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Scientific paper

Ecological notes on the heath community on Mt. Ebeko, Paramushir Island, northern Kuriles

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Abstract: Although the northern Kuriles provide ecologically interesting issues on plant communities owing to their phytogeographical position between Hokkaido with its rich flora and Kamchatka with its poor flora, and to repeated volcanism of the islands, ecological studies of the plant communities in this area still remain insufficient. In 1997 we had an opportunity to visit the east slope of Mt. Ebeko, Paramushir Island, northern Kuriles. This paper documents the vertical distribution of the heath community on the east slope of the mountain at altitudes between 30 m to 650 m. Ecological characteristics of the community are discussed with reference to the effects of volcanic activities of the mountain. The dominant plants of the community were dwarf shrubs, forming a treeless heath community that covers the whole east slope. They included *Calamagrostis purpurascens*, *Loiseleuria procumbens*, *Empetrum nigrum* and *Arcterica nana*, forming a heath community in species composition and physiognomy. The heath community of Mt. Ebeko developed under a highly oceanic climate. Plots at lower altitudes consist of a higher number of species including lots uncommon species appearing only at lower altitudes and more common species, while the plots at higher altitudes consisted of a smaller number of species, with only common species. Such decrease of the number of species per plot toward higher altitude might be due to the effect of repeated volcanic activity of Mt. Ebeko. The treeless dwarf shrub vegetation of Mt. Ebeko resembles the wind exposed dwarf scrubs on Mt. Taisetsu, Hokkaido in dominant species and physiognomy.

1. Introduction

The northern Kuriles include the major Islands Alaid, Shumshu, Paramushir and Onekotan, corresponding floristically to the Northern Kurile Region *sensu* Barkalov (1998, 2000). Floristically they are located between the rich Japanese floral region and the comparatively poor Kamchatka floral region (Hultên, 1933). Climatically they belong to a highly oceanic sector of the subarctic zone, having a few climatic relevant areas in the Northern Hemisphere (Tuhkanen, 1984). Additionally, three major islands, Alaid, Paramushir and Onekotan, have active volcanoes. The plant communities of the islands are expected to show interesting ecological characteristics related to volcanic activities as well as their floristic position and highly oceanic climate.

However, after World War II the northern Kuriles were closed to Japanese botanists. Botanical studies by Russian botanists in the area after World War II are also not abundant (*cf*. Takahashi, 1996). Formerly Kudo (1922) provided an overview of the plant communities and an enumeration of the plants of Paramushir Island. Tatewaki (1934) reported on the flora of the northern Kuriles, and he further noted (Tatewaki, 1944) the dominant species and the distribution of major plant communities of Paramushir and Shumshu Islands. Tatewaki (1957) completed the description of floristic composition and distribution of plants on the Kurile Islands, reviewing the botanical studies before World War II. After World War II Russian botanists started botanical studies on the Kurile Islands (Vorobiev, 1956, 1963; Chernyaeva, 1976). Recently Barkalov (1980, 1981, 1984, 1998, 2000) intensively revealed the flora of the northern Kuriles. Japanese botanists have also recently published notes on the plants of the northern Kuriles (Takahashi and Kuwahara, 1998; Okitsu, 1999, 2000). However, despite these studies, ecological studies of the plant communities in this area remain insufficient.

In 1997 we had an opportunity to visit Paramushir Island, northern Kuriles, and conducted a field survey on the distribution of the plants on the east slope of Mt. Ebeko. This paper records the heath community on the east slope of Mt. Ebeko, Paramushir Island, and notes some ecological characteristics of the community with reference to the volcanic activities of the mountain.

Nomenclature follows Voroshilov (1982).

2. Study area

2.1. Location and physiography

The field survey was conducted on the east slope of Mt. Ebeko, Paramushir Island, northern Kuriles.

The Kurile Islands form a chain of volcanic islands connecting easternmost Hokkaido and the southernmost point of Kamchatka in a northeasterly direction, from 43°36′ to 50°57′N, and 145°24′ to 156°35′E. The Kurile Islands separate the Sea of Okhotsk from the Pacific Ocean (Fig. 1, right).

