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*Scientific paper*

# Occurrence of bryophytes on Paramushir Island, northern Kuriles, Far East Russia

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***Abstract:*** Some differences in species composition between the region facing the Okhotsk Sea and Pacific Ocean on northern Paramushir Island (Ост. Парамушир, lat. 51°N, long. 157°E), northern Kuriles, in far eastern Russia, and also the vertical distribution of bryophytes in vegetation dominated by creeping pine *Pinus pumila* and dwarf heath on the flank of Mt. Ebeko are reported. In the northern Kuriles, research on vegetation was difficult due to political circumstances after World War II. The northern Kuriles occupy a very important position as the halfway point at the vegetation zone, which extends from northern Japan (Hokkaido) to the Aleutian Islands and Bering Strait. Although the northern Kuriles are situated in the lower latitudes of the subarctic zone, dwarf shrub heath and alpine tundra vegetation are distributed at relatively low altitudes on mountain slopes. Most species observed on this island are distributed in boreal or alpine tundra vegetation, owing to shortage of insolation because many cloudy days with fog and drizzle in the growing season (maritime climate) influence the plant growth condition in this area.

## 1. Introduction

Bryophytes in understory vegetation play an extremely important role in the control of the moisture change and protection of the soil surface against erosion. In addition, they contain the dominant species of the understory in shrub or dwarf heath vegetation in the northern region (Longton, 1992). Bryophytes growing in such areas are also very important plants in understanding the vegetation dynamics, *e.g.* succession after a disturbance (Longton, 1992). Ecosystems under severe environmental conditions in arctic and subarctic regions are easily modified by climatic change caused by global atmospheric warming originating in increasing human activities (Oechel and Vourlitis, 1994).

Little knowledge, however, is available about the direct or indirect influence of changes in environment on vegetation in the northern regions. Furthermore, accurate information about distributions of species and vegetation types in those regions, especially in the Far East region of Russia, is also limited. Here, we report some differences in species composition between the region facing the Okhotsk Sea and that facing the Pacific Ocean

on northern Paramushir Island, northern Kuriles, in far eastern Russia, and also report the vertical distribution of bryophytes in vegetation dominated by creeping pine *Pinus pumila* and dwarf heath on the flank of Mt. Ebeko.

## 2. Details of the study area

### *2.1. Studies of bryophyte flora in northern Kuriles*

After World War II, the northern Kuriles were closed to botanists. Even Russian botanists were restricted from entering this area for research. One bryological study of this area had been published before World War II by Horikawa (1933). Fourteen species of bryophytes were collected in this region. After World War II, a number of floristic studies on bryophytes were published in the Kurile Islands (Abramova, 1960; Vasiljeva, 1960; Bardunov and Cherdantseva, 1984; Cherdantseva and Osipov, 1998), but in the northern Kuriles there are only the two reports by Noguchi (1967) and Cherdantseva (1986). Furthermore, there is insufficient information on the ecological-phytogeographical aspects of plants in this area.

### *2.2. Study sites*

The northern Kurile area is an important intermediate point between Northern Japan (Hokkaido) and the Aleutian Islands and north-eastern Siberia facing Bering Strait. There are many young volcanoes on these islands. This is an ecologically very interesting region where the various stages of primary succession after disturbance by an eruption are observed.

Paramushir Island (Ост. Парамушир, lat. 51°N, long. 157°E, Fig. 1) is the largest of the northern Kuriles. It covers more than 2000 $km^2$ in area, with mountainous terrain, formed by glaciation and volcanism. Mountains generally reach 500–1000 m above sea level. Three active volcanoes (Ebeko, Chikurachki and Fuss Peak) and many dormant volcanoes are combined in several large mountain chains.

The Ebeko volcanic group was formed about 2400 years ago. Three volcanoes that formed recently are very active, but the amount of erupted material is relatively small. Volcanologists have counted 35 horizontal layers of volcanic tephra, including those of Alaid, Chikurachki and Fuss Peak volcanoes, in the soil profile at the foot of Mt. Ebeko (Melekestsev *et al.*, 1993). Recent eruptions were in 1934–1935, 1963–1964, 1967, 1969 and 1987–1990. Vast lava fields, of age about 2000 years, are situated on the east and west slopes of Mt. Ebeko. Other slopes are covered by older volcaniclastic material, metamorphosed by intensive and long volcanic activity (by gases and thermal water). Vast deposits of lava comprise the east foot of Mt. Ebeko, where the modern town of Severo-Kuril'sk is situated.

