

FLOGEOGEOGRAPHY OF MIRE PLANTS IN SOUTHERN PART OF QINGHAI-XIZANG PLATEAU AND ITS ADJACENT AREAS

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ABSTRACT: The southern part of the Qinghai-Xizang (Tibet) Plateau and its adjacent area are rich in mire flora. There are 51 families, 101 genera and 220 species. The geographical compositions of this region are very complex, consisting of the following geographical elements: tropic-subtropic elements approximating to 8.33% of the entire flora in the region, tropic-temperate elements 22.71%, temperate elements 43.18%, cosmopolitan elements 9.85%, the Qinghai-Xizang endemic elements 14.39%, north polemountain elements 1.51%. Temperate elements in this region are dominant. The dominant species of mires, *Carex lasiocarpa*, in this region is also found in northeast China, Finland and North America. The origin of mires of this region is earlier than northeast China and Finland. This shows that the southern part of the Qinghai-Xizang Plateau and its adjacent areas may be the centre of the origin and distribution of temperate elements.

KEY WORDS: florogeography, mire plant, the Qinghai-Xizang Plateau

The scope in this article consists of the Xizang (Tibet) Autonomous Region, the western part of Sichuan Province and the Northwestern part of Yunnan Province. The total area amounts to 1.6 million km². This area is used to being called “the roof of the world” and “the third pole of the world”.

I. ECOLOGICAL ENVIRONMENT

This region belongs to semihumid and semiarid climate region in plateau cold-temperate zone. The terrain is high and the climate is severe, unfavorable to extensive development of mire wetlands. According to the preliminary investigation the total area of mire wetlands of this region is about 1.6 million km². The rate of wetland is 1.03 percent. Owing to very complex and varied natural conditions, the distribution of wetland has regional difference, mainly in the region of the Nujiang River head, the upper reaches of the Yarlung Zangbo River and the Zoigê

Plateau in the northeast part of Hengduan Mountains region.

The region of the Nujiang River head is located at the plateau with an elevation of 4500 m in the north of Xizang. Its climatic characteristic are: long winter and no summer, very low temperature from -1°C to -3°C (Table 1). The average January temperature is from -13°C to -15°C , July from 6°C to 10°C . Frost less season is less than one month, the frozen season is seven to eight month long, the frozen layer in peat doesn't melt throughout the year. The annual precipitation is 400 mm to 700 mm, the average annual relative humidity is 50 percent. There are many floodlands and wetlands of lake shore in this region.

The valley of the Yarlung Zangbo River is located in the south part of Xizang. The Zoigê Plateau is located in the northeast part of the Qinghai Xizang Plateau, a relative settlement area in the north part of the Hengduan Mountains, being an enclosed plateau like a mound, is one of the famous wetland distributing area in our country.

Table 1 The characters of climate in different mire regions

Region	Position	Elevation (m)	Mean temperature ($^{\circ}\text{C}$)	Mean precipitation (mm)	Evaporation (mm)
Nujiang River	$31^{\circ}10' - 33^{\circ}25' \text{N}$ $98^{\circ}50' - 99^{\circ}45' \text{E}$	4500	-1 - -3	400- 700	1300- 1400
Zoigê Plateau	$32^{\circ}20' - 34^{\circ}10' \text{N}$ $102^{\circ}15' - 103^{\circ}50' \text{E}$	3400	0.6- 1.2	560- 860	1260- 1290
Sanjiang Plain	$45^{\circ}01' - 48^{\circ}27' \text{N}$ $130^{\circ}13' - 135^{\circ}05' \text{E}$	40- 80	1.6- 3.9	456- 617	536- 652
Lapland Hyttälä	$59^{\circ}31' - 70^{\circ}05' \text{N}$ $19^{\circ}07' - 31^{\circ}35' \text{E}$	200- 300	- 0.4- 5	484- 740	400

II. THE FLORISTIC GEOGRAPHICAL COMPONENTS

1. Floristic Composition and Distribution

According to the initial statistics, there are 220 species of mire plants in this region, belonging to 51 families, 101 genera. Among them, the plant of Cyperaceae family is the most (7 genera, 47 species, being 21.36 percent of the total). The next is the Gramineae family (9 genera, 19 species, 8.64 percent), Ranunculaceae family (8 genera, 17 species, 7.73 percent), Compositae family (6 genera, 12 species, 5.45 percent), Polygonaceae family (3 genera, 11 species, 5 percent), Juncaceae family (1 genus, 10 species, 4.54 percent), other families are all less than 10 species.

