Front. Biol. China (2006) 2:158–162
DOI 10.1007/s 11515-006-0007-x

RESEARCH ARTICLE

Tang Weibin, Zhao Jiancheng

Study on the Bryoflora in Yunmeng Mountain, south Hebei Province, China

Abstract Mountain Yunmeng (37°20′N，113°54′E) is 1 520m above sea level and part of the Taihang Mountains. With a temperate continental monsoon climate, the mountain area belongs to the warm temperate deciduous broad-leaved forest region. This thesis was mostly based on the study of more than 2 000 packages of bryophytes which were mainly collected by the authors in Mt.Yunmeng, Hebei Province. Of these specimens, there are 36 families, 99 genera, and 244 species (including 17 varieties, 5 formes, and 1 subspecies) which have been studied and identified. Moreover, it could be seen that Mt.Yunmeng has a diverse population of bryophytes. The bryoflora could be divided into 10 geographical elements: north temperate element make up the majority, accounting for 52.11% of the entire known bryoflora, and another belongs to the East Asian element, accounting for 19.25%. All temperate elements, not including 14 endemic to China and 31 Cosmopolitans, were added up to 188 species, which took 88.3% of all the entire known bryoflora in Mt.Yunmeng. However, there were only 11 Subtropical and Tropical elements. To all appearances, the bryoflora of Mt.Yunmeng showed obvious temperate characteristics. The authors conclude that the bryoflora in Mt.Yunmeng belongs to the middle type, between the warm and dry northern mountain area and the warm and damp southern mountain area. The microclimatic environment greatly influences the bryoflora.

Keywords bryophytes，bryoflora，Mountoain Yunmeng，south Hebei Province

Translated from *Guihaia*, 2005, 25 (3) [译自：广西植物，2005,25(3)]

Tang Weibin
Department of Biology, Xingtai University, Xingtai 054001, China
Zhao Jiancheng (✉)
College of Life Sciences, Hebei Normal University, Shijiazhuang 050016, China
E-mail: zhaojiancheng@mail.hebtu.edu.cn

1 Introduction

Mountain Yunmeng is a scenic spot developed recently in south Hebei Province, China. It is praised as "northern Jiuzhaigou" for its waterfall and ravine. In the scenic spot, the peak, water, stone, and tree enhance each other's beauty and the pool, stream, deep pool, and waterfall are in picturesque disorder. With various plants spreading, the vegetation coverage ratio is 95%. At present, there are no studies on the bryophytes. Also, bryophytes were rarely studied in Taihang Mountains in south Hebei Province (Gao 1994; Gao 1996; Han et al., 2001; Tang 2001; Tang and Li 2003). From 2000 to 2002, we have investigated the variety, habitat, and ecological geographical distribution of the bryophytes and collected more than 2 000 packages. Based on the studies on the specimens, the species composition and floristic characteristics of the bryophytes in Mt.Yunmeng have been revealed. This study reports more available data on bryoflora in Taihang Mountains, Hebei Province, and even in China.

The evidence specimens are stored in Herbarium of Hebei Normal University (HBNU).

Mt.Yunmeng (37° 20′ N，113° 54′ E), whose surface area is about 30 km^2, is located in Xingtai County of south Hebei Province and east slope of Taihang Mountains. It is the watershed of Hebei and Shanxi provinces. The geological structure belongs to the Third Uplift-belt of Neocathaysian Structural System, between Zanhuang Paleouplift and Wu'an Depression. Ridges and peaks overlay in the district and gullies and gorges are vertical-deep. The highest peak is 1 520 m above sea level. The waterfall is hung highly and stream is constant all yearround, especially in the regions with the elevation above 1 000 m. The water flow along the bottom of the ditch falls down several times and makes the air more humid, which creates superior condition for the growth and distribution of bryophytes.

