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# HIGH-MOUNTAIN LICHEN ELEMENTS OF THE KHANGAI RANGE OF MOUNTAIN (MONGOLIA)

## Hochmontane Flechtenelemente des Changajgebirges (Mongolei)

by

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Key words: Biogeography, Khangai, lichens, Mongolia, mountains.
Schlagwörter: Biogeographie, Changaj, Flechten, Mongolei, Gebirge.

Summary: The lichen flora of the Khangai range of mountains (Mongolia) includes 750 species of different zonal geographical elements with predominance of boreal, arid and arcto-highmountain lichens. In high-mountain belt of the Khangai in altitude more than 2200 - 2450 m above sea level or above the timber-line 320 lichen species were recorded. The main quota fall to arcto-highmountain lichens (31% of total number in belt). Lichen list of high-mountain element flora, i.e. species that mainly grow in mountains of the world above timber-line sometimes also in other belts, contain 18 species with different areal types. They consider particular the areals of *Pertusaria saximontana, Umbilicaria angulata, U. caroliniana, U. phaea* with Asian - American disjunctions. The origin of disjunctions between Mongolia and North America can be explained by the hypothesis of ocean floor spreading - plate tectonics.

Zusammenfassung: Die Flechtenflora des Changajgebirges schließt 750 Arten verschiedener zonaler geographischer Elemente ein, wobei die borealen, ariden und arktisch-hochmontanen Flechten dominieren. 320 Flechtenarten wurden in der hochmontanen Stufe des Changaj in einer Höhe von mehr als 2200-2450 m über dem Meeresspiegel registriert oder es dominierten die arktisch-hochmontanen Flechten (31 % der gesamten Artenzahl in dieser Stufe) über der oberen Baumgrenze. Die Artenliste der Hochgebirgsflechten, d.h. jene Arten, welche hauptsächlich in der Hochgebirgsstufe der Gebirgen über der oberen Baumgrenze und manchmal auch in

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anderen Stufen wachsen können, enthalten 18 Arten der verschiedenen Arealtypen. Gesondert werden die Flechten *Pertusaria saximontana, Umbilicaria angulata, U. caroliniana, U. phaea* mit asischer-amerikanischer Arealdisjunktion diskutiert. Die Entstehung der Disjunktion zwischen Mongolei und Nord Amerika kann mit der Hypothese der Plattenverschiebung erklärt werden.

The Khangai is an extensive mountain range in the centre of the western part of Mongolia (from 93° to 106° in longitude and from 46° to 50° in latitude). In addition to the main ridge, this mountain also includes such ridges as Tarbagatai, Bulnai-Nuru, Khan-Khukhei, Buren-Nuru plus further lesser ones (see fig. 1). It extends almost 800 km from east to west and almost 400 km from north to south. Altitudes range from 1000 to 3905 m above sea level with most ridges being 2000 - 3500 m asl. South of the Khangai are dry steppes and the Gobi desert, whilst to the north is the Siberian taiga. Therefore sometimes plants of the desert and of the taiga may be found together in one community. For example, forest with *Picea obovata* can have an understorey of the desert bush *Caragana jubata*. The composition of plant communities varies in different parts of the Khangai, and includes desertian steppes, taiga forests and goltsy or high-mountain like as tundra communities above the timber-line. Typically, at altitudes of 1500 - 2450 m, the northern slopes of the ridges support forests of mostly *Larix*. Various types of steppes occupy the southern and the northern slopes below the forest zone. Commonly these can be divided into three zones:

(1) a low mountain zone, altitude less than 1500 - 1700 m a.s.l.;
(2) a middle mountain zone, altitude from 1500 - 1700 m to 2200 - 2450 m; and
(3) a high mountain zone, altitude more than 2200 - 2450 m or above the timber-line (Biazrov & al. 1989).

The author collected lichens in various regions of the mountain range of the Khangai during the Soviet-Mongolian Complex Biological Expeditions (1970 - 1980). About 30,000 specimens were collected. Part of the collection has been identified with the help of Prof. T. Ahti, Prof. N. S. Golubkova, Dr. I. M. Lamb, Prof. H. Trass, Dr. O. Vitikainen and Prof. J.-C. Wei. Most of specimens are waiting for identification.

On the basis of these identifications and published data (Ahti 1976; Biazrov & al. 1989; Golubkova 1981; Huneck & al. 1984, 1987, 1992; Schubert & Klement 1971; Wei & Biazrov 1991; Wei & Jiang 1993), the lichen flora of the Khangai currently comprises 750 species distributed across the different zonal geographical elements (Table 1). Particularly prevalent are lichens of the boreal, arid and arcto-highmountain elements, reflecting the position of the Khangai in the centre of Asia between boreal Siberia and Gobi desert.