In this region the natural conditions are complex, the plants growing environment is var-

ied, showing obviously vertical zone distribution. Such vegetation types as the tropics, the subtropics, the temperate and high mountainous frigid zone are distributed from the foot to the top of a mountain. This region is one of the most rich floristic area. The wetland flora is more complicated and extensively related. The florogeographical components are determined according to the modern plant species distribution. Two hundred and twenty species of wetland plants are divided into eight types: the tropic-subtropic, subtropic, tropic-temperate, temperate, cosmopolitan, Qinghai-Xizang plateau special component and the Arctic high mountain component. (Table 2)

(1) The tropic-subtropic distribution: In Xizang and the Hengduan Mountains area, wetland plants belonging to this type have seven genera, being 5.3 percent of the total genera number. They are mainly distributed in valley zone in low latitude, for example, *Ottelia ex-puirolii*, *Phragmites karka*, *Eichhornia crassipes* and so on.

(2) The subtropic distribution: In this region there are 4 genera of wetland plants, belonging to this type, being 3.03 percent. They are *Botrychium ternatum*, *Juncus setchuensis*, *Iris chrysographes* and so on, mainly distributed in the south part with an elevation of 1000 m.

(3) The tropic-temperate distribution: There are nine genera, being 6.81 percent of the total genera. They are mainly distributed in the mountainous zone with an elevation of 1000–2000 m. Some species are distributed in the zone with an elevation of 3000 m, being warm-wet and mild-wet type of wetland. The horizontal distribution appears in temperate zone. For example, *Euryale ferox*, *Alisma orientale*, *Sagittaria trifolia* and *Zizania caduciflora* appear in China, East Asia, Europe and North America.

(4) The subtropic-temperate distribution: There are 21 genera, being 15.9 percent. These wetland plants are mainly distributed in mountains with an elevation of 2000–3000 m. Their horizontal distribution can be found in East Asia, Siberia and North Europe. These plants, belong to warm-wet type of wetland, for example *Polygonum viviparum*, *Menyanthes trifolia*, *Lathrum salicaria*, *Juncus alatus*, *Allium macranthum* and so on.

(5) The temperate distribution: In this type, there are 57 genera of wetland plants being 43.18 percent. It is the main floristic component of wetland plants in this region. Its distributing height is elevation of 2000–4500 m, being warm-wet and cold-wet type of wetland, which corresponds to temperate-subfrigid zone. These floristic components appear in the northeast part of China, Korea, Japan, Siberian, North Europe, even North America. The major representative plants are *Sphagnum squarrosum*, *Ptilium crista-castrensis*, *Equisetum arvense*, *Caltha Palustris*, *Comarum palustre*, *Typha latifolia*, *Carex lasiocarpa*, *Eriophorum latifolium*, *Calla palustris* and so on.

(6) The cosmopolitan distribution: There are 13 genera in this region, being 9.85 percent. They are distributed nearly all over the continents. In this region this type is found in every climatic zone except frigid zone, for example *Pleurozium schrederi*, *Ceratophyllum demersum*, *Utricularia aurea*, *Triglochin palustre*, *Scirpus distigmaticus*, *Juncus effusus* and so on.