This district belongs to the temperate continental monsoon climate. Average annual temperature is between 10~12℃. The frost-free period lasts 200 d. Generally,

average annual precipitation ranges between 600 mm and 700 mm and varies largely year by year. The seasonal distribution of precipitation is not even. The mountain torrents are often formed in summer and very few in winter. Average annual sunlight time is about 2 300~2 600 h.

The main natural vegetation types of Mt.Yunmeng belong to the warm temperate deciduous broad-leaf forest and shrubland. Because the regional condition of temperature and humidity is superior and because the ecoclimate environment is comparatively special and suitable, the plant species is rich. Mt.Yunmeng, with the richest plants species, is located in the center of the middle-south area of the Taihang Mountains (Liu 1996). There are 887 species of tracheophyte belonging to 474 genera in 118 families in this zone (Tang 2003). The distribution of seed plants varies with height and orientation. The sunny-slope grows *Quercus variabilis*, *Platycladus orientalis*, *Ailanthus altissima*, *Picrasma quassioides*, *Juglans regia*ans, *etc*. and there are many species in the shady-slopes, such as *Quercus dentate, Carpinus turczaninowii.* The main bushes are *Vitex trifolia* var. *heterophylla* and *Zizyphus jujuba var*. *soinosa.* The most commonly found herbs include *Bothriochloa ischaemum* and *Themeda japonica*. Lots of bryophytes communities can be seen in this area.

2 Bryofloristic feature

2.1 Species composition

According to the studies on the specimens, there are 36 families, 99 genera, and 244 species (including 17 varieties, 5 formes, and 1 subspecies) in Mt.Yunmeng, which made up 30.76% of the total families, 18.28% of the total genera and 7.95% of total species of national bryophytes (Table 1).

Table 1 Number of bryophytes in Mt.Yunmeng

Klass	Family number	Genus number	Species number	Variety number	Form number	Subspecies number
Hepaticae	9	11	17	0	0	0
Musci	27	89	227	17	5	1
Total	36	100	244	17	5	1

The whole climate environment in Mt.Yunmeng is dry and half-dry, which is manifested by the presence of rare liverworts. There are 134 species of Acrocarpous mosses, which accounts for 59.03% of the total species of mosses. There are 93 species of Pleurocarpous mosses, accounting for 40.97% of the mosses. Acrocarpous mosses only prevail slightly, which results from interaction between the cold-dry north-temperate continental monsoon climate and the local warm-moist microclimatic environment in Mt.Yunmeng.

2.2 Major families and genus composition

The distribution of major families and genus of bryophytes has obvious characteristics that numerous genus and species are concentrated in few families and genus in Mt.Yunmeng (Tables 2,3). These characteristics comply with the rule of plant distribution of the dry and half-dry region in the northern temperate zone. The largest family Pottiaceae, largest genus *Bryum,* and voluminous major families and genus belong to the typical drought sort and the temperate elements are core. It fully exhibits the arid climate environment characteristics of Mt.Yunmeng. Therefore, the main group of bryoflora of this region can be known and it also reflects that the bryoflora of Mt.Yunmeng belong to the vegetation type of temperate zone.

By contrast, the bryophytes in Mt.Yunmeng include richly single-species-family (genus) and single (skinny)-species-genus, which accounts for 58.3% of total families separately and 78.8% of total genus, respectively. They have reflected the complexity of the bryophytes elements and age of bryoflora origin in this district and also proved that this bryoflora had been crossed by the elements in the neighbouring area, which implies their transition.

Table 2 Major families (≥ 10 species) of bryophytes in Mt.Yunmeng

No.	Family name	Genus number	Percentage / %	Species number	Percentage / %
1	Pottiaceae	20	22.2	66	27.05
2	Bryaceae	5	5.1	22	9.02
3	Hypnaceae	10	11.1	20	8.19
4	Amblystegiaceae	5	5.1	20	8.19
5	Brachytheciaceae	5	5.1	17	6.97
6	Mniaceae	5	5.1	11	4.51
7	Thuidiaceae	7	7.1	11	4.51
Total	7	57	57.6	167	68.40

