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Alpine Belts and differentiation of Alpine Vegetation in Japanese Alps

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Abstract

Japanese archipelago is located in the middle latitudes, and true alpine vegetation occurs on the tops of the mountains above 2900 m a.s.l. The origin of Japanese alpine vegetation is connected with the migrations of plants from the north during several glacial periods of the Pleistocene. Modern alpine vegetation is isolated in Japanese archipelago from the main extensive range in northern Asia to high mountains. Some important characteristic species of alpine tundra communities, such as *Saxifraga cernua, Carex rupestris*, have their southern limit in central Japan. The alpine vegetation in Japan is assigned to Loiseleurio-Vaccinietea region and represented by classes Asplenietea rupestria Br.-Bl. 1934, Dicentro-Stellarietea nipponicae Ohba 1969, Carici rupestris-Kobresietea bellardii Ohba 1974, Loiseleurio-Vaccinietea Eggler 1952 and Phyllodoco-Harrimanelletea Knapp 1954.

1. Introduction

The Japanese alpine vegetation is formed under the influence of oceanic climate. The westerly troposphere air jet stream of the middle latitudes forms the winds affecting mainly Japan Sea side of Japanese archipelago and causing much winter precipitation in this area.

The timber line in the montane belt of Fagetea crenatae and Vaccinio-Piceetea regions is represented by fragmental forests in combination with *Sasa*-meadow, *Moliniopsis japonicus* wet meadow and tall forbs that gradually changed to tundra-like communities. This vegetation complex forms the so called pseudo-alpine belt.

A climatic alpine belt is generally developed above 2900 m a.s.l. in Central Honshu and on the highest peak of Japan, the mountain Fuji (3776 m). Most of the Japanese high mountains are composed of Quaternary volcanos, which are covered by species poor (with an exception of Dicentro-Stellarietea nipponicae) alpine vegetation. The species rich and ecologically diverse alpine vegetation occurs mainly on sediment limestone, serpentine basic and ultra basic rocks in the mountains Kitadake (3193 m) in South Alps and Mt. Shiroumadake (2932 m) and Mt. Yukikuradake (2611 m) in North Alps. Mt. Hayachine in Tohoku, Mt. Yubari (1668 m) and Mt. Apoi (810.5 m) in Hokkaido represent another type of rocks and are composed of peridotite.

2. Study area

The alpine vegetation in Japan occurs on the highest mountain peaks of Hokkaido and Honshu. The altitudinal position of the lower boundary of alpine belt varies from 2900 m a.s.l. in central Honshu to approximately 2000 m a.s.l. in Hokkaido. Below these elevations, alpine-like communities can be found on wind exposed and volcanic and sedimentary basic and ultrabasic rock habitats. Southern limit of alpine vegetation is Mt. Tekari (2591 m), 35°20′17″N, 138°05′02″E, where tundra communities include *Carex rupestris*. The northernmost Japanese alpine vegetation is recorded in Rebun Island near Hokkaido, 45°26′N, 141°2′E. The easternmost location is Taisetsu Mt. (2291 m; 43°39′49″N, 142°51′15″) in Hokkaido and the westernmost alpine tundra communities are found on the Mt. Ontake (3063 m; 35°53′34″N, 137°28′49″E) in Chubu prefecture (Fig. 1).