Paramushir Island is in the northernmost group of the Kurile Islands, *ca*. 70 km southwest of the southernmost point of Kamchatka (Fig. 1, right), with two more islands close to it, Shumshu to the northeast and Alaid to the northwest. Paramushir Island consists of two volcanic chains running north to south with altitudes around 900 and 1500 m at the mountain tops. The highest point of the island is 1816 m in altitude (Mt. Chikura) at the northern end of the southern volcanic chain (Fig. 1, left).

Mt. Ebeko (1136 m altitude) is located in the northern part of the volcanic chains of Paramushir Island, situated 10 km southwest of Severo-Kuril'sk city (Fig. 1, left). This mountain is an active volcano, which has erupted repeatedly recently (Menailov, 1992). Lava flows and ash deposits cover the east slope of the mountain, forming a monotonous topography gentle and smooth with an inclination of 10–15°.

2.2. Climate

Tatewaki (1957) provided reliable climatic data on Paramushir Island (data from

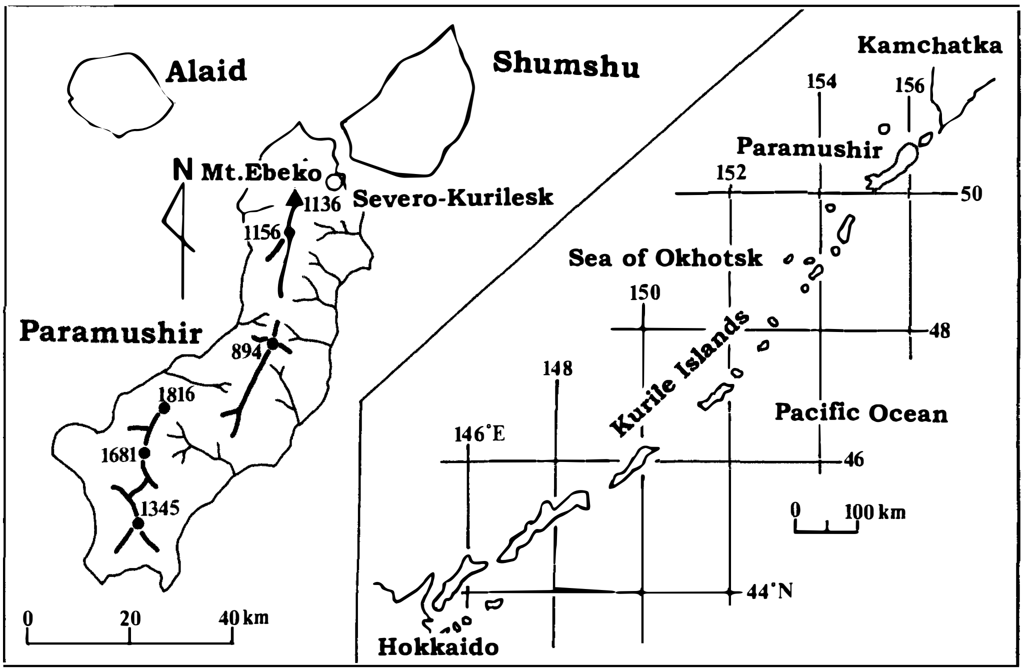

Fig. 1. Location of the Kurile Islands between easternmost Hokkaido and the southernmost point of Kamchatka, and that of Paramushir Island (right). Location of Mt. Ebeko on Paramushir Island (left). The figures on Paramushir Island show altitudes (m a.s.l.) at mountain tops.

Suribachi meteorological station, southeast coast of the island, 50°11′N and 155°45′E, 11 m altitude, 1936–1940). Annual mean temperature on the island is 2.3℃, the mean temperature of the warmest month (August) 11.0℃, and that of the coldest month (January) −4.6℃. The Warmth Index (WI: a summation of mean monthly temperatures more than 5℃: Kira (1949), *cf.* Hämet-Ahti *et al.* (1974)) comes to 16.9℃•month. Annual mean relative humidity is 84.8% with very small fluctuations during the year, and mean annual precipitation amounts to 1376 mm. Those two climatic parameters indicate a very humid climate. Paramushir Island experiences a highly oceanic climate, as Tuhkanen (1984) pointed out, having very few climatically relevant regions in the Northern Hemisphere (Tuhkanen, 1984).

2.3. Vegetation

Three major altitudinal vegetation belts occupy the east slope of Mt. Ebeko: a belt from the lowermost part of the slope to altitude 350 m, altitudes between 350 m to 650 m, and from 650 m upward.

