

BRYOPHYTE FLORA OF HELAN MOUNTAIN IN CHINA

БРИОФЛОРА ГОРЫ ХЕЛАН, КИТАЙ

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ДОНГ-ПИНГ ЖЧАО, ХУ-ЛИАНГ БАЙ, СИАНЬ-ДАО ВАНГ, ХУ-МИН ЖИНГ

Abstract

The bryophyte flora of Helan Mountain (China, Inner Mongolia Province) is studied and analyzed. It includes 201 taxa (10 Hepaticae and 191 Musci, including subspecies and varieties) from 77 genera and 30 families. Most of species have a broad North Temperate distribution. With the increase of altitudes and the variation of habitats, the distribution of bryophytes on Helan Mt. shows a clear vertical zonation. Based on our observation, we have classified the zonation of bryophytes in Helan Mountain into 5 altitudinal belts.

Резюме

Изучена и проанализирована бриофлора горы Хелан (Китай, провинция Внутренняя Монголия). Она включает 201 таксон (10 печеночников и 191 мох, в том числе несколько подвидов и разновидностей) из 77 родов и 30 семейств. Большинство видов имеет широкое распространение в умеренной зоне Северного полушария. По мере повышения абсолютной высоты на горе Хелан возрастает разнообразие местообитаний, формирующее выраженную вертикальную поясность; по мохообразным можно выделить до пяти поясов.

INTRODUCTION

Helan Mountain is situated at the provincial border between Inner Mongolia and Ningxia of China. The study of bryophytes of Helan Mountain started in the 60s, from 1962 to 1965. Tong (1963) made the first bryophytes collections in the western slope of Helan Mountain and compiled a moss list based on the specimens. Since then, other bryologists, such as, Bai, Gao, and Lu, have collected bryophytes in western and eastern slope of the mountain. Lu (1998) identified 29 taxa of frequent bryophytes in the eastern slope. Bai carried out long-term bryological works in this area in 1987-1998 and, together with other authors, reported 2 genera and 14 species from Helan Mountain as new to China, by then, 164 mosses were known from the western slopes. In 2000, Bai and Tan described a new species *Tayloria rudimenta* X.-L. Bai & B.C. Tan (Musci, Splachnaceae) collected in Suyukou.

Still, as a whole, the reports of bryophytes from Helan Mountain have been rather scattered and incomplete, due especially to a lack of specimens collected from and the systematic study of the bry-

oflora on the eastern slope. Thus, the development of a list of bryophytes found in this area is particularly needed. In order to complete the study of bryophyte flora and species diversity, we conducted a field survey of the bryophyte diversity from the eastern slope of Helan Mountain between 2003 and 2004. The collection localities are shown in Fig. 1

STUDY AREA

Helan Mountain is located at 33°07'–39°30' N, 105°20'–106°45' E. The highest peak is known as "Obogda", up to 3556 m above sea level. Helan Mountain occupies an area of 6000 sq. km, and extends about 250 km from north to south and about 20-40 km east to west. Its general altitude ranges from 2000 to 3000 m and the relative elevations are from 1500-2000 m (Shi et al., 1989).

CLIMATE

The climate of the study area is typically continental one, with four distinct seasons. Although the area is dry with little precipitation, the acute exchanges of cold and warm air masses at high elevations produce a mountain climate in the study area. Based on the data provided by the meteorological stations, Tian (1996) reported that the av-

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Fig. 1. The collecting localities of bryophytes in Helan Mountain: 1–Rujigou (RJ), 2–Beisi (BS), 3–Halawugou (HL), 4–Shaguozhou (SG), 5–Suyukou (SY), 6–Nansi (NS), 7–Huangqikou (HQ), 8–Xiaokouzi (XK).

GEOLOGY AND SOILS

The study territory has a complicated geological structure. The most widespread bedrocks are limestones, gneisses, sandstones and shales and quartzites (Di, 1986). From our own field observation, channels and banks of streams are often not rocky. However, boulders occur everywhere on slopes of the mountains, and large rocky outcrops are located mainly in the river valleys, on mountain peaks and on abruptly vertical cliffs.

The types of soil in the study area are the mountain meadow soil, mountain sierozem soil and mountain grey cinnamon soil (Xie & al., 1999).

STUDIES OF VERTICAL DIFFERENTIATION OF BRYOPHYTE DISTRIBUTION

Except on the eastern slope, Helan Mountain is surrounded by the desert at the western, northern and southern side. The desert landscape is seen at the forefront, reaching about 1500 m alt. In this habitat, the surface is bestrewed with rock debris and a lot of small plants occur in rock crevices or on coarse rocky efflorescence. The desert vegetation is mainly composed of gobi and tethyan floral elements, such as *Reaumuria soongorica*, *Salsola passerina*, *Stipa breviflora*, *Stipa glareosa*, etc., according to a report prepared by the Inner Mongolia-Ningxia complex expert team of the Chinese Academy of Sciences (1985).

Only a few of bryophytes have been found on soil in the flat desert, however, a small low rocky outcrop within a flat area will allow the growth of some mosses. We were able to find 31 species in such a habitat. The most common mosses in these xeric habitats are: *Didymodon vinealis*, *Hypnum cupressiforme*, *Bryum argenteum*, *Syntrichia sinensis*, *Crossidium squamiferum*, *Aloina rigida* and *Grimmia laevigata*.

Since Helan Mountain is the highest range in Inner Mongolia with a relatively high elevations of about 2100 m (Tian, 1996), the local vegetation shows clearly vertical zonation that are quite similar between the eastern slopes and the western slopes (Tian, 1996; Liang et al., 2004).

erage local annual temperature decreased from +8.5°C at the base of mountain to -0.8°C in alpine zone, and the temperature dropped 0.62° at every increase of 100 m of the elevation. The precipitation, reportedly, occurred mainly between July and September and the mean annual precipitation is between 183.3 mm (Shizuishan) and 202.8 mm (Yinchuan); vertical differences are also seen: the amount of precipitation is increasing by 13.2 mm at every increase of 100 m.

VEGETATION

Helan Mountain forms an important boundary of climatic pattern and vegetation in north-west China: the eastern slope of Helan Mountain belongs to the steppe climate with steppe vegetation, while the western slopes are characterized by having a desert climate, and a desert vegetation. There is also a strong differentiation of vegetation on sunny and shady slopes. In the steppe belt on low hillsides, steppe communities inhabit the sunny slopes but mesophilous shrubs occur on shaded slopes (Liang & al., 2004). In the coniferous forest belt at the mid-elevation zone, the community of *Picea crassifolia* are distributed widely on shaded slopes, but open forests of *Ulmus glaucescens* and *Juniperus rigida*, and other mesophilous shrubs occur on the sunny slopes. At 3000m and upwards, the vegetations of sunny and shady slopes become similar.

The distribution of bryophytes is closely correlated with the distribution of tracheophytes in each of the corresponding zones.

We investigated the changes of bryophyte zonation in a, vegetatively speaking, typical area starting from a valley near "Obogda" to the alpine zone at Suyukou. Based on the field data of elevation, local climate, relative humidity, and the characterization of the major communities of tracheophytes and bryophytes, we have formulated the following five vertical zonations of bryophyte distribution on Helan Mountain.

(1) At lower elevations, below 1900 m, the climate is relative warm and arid, and soil type is mainly mountain sierozem soil. The Mongolia steppe communities inhabit the sunny slope, but mesophilous shrubs occur on shaded slopes. The more widespread species here are the xeric mosses, like *Didymodon vinealis*, *Syntrichia sinensis*, *Grimmia laevigata*, *Aloina rigida*, etc.

(2) Between 1900-2200 m, the temperature dropped a little. Soil type is the common mountain grey cinnamon soil, and the soil layer is rather thick. In this zone, stands of *Pinus tabulaeformis*, with the relative humidity under the forest canopy varying from 65% to 70%, cover most parts of the area forming the principal plant resource. The bryophytes are in an inferior position in local niche competition; still, altogether, we collected 55 species in this belt. The mosses were found mostly growing on soil and rocks in ravines, slopes, canyons and on brook banks. They are: *Abietinella abietina*, *Amblystegium serpens*, *Brachythecium albicans*, *Bryoerythrophyllum brachystegium*, *B. gymnostomum*, *B. recurvirostre*, *Didymodon rigidulus* var. *flexicuspis*, *D. rigidulus* var. *icmadophilus*, *D. tophaceus*, *D. vinealis*, *Encalypta alpina*, *Fissidens bryoides*, *Gymnostomum calcareum*, *Hymenostylium recurvirostrum*, *Hypnum cupressiforme*, *H. hamulosum*, *H. pallescens*, *H. vaucheri*, *Timmia bavarica*, *Timmia anomala*, etc. The dominant moss taxa of the colonizing synusia are *Hypnum*, *Brachythecium* and *Didymodon*.

(3) From elevations 2200 m to 2350 m, mixed forests consisting of *Picea crassifolia* and *Populus davidiana* dominate the zone. The soil type is mountain leach grey cinnamon soil, and the relative humidity is 75%–81%. This elevational zone

is relatively rich in bryophytes. Here we recorded 92 species. The local moss flora is composed of many petrophytic mosses: *Abietinella abietina*, *Brachythecium albicans*, *B. kuroishicum*, *B. salebrosum*, *Cirriphyllum piliferum*, *Ditrichum flexicaule*, *Hypnum cupressiforme*, *Timmia bavarica*, *Trachycystis ussuriensis*. The dominant taxa of the colonizing synusia are *Abietinella*, *Brachythecium*, *Timmia*, *Cirriphyllum*, *Trachycystis* and *Ditrichum*.