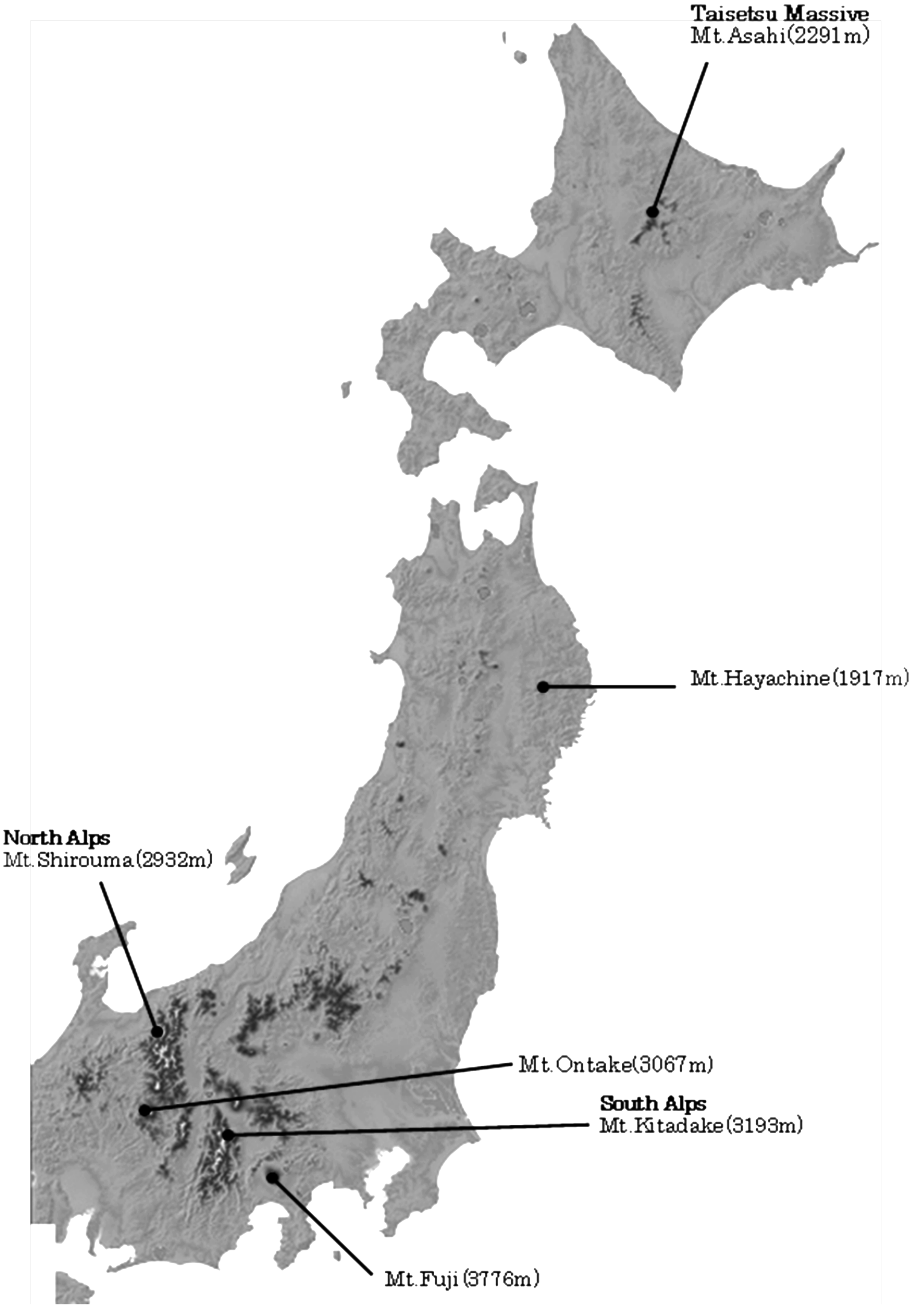

Fig. 1: Location of high mountains in central and northern Japan

The climatic condition of alpine belt in Japan is characterized by low temperatures (mean temperature of warmest month is less than 10˚C, Kira's warmth index is from 0 to 15 ˚C). The measurements made on Mt. Norikuradake (2800 m a.s.l.) showed the mean temperature of the warmest month varying between 10 and 12.2˚C, and those of the coldest month between -14.9 and -16.0˚C (SUZUKI 2009).