Table 2 Florogeographical elements of species of mire plants in the southern part of the Qinghai-Xizang Plateau and its adjacent areas

Floro-geographical elements	Species
Tropic subtropic	<i>Parnassia wightiana</i> , <i>Ixeris gracilis</i> , <i>Ottelia acuminata</i> , <i>O. alismoides</i> , <i>O. espuirolii</i> , <i>Leersia hexandra</i> , <i>Phragmites Karika</i> , <i>Carex nubigena</i> , <i>Eichhornia crassipes</i>
Subtropic	<i>Botrychium ternatum</i> , <i>Alternanthera philoxeroides</i> , <i>Juncus sikkiensis</i> var. <i>pseudocastaneus</i> , <i>J. setchuensis</i> , <i>J. sphaelatus</i> , <i>Iris chrysocephala</i>
Tropic temperate	<i>Euryale ferox</i> , <i>Nymphaea tetragona</i> , <i>Glaux maritima</i> , <i>Hemipeta lytata</i> , <i>Potamogeton malianus</i> , <i>Alisma orientale</i> , <i>Sagittaria trifolia</i> , <i>Zizania caduciflora</i> , <i>Scirpus triangulatus</i> , <i>Acorus calamus</i>
Suptropic temperate	<i>Polygonum amphibium</i> , <i>P. caespitosum</i> , <i>P. hydropiper</i> , <i>P. sphaerostachyum</i> , <i>P. viviparum</i> , <i>P. sibiricum</i> , <i>Stellaria uda</i> , <i>Callitriche palustris</i> , <i>Anemone ovalifolia</i> , <i>A. trullifolia</i> , <i>Tuollius ranunculoides</i> , <i>Epilobium hirsutum</i> , <i>Oenothera sinense</i> , <i>Gentiana scabra</i> , <i>Halenia fischerii</i> , <i>Sparganium glomeratum</i> , <i>Najas marina</i> , <i>N. minor</i> , <i>Bedmannia syzigachne</i> , <i>Glyceria leptolepis</i> , <i>Phalaris arundinacea</i> , <i>Carex pleistogyna</i> , <i>Scirpus yagara</i> , <i>Juncus alatus</i> , <i>J. amplisolius</i> , <i>J. luicanthus</i> , <i>Aletrispauciflora</i> , <i>A. spicata</i> , <i>Allium macranthum</i>
Temperate	<i>Sphagnum starrosomum</i> , <i>S. qeres</i> , <i>Drepanocladus uncinatus</i> , <i>Ptilium cuista-castensis</i> , <i>Hylocomium splendens</i> , <i>Equisetum arvense</i> , <i>E. heleocharis</i> , <i>E. palustre</i> , <i>Salix purpurea</i> , <i>Rumex acetosa</i> , <i>Bartradium trichophyllum</i> , <i>Caltha palustris</i> , <i>Halerpestes cymbalaria</i> , <i>H. sarmentosa</i> , <i>H. tricuspis</i> , <i>Oxygraphis delavayi</i> , <i>O. glacialis</i> , <i>Ranunculus brotherusii</i> var. <i>tanguticus</i> , <i>R. chinensis</i> , <i>R. palchellus</i> , <i>R. nephelogenes</i> , <i>Thalictrum alpinum</i> , <i>Comarum palustre</i> , <i>Dasiophora fruticosa</i> , <i>Pentstemon anserina</i> , <i>Sanguisorba parviflora</i> , <i>Vicia cracca</i> , <i>Caragana erinacia</i> , <i>Chamaenerion angustifolium</i> , <i>Epilobium palustre</i> , <i>Trapa maximowiczii</i> , <i>Myriophyllum spicatum</i> , <i>Hippuris vulgaris</i> , <i>Cicuta virosa</i> , <i>Rhododendron thymifolium</i> , <i>Glaux maritima</i> , <i>Plantago depressa</i> , <i>Gentiana leucomelæna</i> , <i>Ajuga campylanthoides</i> , <i>Pedicularis longiflora</i> , <i>Veronica ananthis-aquatica</i> , <i>Veronica serpyllifolia</i> , <i>Utricularia vulgaris</i> , <i>Aster asteroides</i> , <i>A. flaccidus</i> , <i>Bidens tripartita</i> , <i>Typha