(4) The elevation range, 2360-2900 m, supports a constructive plant communities — *Picea crassifolia* forest. The type of soil covering this belt is the mountain leach grey cinnamon soil. The forest floor is shaded and damp with a relative humidity of 78%–87%. Here the vascular plants are rather sparse while mosses grow well. In many places, the forest floor is entirely covered with bryophytes, with coverage reaching 82.52%. Altogether we collected 99 species of bryophytes, with the mesophytes and petrophytes in dominant position. The mosses composed of about 11 species: *Abietinella abietina*, *Distichium capillaceum*, *Ditrichum flexicaule*, *Hypnum bambergeri*, *H. cupressiforme*, *H. fertile*, *H. pallescens*, *Mnium heterophyllum*, *M. laevinerve*, *M. thomsonii* and *Pseudostereodon procerrimus*. The dominant species of colonizing synusia are *Abietinella*, *Distichium*, *Ditrichum*, *Hypnum* and *Pseudostereodon*.

(5) From 2900 m to the summit is the uppermost zone of the mountain where the temperature is cold and the precipitation is abundant. The soil type is of mountain meadow soil. The relative humidity varies greatly between 45% and 75%. The habitat is too hostile to allow for the growth of trees. Several alpine shrubs known from the alpine meadow zone are represented here, such as *Caragana jubata*, *Salix cupularis* var. *lasiogyne* and some *Artemisia* (Xie et al., 1999). Here we found 64 species of mosses and the most common communities belong to the petrophytes and geophytes. Interestingly, the mosses often occur here randomly in small, isolated spots. The dominant taxa of moss communities are *Hypnum*, *Didymodon* and *Grimmia*. The most common species are *Didymodon rufidulus*, *D. giganteus*, *Grimmia subanodon*, *Jaffueliobryum wrightii* and *Voitia nivalis*.

The species composition and zonal distribu-

tion of mosses on the eastern slope is similar to that seen on the western slope. For examples, at foothill, one sees the same *Pterygoneurum subsessile*, *Aloina rigida*, *Didymodon vinealis*, etc. In the *Pinus tabulaeformis* forest, the presence of *Hypnum cupressiforme*, *H. vaucheri*, *Brachythecium albicans*. In *Picea crassifolia* forest are common as *Pseudostereodon procerrimus*, *Abietinella abietina*, *Ditrichum flexicaule*, *Distichium capillaceum*, etc, are common. The main reason for this similarity is that both eastern slope and western slope have the same prevailing climate and vegetational zones, for instance. Both the two slopes possess abundant in forests dominated by *Pinus tabulaeformis*, *Picea crassifolia*, and mixed forest, as well as alpine meadows.

ANALYSIS OF THE CHARACTERISTICS OF SPECIES COMPOSITION

In total, the bryophyte flora of the area includes 201 taxa (including subspecies and varieties) belonging to 77 genera and 30 families, including 10 species of Hepaticae and 191 species of Musci. The number is rather high not only in families and genera, but also in species. Obviously, the main diversity is confined to the forests or to areas sheltered by mountain, like deep canyons and inner portions of mountain massif.

Helan Mountain is located at inland of China and the climate is relatively cold and xeric. Due to the xeric climate, the species of hepatics are generally rare. The xeric environment of the study area can be characterized by its species composition of the flora:

(1) In the present checklist of bryophytes of Helan Mountain, 66 species of Pottiaceae are listed. The family is abundant both in the number of genera and species of xeric mosses, such as *Aloina brevirostris*, *Tortula atrovirens*, *Syntrichia pagorum*, *Crossidium squamiferum*, *Pterygoneurum subsessile*, *Microbryum starckeanum*. Members of Pottiaceae occur in the woodland, in forests in open areas, along border of forests and in alpine meadows, on rock outcrops and soils.

Grimmiaceae include 12 species. Most species of this family are cosmopolitan and also have broad distribution in the subtropical and temperate zones. Helan Mountain is located in North temperate zone and the climate is relatively xeric what it is very suitable for the growth of Grimmiaceae.

For example, *Grimmia ovalis* and *Grimmia laevigata* have wide distribution in the study area; in Helan Mountain *Indusiella thianschanica* and *Jafeliobryum wrightii* which were known from Tibet and Xinjiang are found in abundance. In addition, we also collected *Coscinodon cribrosus* that was reported previously only from Taiwan and Qinling Mt. in mainland China.

(2) Bryaceae is quite rich in species diversity: 19 species were identified; members of this family, as well as it is represented worldwide, have extensive ecological amplitude and are adapted to various habitats. In Helan Mountain most species are found in xeric environment, springy or swampy area, and forest floor.

A total of 17 species of the family Hypnaceae were collected in this area, and the most common species are also the Cosmopolitan, North temperate and East Asia elements. Members of this family are among the dominant components of moss cover in forests, e.g. *Eurohypnum leptothalum*, *Hypnum bambergeri*, *H. cupressiforme*, *H. vaucheri*, *Podperaea krylovii*, *Pseudostereodon procerrimus*.

In the study area, the family Mniaceae consists of 13 species. The family is known from many countries around the world, and its general distribution obviously seems to center more or less in temperate territories. Members of Mniaceae can be found on soil, rotten logs and wet rocks in forest and springy or swampy sites in the study area.

(3) Only 11 taxa of the family Amblystegiaceae were found in the area. Most species are hydrophytic mosses, and are adapted to very wet conditions ecologically. One can see that the presence of Amblystegiaceae reflects that the environment of Helan Mt. is characteristic of complicated and diverse landform.

In conclusion, the pattern of moss diversity as a whole, and in Helan Mt. in particular is obviously correlated with the availability of water. Because of the xeric environment, the xerophytic mosses, such as Pottiaceae and Grimmiaceae, are in dominant position.

FLORISTIC ELEMENTS

Bryophytes of Helan Mountain can be divided into different floristic elements based on their ranges. The names given to each of the floristic elements of bryophytes are different when enu-

merated and used by different authors. In this paper, we adopt the categorical names based on the distribution of carpophyte of China as documented by Wu (1983)

(1) Most species of bryophytes in the study area, about 105 species, have wide **North Temperate** distribution and they are quite common also in other parts of Inner Mongolia (e.g. *Abietinella abietina*, *Brachythecium plumosum*, *Cephaloziella rubella*, *Distichium capillaceum*, *Ditrichum flexicaule*, *Entodon concinnus*, *Jamesoniella autumnalis*, *Hypnum vaucheri*, *Pseudostereodon procerrimus*, *Syntrichia princeps*, *Timmia bavarica*, etc.).

(2) **East Asia and North American elements.** These are species occurring in temperate East Asia and North America. Examples are *Grimmia pilifera*, *Orthotrichum sordidum* and *Anomodon minor* (Wu & al., 2001). The species of East Asian element have their distribution within the temperate and warm temperate zones in China, Japan and Korea. Some of them extend their range to the Himalayas. This element includes three sub-elements:

(a) *Sino-Himalaya element.* These bryophytes occur only in the Himalayas and in the Chinese provinces of Yunnan and Sichuan, e.g. *Anoetangium thomsonii*, *Bryoerythrophyllum gymnostomum*, *Hymenostylium recurvirostrum* var. *cylindricum*, etc.

(b) *Sino-Japanese element.* They are bryophytes occurring in Japan and central China, but absent in the Himalayan region. e.g., *Bryoerythrophyllum brachystegium*, *Hymenostylium recurvirostrum* var. *insigne*, *Hypnum vaucheri* f. *tereticaulis*, *Okamuraea brachydictyon*, *Plagiomnium maximoviczii*, etc.

(c) *Japan-Sino-Himalaya element.* They are bryophytes occurring in Japan and the Himalayas, e.g. *Anoetangium aestivum*, *Brachythecium buchananii*, *Didymodon rigidulus* var. *flexicipis*, *Entodon caliginosus*, etc.

(3) **Endemic elements** contain taxa which appear to be endemic in smaller areas, such as:

(a) *Endemic to China.* This element contains 7 species: *Aloina obliquifolia*, *Didymodon rufidulus*, *Molendoa sendtneriana* var. *yunnanensis*, *Weissia edentula*, *Weissia semipallida*, etc.

(b) *Endemic to Mongolia Plateau.* Only one species: *Syntrichia bidentata*.

(c) *Endemic to Helan Mountains.* Examples are *Cratoneuron longicostatum* and *Tayloria rudimenta*.

NEW RECORDS FOR THE BRYOPHYTE

FLORA OF CHINA

The results of our survey brought the following addition of three new moss records for China. The description of the species is based on Chinese specimen(s) collected.

Microbryum starckeanum (Hedw.) Zand., Gen. Pottiaceae: Moss. Harsh. Envir., Bull. Buffalo Soc. Nat. Sci. vol. 32: 240. 1993. *Pottia starckeanum* (Hedw.) C. Müll., Syn. Musc., 1849; Moss Flora Brit. Irel. 235. 1978. *Weissia starckeanum* Hedw., Spec. Musc. 65, 1801. — Fig. 2.

Plants small, crowded, forming a low tufts, green above, reddish brown below. Stems very short. Leaves oblong-lanceolate or very broadly ovate, acute, 0.7-1.2 mm long; margins strongly recurved, entire, marginal cells less papillose and somewhat thicker walled than medial; costa reddish, excurrent in a cuspidate point, costa cells papillose; cells above small, 10-16 μm wide, round-quadrate to hexagonal, densely papillose; basal cells rectangular, ca. 23-49 μm long, 10-15 μm wide, with thin walls. Paroicous. Setae erect, ca. 2.7 mm long; capsule ellipsoid, ca. 0.5 mm, dark brown, not wide-mouthed; Operculum short conical; calyptra cucullate; annulus absent; peristome absent or rudimentary. Spores about 16-21 μm , light brown, obtusely tuberculate.

Distribution: Central, West and south Europe, Canaries, Madeira, Algeria, Syria, Western part of America, Australia.

Habitat: In Helan Mountain it was found On soil in *Pinus tabulaeformis* + *Juniperus rigida* forest.

Chinese specimens examined: Helan Mountain: SY029, RJ340, alt.: 2300 m.

Operculum of *Microbryum starckeanum* (Fig. 2-1) was drawn from dry plants. Strongly recurved leaf margins may be the result of xeric environment of Helan Mt.