Annual precipitation of high mountains in Japan exceeds 2000 mm, in some areas reaching more than 3000 mm. Winter precipitation is clearly higher in Japan Sea side of Japanese Archipelago. Snow cover here in average exceeds the depth of 100 cm, while the extremes of more than 600 cm are recorded in some heavy snow areas. The extensive over-summer snow patches and frequent snow avalanches in winter and early spring seasons cause a wide distribution of snow patch vegetation communities in this region. On the Pacific side of Japan the winters are not so snowy, however the summer precipitation is much higher because of typhoons.

3. Method

Classification and hierarchy of Japanese alpine vegetation are thoroughly discussed by OHBA (1967, 1968, 1969, 1974), SUZUKI (1964), NAKAMURA (1986, 1987, 1999). Some phytosociological studies of montane tundra communities were performed in adjacent regions of the Russian Far East. NAKAMURA & KRESTOV (2007) surveyed the alpine vegetation of Northeast Asia. This study intends to show the geographical character of Japanese alpine vegetation using tools of vegetation classification and environmental differentiation.

4. Results

4.1 Definition of Japanese Alpine Vegetation

Japanese understanding of a timber line is based on physiognomic approach and assumes the presence of tree and forest limits. This means that the lower boundary of the alpine belt lies between the Picea-Abies forest and dwarf pine shrub. However European dwarf pine, *Pinus mugo*, forms shrub communities in the subalpine belt which belong to Vaccinio-Piceion, Vaccinio-Piceetea (ELLENBERG 1978). In Siberia, the *Pinus pumila* communities occur in the boreal and subarctic zones, but not in the polar zone. Therefore, the Japanese dwarf pine thickets should belong to the subalpine belt and not to the alpine belt.

Japanese alpine vegetation is composed of dwarf shrub species belonging to genera *Arctous*, *Arcterica*, *Empetrum*, *Loiseleuria*, *Phyllodoce*, *Diapensia*. On the wind exposed sites it is represented by alpine meadows dominated by *Pedicularis*, *Dryas*, *Oxytropis*, *Astragalus*, *Lloydia*, *Carex*, *Kobresia*. On dry sites half dessert communities with abundant *Arenaria*, *Minuartia*, *Stellaria*, *Cerastium*, *Draba*, *Arabis*, *Lagotis*, *Penstemon* and *Viola* are widespread. The snow patch communities are dominated by species of *Phyllodoce*, *Harrimanella*, *Fauria* and *Primula*.

4.2 Speciality of Japanese alpine vegetation

The species pool of Japanese alpine vegetation comprises the northern elements - mostly circumpolar, Pacific Ocean and Northeast Asian species, which entered Japan from the continent in different periods of the ice age (Fig. 2). The migration routes were connecting Hokkaido with Siberia through Sakhalin and Kamchatka and with North America through Kuril and Aleutian Island Arcs. Typical species of Siberian origin are *Lagotis glauca*, *Viola crassa*, *Pulsatilla nipponica*, *Stellaria ruscifolia*, *Saxifraga merckii*. Typical species of northern Pacific origin are *Phyllodoce aleutica*, *Harrimanella stelleriana*, *Fauria crista-galli*, *Primula*