In the lowermost belt up to the altitude 350 m, *Alnus crispa* (Ait.) Pursh (=*A. maximowiczii* Call.) thickets dominate (Kudo, 1922). *Pinus pumila* (Pall.) Regel thickets cover less area mixed with *Alnus crispa* thickets as a subordinate element (Tatewaki, 1944). This belt is characterized by the *Alnus crispa* thickets. The most prominent feature of the vegetation not only of this belt but also of Paramushir Island on the whole is principally the lack of forests such as *Betula ermanii* Cham., *Picea jezoensis* (Sieb. et Zucc.) Carr. and

Larix gmelinii (Rupr.) Rupr. (Kudo, 1922; Tatewaki, 1957). Only *Salix udensis* Trautv. et Mey. (= *S. sachalinensis* Fr. Schmidt) forms small patches of forests along streams, reaching the height of *ca.* 10 m (Kudo, 1922; Tatewaki, 1944, 1957). In this zone the heath community occurs only sporadically on exposed slopes among *Alnus crispa* and *Pinus pumila* thickets.

In the belt from 350 m to 650 m altitude, dwarf shrubs and herbaceous plants prevail, forming a heath community belt. The dominant plants include *Calamagrostis purpurascens* R.Br., *Loiseleuria procumbens* (L.) Desv., *Empetrum nigrum* L. *sensu lato* and *Arcterica nana* (Maxim.) Makino.

In the uppermost belt from 650 m upward, the vegetation become scarce with sporadic occurrence of *Saxifraga merkii* Fisch, *Luzula arcuata* (Wahl.) Sw. and *Calamagrostis purpurascens* R. Br. owing probably to present volcanic activity.

3. Methods

The field survey was concentrated on the east slope of Mt. Ebeko from the lower part of the slope at 30 m altitude up to 650 m altitude; on the slope from 650 m upward vegetation cover becomes very scarce. Heath community dwarf shrubs and herbaceous plants were exclusively surveyed, because they occupy the widest altitudinal range on the slope covering altitudes from 30 m to 650 m, dominating the physiognomy of the slope.

In all 107 lie on the slope at altitudes from 30 to 650 m. Micro-topographically the plots were located on the straight, flat slopes, having similar conditions. The plot size was generally 2×2 m^2. In each plot, the species which occurred were recorded.

4. Results and discussion

4.1. Plant occurrence and ecological characteristics of the community

The total number of species in the area surveyed was 58 (Table 1). Thirteen of 58 species (22%) occur with relatively high frequency of more than 40% (43 plots); *Calamagrostis purpurascens*, *Loiseleuria procumbens*, *Empetrum nigrum*, *Arcterica nana*, *Geum calthifolium*, *Salix arctica*, *Cnidium ajanense*, *Phyllodoce aleutica* and *Cassiope lycopodioides*, *Solidago decurrens*, *Rhododendron aureum*, *Rhododendron camtschaticum* and *Agrostis flaccida*. These species can be regarded as common species. In contrast, 38 of 58 species (66%) occurred sporadically with low frequency of less than 10%. The species composition of the plant community on the east slope of Mt. Ebeko consists of a small number (13 of 58) of common species associated with many sporadic ones.

The common thirteen species of the community include eight dwarf shrubs and five herbaceous plants. Physiognomically the dwarf shrubs dominated all over the plots surveyed. The plant community of the study area can be regarded as a heath community represented primarily by dwarf shrubs in terms of the species composition and physiognomy. This heath community is essentially treeless. Kudo (1922) and Tatewaki (1957, 1958) pointed out that heath is the most important type of community in the central and northern Kuriles. Tuhkanen (1984) also considered the treeless heath in this area to be the representative vegetation of the highly oceanic sector of northern and middle boreal subzone of eastern Eurasia including the Kurile Islands. Thus the dwarf shrub community or heath

Table 1. *Frequency occurrence (%) of plant species in four different altitudinal ranges on the east slope of Mt. Ebeko, Paramushir Island, northern Kuriles.*