latifolia</i> , <i>Sparganium stoloniferum</i> , <i>Potamogeton natans</i> , <i>P. nodosus</i> , <i>P. pectinatus</i> , <i>Catabrosa aquatica</i> , <i>Deschampsia caespitosa</i> , <i>Echinochloa colonum</i> , <i>Glyceria aquatica</i> , <i>Poa calliopsis</i> , <i>P. pratensis</i> , <i>Polypogon monspeliensis</i> , <i>Blysmus compressus</i> , <i>B. sinocompressus</i> , <i>B. rufus</i> , <i>Carex atrofusca</i> , <i>C. oxyleuca</i> , <i>C. daniana</i> , <i>C. forestii</i> , <i>C. enervis</i> , <i>C. lasiocarpa</i> , <i>C. melananth</i> , <i>C. meyeriana</i> , <i>C. moorecroftii</i> , <i>C. reptabunda</i> , <i>C. tibetica</i> , <i>C. uncinoides</i> , <i>C. scabrirostris</i> , <i>Eleocharis valleculosa</i> , <i>E. liouana</i> , <i>E. ovata</i> , <i>E. pauciflora</i> , <i>Eriophorum latifolium</i> , <i>Kobresia parva</i> , <i>K. persica</i> , <i>K. humilis</i> , <i>K. microglochis</i> , <i>K. royleana</i> , <i>Scirpus prmilus</i> , <i>Calla palustris</i> , <i>Juncus concinnus</i> , <i>J. lampocarpus</i> , <i>J. thomsonii</i> , <i>Allium beesianum</i> , <i>A. condensatum</i> , <i>Iris delavayi</i> , <i>Orchis salina</i> , <i>Spiranthes lancea</i> , <i>Gymnadenia conopsea</i>
Cosmopolitan	<i>Leptodictyum riparium</i> , <i>pleurozium Schrederi</i> , <i>Polytrichum juniperinum</i> , <i>Ceratophyllum demersum</i> , <i>Utricularia aurea</i> , <i>Typha angustifolia</i> , <i>Potamogeton crispus</i> , <i>P. perfoliatus</i> , <i>P. pusillus</i> , <i>Triglochin maritimum</i> , <i>T. palustre</i> , <i>Hydrilla verticillata</i> , <i>Phragmites australis</i> , <i>Pycreus globosus</i> , <i>Scirpus distigmaticus</i> , <i>S. juncooides</i> , <i>S. setaceus</i> , <i>S. validus</i> , <i>Juncus effusus</i>
Endemic	<i>Polygonum sibiricum</i> var. <i>thomsonii</i> , <i>Cerastium thomsoni</i> , <i>Caltha scoposa</i> , <i>Saxifraga densifoliata</i> var. <i>nedongensis</i> , <i>Sanguisorba filiformis</i> , <i>Chamaesium paradoxum</i> , <i>Rhododendron anthopogn</i> , <i>R. chloranthum</i> , <i>R. tapetiforme</i> , <i>R. thymifolium</i> , <i>Primula tibetica</i> , <i>Gentiana aristata</i> , <i>G. clarkeri</i> , <i>G. phyllocalex</i> , <i>Lamiophlomis rotata</i> , <i>Lancea tibetica</i> , <i>Pedicularis densispica</i> , <i>P. longiflora</i> var. <i>tubiformis</i> , <i>Nardostachys chinensis</i> , <i>Cremanthodium campanulatum</i> , <i>C. decaisnei</i> , <i>C. lineare</i> , <i>C. plantagineum</i> , <i>C. pleurocaule</i> , <i>Ligularia virgaurea</i> , <i>Potamogeton perfoliatus</i> , <i>P. pusillus</i> , <i>Poa calliopsis</i> , <i>P. lithophila</i> , <i>P. pachyantha</i> , <i>Sinarundinaria chungii</i> , <i>Carex angustifructus</i> , <i>C. muliensis</i> , <i>C. satakeana</i> , <i>C. scabrirostris</i> , <i>Kobresia cercostachys</i> , <i>K. cuneata</i> , <i>K. humilis</i> , <i>K. littledalei</i> , <i>K. prattii</i> , <i>K. setchwanensis</i> , <i>K. tibetica</i> , <i>K. uncinoides</i>
Arctic mountain	<i>Koenigia islandica</i> , <i>Kobresia microglochis</i>