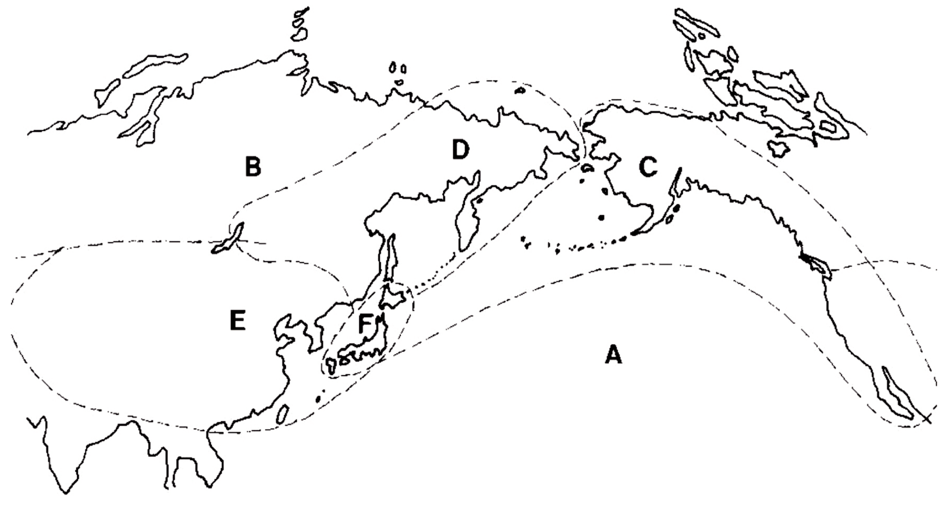

Fig. 2: Distribution of phytogeographic elements of Japanese alpine flora (SHIMIZU 1982, 1983, simplified). A–Panarctic element; B–Circumpolar element; C–Pacific element; D–Northeast Asian element; E–East Asian element; F–Japanese endemic element; G–Lower montane element

cuneifolia (HULTÉN 1968). The phytogeographical analysis shows that alpine half desert communities are composed of mainly Siberian species and snow patch comminities of Northern Pacifica species. However most of the species composition of communities in alpine belt are represented by circumpolar elements that include *Dryas octopetala* var. *asiatica*, *Lloydia serotina*, *Pedicularis verticillata*, *Gentiana algida*, *Vaccinium uliginosum*, *Empetrum nigrum*, *Loiseleuria procumbens*. Some species are widely distributed in Hokkaido and have limited modern distribution in Honshu, (*Oxytropis nigrescens* and its variety *japonica*, *Arenaria arctica* and its variety *hondoensis*), likely, entered in Honshu before Pleistocene Maximum and further were isolated.

The flora of alpine belt is composed of seven geographical elements:

A: Panarctic element: includes species distributed widely in arctic and alpine regions.
B: Circumpolar element: species distributed widely in high latitudes of the Northern Hemisphere.
C: Pacific element: species distributed around the northern Pacific Ocean.
D: Northeast Asian element: species distributed in Kamtchatka, Sakhalin and northeast Asia.
E: East Asian element: species distributed in Japan, Korea and Eastern China.
F: Japanese endemic element: species restricted to Japan.
G: Lower montane element: species distributed in lower montane areas of Japan and eastern China.

Species combination of plant communities shows the spectrum of geographical elements of the community.

The element values were calculated from the syntaxonomical summarized table and total species number of phytogeographical elements were used for analysis:

Element Value= (presence value P × number of species with constancy degree S), (P=0.1, 0.5, 1, 2, 3, 4, 5, S=r, +, I, II, III, IV, V, if S is +, then P is 0.5).

Figure 3 shows the spectrum of geographic elements of typical alpine vegetation. Most of the flora is represented by the northern elements. In contrast, subalpine vegetation belonging