Altitudinal range (m)	0-399	400-499	500-599	600-650	Total
Number of plots	21	24	42	20	107
Total number of species	50	27	26	20	58
Mean number of species per plot	12.4	10.5	9.2	8.4	10.0
Calamagrostis purpurascens R. Br.	38	100	76	80	75
Loiseleuria procumbens (L.) Desv.	57	96	67	75	73
Empetrum nigrum L.	48	92	71	70	71
Arcterica nana (Maxim.) Makino	38	79	62	75	64
Geum calthifolium Menz.	48	54	57	85	60
Salix arctica Pall.	43	33	79	40	54
Cnidium ajanense (Regel et Til.) Drude	43	58	57	50	53
Phyllodoce aleutica (Spreng.) Heller	62	42	55	35	50
Cassiope lycopodioides (Pall.) D. Don	19	38	57	80	50
Solidago decurrens Lour.	71	42	57	15	49
Rhododendron aureum Georgi	38	54	50	30	45
Rhododendron camtschaticum Pall.	52	50	50	20	45
Agrostis flaccida Hack.	67	29	43	25	41
Carex koraginensis Meinsh.	14	33	21	65	31
Oxytropis revoluta Ledeb.	29	71	19	–	29
Vaccinium uliginosum L.	48	50	7	–	23
Saussurea riederi Herd.	10	38	21	15	22
Pedicularis chamissonis Stev.	48	17	–	–	13
Deschampsia flexuosa (L.) Nees	–	17	19	–	11
Spiraea betulifolia Pall.	24	4	–	25	10
Geranium erianthum DC.	29	17	–	–	9
Cassiope stelleriana (Pall.) DC.	–	–	21	5	9
Calamagrostis purpurea (Trin.) Trin.	38	8	–	–	9
Geum pentapetalum (L.) Makino	33	4	–	–	8
Anaphalis margaritacea (L.) Clarke	33	–	–	–	7
Viola biflora L.	29	–	2	–	7
Penstemon frutescens Lamb.	5	4	–	20	6
Maianthemum kamtschaticum (Cham.) Nakai	24	4	–	–	6
Cirsium kamtschaticum Ledeb. ex DC.	19	4	–	–	5
Vaccinium vitis-idaea L.	19	–	–	–	4
Sibbaldia procumbens L.	19	–	–	–	4
Rubus arcticus L.	19	–	–	–	4
Aruncus dioicus (Walt.) Fern.	19	–	–	–	4
Trisetum spicatum (L.) K. Richt	–	–	7	5	4
Lycopodium alpinum L.	5	13	–	–	4
Rumex acetosella L.	19	–	–	–	4
Pedicularis verticillata L.	14	–	–	–	3
Trientalis europaea L.	10	–	2	–	3
Veronica stelleri Pall. ex Link	14	–	–	–	3
Bryanthus gmelinii D. Don	–	–	–	15	3
Cerastium fischerianum Ser.	14	–	–	–	3
Primula cuneifolia Ledeb.	–	–	7	–	3
Fritilaria camtschatcensis (L.) Ker-Gawl.	5	–	2	–	2
Sorbus sambucifolia (Cham. et Schlecht) M. Roem	10	–	–	–	2
Artemisia unalaskensis Rydb.	10	–	–	–	2
Luzula oligantha Sam.	10	–	–	–	2
Senecio cannabifolius Less.	10	–	–	–	2
Juncus beringensis Buchenau	–	–	5	–	2
Lonicera caerulea L.	5	–	–	–	1
Swertia tetrapetala Pall.	5	–	–	–	1
Veratrum oxysepalum Turcz.	5	–	–	–	1
Picris hieracioides L.	5	–	–	–	1
Rosa rugosa Thunb.	5	–	–	–	1
Ixeris dentata (Thunb.) Nakai	5	–	–	–	1
Saxifraga sachalinensis Fr. Schmidt	–	–	2	–	1
Saxifraga merckii Fisch.	–	–	–	5	1
Deschampsia caespitosa (L.) Beauv.	5	–	–	–	1
Viola langsdorffii Fisch. ex Ging	5	–	–	–	1

community of Mt. Ebeko corresponds well with the treeless heaths described by Tatewaki (1958) and Tuhkanen (1984).