Table 3 Major genus(≥ 5species) of bryophytes in Mt.Yunmeng

No.	Genus name	Species number	Percentage / %
1	*Bryum*	16	6.56
2	*Didymodon*	13	5.33
3	*Brachythecium*	10	4.10
4	*Enotodon*	9	3.69
5	*Fissidens*	9	3.69
6	*Weissia*	8	3.28
7	*Hypnum*	7	2.87
8	*Drepanocladus*	7	2.87
9	*Hyophila*	6	2.46
10	*Tortula*	5	2.05
11	*Gymnostomum*	5	2.05
12	*Amblystegium*	5	2.05
13	*Grimmia*	5	2.05
14	*Trichostomum*	5	2.05
15	*Anoectangium*	5	2.05
Total	15	115	47.13

3 Bryofloristic analysis

According to the general concept of flora division, the viewpoints of Wu Zhengyi and Wang Hesheng(Wu and Wang 1983), the modern geographical distribution materials of the bryophytes, and combining one's own characteristics, the bryoflora in Mt.Yunmeng was categorized into 10 geographical elements (Table 4).

Table 4 Bryofloristic elements of the species in Mt.Yunmeng

Bryofloristic elements	Species number	Percentage / %
Cosmopolitans	31	*
Pantropical elements	2	0.94
Trop.Asian elements	9	4.23
North Temperate elements	111	52.11
Old World Temperate elements	13	6.10
Temperate Asia elements	13	6.10
Mediterranean, West Asain and Centrai Asian elements	1	0.47
East Asia and North American elements	9	4.23
East Asian elements	13	6.10
Sino-Himalayan elements	5	2.35
Sino-Japanese elements	23	10.80
Endemic to China	14	6.57

Statistics（not including Cosmopolitans）show that there are 11 tropical elements bryophytes in Mt.Yunmeng, which accounts for 5.17% of the total species. There are 188 temperate elements (not including those endemic to China), which account for 88.26% of the total species. It can be found out that the temperate elements play a leading role in this bryoflora and this can prove that there is a remarkable temperate characteristic in the bryoflora on Mt.Yunmeng, which accords with the geographical position and climatic conditions of the temperate zone in this area and is identical with the distribution law of seed plant in this area.

Further analysis shows that there are 111 species of north temperate elements, which account for 52.11% of the total species. This species group has remarkable advantages, is the main group of bryoflora in Mt.Yunmeng, and includes most of the elements in above-mentioned major families: 22 species in Pottiaceae, 15 species in Bryaceae, 11 species in Amblystegiaceae, 10 species in Hypnaceae, and 7 species in Brachytheciaceae and Mniaceae.

There are 13 species of Old World Temperate elements in this area, which account for 6.10%. They are mainly Trachycystis ussuriensis, Frullania muscicola, Fissidens zippelianus, Molendoa hornschuchiana, Tortula muralis var.obcordata, and Rhynchostegium confertum.

There are 124 species in Mt.Yunmeng the same as those in Europe, which account for 58.22% of the total species. Analysis on the two above-mentioned elements shows that the bryoflora elements composition has great resemblance between this area and Eurasia. This is because Taihang Mountains, located in east edge in Eurasia, links Europe Continent with land and thus the plant elements can permeate into each other and spread along the land. Also, in the later stage of Glacier Period of Tertiary Period, European species migrated south and moved east in a large amount. Later, at the end of ultimate Glacier Period in Quaternary Period, large quantities of plants developed northwards. Most extant European elements might be the legacy of that period.

There are 13 species of Temperate Asia elements in Mt.Yunmeng, including Porella chinensis, Anoectangium thomsonii, Anomodon minor ssp. integerrimus, Eurhynchium eustegium, Entodon giraldii, and Hondaella brachytheciella.

Mediterranean, West Asian, and Central Asian elements present in Mt.Yunmeng are only *Bryum sauteri,* which live in the low distinct area just above sea level with a warm and drier environment. The reason of its appearence may be attributed to the fact that some species of the north temperate zones and Tethys split up, developed or were incomplete, on the mountain region or the arid flat of mid-Asian, with gradual drought of temperate climate in middle Asia(Zhao 1993).