Hypnum bambergeri Schimp., Syn. Musc. Eur., 698, 1860. — Fig. 3.

Plants medium-sized, in green or yellow-green cushions. Stems prostrate to ascending, to 3-8 cm long, with weak central strand, irregularly to sub-pinnately branched. Pseudoparaphyllia broadly

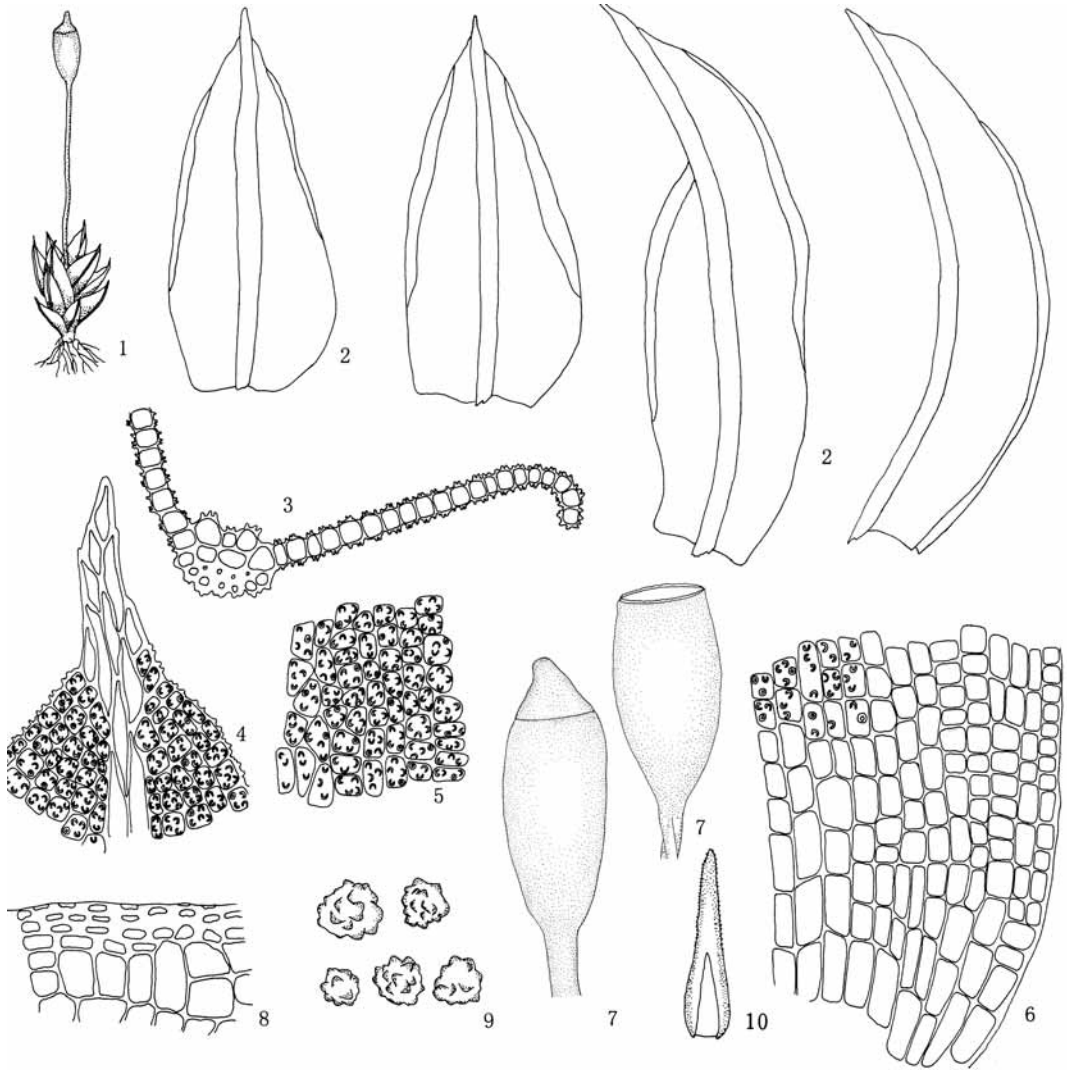


Fig.2. *Microbryum starckeanum* (Hedw.) Zand. 1: Plant with sporophyte ($\times 7.9$); 2: leaves ($\times 68$); 3: Cross section of costa and portion of leaf ($\times 284$); 4: apical leaf cells ($\times 284$); 5: median leaf cells ($\times 284$); 6: basal marginal leaf cells ($\times 284$); 7: capsules with operculum ($\times 26$); 8: cells at mouth of capsule ($\times 284$); 9: spores ($\times 284$); 10: calyptra ($\times 26$).

ovate. Stem and branch leaves similar, crowded, falcate to circinate-secund, 1.9-2.4 mm long; margins plane, entire; costa double, yellow, very slender; upper leaf cells 28-49 μm long; median leaf cells 41-62 μm long; alar cells subquadrate to rectangular, thick-walled. Dioicous. Sporophytes not seen in Helan Mountain.

Distribution: *Hypnum bambergeri* has an arctic-alpine distribution in Europe and occurs in Azores and Siberia, in North America from British Columbia in the west to Newfoundland and

Quebec in the east. The species is widespread across the Arctic region.

Habitat: In Helan Mountain it was found on soil in *Picea crassifolia* forest and alpine meadows.

Chinese specimens examined: Helan Mountain: SY380, Alt.: 2500 m; SG113, alt.: 3400 m.

Bryum elegans Nees ex Brid., Bryol. Univ. 1: 849. 1827; *Arctoa*. 9: 212. 2000.— Fig. 4.

Plants in dense, soft green tufts. Stem reddish, straight, 0.5-1.5 cm long. Upper leaves closely imbricate, appressed, sometimes loosely

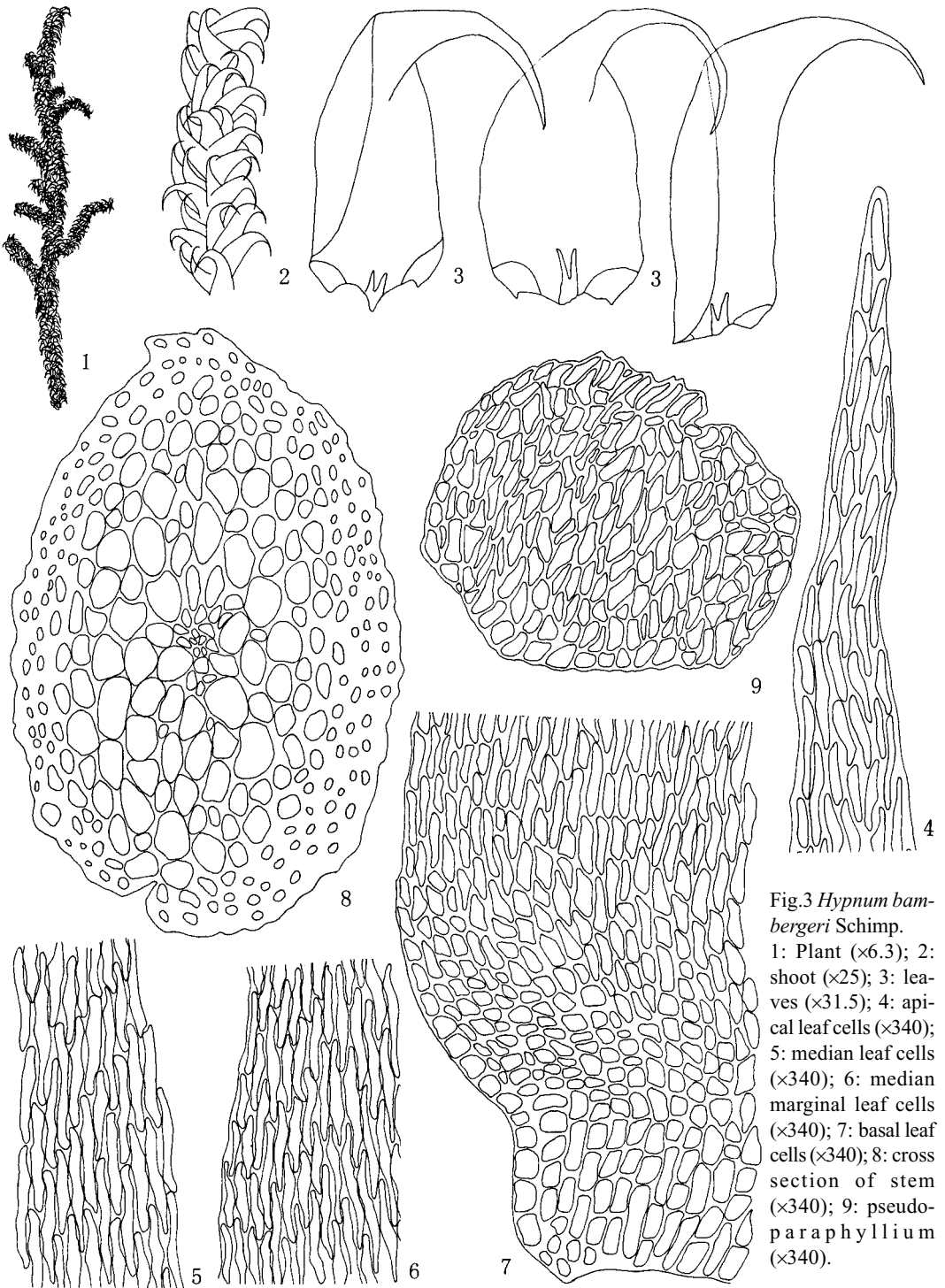


Fig.3 *Hypnum bambergi* Schimp.