Hämet-Ahti and Ahti (1969) stated that the occurrence of treeless boreal heaths is closely related to the distribution of alder forests, and that the lowlands of Iceland, the Aleutian Islands and the Kurile Islands are referred to as boreal heath sections rather than to the arctic. Hämet-Ahti (1981) additionally stressed that treeless heaths occur exclusively along the most oceanic coastal areas of the boreal zone. The heath community of Mt. Ebeko is a type of plant community related to a highly oceanic climate in the northern boreal subzone.

4.2. Vertical distribution of plants and the effect of volcanism on it

The total number of species in an altitudinal range decreased from lower to higher altitude, from 50 to 20 (Table 1). The mean number of species per plot in each altitudinal range also decreased from lower to higher altitude, from 12.4 to 8.4 (Table 1). The thirteen common species showed no clear altitudinal dependence. The higher number of species (*e.g. Oxtropis revolta*, *Vaccinium uliginosum* and *Pedicularis chammisonis*) per plot at lower altitude consisted of many sporadic species appearing only at lower altitude as well as the common species (Table 1). The plots in the lowest altitudinal range contained many sporadic species with frequency less than 10%. The species at higher altitude were almost entirely common species.

The decreasing number of species toward higher altitude can be partly explained by the effect of repeated volcanism. The community at higher altitudes remains at an earlier stage of succession. The relatively low number of species (58) and the scarce vegetation cover on upper slopes (650 m upward) supports this hypothesis.

Okitsu (1987) pointed out that on active volcanoes of Hokkaido, timberline is lower than on dormant volcanoes and non-volcanic mountains, and that *Pinus pumila* thickets and associated dwarf shrub community occupy non-forested areas on such mountains. This finding can explain the effect of volcanic activity of Mt. Ebeko on the decreasing number of species toward higher altitude.

Another issue relating to the effect of volcanic activity on a plant community is admixture of species in different habitats. The heath community on Mt. Ebeko contains species in different habitats; species on wind-exposed slopes are *Calamagrostis purpurascens*, *Loiseleuria procumbens*, *Arctoerica nana*, *Salix arctica* and *Cassiope lycopodioides*, while those in snow bed habitats are *Geum calthifolium*, *Cindium ajanense*, *Phyllodoce aleutica* and *Solidago decurrens*. There is no clear species segregation at high altitude, suggesting that repeated volcanism effectively aborts any development of habitat segregation. The plots at lowermost altitudes contain many species which only occur there. Examples are *Vaccinium vitis-idaea*, *Sibbaldia procumbens*, *Rubus arctics*, *Rumex acetosella*, *Pedicularis verticillata*. This species occurrence suggests less frequent effect of volcanism on the lower part of the mountain.

The insufficiency of time for maturation of the heath community causes some species to occur only sporadically with no clear altitudinal tendency. Examples of such species include *Spiraea betulifolia*, *Cassiope stelleriana*, *Penstemon frutescens*, *Lycopodium alpinum* and *Bryanthus gmelinii*. Those species appeared at higher altitude rather than lower altitude.

4.3. Comparison between wind exposed dwarf shrubs on Mt. Taisetsu and the heath community on Mt. Ebeko

On top of Mt. Taisetsu, central Hokkaido, Japan, treeless vegetation similar to that on Mt. Ebeko, wind exposed dwarf shrubs (Okitsu, 1987, 1999), appears. It is ecologically worthwhile to compare them.

The dominant species among wind exposed dwarf shrubs on Mt. Taisetsu are *Diapensia ovobata* (Fr. Schmidt) Nakai, *Arctous alpina* (L.) Niedz., *Loiseleuria procumbens*, *Empetrum nigrum*, *Arcterica nana*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum* and *Rhododendron aureum* (Okitsu, 1999). Five of those eight species (except *Diapensia ovobata*, *Arctous alpina* and *Vaccinium vitis-idaea*) are also the dominant species of the dwarf shrub vegetation on Mt. Ebeko (Table 1). This indicates that the wind exposed dwarf shrub vegetation on Mt. Ebeko is similar to that on Mt. Taisetsu. Floristically, only six of 58 species listed in Table 1 are absent from Mt. Taisetsu; *Salix arctica*, *Solidago decurrens*, *Carex koraginensis*, *Oxytropis revolta* and *Artemisia unalaskensis* (*cf.* Tatewaki and Samejima, 1959). This floristic comparison also supports the similarity between the heath community on Mt. Ebeko and wind exposed shrubs on Mt. Taisetsu.

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