Nine varieties, belonging to East Asia and North American elements, account for 4.23%. The main species are Ptychomitrium sinense, Entodon macropodus, Anomodon minor, Venturielle sinensis, Fissidens geminiflorus, Taxiphyllum taxirameum, and Claopodium papillicaule. Eurasia and North America was once connected by the Berling Strait, which had already sunk to the seabed. There was no natural obstacle during species formation and exchange between plants of Asia and North America. The existence of east Asia and north American elements has further verified the origin of the two areas in geological history and also explained the wide-raging connection between east Asian and north American flora..

There are 41 species (accounting for 19.25% of the total species) of East Asian elements and subtypes of bryoflora in Mt.Yunmeng, which is an obvious characteristic of east Asia. The geographical elements play an important role in this bryoflora, which reflects a certain floral relation between the Himalayas and Japan. Based on the race spreading centers Sino-Himalayan and Sino-Japanese, East Asian elements can be further divided into two distribution regions. The species include *Frullania schensiana*, *Anoectngium stracheyanum*, *Weissia planifolia*, *Desmatodon gemmascens var.gemmascens*, *Entodon prorepens*, *Bellibarbula kurziana*, *Fissidens bryoides var.ramosissimus*, *Didymodon japonicus*, *Ptychomitrium dentatum*, *Homomallium connexum*, *Heterocladium angustifolium*, *Didymodon rufidulus*, *etc*.

There are 14 species endemic to China, which account for 6.57% (Table 5). Endemic to China element is numerous, which not only proves the higher peculiar character, but also reflects the variability of bryophytes in Mt.Yunmeng. It is significant to study the origin and evolution of bryophytes in North China.

Table 5 Endemic species to China and its distribution of bryophytes

Distribution	*Molendoa sendtneriana var. yunnanica*	*Weissia semipallida*	*Rhamphidium crassicostatum*	*Timmiella diminuta*	*Didymodon rivicolus*	*D.rufidulus*	*D.rigidulus var.ditrichoides*	*Desmatodon gemmascens var. hopeinsis*	*Tortula Yunnannesis*	*Lindbergia sinensis*	*Cratoneuron longicostatum*	*C.taihangense*	*Entodom compressus var. zikaiwiensis*	*E. micropodus*
Yunnan	+	+	+	+	+	+	+		+	+				+
Tibet	+	+	+	+	+	+	+		+	+				+
Sichuan	+	+	+	+	+	+	+			+				
Xinjiang	+				+	+	+			+				
Shanxi	+	+	+	+	+	+	+		+	+				+
Gansu				+	+									
Qinghai							+							
Anhui	+		+	+			+							+
Jiangsu		+		+			+							
Shanghai		+					+			+			+	
Zhejiang		+				+	+							
Hunan		+					+							
Jiangxi	+	+					+							
Hubei						+	+							
Guizhou					+		+							
Fujian			+			+	+		+	+				
Taiwan		+	+			+	+							
Inner Mongolia	+	+		+	+	+	+		+	+	+		+	+
Henan	+		+	+			+							
Shandong		+		+	+					+				
Shanxi	+		+	+		+	+							+
Hebei	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Liaoning			+	+		+	+			+				
Beijing			+	+				+						
Jilin		+			+	+							+	
Heilongjiang		+		+						+			+	

According to the distribution range in China, endemic elements mentioned above can be divided into four types, most of which belong to the endemic species to China, such as *Weissia semipallida*, *Didymodon rigidulus var. ditrichoides*, *Timmiella diminuta*. Their distribution law in China regards southwest region such as Yunnan, Tibet, Sichuan. as the center. These species radiate and spread to the Southeast, North, Northeast, and Northwest China and it appears that the trend reduces gradually. Secondly, there are areal-type species in East, North, and Northeast China, such as *Entodom compressus* var. *zikaiwiensis*. Areal-types of North China include *Desmatodon gemmascens var. hopeinsis* and *Cratoneuron longicostatum*. *Cratoneuron taihangense* belongs to the endemic species in Taihang Mountains.