1: Plant ($\times 6.3$); 2: shoot ($\times 25$); 3: leaves ($\times 31.5$); 4: apical leaf cells ($\times 340$); 5: median leaf cells ($\times 340$); 6: median marginal leaf cells ($\times 340$); 7: basal leaf cells ($\times 340$); 8: cross section of stem ($\times 340$); 9: pseudoparaphyllium ($\times 340$).

twisted when dry, concave, broadly ovate, not decurrent, 1.1-1.9 mm long, 0.6-1.0 mm wide, lower leaves less smaller; margin plane, entire,

narrowly recurved at base; border distinct, 1-2 rowed, composed of somewhat longer and narrower cells; costa strong, tapered in upper leaf

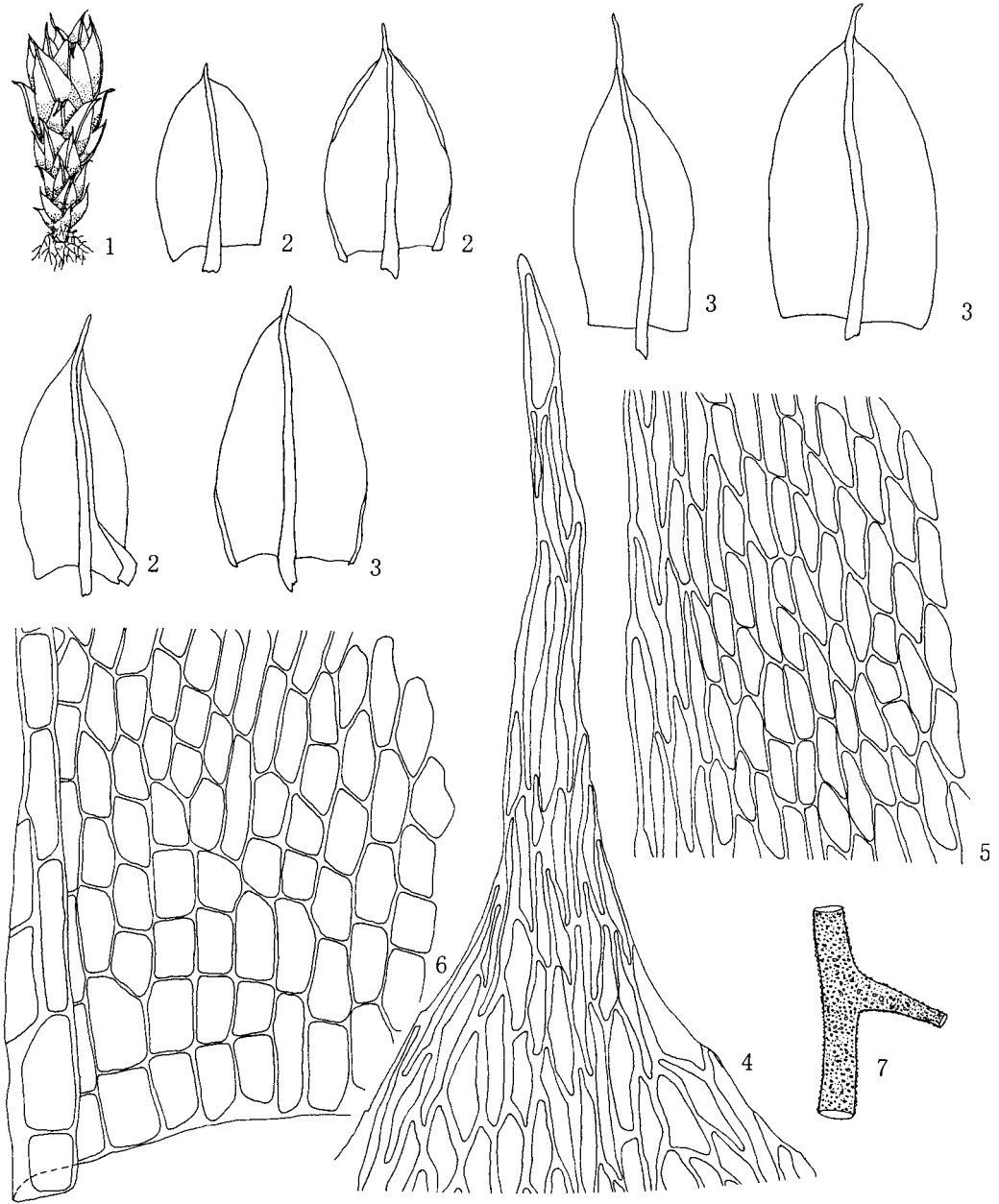


Fig.4. *Bryum elegans* Nees ex Brid. 1: Plant ($\times 12.6$); 2: perigonial leaves ($\times 31.5$); 3: perichaetial leaves ($\times 31.5$); 4: apical leaf cells ($\times 340$); 5: median marginal leaf cells ($\times 340$); 6: basal marginal leaf cells ($\times 340$); 7: rhizoid ($\times 340$).

and ending below acumen, or strongly excurrent in mucronate to piliferous point; upper cells regular or irregular rhombic; basal cells oblong to rectangular, thin-walled, $36-62 \times 15-26 \mu\text{m}$. Perichaetial leaves lanceolate, margin plane, costa percurrent. Rhizoids brown to reddish-brown, very coarsely papillose. Axillary filaments lack-

ing. Sporophytes not found in the study area.

Distribution: Northern and montane parts of Europe, Middle European Russia, Iceland.

Habitat: On soil in alpine meadows.

Chinese specimens examined: Helan Mountain: SG82, alt.: 3400 m.

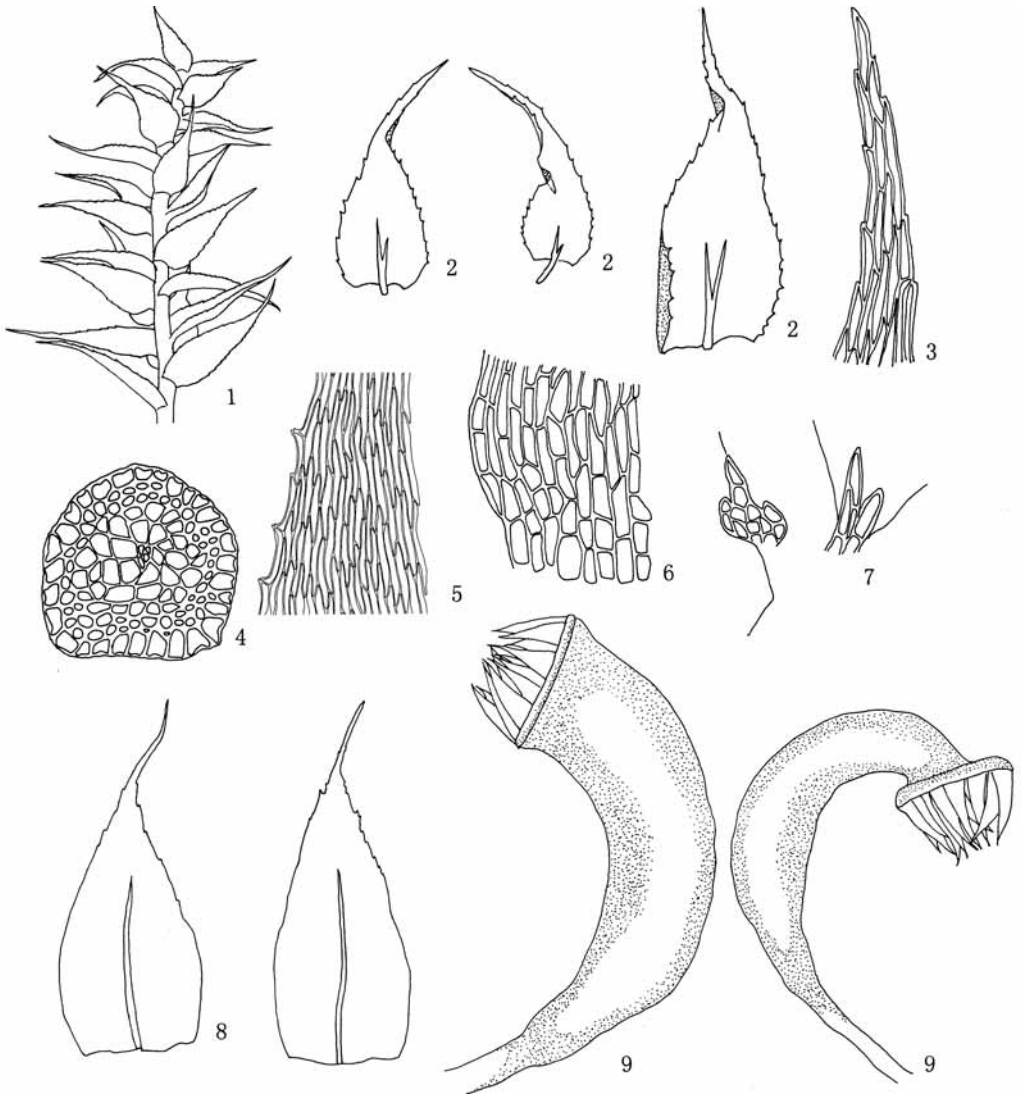


Fig. 5. *Podperaea krylovii* (Podp.) Iwats. & Glime 1: Portion of plant ($\times 29.5$); 2: leaves ($\times 59$); 3: apical leaf cells ($\times 236$); 4: cross section of stem ($\times 236$); 5: median marginal leaf cells ($\times 236$); 6: basal marginal leaf cells ($\times 236$); 7: pseudoparaphyllia ($\times 236$); 8: perichaetial leaves ($\times 29.5$); 9: capsules, showing when moist and dry ($\times 29.5$).