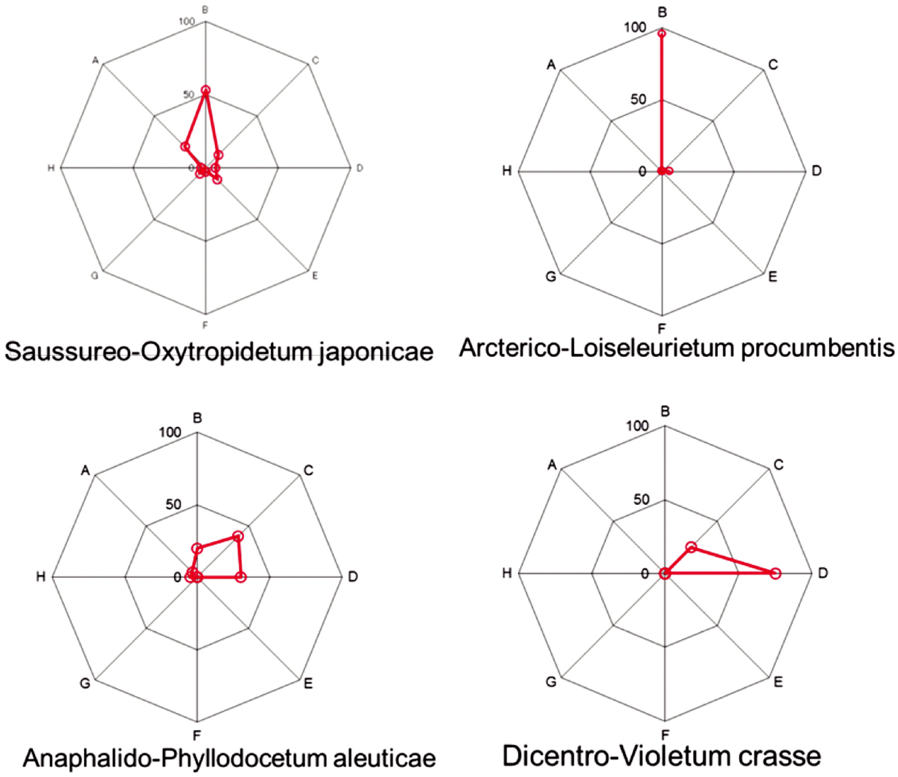

Fig. 3: Spectra of phytogeographic elements in different community types (NAKAMURA 1987). Abbreviations of elements as in Fig. 2

to Betulo-Ranunculetea acris-japonici and Vaccinio-Piceetea is characterized by Japanese endemic or lower montane elements. The Saussureo-Oxytropidetum japonicae communities occur on the wind exposed face of high mountains of Central Honshu above 3000 m a.s.l. and are composed of species belonging to circumpolar, Northeastern and Pacific Ocean elements. The Dicentro-Violetum crassae communities of Dicentro-Stellarietea nipponicae occur on the structural soils and rhyolite collapse of North Alps and are characterized by northeastern elements. In contrast, the Anaphalido-Phyllodocetum aleuticae communities of Phyllodoco-Harrimanelletea occur near the snow patches under the influence of oceanic climatic conditions and are characterized by Pacific Ocean elements. The Arcterico-Loiseleurietum procumbentis communities of Loiseleurio-Vaccinietea represent the climatic climax vegetation of alpine belt and are characterized by pure circumpolar elements.

Ultrabasic rocks, such as peridotite and serpentine, are one of the unique habitats for alpine vegetation. The Arenarion katoanae communities of Dicentro-Stellarietea nipponicae and the Leontopodion hayachinensis communities of Carici-Kobresietea bellardii are characteristic of the alpine belts of Mt. Yubaridake (1668 m), Mt. Apoidake (810 m) in Hokkaido, Mt. Hayachine (1917 m) in Tohoku, Mt. Shibutsu (2228 m) in Kanto and Mt. Yukikuradake (2611 m) in Chubu. Plant communities include relic and endemic species. Limestone outcrops provide a unique habitat for alpine vegetation, supporting the development of chasmophyte plant communities belonging to the class Asplenietea rupestria on Mt. Kitadake (3193 m) and Mt. Yarigatake (2903 m).

Most of the Japanese high mountains, such as Taisetsu Massive (2291 m), Mt. Iwate (2038 m), Mt. Yatsugatake (2899 m), Mt. Fuji (3776 m), Mt. Ontake (3063 m), Mt. Norikura (3026 m) and Mt. Hakusan (2702 m) are Quaternary volcanoes, where the communities of Dicentro-Stellarietea nipponicae occupy sites on scoria and ash deposits.

4.3 Vertical distribution of Japanese alpine vegetation

Alpine vegetation occurs above the timber line of the dwarf pine belt. Figure 4 shows the typical vegetation profile, which is composed of the communities of Dicentro-Stellarietea nipponicae Ohba 1969, Carici rupestris-Kobresietea bellardii Ohba 1974, Loiseleurio-Vaccinietea Eggler 1952, Phyllodoco-Harrimanelletea Knapp 1954.