Mt.Yunmeng is close to the different geological plate intersections between North China Plain and Mt.Yanshan region. Geological condition here is complicated and varies and the local environmental condition is unique.Besides such distinctiveness, it submits to the law of plant migration and development. Meanwhile, it retains the ancient flora characteristics and offers the condition to accommodate and have endemic species.

4 Relationship with other bryoflora in China

According to the concept of Floristic Spectrum which was presented by Mr. MaKeping, this research chooses 14 domestic representative mountain areas including Mt.Yunmeng, utilizes the software of STATISTICA to calculate the contribution ratio of different bryoflora elements to one's own flora, and makes the arborescent analysis chart that can fully show the relationship between 14 bryofloras of the mountain region (Fig. 1).

(1)The relation between Taishan and Laoshan, Baishilazi and Changbai Mountains, the Inner Mongolia and Mt. Xiaowutai is very close and the floral composition is similar. These and Xianrendong, Mt. Kunyu, and the north Hebei Province belong to the northern mountain area types which are cold and dry in winter and warm and rainy in summer. The bryoflora composition of Mt.Gutian and Mt. Jinfu is similar. These mountain regions and Mt. Jiuwan belong to the warm and moist southern type mountain regions. Eastern section of Tianshan Mountains in Xinjiang lies in the Eurasia hinterland. The bryoflora composition leans towards the northern mountain region type. Mt.Yunmeng is a middle type.

(2) Climate and environmental conditions play a decisive role in the bryoflora composition of the mountain regions, but environmental conditions in the specific area affect the bryoflora composition. The latitudes of Mt.Yunmeng and Mt. Kunyu are the same and similar to Laoshan and Taishan and are similar to Xiaowutai on the longitude. Overall, the bryoflora composition of Mt.Yunmeng and these mountain regions are in the warm temperate zone but the bryoflora composition of Mt.Yunmeng demonstrates certain differences. The main reason, besides the geographical position, is the local climatic conditions on Mt.Yunmeng.

The low hill of Mt.Yunmeng is located in the east of Taihang Mountain and some specific region has a deep gully and is serene, with several streams of springs gushing, ceaselessly all year. In the place where the stream flows, a warm and moist little environment was formed. The tropical-subtropical bryophytes species, which adapt to warm and moist environment, can survive here. Thus, the Floristic Spectrum in the middle type, between warm and dry northern mountain area and warm and damp southern mountain area, is formed.

(3) The difference of bryoflora characteristics between Mt. Jiuwan and other 13 regions is remarkable. Mt. Jiuwan in Guangxi is located in the south edge of subtropical zone. It is affected comparatively and largely by a tropical climate. It has an obvious tropical floral relation but the subtropical composition is still very abundant and has the transitional characteristic from subtropical zone to tropical zone.