SECOND RECORD FOR CHINA

Ignatov et al. (1996) reported *Podperaea krylovii* as a new record for China, but very briefly and without any description and illustration of Chinese plants, so they are here as follow:

Podperaea krylovii (Podp.) Iwats. & Glime, J. Hattori Bot. Lab. 55: 495. 1984. *Chrysohypnum krylovii* Podp., Spisy Prir. Fak Masarykovy Univ. 116, t. 28, f. 'krylovi'. 1929. — Fig. 5

Plants in small, loose green mats. Stem prostrate, ca. 1 cm long, without central strand, irreg-

ularly branched. Pseudoparaphyllia ovate to lanceolate. Leaves lanceolate, gradually acuminate, 0.4-0.7 mm long, serrate all around, the teeth near the base double-celled; costa double or forked, short and weak; basal cells oblong or rectangular, 14-28 x 7-15 μm . Autoicous. Perichaetial leaves 1.4 x 0.6 mm, serrulate, smooth, costa reaching above mid-leaf. Capsules ca. 1 mm long, arcuate and strongly contracted below the mouth when dry; operculum conic; annulus not differentiated; peristome double.

Distribution: South Siberia (westward to Altai), Russian Far East, northern Japan (Hokkaido) and north-eastern China.

Habitat: On soil at rock bases in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Juniperus rigida* forest.

Chinese specimens examined: Helan Mountain: HQ269, alt.: 1900 m.

Podperaea krylovii was collected not only in Helan Mt. but also in Ordos and the northern Yanshan of Inner Mongolia.

UPDATED LIST OF SPECIES COLLECTED FROM HELAN MOUNTAIN

(Note: ‘**’ indicates a new record species to China, and ‘*’ new to Helan Mountain)

LIST OF HEPATICAE

* *Cephaloziella rubella* (Nees) Warnst. [2000-2500 m/SY057-058, SY075, SY088, SY124, SY131-132, SY136, SY152-153, SY160, SY180] – On soil in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.

* *Jamesoniella autumnalis* (DC.) Steph. [2500 m/BS1279J] On soil in *Picea crassifolia* forest.

* *Mannia fragrans* (Balbis.) Fry et Clark [2500-3000 m/SY024, XK212, XK221, XK245] – On soil at rock bases, in *Picea crassifolia* forest.

* *M. triandra* (Scop.) Grolle [2000-2500 m/XK216-218, XK250-251, NS2173, SY88] – On dry rocks on cliff in alpine zone, on soil in *Picea crassifolia* forest.

Marchantia polymorpha L. [2600 m/HL1364] – On wet rock outcrops along creeks in *Picea crassifolia* forest.

* *Plagiochasma rupestre* (Forst.) Steph. [2000-2500 m/XK196, XK204, XK213] – On soil under shady rocks, in rock crevices.

Plagiochila ovalifolia Mitten [2500m-3400 m/SG98, HL1331, HL1344, as *P. asplenioides*] – On soil in *Picea crassifolia* forest at creek bank, on soil in alpine meadows.

* *Reboulia hemisphaerica* (L.) Raddi [2300 m/XK196] – On soil under shaded rocks.

* *Riccia sorocarpa* Bisch. [2200-2350 m/XK214, XK226] – On wet soil at rock bottom.

Scapania cuspiduligera (Nees) K.Müll. [2600-3000 m/SY025, HL2007] – On soil in *Picea crassifolia* forest, on rocks in alpine meadow.

LIST OF MOSSES

Abietinella abietina (Hedw.) Fleisch. (= *Thuidium abietinum* (Hedw.) Turn.) [2100-2700 m/SY023, SY055, HQ293, RJ366, BS1215, HL1867, NS2113] – It is the dominant species of moss cover in *Picea crassifolia* forest and *Picea crassifolia*+ *Populus davidiana* forest.

* *Aloina brevirostris* (Hook. & Grev.) Kindb. [2200 m/SY114] – On soil on sunny slopes with numerous rocky outcrops.

A. obliquifolia (C.Müll.) Broth. [1900-2400 m/SY001, SY182-183, HL1848, NS2127] – On soil on slopes, on the top of old walls; on soil in relatively mesic habitats (close to creeks), often found on soil in forest.

A. rigida (Hedw.) Limpr. [1560-2500 m/SY006, SY072, SY108, XK240, RJ305, BS1156, HL2061, NS2122, HL1835] – On soil on old walls.

Amblystegium riparium (Hedw.) B.S.G. (= *Leptodictyum riparium* Hedw.) [2600-2800 m/HQ279, BS1288] – On wet soil in the valley with temporary creek.

A. serpens (Hedw.) B.S.G. [2000-2900 m/SY010, SY044, SY159-160, SY171, XK197-198, BS1252, HL2063] – On damp soil and wet shaded rocks in *Picea crassifolia* and *Pinus tabulaeformis* forest.

A. serpens var. *juratzkanum* (Schimp.) Rau & Herv. [2700 m/BS1298] – On wet soil.

A. tenax (Hedw.) C.Jens. var. *spinifolium* (Schimp.) Crum & Anderson (= *Hygroamblystegium tenax* var. *spinifolium* (Schimp.) Jenn.) [2300 m/BS1173] – On wet rocks in creek in springy area.

* *Anoetangium aestivum* (Hedw.) Mitt. [2000-2400m/SY032, SY070, SY075, SY137] – On soil on shady rock faces in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest; on wet soil in creek valleys.

A. thomsonii Mitt. [2000-2400 m/SY039, SY070, SY148, XK191, XK201, BS1220] – On soil on shady rock faces in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.

* *Anomobryum filiforme* (Dicks.) Husn. [1800 m/XK200] – On soil in spring area; on wet to mesic soil at creek bank.

Anomodon minor (Hedw.) Fuernr. [2300 m/XK247] – On soil at rocks bases.

Barbula indica (Hook.) Spreng. in Steud. (= *Semibarbula indica* (Hook.) Herz. ex Hilp.) [3000-3200 m/HL1953, HL1324] – On soil on rock faces; on shaded ground under the canopy of shrubs in mountain steppe.

- * *B. unguiculata* Hedw. [2000-2700 m/SY030, SY088, SY125-126, SY165, XK242, SY98] – On soil under open rocks in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.
- Brachythecium albicans* (Hedw.) B.S.G. [1800-2700 m/SY089, HQ289, BS1162, NS2169] – On soil on rocks in *Pinus tabulaeformis* forest and *Picea crassifolia* + *Populus davidiana* forest.
- B. buchananii* (Hook.) Jaeg. [2500 m/HL2044] – On rotten logs and rocks in *Picea crassifolia* forest.
- * *B. kuroishicum* Besch. [2300-3400 m/SY140, SG129] – On soil on rocks in the valley with transient creek.
- B. plumosum* (Hedw.) B.S.G. [2400-3100 m/SY024, SY129, HQ272, SG92-93, NS2151] – On rocks in *Picea crassifolia* forest.
- B. salebrosum* (Web. & Mohr) B.S.G. [2300-2900 m/SY129, HQ278, RJ366, BS1297] – On soil in *Picea crassifolia* forest.
- Bryoerythrophyllum brachystegium* (Besch.) Saito [2200-2500 m/SY126, HL2027] – On calcareous soil on rocks in *Pinus tabulaeformis* forest, *Picea crassifolia* forest, *Populus davidiana* forest and *Ulmus glaucescens* forest.
- B. gymnostomum* (Broth.) Chen (= *B. ferruginascens* (Stirt.) Giac.) [1900-2100 m/HQ295, RJ366, NS2179, NS2178] – On calcareous soil layer on rocks.
- * *B. inaequalifolium* (Tayl.) Zand. [2450 m/HL2023] – On calcareous soil.
- B. recurvirostrum* (Hedw.) Chen [1900-3100 m/SY007, SY019, SY043, XK251, HQ272-273, HQ278, RJ338, SG93, HL1886, BS1197, HL1996, NS2192] – On calcareous soil on rocks, on soil in *Pinus tabulaeformis* forest, on creek bank in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* + *Ulmus glaucescens* forest.
- Bryum algovicum* Sendt. ex C.Müll. [1800 m/BS1144] – On calcareous soil at creek bank, on relatively dry cliffs in shady canyons.
- B. alpinum* Huds. ex With. [1800-2300 m/SY131, NS2175, NS2180] – On soil in relatively mesic places along stream.
- B. arcticum* (R.Brown.) B.S.G. [2900 m/BS1294] – On soil in various habitats.
- B. argenteum* Hedw. [1600-2500 m/SY002, SY008, XK257, RJ300-304, BS1176, HL2023, NS2137] – One of the most widespread species in the area, tolerating heavy trampling and occurring everywhere, e.g. on soil among rocks on slopes, on rocks in *Pinus tabulaeformis* forest and *Picea crassifolia* forest.
- * *B. bicolor* Dicks. (= *B. dichotomum* Hedw.) [2100-2300 m/SY048, SY069, SY166] – On soil in rocks crevice in *Pinus tabulaeformis* forest; at trunk bases in *Ulmus glaucescens* forest.
- B. caespiticium* Hedw. [2000-3400 m/SY001, SY007, XK199, HQ275-276, BS1184, HL1885, HL2010, NS2109] – Rather common in various habitats.
- B. capillare* Hedw. [2300-2600 m/SY175, HL2050] – On arenaceous soil in *Picea crassifolia* forest, on rocks in canyon in *Pinus tabulaeformis* + *Picea crassifolia* forest.
- B. cirrhatum* Hoppe et Hornsch. (= *B. lonchocaulon* C.Müll.) [2000-2400 m/SY003, SY177-178, HQ276, NS2144, NS1350] – On soil in *Picea crassifolia* + *Pinus tabulaeformis* forest.
- ** *B. elegans* Nees ex Brid. [3000 m/SG82] – On soil in alpine meadows.
- B. pallens* Swartz [2400-3300 m/HL1360, HL2050, HL1993] – On humus in *Picea crassifolia* forest and in alpine meadows.
- * *B. pallescens* Schleich. ex Schwägr. [2300 m/HL1912] – On soil among grasses on wet meadows.
- * *B. pseudotriquetrum* (Hedw.) Gaertn. et al. [2500 m/HL1918] – On rock outcrops along creeks, streams.
- B. rutilans* Brid. [1800-2400 m/BS1144, HL1360] – On wet soil at creek side.
- * *B. thomsonii* Mitt. [2100-2300 m/SY126] – On soil on rock faces; on soil in forest of *Pinus tabulaeformis*, *Picea crassifolia*, *Populus davidiana* and *Ulmus glaucescens*.
- B. turbinatum* (Hedw.) Turn. [2100-2300 m/HL1899, HL2073] – On rock outcrops along creeks.
- B. uliginosum* (Brid.) B.S.G. [2100-3200 m/SY010, SY161, HQ276, BS1245, HL1900, HL1981] – On soil in various habitats.
- Campylium hispidulum* (Brid.) Mitt. [2000-2700 m/SY003, SY025, HQ272-273, BS1185, NS1220] – On rocks and at trunk bases in *Picea crassifolia* forest.
- C. hispidulum* (Brid.) Mitt. var. *sommerfeltii* (Myr.) Lindb. [2200-2500 m/BS1275, NS2092] – On soil on slopes and at trunk bases in *Picea crassifolia* forest and mixed forest.
- C. stellatum* (Hedw.) C.Jens. [2400-2900 m/BS1205, HL1352, HL2028, NS2114] – On humus in *Picea crassifolia* forest.
- Cirriphyllum cirrhosum* (Schwägr.) Grout [2500-2700 m/SY382, HL1949] – On soil in *Picea crassifolia* forest.

