those in the Wuyi Mountains.

From the comparison of genera in Table 4, it is evident that except for *Fagus* and *Quercus*, the number of species of every genus in the Wuyi Mountains is greater than that in Japan, indicating that Fagaceae has a main distribution center in the tropical mountain areas of Southeastern Asia. By comparing the obvious laurel forests of the Wuyi Mountains with those in Japan, we can understand the difference in the geographic position between the Wuyi Mountains and Japan; that is, the Wuyi Mountains are directly connected to the Malaysian region.

The above only makes a comparison among Wuyi Mountains, Yakushima Island, and Japan in terms of the number of genera and species. As there are so many plants of ancient origin in the Wuyi Mountains, this region assumes importance as a reference point when we study the laurel forests in Japan.

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Summary

Lying at the eastern edge of the Asian continent, the Wuyi Mountains are one of the nearest mountain ranges to Japan. The Wuyi Natural Reserve has preserved plenty of primary vegetation on the slopes of deep valleys. As the upper part of the slopes, the warm-temperate evergreen forest, composed mainly of Fagaceae, Theaceae, and Lauraceae, seems well-developed.

The evergreen broad-leafed forests are scattered under 1,700 m, and there are several kinds of different communities with the change of altitude and habitat. The plants of Fagaceae (6 genera and 31 species), are the main part of the broad-leafed forests. The following genera are common in the forests: *Castanopsis*, *Lithocarpus*, *Cyclobalanopsis*, *Schima*, *Eurya*, *Photinia*, *Machilus*, *Symplocos*, *Rhododendron* and *Phyllostachys*, and some subtropical montane deciduous trees, such as *Betula*, *Quercus*, *Prunus*, and *Liquidambar* are scattered in the evergreen forests. As the forest canopy is so densely covered, the herbs in the forest floor are not so developed.

On the coniferous trees, *Cunninghamia lanceolata* has been planted mixed with *Phyllostachys heterocycla* below 1,000 m alt. and *Pinus massoniana* can be recognized as the natural secondary forest about 1,000 m alt. *Pinus taiwanensis* is usually grows in areas above 1,200 m alt. It often grows as a natural forest on the ridge or at the peak of a mountain. At 1,500~1,800 m alt., there are *Tsuga chinensis* var. *tchekiangensis* mixed with broad-leafed trees or *Pinus taiwanensis*.

To make a comparison of the above with that of Yakushima Island and Japan;

- ① the genera and species numbers of gymnosperms in the Wuyi Mountains and Yakushima Island are similar, and most of the genera are common to both areas.
- ② the number of amentiferous plants in the Wuyi Mountains is greater: the number of genera is 10 greater and that of species is double.
- ③ as to the apocarpous families, the genera and species in the Wuyi Mountains are more numerous than those in Japan if the Ranunculaceae are excluded.
- ④ the species number of many genus of Fagaceae in the Wuyi Mountains is greater than that in Japan, indicating that Fagaceae has a main distribution center in the tropical mountain areas of Southeastern Asia.

摘 要

武夷山系は中国大陸の東縁に位置し、日本に最も近い山塊の一つであるにもかかわらず、紹介されることの少なかった地域である。今回調査した武夷山自然保護区には主峰黄崗山(標高2,158 m)が含まれ、立派な照葉樹林が保存されている。常緑広葉樹林は標高およそ1,700 m 以下に発

達し、標高差および諸条件の違いにより異なる群落認められる。なかでもブナ科植物は保護区内だけでも6属31種が確認されていて、常緑広葉樹林の中心的構成種群となっている。出現する属としてはブナ科の *Castanopsis*, *Lithocarpus*, *Cyclobalanopsis* などの他に、*Schima*, *Eurya*, *Photinia*, *Machilus*, *Symplocos*, *Rhododendron* などが多い。これらの常緑樹群に混じって、*Betula*, *Quercus*, *Prunus*, *Liquidambar* などの亜熱帯山地性落葉樹も混在する。林冠はうっ閉していて草本層の発達が悪い。

針葉樹では標高1,200 m 以上の岸壁やその頂部に黄山松 *Pinus taiwanensis* が現れ、標高1,700 m の谷筋には南方鉄杉 *Tsuga chinensis* var. *tchekiangensis* の群落が望めた。後者は樹高20~23 m の巨木群で、この山域の希産種に挙げられている。またコウヨウザン *Cunninghamia lanceolata* が標高1,000 m 以下のやや湿った場所に植林され、比較的乾いた場所には *Pinus massoniana* の植林が見られた。

武夷山自然保護区の植物を、面積や標高などの諸条件が類似すると思われる鹿児島県屋久島、および日本全体のものと比較すると以下のものであった。

①屋久島と武夷山の裸子植物相は類似の種類をもち、属はほとんど共通であった。

②尾状花序群の種群を比較すると、武夷山のそれは屋久島より10属、種類で2倍数を超え、日本全体の種数に匹敵した。

③離生心皮をもつ種群を比較しても、キンポウゲ科を除けば、武夷山自然保護区は日本全土におけるより属、種類とも多い。

④日本の照葉樹林においてもブナ科植物は重要だが、武夷山におけるその位置には遠く及ばない。*Fagus*, *Quercus* を除き、すべての属で日本全体の種類にまさる。

以上、単純に武夷山を屋久島や日本全体における属や種数で比較したにすぎないが、武夷山は古い起源の植物を多く含み、日本の照葉樹林を考察するうえで重要な山塊と位置づけられよう。

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