(7) The endemic species of the Qinghai-Xizang Plateau: There are 19 genera in this region, being 14.39 percent. They are mainly distributed in the Qinghai-Xizang Plateau, and can be found in every climatic zones in the plateau, but mainly in temperate-subfrigid zone. These wetland plants, distributing on different altitudes, are formed through the natural selection and specialization on the spot during the time of the plateau rise, for example, *Caltha scoposa*, *Chamaesium paradosum*, *Primula tibetica*, *Lancea tubetica*, *Carex muliensis*, *Kobresia littledalei*, *K. tibetica* and so on.

(8) Arctic-high mountain distribution: There are only 2 genera in this region, occupying 1.51 percent.

2. Temperate Component Being Major

It can be seen from Table 2, that in Xizang and the Hengduan Mountains area, floristic composition contains richer temperate components, which mean the plants distributing in temperate zone of Eurasia continent and North America. In this area, the genus and species number are all in the first place. The wetland plants in this area are mainly temperate components, indicating the relation and unity of wetland plants between this area and north temperate zone in origin. This characteristic is determined by the reason of geological history and the special geographical environment of this area.

3. Complicated Floristic Components and Many Endemic Plants

This region is one of the areas where there are the most complicated floristic components and most endemic plants in our country. Among the special geographical conditions in the Hengduan Mountains, the north and south valley is convenient to exchange of north and south plants, moreover, this region hasn't been influenced by the severe climate of ice-era since the Tertiary period, which makes varieties of distributing types of family and genus which are ancient, primeval or more progressive. Therefore this region is called "the refuge of plants". Though the wetland plants are part of unazonal vegetation, their floristic components are complicated and various. The wetland floristic components of this region have such distributing types as the tropics, subtropics, temperate, Arctic high mountains, cosmopolitan and endemic species (Table 2), indicating that the wetland floristic components are complicated.

There are many endemic plants in this region, among them, the Qinghai-Xizang Plateau endemic genera and species make up one seventh of the total genus and species number. Major wetland plants, such as *Kobresia littledalei*, *K. tibetica*, *K. setchwanensis*, *Carex muliensis*, *Gemanthodium plantagineum* and *Pedicularis longiflora* var. *tubiformis*, *Sanguisorba filiformis*, and *Caltha scoposa* are all major species distributing in the wetland and mire with an elevation of 3000–5000 m. During the plateau rise, plants experienced long-term rise and drop, and formed on the spot through natural selection and specialization. Among them *Kobre-*

sia tibetica and *K. littledalei*, as major species in the zoigê Plateau and the Qinghai-Xizang Plateau respectively formed the unique mire landscape of the Qinghai-Xizang Plateau.

III. RELATION WITH MIRE FLOROGEOGRAPHY OF OTHER REGIONS

The comparative research on wetland between the studied area and northeast China and Lapland-Hyytiäinen in Finland has been done. The northeast China is located at 38°41′ – 53°40′ N, including the Da and Xiao Hinggan Mountains, the Changbai Mountains and its piedmont tableland, the Sanjiang Plain, the Songliao Plain and so on. As to the vegetation and natural landscape zone, from north to south, there are frigid coniferous forest, temperate coniferous and broadleaf mixing forest and warm-temperate deciduous broadleaf forest. It is one of the mire areas having the biggest area and the most extensive distribution in our country. Finland is located at 59°31′ – 70°05′ N, including wavy plain hill and low mountains, belonging to the Taiga forest zone in the natural landscape. Its mire area is one third of the total country area. Finland is the country with the highest mire covering rate in the world. The share rate of family, genus and species among the studied area and other two places mentioned above is in the order of “decreasing power” (Table 3), the share rate between the studied area and northeastern