- C. piliferum* (Hedw.) Grout [2000-2700 m/SY001, HQ286, BS1227, HL1322, HL1889, NS2098, HL2114] – On soil in *Picea crassifolia* + *Populus davidiana* mixed forests.
- * *Coscinodon cribrosus* (Hedw.) Spruce [2250 m/SY4345, SY4347] – On soil-covered rocks on open place.
- Cratoneuron filicinum* (Hedw.) Spruce [1700-2700 m/SY049, XK200, BS1252, HL1347, HL2050] – On rock on bank of permanent brook in *Picea crassifolia* forest and *Pinus tabulaeformis* forest.
- C. longicostatum* X.L. Bai [2700 m/BS1249] – On soil on xeric slopes.
- * *Crossidium crassinerve* (De Not.) Jur. (as *C. chloronotos*, Flora Bryophyt. Intramongol.) [1800-2200 m/SY102-103, XK208, XK241-242] – On soil on rock faces.
- C. squamiferum* (Viv.) Jur. [2000-2200 m/SY112-113, RJ364, HL1860, NS2124] – On soil on slopes under the shrubs.
- Didymodon asperifolius* (Mitt.) Crum [2300-3200 m/SY024, SY096, SY189, RJ317, BS1143, HL1865, HL1986, NS2193] – On calcareous soil on rocks within shrubs community and forest.
- D. fallax* (Hedw.) Zand. [2200 m/HL1888] – On calcareous soil on rocks.
- D. ferrugineus* (Schimp. ex Besch.) Hill (= *D. rigidicaulis* (C. Müll.) Saito) [2400-3400 m/SY025, SY123-124, XK191, XK241-242, RJ320, SG131, NS2183] – On calcareous soil on rocks.
- D. giganteus* (Funck) Jur. [3100 m/HL2002, HL2007] – On calcareous soil on rocks in alpine zone, often found on higher mountains above 3000m alt.
- D. johansenii* (Williams) Crum [2200-3300 m/SY098, SG102, HL1948, HL1312, NS2163] – On calcareous soil in alpine meadows.
- D. michiganensis* (Steere) Saito [1950 m/NS2178] – On thin soil on rock faces.
- D. nigrescens* (Mitt.) Saito [2000-3000 m/SY004, SY006, SY016-017, SY102-103, SY154-156, RJ317, HL1854] – On calcareous soil on rocks under shrubs.
- D. perobtusus* Broth. [3000-3400 m/SG104-105, SG126, HL1948, HL1988] – On calcareous soil on cliffs; in alpine meadows.
- D. rigidulus* Hedw. [2200-3250 m/SY045, SY096, SY179, RJ320, NS2121, HL1994] – On calcareous soil on rocky slopes in shrub community and forest.
- D. rigidulus* var. *ditrichoides* (Broth.) Zand. [2300-3000 m/SY71, HL1950, NS2088] – On calcareous soil on rocks.
- D. rigidulus* var. *flexicuspis* (Broth.) comb. nov. – *Barbula flexicuspis* Broth. Hedwigia 80: 203. 1941. [1900-2200 m/SY059, SY073, SY148, NS2190] – On calcareous soil on rock faces; on soil in *Pinus tabulaeformis* forest.
- D. rigidulus* var. *gracilis* (Schleich. ex Hook. & Grev.) Zand. [2700-2900 m/NS2107, SY12-13] – On calcareous soil on rocky slopes.
- D. rigidulus* var. *icmadophilus* (Schimp. ex C. Müll.) Zand. [1900-2200 m/SY023, SY163, XK247, NS2183, HL1310] – On soil in *Picea crassifolia* forest and *Pinus tabulaeformis* forest.
- D. rufidulus* (C. Müll.) Broth. [2400-3000 m/SG84, SG85, SG128, HL1975, HL1315] – On calcareous soil on alpine zone, occasionally on trunks in various forest.
- D. tophaceus* (Bird.) Lisa [1900-2300 m/SY056-068, SY154-155, HL1848, NS2160] – On soil on rocks along shaded creeks in forests.
- D. vinealis* (Bird.) Zand. [1500-3400 m/SY001, SY021-022, XK203-204, HQ261, RJ367-368, RJ371-372, SG78-79, HL1840, NS2126, HL1309] – One of the most widespread species in the area, tolerating heavy trampling and occurring everywhere.
- Distichium capillaceum* (Hedw.) B.S.G. [1900-3400 m/SY030-031, SY180-181, HQ277, SG82-83, SG133, BS1170, NS2091, HL1870, SY57] – It is one of the dominant species on soil in forests of *Pinus tabulaeformis*, *Picea crassifolia*, and *Picea crassifolia* + *Populus davidiana*.
- D. inclinatum* (Hedw.) B.S.G. [2500-3000 m/SG99, BS1251, SY17] – On soil in *Picea crassifolia* forest, on soil in shrubs on alpine meadows.
- Ditrichum flexicaule* (Schwägr.) Hampe (= *D. crispatisimum* (C. Müll.) Par.) [2100-3400 m/SY030, SY085, SY378, SG115, SG119-123, BS1229, NS2103] – Relatively common and abundant in *Picea crassifolia* forest where it often forms pure population on the ground layer.
- * *D. pallidum* (Hedw.) Hampe [2500 m/BS1230] – On soil in *Picea crassifolia* forest.
- D. pusillum* (Hedw.) Hamp. [2200 m/SY088] – On soil on rock faces in *Pinus tabulaeformis* forest.
- Drummondia sinensis* C. Müll. [1800-2500 m/HL2045, NS2187] – On soil on rocks, at trunk bases of *Picea crassifolia* in *Picea crassifolia* forest.
- Encalypta alpina* Sm. [2000-3400 m/SY026, SY124, RJ368, SG83, SG86, NS2147, HL2025, BS2019, SY54] – On soil in *Pinus tabulaeformis* forest, *Picea crassifolia* forest and *Populus davidiana* forest; on rocks in alpine meadow.