The present paper is concerned with high-mountain lichens. The term "high-mountain" may be defined in a wide sense, i.e. to include all species

found in the high-mountain zone studied, or in a narrower sense, including those species that grow mainly above timber-line of mountains in general (GOLUBKOVA 1983).

The Khangai high-mountain zone generally represents a flat-topped ridge with a summit consisting of meadows, marshes, a sparse growth of trees, and small lakes. On the northern slopes are widespread tundra-like communities with *Empetrum sibirica, Betula rotundifolia, Salix rectijulis, S. recurvigemnis* and *Dryas oxydonta,* although the main vegetation type here is meadows with *Kobresia sibirica, Carex stenocarpa, C. melanantha* and *C. norvegica.*

Three hundred and twenty lichen species were recorded in the studied (high-mountain-)area:

*Acarospora cervina, A. cinereoalba, A. frigidodeserticola, A. fuscata, A. gobiensis, A. impressula, A. schleicheri, A. veronensis, A. versicolor, Alectoria nigricans, A. ochroleuca, Allantoparmelia alpicola, Allocetraria madreporiformis* (Syn.: *Dactylina madreporiformis), Anema decipiens, Arctomia delicatula, Arctoparmelia centrifuga, A. incurva, A. separata, Arthopyrenia humicola, Arthrorhaphis vacillans, Asahinea chrysantha, A. scholanderi, Aspicilia alphoplaca, A. alpina, A. caesiocinerea, A. cinerea, A. complanata, A. contorta, A. cupreoatra, A. desertorum, A. determinata, A. lacteola, A. lacustris, A. maculata, A. mikhnoi, A. reticulata, Bacidia muscorum, Baeomyces carneus, B. placophyllus, Brodoa atrofusca, B. oroarctica, Bryocaulon divergens, Bryonora castanea, Bryoria chalibeiformis, B. nitidula, B. simplicior, B. vrangiana, Calicium sphaerocephalum, C. trabinellum, Caloplaca ammiospila, Caloplaca bryochrysion, C. hedinii, C. jungermanniae, C. schoeferi, C. stillicidiorum, C. tetrasporella, C. tirolensis, Candelariella kansuensis, C. vitellina, Catapyrenium cinereum, Cetraria ericetorum, C. islandica, C. laevigata, C. odontella, C. potaninii, Cetrariella delisei, Chrysothrix chlorina, Cladina arbuscula, C. rangiferina, C. stellaris, Cladonia acuminata, C. alinii, C. amaurocraea, C. borealis, C. botrytes, C. cariosa, C. cervicornis, C. chlorophaea, C. coniocraea, C. cornuta, C. crispata, C. cyanipes, C. ecmocyna, C. fimbriata, C. furcata, C. gracilis, C. libifera, C. macroceras, C. macrophylla, C. mongolica, C. ochrochlora, C. pocillum, C. pyxidata, C. subulata, C. sulphurina, C. symphycarpa, C. uncialis, Coelocaulon aculeatum, C. steppae, Collema auriculatum, C. bachmanianum, C. polycarpon, C. tenax, Cornicularia normoerica, Cyphelium tigillare, Dactylina arctica, Dermatocarpon arnoldianum, D. deminuens, D. intestiniforme, D. meiophyllizum, D. miniatum, D. vellereum, D. weberi, Dibaeis baeomyces, Dimelaena oreina, Diploschistes albissimus, D. muscorum, D. ocellatus, D. scruposus, Endocarpon subfoliaceum, Endopyrenium desertorum, E. hepaticum, Ephebe lanata, Epilichen scabrosus, Evernia mesomorpha, E. perfragilis, E. terrestris, Flavocetraria cucullata, F. nivalis, Fulgensia bracteata, Gyalecta foveolaris, G. geoica, Hypogymnia bitteri, H. intestiniformis, H. subobscura, H. vittata, Icmadophila elveloides, Immersaria athroocarpa, Lasallia pertusa, L. rossica, Lecanora baicalensis, L. bicincta, L. cenisia, L. chlarona, L. epibryon, L. hagenii, L. lithophila, L. marginata, L. muralis, L. nephaea, L. rupicola, L. tschomolongmae, Lecidea albocaerulescens, L.*