Table 3 Comparison of the mire plants flora between the southern Qinghai-Xizang Plateau and its adjacent areas with other regions

Region	Family number	Same family	Same coeffi(%)	Genus number	Same genus	Same coeffi. (%)	Species number	Same species	Same coeffi(%)
Xizang Hengduan Mts.	51			101			220		
Northeast China	79	38	88.3	194	77	77.8	224	57	27.9
Lapland Hyytiäinen	64	35	81.4	106	39	39.4	223	21	10.3

part of China is high, that between this area and Finland is low. Seven dominant species in Xizang and the Hengduan Mountains (Fig. 1) appear in the northeast part of China(Fig. 2) and five appearing in Finland (Fig. 3). The spare rate between study area and the northeast part of China is higher than that between study area and Finland. The above comparison indicates that the mire plants of Xizang and the Hengduan Mountains, including dominant species and constructing species, can be found in the same floristic components in the northeast part of China and Finland. Meanwhile, the share rate is different between the northeast part of China and Finland. This difference can be explained with the geographical distance and the climatic change.

This studied region located in the subtropics (basic zone), is 3000km apart from the northeast



Fig. 1 The dominant species of mire in southern Qinghai-Xizang Plateau and its adjacent areas

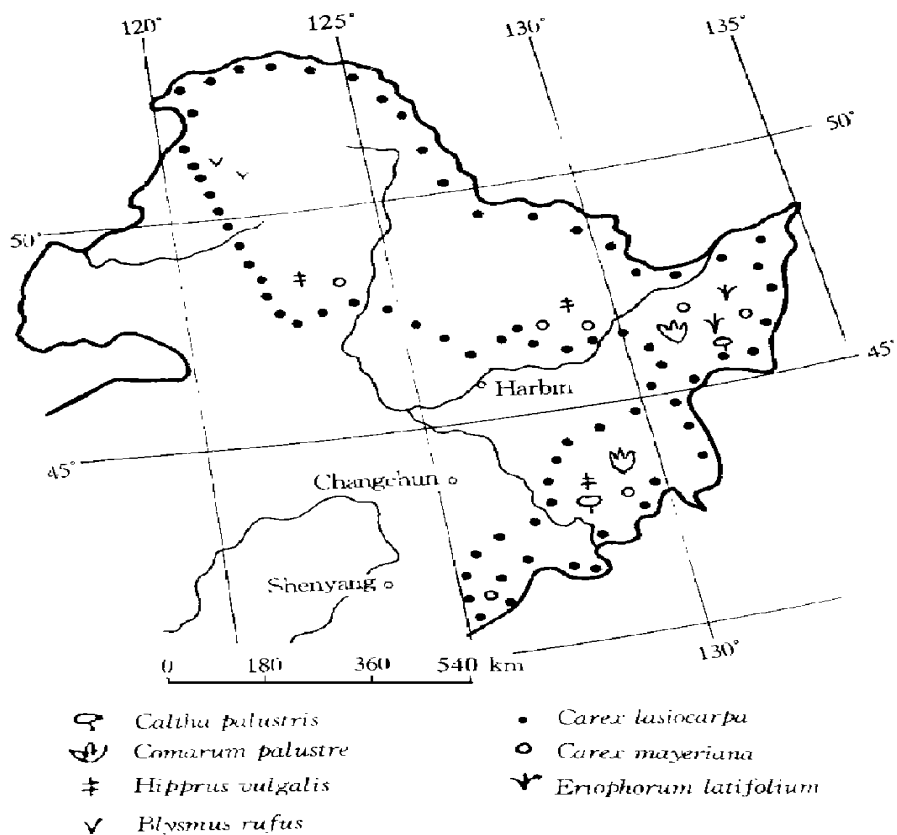


Fig. 2 The dominant species of mires of southern Qinghai-Xizang Plateau and its adjacent areas collected from Northeast China