- E. rhabdocarpa* Schwägr. [2000-3400 m/SY131, SY135, SY149, HL1989, NS2111, BS1158] – Often found on soil in forests.
- * *E. spatulata* C.Müll. [2000-2800 m/SY021, RJ364-365, RJ372] – On rocks in *Pinus tabulaeformis* forest; on thin soil on the peak.
- * *E. tibetana* Mitt. [2000-2500 m/SY078, SY172] – On rock faces in forests of *Pinus tabulaeformis*, *Picea crassifolia*, *Populus davidiana* and *Ulmus glaucescens*; on wet soil in creek valleys.
- E. vulgaris* Hedw. [2000-3000 m/SY003, XK215-216, SG86, NS2136, HL1837] – On rock faces in *Pinus tabulaeformis* forest and *Ulmus glaucescens* forest; on rock outcrops in alpine meadows; on wet soil in creek valleys.
- Entodon caliginosus* (Mitt.) Jaeg. [2400-2900 m/BS1260, NS2116, HL2035] – Often forms almost pure populations on soil and occurs as part of moss ground cover in *Picea crassifolia* forest.
- E. concinnus* (De Not.) Par. [2300-2900 m/HQ266, SY375, BS1218, HL1887, NS2102] – It is one of the dominant species forming the moss cover in *Picea crassifolia* forest.
- Eurohypnum leptothallum* (C.Müll.) Ando [2200-3200 m/SY065, HQ279, RJ331, RJ360, SG118, SG124, BS1141, NS2182] – On soil near rocks and on bare rocks on alpine meadows.
- * *E. leptothallum* (C.Müll.) Ando var. *tereticaule* (C.Müll.) Gao & Chang [2600-3400 m/HQ287, SG133] – On soil in *Picea crassifolia* forest, in alpine meadows.
- Fabronia ciliaris* (Brid.) Brid. [1900-2600 m/SY034, SY120, SY130, SY143, XK230, XK241, BS1212, HL2086, NS2159] – On trunks in forest and shrubs.
- F. matsumurae* Besch. [2200-2300 m/SY121, XK235] – On trunks of *Ulmus glaucescens* along roads, occasionally also on soil.
- Fissidens bryoides* Hedw. [1600m-2500 m/SY017, XK249-251, HQ269, RJ304, NS2145, HL1850, SY73] – On dank soil.
- * *Funaria discelioides* C.Müll. [2200 m/SY145] – On soil in *Ulmus glaucescens* forest on sunny slopes.
- F. hygrometrica* Hedw. [2200 m/SY107] – On soil on rocks on open slopes and among open shrubs.
- F. muhlenbergii* Turn. in Schwägr. [1900-2300 m/SY149-150, NS2177] – One of the most common species in xeric areas.
- Grimmia anodon* B.S.G. [3100 m/HL1962, NS2115] – On calcareous soil on rocks in alpine areas above 3000 m alt.
- G. laevigata* (Brid.) Brid. [2100-3000 m/SY015, SY094, XK248, RJ336-337, BS1189, HL1853, HL1950, NS2087] – Relatively common and abundant on rock faces in high mountain where it often forms pure population.
- G. ovalis* (Hedw.) Lindb. [2000-3200 m/SY005, XK210, HQ260, RJ370, SG105, HL1309, HL1966] – On calcareous soil on rocks; on rather dry rocks in mountain area.
- G. pilifera* P.Beauv. [3300 m/HL2006] – On soil on rocks in higher mountain above 3000m alt.
- G. subanodon* Ochyra [3000 m/HL1954] – On calcareous soil on rocks and rock-fields at higher elevations.
- * *G. tergestina* Tomm. ex B.S.G. [2000 m/SY162] – On calcareous soil on rocks, on dry cliffs and rocks on open slopes and in rather dry canyons.
- G. unicolor* Hook. in Grev. [3200 m/HL1972] – On calcareous soil on rocks in alpine zone above 3000 m alt.
- Gymnostomum aeruginosum* Sm. [2000-2200 m/SY083, HL1909, NS2118] – On soil on rock faces in *Pinus tabulaeformis* forest and *Sabina chinensis* forest.
- G. calcareum* Nees & Hornsch. [2000-3400 m/SY016, SY086, SY188, XK207, SG105, HL1862, NS2167, BS1138, NS2140] – On soil on old wall and rock faces in *Pinus tabulaeformis* forest, *Ulmus glaucescens* forest and *Picea crassifolia* forest.
- Hilpertia velenovskii* (Schiffn.) Zand. (= *Tortula velenovskii* Schiffn.) [1600-2100 m/SY185-186, BS1175, NS2125, HL1836] – On old loessial wall.
- Homalothecium sericeum* (Hedw.) B.S.G. [2100-3100 m/SY058, HQ295, SG107, BS1214, NS2146] – On soil in *Picea crassifolia* forest, on rotten logs, on soil in rocks crevices.
- * *Hymenostylium recurvirostrum* (Hedw.) Dix. (= *Gymnostomum recurvirostrum* Hedw.) [2100-3400 m/SY041, SY049, SG114, HL2059] – On rather wet rock faces along creeks in *Pinus tabulaeformis* forest and in alpine meadows.
- H. recurvirostrum* var. *cylindricum* (Bartr.) Zand. (= *Gymnostomum aurantiacum* (Mitt.) Jaeg.) [2000-2200 m/SY148, HL1938] – On soil on shady rock faces in *Pinus tabulaeformis* forest, *Picea crassifolia* forest, *Populus davidiana* forest and *Ulmus glaucescens* forest.
- H. recurvirostrum* var. *insigne* (Dix.) Bartr. (= *Gymnostomum subrigidulum* (Broth.) Chen.) [2400 m/BS2019] – On calcareous soil on rock faces.
- * *Hypnum bambergieri* Schimp. [2500-3300 m/SY380, SG113] – On soil in *Picea crassifolia* forest and alpine meadows.

- H. cupressiforme* Hedw. [2000-3200 m/SY003, SY004, HQ289, RJ335, HQ385, SG85-86, BS1169, HL1310, HL1843, NS2093] – Relatively common, found in various habitats in Helanshan.
- H. cupressiforme* Hedw. var. *lacunosum* Brid. [2600-3400 m/HQ273, SG129, NS2101, HL1966] – On dry soil in *Picea crassifolia* forest; on rocks in alpine meadows.
- H. fertile* Sendt. [2600 m/BS1282] – On soil on slopes with numerous rock outcrops in *Picea crassifolia* forest.
- * *H. hamulosum* B.S.G. [2000-3400 m/SY016, SY023, SY127, SG131] – On soil in the valley with transient creek; on bare soil in alpine meadows.
- H. lindbergii* Mitt. (= *Callieryoniella lindbergii* (Mitt.) Hedenäs) [2300-3200 m/SG107, BS1262] – On wet rocks in *Picea crassifolia* forest and in alpine meadows.
- H. pallescens* (Hedw.) P. Beauv. [2200-2800 m/SY079, BS1179] – On trunks in *Picea crassifolia* forest, on soil in *Pinus tabulaeformis* forest.
- H. revolutum* (Mitt.) Lindb. [2400-3200 m/BS1236, HL1358, HL2003, HL2033] – On rather dry soil on slopes, in *Picea crassifolia* forest, alpine meadows.
- H. vaucheri* Lesq. [1800-3200 m/SY003, RJ330, RJ352-353, RJ367, SY383, SG100, BS1155, HL1856, NS2088] – On soil in *Pinus tabulaeformis* + *Picea crassifolia* forest and alpine meadows.
- H. vaucheri* f. *gracile* Ando [2300-2500 m/BS1213, HL1303] – At trunk bases of *Picea crassifolia*; on rocks in *Picea crassifolia* forest.
- H. vaucheri* f. *tereticaulis* Ando [3000-3200 m/HL1318, HL1979] – On soil in shrubs on alpine meadows.
- Indusiella thianschanica* Broth. & C.Müll. [1700-2100 m/BS1137, HL1855] – On soil among dry rocks in mountain, as well as in rocky areas in deserts.
- * *Isopterygiopsis pulchella* (Hedw.) Iwats. [2300-2400 m/SY088, SY175] – On soil in canyon beside creek in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.
- Jaffueliobryum wrightii* (Sull.) Thér. [2100-2800 m/RJ329, RJ359, HL1859, HL2085] – Cliff crevices in alpine zone.
- Leskeella nervosa* (Brid.) Loeske [2700-3100 m/HL1924, HL1978] – On rock outcrops in *Picea crassifolia* forest.
- Leucodon sciuroides* (Hedw.) Schwägr. [2400-3000 m/HL1317, HL1936, NS2089] – On trunk bases of *Picea crassifolia* and shrubs, also on rock in forest.
- Lindbergia brachyptera* (Mitt.) Kindb. [1900 m/NS2188] – On rocks in shrubby community and *Pinus tabulaeformis* forest.
- * *L. sinensis* (C.Müll.) Broth. [3200 m/HL1976] – On rather dry rocks in alpine meadows.
- ** *Microbryum starckeana* (Hedw.) Zand. (= *Pottia starckeana* (Hedw.) C.Müll.) [2300 m/SY029, RJ340] – On soil in *Pinus tabulaeformis* + *Juniperus rigida* forest.
- * *Mielichhoferia mielichhoferiana* (Funck ex Hook.) Loeske [2250 m/SY4346, SY4349] – On cliffs and rather dry rocks on steep slope in high elevation.
- * *Mnium heterophyllum* (Hook.) Schwägr. [2300-3200 m/SY141, HQ291, SG107] – On soil and on rock faces in *Picea crassifolia* forest.
- * *M. laevinerve* Card. [2300-3200 m/SY138, SG103] – On soil on rock faces in mixed forest of *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens*.
- M. lycopodioides* Schwägr. [2300-2800 m/BS1267, HL1881, NS2152] – On soil in *Picea crassifolia* forest and shrubs, alpine meadows.
- M. marginatum* (Dicks ex With.) P.Beauv. [2000-3200 m/SY081, SY170, HQ384, SG107, BS1198, HL1882, NS2102] – On soil and rocks in *Pinus tabulaeformis* forest, shrubs and alpine meadows.
- M. spinosum* (Voit.) Schwägr. [1700-2500 m/SY181, HQ274, BS1236, HL1844, NS2113] – On soil under forest and shrubs.
- M. thomsonii* Schimp. (= *M. orthorrhynchum* Brid.) [2400-3100 m/SG99, HL1346, HL1959, HL2041] – On soil in *Picea crassifolia* forest, alpine meadows.
- Molendooa schliephackei* (Limpr.) Zand. (= *Pleuroweisia schliephackei* Limpr.) [2000 m/XK244, HL1926] – On cliffs, soil on rock faces and in cliff crevices.
- M. sendtneriana* (B.S.G.) Limpr. [2000-2150 m/SY001, XK255-256, HL1897, NS2185] – Habitat similar to the previous species.
- M. sendtneriana* var. *yunnanensis* Gyoerf. (= *Didymodon japonicus* (Broth.) Saito) [1900 m/NS1163] – On soil on rock faces.
- Myurella julacea* (Schwägr.) B.S.G. [2700-3200 m/BS1235, HL1989] – On rock outcrops in *Picea crassifolia* forest, alpine meadows.
- M. sibirica* (C.Müll.) Reim. [3400 m/HL2012] – On rock faces in alpine meadows.
- M. tenerrima* (Brid.) Lindb. [2000-3200 m/SY053, SY088, SG112-113, HL2010] – On soil in *Pinus tabulaeformis* forest, alpine meadows.
- * *Okamuraea brachydictyon* (Card.) Nog. [2900 m/NS2100] – On rocks in *Picea crassifolia* forest.