Chikurachki volcano is situated on the south-western part of the island. It is an active stratovolcano, formed by lava flows and pyroclastics (bombs and lapilli). A huge eruption occurred in 1853, and about 1 $km^3$ of volcaniclastic material was erupted. The pyroclastics cover the ground to a depth of 25 cm at a distance of about 25 km (Gorshkov, 1967). Taking into account the most recent data on Kamchatka (Braitseva *et al.*, 1997), it was the largest eruption of the 19th century in the Kuriles-Kamchatka region. A few eruptions have taken place in this century (1958, 1961, 1964, 1973), the latest in 1986, with 0.1 $km^3$ of volcaniclastic material (Ovsyannikov and Muravyev, 1992).

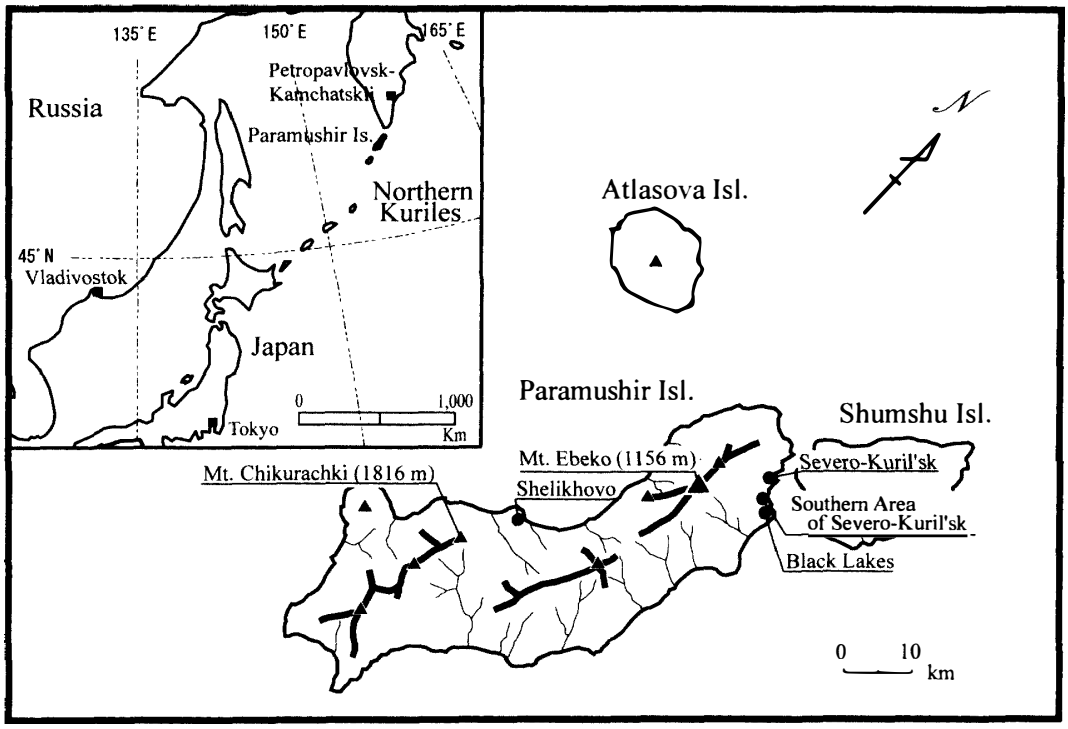


*Fig. 1. Location of Paramushir Island, northern Kuriles, and the study sites.*

The climate of the northern Kuriles is very severe, with a cold vegetation period. This condition does not allow forest to form. There is a large amount of precipitation, especially snow. Snow cover may reach a depth of 5 m on the east slope of Mt. Ebeko, and more than 20 m in deep river valleys. As a result, snow patches may persist for many years, even near sea level.

The northern Kuriles belong to the marine sector of the subarctic zone climatically (Grishin, 1995). Although the northern Kuriles are situated at lower latitude than the subarctic zone, dwarf shrub heath or alpine tundra vegetation is distributed from relatively low altitude on mountain slopes. A shortage of insolation owing to many cloudy days with fog and drizzle in the growing season influences the plant growth condition in this area (Cherdantseva, 1998). Kira's Warmth Index around the northern Kuriles is extremely low, reaching below 15℃•month (Grishin, 1995). Therefore, the predominant tree species in this region are creeping or shrub types, *e.g. Pinus pumila* and *Alnus crispa*.

The four study sites on this island were Black Lakes, southern area of Severo-Kuril'sk (expressed hereafter as Southern Area), City of Severo-Kuril'sk (expressed hereafter as City), and Shelikhovo (Fig. 1). We also set study sites on the flank of Mt. Ebeko on the northern part of this island, at altitudes from 370–650 m.