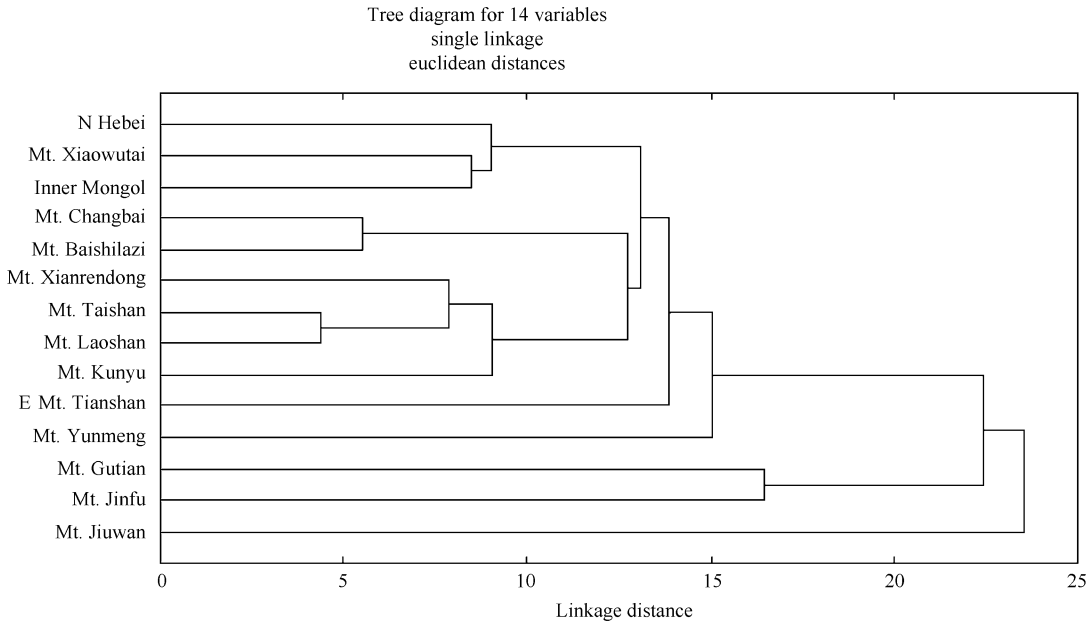

Fig. 1 Bryoflora relationship in Mt.Yunmeng and 13 other mountains in China

(3) The difference of bryoflora characteristics between Mt.Jiuwan and other 13 regions is remarkable. Mt. Jiuwan in Guangxi is located in south edge of subtropical zone. It is affected comparatively and largely by torpics climate. It has obvious tropical floral relation. But the subtropical composition is very abundant still, and appears the transitional characteristic from subtropical zone to tropical zone.

Acknowledgemwnts This project was supported by the Natural Science Foundation of Hebei Province (No. 301107) and the Scientific and Technological Department Brainstorm Plan Project of Hebei Province (No. 20034201).

References

Gao Q, 1994, Flora Bryophytarum Sinicorum, Vol.1, Beijing: Science Press[高谦，中国苔藓志，第一卷，北京：科学出版社，1994]

Gao Q, 1996, Flora Bryophytarum Sinicorum, Vol.2, Beijing: Science Press[高谦，中国苔藓志，第二卷，北京：科学出版社，1996]

Han L.-F., Zhao J.-C. and Tang W.-B., A preiliminary study of *Fissidens* Hedw. (Musci:Fissidentaceae) in Hebei Province, China, Acta Bot .Boreal.-Occident. Sin., 2001, 21(4): 740–748[韩留福，赵建成，唐伟斌，河北省凤尾藓属植物的初步研究，西北植物学报，2001，21(4)：740–748]

Liu L., Vegetation of Hebei, Province, China, Beijing: Science Press, 1996[刘濂，河北植被，北京：科学出版社，1996]

Tang W.-B. and Li R.-G., A bryoflora analysis of Xiaotianchi, Lincheng County, Bull. Bot. Res., 2003, 23(1):18–23[唐伟斌，李瑞国，河北临城小天不池森林区苔藓植物区系，植物研究，2003，23(1)：18–23]

Tang W.-B., Common wild plants in the South Hebei Province, Beijing: Chinese Drama Press, 2003[唐伟斌，河北南部常见野生植物，北京：中国戏剧出版社，2003]

Tang W.-B., Study of the bryophytes of Mt.Yunmeng and neighboring region, Hebei Province, Shjiazhuang: Hebei Normal University, 2001 [唐伟斌，云梦山及邻近区域苔藓植物区系研究，河北省石家庄：河北师范大学，2001]

Wu Z.-Y., Wang H.-S., Chinese Natural Geography-Phytogeography, Beijing: Science Press, 1983[吴征镒，王荷生，河北植被，北京：科学出版社，1996]

Zhao J.-C., A preiliminary study on the bryophytyes of eastern section of Tianshan Mountains, Northwest China, Chenia, 1993, 1(1): 99–112