- Orthotrichum affine* Schrad. ex Brid. [2500-3500 m/ HQ278, HL2004] – On *Picea crassifolia* trunks; on rotten logs in alpine meadows; on rock faces.
- O. anomalum* Hedw. [2300-3000 m/SY144, HQ278, BS1220, HL1310, HL1948] – Habitats as in previous species.
- O. obtusifolium* Brid. [2300-2600 m/SY084, HQ267, BS1201, HL1945, NS2095] – On trunk of *Picea crassifolia* and *Ulmus glaucescens*.
- * *O. sordidum* Sull. & Lesq. in Aust. [2300-2800 m/ SY120-121, HQ279, RJ347] – On rotten logs of *Picea crassifolia*.
- O. speciosum* Nees in Sturm [2400-3400 m/HL2012, NS2095] – On *Picea crassifolia* trunks in *Picea crassifolia* forest, and occasionally also on soil.
- * *O. striatum* Hedw. [2500-3100 m/HQ278, RJ345, SG97] – On fallen logs in *Picea crassifolia* forest.
- Plagiomnium confertidens* (Lindb. & H. Arn.) T. Kop. [2350 m/HL1941] – On soil on rocks in *Picea crassifolia* forest.
- P. ellipticum* (Brid.) T.Kop. [2500 m/HL1357] – On wet soil along permanent creeks.
- P. maximoviczii* (Lindb.) T. Kop. [2400 m/HL1913] – On soil in *Picea crassifolia* forest on steep slopes.
- P. rostratum* (Schrad.) T. Kop. [1900-2400 m/HL1904, NS2192] – On soil among grasses in *Picea crassifolia* forest.
- * *P. vesicatum* (Besch.) T. Kop. [1900-2300 m/HL2070, NS2192] – On soil in tussock in *Picea crassifolia* forest.
- * *Podperaea krylovii* (Podp.) Iwats. & Glime [1900 m/ HQ269] – On soil at rock bases in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Juniperus rigida* forest.
- Pogonatum alpinum* (Hedw.) Röhl. (= *Polytrichastrum alpinum* (Hedw.) G.L.Smith) [3000 m/HL1990] – On soil under shrubs; in alpine meadows.
- Pohlia cruda* (Hedw.) Lindb. [2800 m/NS2111] – On humus in *Picea crassifolia* forest.
- Pottia intermedia* (Turn.) Fuernr. (= *Tortula modica* Zand.) [2100 m/NS2143] – On soil on rock faces.
- P. lanceolata* (Hedw.) C.Müll. (= *Tortula lanceola* Zand.) [1900-2200 m/BS1178, NS2160] – On soil on rocks.
- * *P. truncata* (Hedw.) B.S.G. [2600-2900 m/RJ03340] – On soil in *Picea crassifolia* forest.
- Pseudoleskeella catenulata* (Schrad.) Kindb. [2400-3400 m/HL1330, HL1924, HL2008] – On soil in *Picea crassifolia* forest, in shrub community, and in alpine zone.
- P. tectorum* (Brid.) Kindb. [3200 m/HL1987] – On rocks in alpine meadows.
- Pseudostereodon procerrimus* (Mol.) Fleisch. in Broth. [1900-3400 m/SY031, HQ276, HQ386, SG132, BS1186, HL1308, HL1902, NS2099] – On soil in *Pinus tabulaeformis* + *Picea crassifolia* and *Ulmus glaucescens* forest.
- Pterygoneurum ovatum* (Hedw.) Dix. [2300-2500 m/ XK243, HL1844, HL2027] – On mesic soil on shady slopes.
- P. subsessile* (Brid.) Jur. [1500-2600 m/SY008, SY111-112, XK195, XK240, RJ300-301, RJ311, HL2023, NS2124, NS2189] – On damp soil in *Pinus tabulaeformis* forest and *Picea crassifolia* forest; occasionally also on trunks.
- Ptilium crista-castrensis* (Hedw.) De Not. [2500 m/ HL1339] – On soil in *Picea crassifolia* forest.
- * *Pylaisiella polyantha* (Hedw.) Grout [2800 m/HQ267] – On trunk of *Picea crassifolia*, on ground in *Picea crassifolia* forest.
- * *Rhizomnium punctatum* (Hedw.) T.Kop. [1900-2200 m/XK237, XK249-251] – On soil among rocks in canyon beside creeks.
- Rhytidium rugosum* (Hedw.) Kindb. [2600 m/HL1363] – On soil in *Picea crassifolia* forest.
- Sanionia uncinata* (Hedw.) Loeske (= *Drepanocladus uncinatus* (Hedw.) Warnst.) [2500-3000 m/BS1203, HL1332, HL2048] – On soil in *Picea crassifolia* forest; in shrub community, and in alpine zone.
- Schistidium apocarpum* (Hedw.) B.S.G. [2500-3400 m/ HL1313, HL1879, HL1983, NS2097, NS2117] – It is the dominant species on rocks in alpine zone.
- S. strictum* (Turn.) Loeske ex O.Maort. [2500-3300 m/ SG122, HL1312, HL2039, HL1952, NS1359] – Relatively common and abundant on rock faces in high mountain where it often forms pure population.
- Stegonia latifolia* (Schwägr.) Vent. ex Broth. [2200-3400 m/SY097, SY114, RJ315, SG95, HL1306, HL2016, NS2110] – On soil in meadows in alpine zone, and occasionally also in *Pinus tabulaeformis* + *Picea crassifolia* forest.
- Syntrichia bidentata* (X.-L.Bai) X.-L.Bai (= *Tortula bidentata* X.-L.Bai) [2800 m/RJ357] – On soil at the edge of *Picea crassifolia* forest.
- S. caninervis* Mitt. (= *Tortula caninervis* (Mitt.) Broth.) [2300-2800 m/RJ336, HL2076] – In rock crevices at mountain top, and in cliff crevices under overhangs.
- S. laevipila* Bird. [1800-2300 m/SY046, RJ318, BS1152, NS2168] – On soil in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.

- S. pagorum* (Milde) Amann (= *Tortula pagorum* (Milde) De Not.) [2200-2500 m/SY066, SY151, HQ281, BS1212, BS1152, HL2030] – On soil among rocks and on trunks of trees
- S. princeps* (De Not.) Mitt. (= *Tortula princeps* De Not.) [2300-3400 m/RJ308-309, RJ313, RJ350-352, SG119-121, HL1961] – On soil under *Picea crassifolia* forest and shrub community.
- S. ruralis* (Hedw.) Web. & Mohr (= *Tortula ruralis* (Hedw.) Gaertn. et al.) [2500-3100 m/BS1236, HL1304] – Same habitats as in previous species.
- S. sinensis* (C.Müll.) Ochyra (= *Tortula sinensis* (C.Müll.) Broth. in Levier) [2000-2500 m/SY037, SY143, XK253, BS1168, HL1876, NS2171] – Rare, on soil on rock faces.
- Tayloria rudimenta* X.-L.Bai & B.C.Tan [2050 m/SY099] – Rare, on humus within forest in swampy area where light can hardly shine in. Second known locality in China.
- Thuidium philibertii* Limpr. [2700 m/BS1253, HL1356] – On soil in *Picea crassifolia* forest where it often forms almost pure populations on the ground layer.
- Timmia bavarica* Hessel. (= *T. megapolitana* ssp. *bavarica* (Hessel.) Brid.) [2200-3400 m/SY010, SY140-141, XK252, HQ296, SY379, SG129-130, BS1180, HL1334, HL1890, NS2151] – Relatively abundant and common species in *Pinus tabulaeformis* forest and *Picea crassifolia* + *Populus davidiana* forest where it is often codominates in forming the moss cover on soil.
- T. megapolitana* Hedw. [2500-2600 m/HQ288, HL1360] – On soil on slopes with numerous rock outcrops in *Picea crassifolia* forest.
- Timmiella anomala* (B.S.G.) Limpr. [1700-2000 m/XK196, XK213, XK246, NS2172, NS2173] – On calcareous soil in cliff crevices.
- Tortella fragilis* (Hook. & Wils.) Limpr. [2000-3400 m/SY051, SY077, XK242, SG122-123, BS1221, HL1880] – On calcareous soil on open slopes, in alpine meadows, on soil in canyon in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.
- T. tortuosa* (Hedw.) Limpr. [2200-3200 m/HL1889, HL1984] – On calcareous soil on rocks, and in alpine meadows.
- Tortula atrovirens* (Sm.) Lindb. (= *Desmatodon convolutus* (Brid.) Grout) [1700-2400 m/SY008, XK259, RJ300-301, BS1181, HL2077, NS2176] – On soil on rocks in *Pinus tabulaeformis* forest and shrubs, in canyon beside creeks.
- T. leucostoma* (R. Br.) Hook. & Grev. (= *Desmatodon suberectus* (Hook.) Limpr.) [3100 m/HL1306] – On soil on slopes with numerous rock outcrops.
- T. mucronifolia* Schwägr. [2000-3200 m/SY017, SY164, SY169, SY171, HQ262, HQ278, RJ362, SG94, BS1197, NS2139, HL1878] – On soil on rock faces.
- T. systylia* (Schimp.) Lindb. (= *Desmatodon systylius* Schimp.) [3200 m/HL1306] – On soil near a base of shrubs in alpine zone.
- T. yunnanensis* Chen [2500-3300 m/RJ320, SG127, HL1959] – On soil; in shrubby community; on slopes; in alpine meadows.
- Trachycystis ussuriensis* (Maaack & Regel) T.Kop. [2400-2900 m/HQ291, SY376, BS1284] – On soil in *Picea crassifolia* forest.
- * *Trichostomum crispulum* Bruch in F.A.Müll. [2000-2300 m/SY005, SY172, SY175] – On rock faces in shady creek in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.
- T. planifolium* (Dix.) Zand. [2400 m/HL2023] – On soil on rocks.
- Voitia nivalis* Hornsch. [2100-3200 m/SY082, SY091-092, SG110, BS1288, HL2015, NS2130] – On humus in *Picea crassifolia* forest and alpine meadows.
- * *Warnstorfia fluitans* (Hedw.) Loeske (= *Drepanocladus fluitans* (Hedw.) Warnst.) [1800 m/BS1142] – On rocks in stream in springy area.
- * *Weissia controversa* Hedw. [2000 m/XK206, XK214] – On soil under rocks on sunny slopes.
- * *W. edentula* Mitt. [2100-2300 m/SY052, SY118] – On soil under rocks in shady creek in *Pinus tabulaeformis* + *Picea crassifolia* + *Populus davidiana* and *Ulmus glaucescens* forest.
- * *W. newcomeri* (Bartr.) Saito [2000-2300 m/SY029, SY086, XK206, XK242] – On soil in rock crevices in *Pinus tabulaeformis* + *Juniperus rigida* forest.
- W. semipallida* C.Müll. [1500-2900 m/SY104, XK193, HL1945, NS2109] – On soil on rock faces on sunny slopes.

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