## 3. Results and discussion

### *3.1. Species composition observed on Paramushir Island*

The bryophyte compositions sampled from the four study sites are shown in Table 1.

*Table 1. Composition table of the main bryophytes on Paramushir Island.*

| | Study site / Species | Black lakes | Southern area | City | Shelikhobo | Mt. Ebeko |
|---|---|---|---|---|---|---|
| M* | *Polytrichum juniperinum* | II | I | – | I | I |
| M | *Arctoa fuluvella* | – | I | I | I | I |
| M | *Rhytidiadelphus subpinnatus* | II | I | – | – | I |
| M | *Ceratodon purpureus* | II | – | – | I | I |
| M | *Sanionia uncinata* | II | I | – | – | – |
| M | *Rhytidiadelphus calvescens* | II | II | – | – | – |
| M | *Dicranum hamulosum* | II | I | – | – | – |
| M | *Plagiomnium acutum* | II | – | – | I | – |
| M | *Brachythecium populeum* | II | – | – | – | I |
| M | *Pleurozium schreberi* | – | I | – | – | I |
| M | *Philonotis fontana* | – | I | – | II | – |
| M | *Dicranum majus* | – | I | – | I | – |
| M | *Polytrichum piliferum* | – | I | – | – | I |
| M | *Dicranoweisia crispula* | – | – | II | – | I |
| M | *Ditrichum heteromallum* | – | – | II | – | III |
| M | *Pohlia wahlenbergii* | – | – | II | I | – |
| M | *Aulacomnium palustre* | – | – | – | I | I |
| M | *Bryum* sp. | – | – | – | I | I |
| M | *Racomitrium heterostichum* | – | – | – | I | I |
| M | *Racomitrium canescens* | – | – | – | I | I |
| M | *Polytrichum formosum* | II | – | – | – | – |
| M | *Plagiothecium cavifolium* | – | I | – | – | – |
| M | *Herzogiella turfacea* | – | – | II | – | – |
| M | *Andreaea nivalis* | – | – | II | – | – |
| M | *Philonotis* sp. | – | – | II | – | – |
| M | *Pogonatum dentatum* | – | – | II | – | – |
| M | *Mnium stellare* | – | – | II | – | – |
| M | *Amblystegium juratzkanum* | – | – | II | – | – |
| M | *Dicranum viride* | – | – | II | – | – |
| M | *Cyrtomnium hymenophyllum* | – | – | – | I | – |
| M | *Dicranum fuscescens* | – | – | – | I | – |
| M | *Amblystegium varium* | – | – | – | I | – |
| M | *Amblystegium serpens* | – | – | – | I | – |
| M | *Calliergon cordifolium* | – | – | – | I | – |
| M | *Calliergon richardsonii* | – | – | – | I | – |
| M | *Bryum schlecheri* | – | – | – | I | – |
| M | *Funaria hygrometrica* | – | – | – | I | – |
| H** | *Diplophyllium* sp. | – | – | – | I | – |
| M | *Grimmia olympica* | – | – | – | – | IV |
| M | *Kiaeria starkei* | – | – | – | – | II |
| M | *Kiaeria falcata* | – | – | – | – | I |
| M | *Pohlia nutans* | – | – | – | – | I |
| M | *Oligotrichum aligerum* | – | – | – | – | I |
| M | *Pogonatum urnigerum* | – | – | – | – | I |
| M | *Pogonatum sphaerothecium* | – | – | – | – | I |
| M | *Polytrichastrum alpinum* | – | – | – | – | I |
| M | *Polytrichum norvegicum* | – | – | – | – | I |
| M | *Cratoneurella uncinifolia* | – | – | – | – | I |
| M | *Atrichum* sp. | – | – | – | – | I |
| M | *Fissidens* sp. | – | – | – | – | I |
| M | *Orthotrichum* sp. | – | – | – | – | I |
| M | *Pohlia* sp. | – | – | – | – | I |
| H | *Jungermannia* sp. | – | – | – | – | I |
| M | *Dicranum* sp. | – | – | – | – | I |

Roman numerals show frequency: V, 100–80%; IV, 80–60%; III, 60–40%; II, 40–20%; I, 20–1%.
*: M, Moss.
**: H, Hepatics.