*armeniaca, L. asiaecentralis, L. atrobrunnea, L. hedinii, L. leptoboloides, L. limosa, L. paratropoides, L. tesselata, Lecidella carpathica, L. euphorea, L. inamoena, L. stigmatea, Lecidoma demissum, Lepraria incana, Leptogium burnetiae, L. menziesii, L. saturninum, L. sinuatum, Lobaria linita, Lobothallia melanaspis, Masonhalea richardsonii, Massalongia carnosa, Megaspora verrucosa, Melanelia albertana, M. panniformis, M. sorediosa, M. stygia, M. tominii, Micarea assimilata, Microglaena biatorella, Mycoblastus alpinus, M. sanguinarius, Neofuscelia verruculifera, Nephroma arcticum, Nephromopsis komarovii, Neuropogon sulphureus, Ochrolechia alboflavescens, O. frigida, O. lapuensis, O. upsaliensis, O. yasudae, Ophioparma ventosa, Pannaria conoplea, P. hookeri, P. leucophaea, P. pezizoides, P. praetermissa, Parmelia fraudans, P. omphalodes, P. saxatilis, P. sulcata, Parmeliella triptophylla, Parmeliopsis ambigua, Peltigera aphthosa, P. canina, P. continentalis, P. didactyla, P. evansiana, P. horizontalis, P. lepidophora, P. leptoderma, P. leucophlebia, P. malacea, P. mauritzii, P. membranacea, P. praetextata, P. retifoveata, P. rufescens, P. scabrosa, P. venosa, Pertusaria glomerata, P. octomela, P. saximontana, Phaeophyscia kairamoi, P. sciastra, Phaeorrhiza nimbosa, P. sareptana, Physcia caesia, P. dubia, P. magnussonii, P. phaea, P. wainioi, Physconia grisea, P. muscigena, Placidiopsis cervinula, P. tominii, Placynthium nigrum, Pleopsidium chlorophanum, Polychidium muscicola, Polysporina simplex, Protoparmelia badia, Pseudephebe pubescens, Pseudevernia furfuracea, Psora globifera, P. rubiformis, Psoroma hypnorum, Psorula rubonigra, Ramalina capitata, Rhizocarpon disporum, R. eupetraeoides, R. geographicum, R. montagnei, Rhizoplaca chrysoleuca, Rinodina cinnamomea, R. conradii, R. milvina, R. mniaraea, R. roscida, R. turfacea, Sagiolechia rhexoblephaea, Sarcogyne privigna, Solorina bispora, S. crocea, S. octospora, S. saccata, S. spongiosa, Sphaerophorus fragilis, S. globosus, Squamarina lentigera, Staurothele lithina, Stereocaulon alpinum, S. condensatum, S. dactylophyllum, S. glareosum, S. myriocarpum, S. paschale, S. rivulorum, S. tomentosum, Tephromela atra, Thamnolia subuliformis, T. vermicularis, Thelidium velutinum, Thrombium epigaeum, Thyrea pulvinata, Toninia candida, Tuckermanopsis scpincola, Umbilicaria angulata, U. arctica, U. caroliniana, U. cinereorufescens, U. corrugata, U. crustulosa, U. cylindrica, U. decussata, U. krascheninnikovii, U. leiocarpa, U. lyngei, U. muehlenbergii, U. phaea, U. polyphylla, U. polyrrhiza, U. proboscidea, U. rigida, U. torrefacta, U. vellea, U. virginis, Usnea subfloridana, Verrucaria lecideoides, Vulpicida juniperinus, V. pinastri, V. tilesii, Xanthoparmelia camtschadalis* (Syn.: *Parmelia vagans*), *X. conspersa, X. taractica, X. tinctina, Xanthoria aureola, X. elegans* (Table 2).

Most of these are arcto-high mountain species (Table 3), in contrast to the middle-mountain zone, where species of the boreal, arid and nemoral elements predominate, and the low-mountain zone where lichens of the arid element mainly occur. Of these 320 species, 120 were found only in the high-mountain zone of Khangai. Two hundred species were collected in the middle-mountain

zone also and 57 in the low-mountain zone (Table 2).

In the narrowest sense, the high-mountain element contains 18 lichen species belonging to different biogeographic groups (Table 4). All of these species were recorded in the high-mountain zone of Khangai, with a few also in the middle-mountain zone. Most were found on rocks (11 species), with seven species occurring on soil and some also on plants.

Particularly noteworthy are four lichens with Asian - American disjunctions. Previously known only from America, these are recorded for Central Asia or Asia for the first time. *Pertusaria saximontana* was recorded by DIBBEN (1980) for western North America as corticolous on conifers, whereas in the Khangai, this species is found on soil and plants in the high-mountain meadows of Khan-Khukhei, Tarbagatai and other ridges. *Umbilicaria caroliniana* was known previously from western North America, Japan and East Asia, *Umbilicaria angulata* only from western North America, and *Umbilicaria phaea* from western North America and from South America (see maps of species *Umbilicaria* distribution in WEI & BIAZROV 1991).