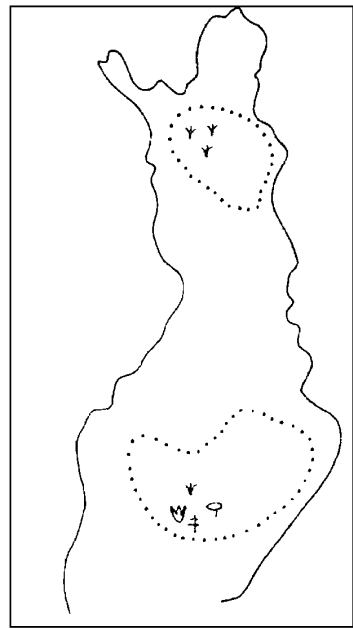
part of China and 7000 km apart from Finland, cross warm-temperate zone and temperate zone respectively, the climate is different, too (Table 1). Therefore, the mire floristic components of this region, the northeast part of China and Finland have the variation and division.

Taking *Carex lasiocarpa* community as an example, there is a same mire type in this area, the northeast part of China and Finland both have the dominant species, *Carex lasiocarpa*, distributing in the Zoigê Plateau with an elevation of 3000 m, the Northeast Plain of China with an elevation of 60 m and Hyytä of Finland with an elevation of 50 m respectively, but the accompanying species is not completely same. The major accompanying plants of *Carex lasiocarpa* mire in the Zoigê Plateau are *Carex muliensis*, *Halerpestes sarmentosa*, *Caltha palustre*, *Menyanthes trifolia*, *Utricularis vulgaris* and so on, *Iris laevigata*, *Glyceria poiculosa*, *Sphagnum oligoporum* and so on in the Northeast Plain of China. In Hyytä of Finland the accompanying plants are *C. capitata*, *C. dioica*, *C. flava*, *Carex livida*, *Molinia caerulea*, *Equisetum palustre*, *Soussuria alpina*, *Eriophorum latifolium*, *Geranium sylvaticum* and so on. Among the accompanying species, the share number of the northeast part of China is higher than that of Finland. The above comparison demonstrates again that the same mire plant, even the similar mire vegetation type, can appear in different zones. The mire vegetation has a zonal characteristic, but the mire vegetation of different zones has difference in floristic components, the mire vegetation has zonal feature.

The information shows that the mire of the Zoigê Plateau formed in 9500 a B. P. (some information is about 12 000 a B. P.), the mire of the northeast part of China formed between 9500– 5000 a B. P., and Finland mire formed after the Holocene, which was covered by ice-cover 10000 years ago. Therefore, according to the geological history and modern mire floristic components analysis, this region, especially the Hengduan Mountains, is possibly the original place and distributing center of “north temperate zone component”.

IV. THE CONCLUSION

The florogeography of mire plants in Xizang and the Hengduan Mountains area are domi-



- ♥ *Comarum palustre*
- ‡ *Hippuris vulgaris*
- *Carex lasiocarpa*
- ∨ *Eriophorum latifolium*

Fig. 3 The dominant species of mire of southern Qinghai-Xizang Plateau and its adjacent areas collected from Finland

nated by temperate components. The florogeographical compositions are very complex, with many special plants.

The region is far away from the mires in northeast China and Finland. The share rates of common families, genera and species of mire plants indicate that different zones have same florogeographical compositions of mire plants, and also similar vegetation types. The distribution of mires go across natural zones. In the meantime, the difference of florogeographical compositions also exists. Each mire possesses local species, which reflects that the vegetation of mire is also influenced by the zonal divisional regularity.

The florogeography of mire plants is dominated absolutely by temperate elements. Typical temperate elements and dominant species are: *Carex lasiocarpa* distributing intermittently in northeast China, Finland and north America. Mires in the studied region were formed a little earlier than other regions. From the analysis of florogeography, distribution and geological history of mire plants, the Hengduan Mountains are may be the origin and divisional centre of the north temperate elements.

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