The bryophyte nomenclature follows Ignatov and Afonina (1992). Most species observed on this island are distributed in boreal or alpine tundra vegetation (Cherdantseva and Osipov, 1998; Czernyadjeva, 1995). Half of the species reported by Horikawa (1933) were found on Paramushir Island in this research. *Rhitidiadelphus calvescens* and *Sanionia uncinata* were characteristics species in both the Black Lakes and Southern Area. The bryophyte flora in both sites was very similar, because both sites are closely situated. The bryophyte composition in City, however, was considerably different, although City was adjacent to the other two sites. Artificial environmental factors may influence the distribution of bryophytes. The bryophyte flora in Shelikhobo and Mt. Ebeko was also similar to each other. As Shelikhobo is situated on the northern side of Mt. Chikurachki, this area is affected by volcanic activity. Therefore, the bryophyte species composition is similar that on Mt. Ebeko. Species which were distributed only either Shelikhobo or Mt. Ebeko were also observed. In Shelikhobo facing the Okhotsk Sea (Fig. 1), we found some species distributed mainly in wet conditions. These species could not be found on Mt. Ebeko. Mt. Ebeko is a volcano, so species growing on volcanic soil or rocks are observed, *e.g. Grimmia olympica, Kiaeria starkei, etc.*

The northern Kuriles occupies a very important position as the halfway point of the vegetation zone, which occupies the chain of the volcanic islands connecting the Aleutian Islands and Bering Strait from Hokkaido. Most species observed on Paramushir Island have a wide distribution range from Kamchatka peninsula (Cherdantseva and Osipov, 1998; Czernyadjeva, 1995) to Hokkaido (Iwatsuki and Inoue, 1972).

*Table 2. Vertical distribution of bryophytes on the flank of MT. Ebeko*

| Species | Altitude (m) | 250 | 300 | 370 | 400 | 450 | 500 | 550 | 620 |
|---|---|---|---|---|---|---|---|---|---|
| M | *Grimmia olympica* | | | | | | | | |
| M | *Kiaeria starkei* | | | | | | | | |
| M | *Ditrichum heteromallum* | | | | | | | | |
| M | *Racomitrium fasciculare* | | | | | | | | |
| M | *Kiaeria falcata* | | | | | | | | |
| M | *Pohlia nutans* | | | | | | | | |
| M | *Racomitrium heterostichum* | | | | | | | | |
| M | *Polytrichum juniperinum* | | | | | | | | |
| M | *Dicranum scoparium* | | | | | | | | |
| M | *Arctoa fuluvella* | | | | | | | | |
| H | *Jungermannia* sp. | | | | | | | | |
| H | *Hepaticae* sp. | | | | | | | | |
| M | *Cratoneurella uncinifolia* | | | | | | | | |
| M | *Pogonatum sphaerothecium* | | | | | | | | |
| M | *Polytrichum norvegicum* | | | | | | | | |
| M | *Polytrichum piriferum* | | | | | | | | |
| M | *Atrichum* sp. | | | | | | | | |
| M | *Fissidens* sp. | | | | | | | | |
| M | *Oligotrichum aligerum* | | | | | | | | |
| M | *Orthotrichum* sp. | | | | | | | | |
| M | *Pogonatum urnigerum* | | | | | | | | |

Solid lines show frequent distribution and dotted lines show rare distribution of each species with altitude.

*3.2. Vertical distribution of bryophytes on Mt. Ebeko*

Mt. Ebeko is situated on the northern part of Paramushir Island (Fig. 1). *Pinus pumila* is the predominant tree species, with *Empetrum nigrum* and *Rhododendron aureum* on the flank of Mt. Ebeko. There are many windy sites on the slopes. Dwarf shrub heath vegetation is found at alt. 400 m asl. *Grimmia olympica*, *Kiaeria starkei* and *K. falcata* with scrub *Pinus pumila* were observed in volcanic substrata.

The distribution of the main bryophyte species from alt. 370 to 650 m on the flank of Mt. Ebeko is shown in Table 2. Dwarf shrub heath and alpine tundra develop at all of these elevations. The distribution of most bryophyte species is restricted to certain elevations, except for a few species adapted to quite unstable and oligotrophic conditions, *e.g.* *Grimmia olympica*, *Kiaeria starkei* and *Ditrichum heteromallum*.

Generally, high-alpine and arctic ecosystems are mostly oligotrophic. Indigenous plants demonstrate strategies based on resource uptake and efficiency of resource usage rather than resource availability (Shaver and Chapin, 1980). Similar environmental condition can be found when snow melt streams flow onto landslide scar on volcanic lands. Many young volcanoes sprinkled over the northern Kurile Islands, and the ground surface on flanks of mountains, show quite unstable and oligotrophic conditions because of accumulation of volcanic ash and gravel. Mt. Ebeko has also such a ground condition produced by the volcanic materials, so the bryophyte composition is represented by distinctive species (such as *Grimmia olympica* or *Kiaeria starkei*), especially on flanks at higher altitude.

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