Analogous disjunctions are also found for *Asahinea scholanderii, Cladonia cyanipes, Masonhalea richardsonii* and *Umbilicaria muehlenbergii*.

Northern-Pacific disjunctions of plants are commonly explained by three hypotheses:

(1) landbridges,
(2) a polar origin of floras, and
(3) continental drift (GALLOWAY 1996).

However, it is necessary to note that there has been no convincing evidence to confirm the existence of landbridges across the Pacific Ocean, the Atlantic Ocean and the Indian Ocean, except for the Bering Landbridge hypothesis. Therefore, other recognised disjunctions of plants as the Tropical, South Pacific or South Atlantic disjunctions can not be explained readily by the hypothesis of landbridges.

The hypothesis of the polar origin of the floras seems unacceptable because it is based on the theory of the permanence of continents and oceans.

The hypothesis of ocean floor spreading and plate tectonics was established in the beginning of 1960s. It is now accepted by most scientists in the fields of geology, geography and biogeography and is playing an increasingly important role in the explanation of the disjunction between continents. According to the present knowledge of palaeogeography, in the Miocene, about 15 million years ago, the Bering landbridge was replaced by the Bering Strait, and in the early Cretaceous period, about 135 million years ago, the southern part of South America and the southern part of Africa began to separate. Thus, the origin of the disjunctions between Mongolia and North America of *Pertusaria saximontana, Umbilicaria angulata, Umbilicaria caroliniana,*

*Umbilicaria phaea* in the North Pacific zone can be explained by the hypothesis of ocean floor spreading - plate tectonics.

Each of these three hypotheses assumes that particular species originate only in one site and then spread from their point of origin. It is possible, however, that some species, including symbiotic organisms such as lichens, have originated simultaneously in several sites, although this notion requires further analysis.

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Table 1: Zonal elements of the Khangai lichen flora

| Zonal element | Number of species | % |
|---|---|---|
| Polyzonal | 69 | 9 |
| Boreal | 161 | 22 |
| Nemoral | 99 | 13 |
| Arid | 124 | 17 |
| Arcto-highmountain | 122 | 17 |
| Mountain | 63 | 8 |
| High-mountain | 18 | 2 |
| Hypoarctomountain | 56 | 7 |
| Unassigned | 38 | 5 |
| Total | 750 | 100 |

Table 2: Number of lichen species in mountain zones of the Khangai.

| Zone | High-mountain | Middle-mountain | Low-mountain | Number of species |
|---|---|---|---|---|
| High-mountain | 120 | | | |
| Middle-mountain | 200 | 330 | | |
| Low-mountain | 57 | 45 | 45 | |
| Number of species | 320 | 575 | 147 | 750 |

Table 3: Zonal elements in the lichen flora of the Khangai high-mountain zone (more than 2200 - 2450 m asl.)

| Zonal element | Number of species | % of total in zone | % from element total number in the Khangai |
|---|---|---|---|
| Polyzonal | 42 | 13 | 61 |
| Boreal | 40 | 13 | 25 |
| Nemoral | 10 | 3 | 10 |
| Arid | 36 | 11 | 29 |
| Arcto-highmountain | 100 | 31 | 82 |
| Mountain | 29 | 9 | 46 |
| High-mountain | 18 | 6 | 100 |
| Hypoarctomountain | 31 | 10 | 55 |
| Unassigned | 14 | 4 | - |
| Total | 320 | 100 | 43 |

Table 4: Distribution types of high-mountain lichens of the Khangai

| Type of distribution | Species |
|---|---|
| Holarctic | *Cornicularia normoerica* |
| | *Immersaria athroocarpa* |
| | *Lecanora marginata* |
| | *Lobothallia melanaspis* |
| Eurasian-North American | *Catapyrenium cinereum* |
| Asian-American | *Pertusaria saximontana* |
| | *Umbilicaria angulata* |
| | *Umbilicaria caroliniana* |
| | *Umbilicaria phaea* |
| Eurasian | *Placidiopsis cervinula* |
| | *Lecidea leptoboloides* |
| | *Lecidea paratropoides* |
| Central Asian | *Acarospora frigidodeserticola* |
| | *Caloplaca hedinii* |
| Altaian-Khangaian-Tibetian | *Cetraria potaninii* |
| Altaian-Khangaian | *Evernia terrestris* |
| Himalayan-Mongolian | *Lecanora tschomolongmae* |
| East Asian-Khangaian | *Cladonia alinii* |

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