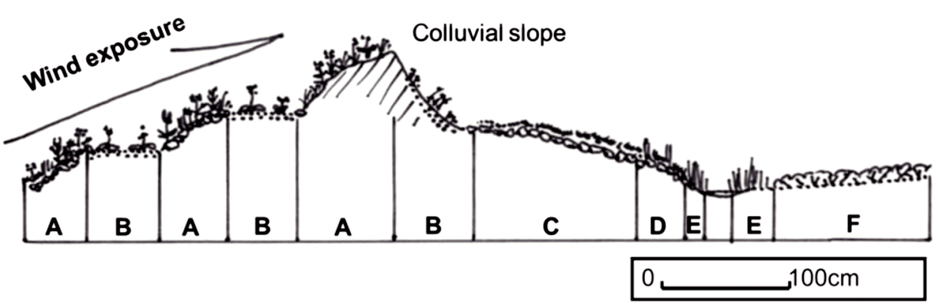

Fig. 4: Schematic vegetation profiles on the alpine belt. A: Carici rupestris-Kobresietea bellardii; B: Dicentro-Stellarietea nipponicae; C: Loiseleurio-Vaccinietea; D: Phyllodoco-Harrimanelletea Phyllodocion aleuticae; E: Montio-Cardaminetea; F: Phyllodoco-Harrimanelletea Faurion crista-galli

Vertical distribution of vegetation along the altitudinal gradient between the montane and alpine belts in Pacific Ocean side is controlled by climate. A typical vegetation pattern for this area can be demonstrated by the belt sequence of Mt. Kitadake. The Sasamorpho-Fagetum crenatae predominates in elevation range from the bottom up to 1600 m a.s.l., then it is replaced by the Maiantho-Tsugetum diversifoliae that occurs up to an elevation of 1800 m a.s.l., Abietetum veitchio-mariesii up to 2650 m a.s.l., Vaccinio-Pinetum pumilae up to 2900 m a.s.l. and by the tundra communities of Arctoo-Loiseleurietum procumbentis or Kobresio-Oxytropidetum nigrescens japonicae up to summit, 3172 m a.s.l. Heavy snow strongly affects the vertical vegetation distribution on the Japan Sea side of Japanese Archipelago. Due to deep snow cover, the beech forests in the lower belt are replaced by dwarf bamboo meadows and Nanoquercetum shrub. In the upper montane Vaccinio-Piceetea region, the Abietetum mariesii occurs on stable sites, such as ridges or gentle slopes, but the most slopes with moderate inclination are occupied with tall forb and shrub communities belonging to the Betulo-Ranunculetea. Therefore the location of the timber line here is not so evident. In the heavy snow area spread between the prefectures Toyama and Niigata the Saso-Fagion crenatae region is delineated. Bulk vegetation of this region is represented by the Leuchotoo-Sasetum kurilensis or Moliniopsietalia japonicae wet meadows, or, so-called quasi-alpine belt. The alpine belt here starts at an elevation of 2700 m, which is much lower compared with Pacific Ocean side of Japan because of extremely hard winter monsoon with its heavy winter precipitation and wind influence. In heavy snow areas of other parts of Asia the same phenomenon is observed. The timber line is represented by mosaic combination of tall forbs and dwarf pine in Kamchatka (KRESTOV et al. 2008).

5. Japanese alpine vegetation

5.1 Asplenietea rupestria Br.-Bl. 1934

In Japan, we don't follow European approach for classification the chasmophyte plant communities that involve the character of habitat and substrates (like carbonate and non-carbonate orders). The Potentilletalia dickinsii communities occur below the Fagetea crenatae region, and the Juncetalia maximowiczii communities above the Vaccinio-Piceetea region. Species rich communities of the Asplenietea rupestria are found on limestones in the alpine belt (Tables 1, 2).

Table 1: Syntaxonomical structure of alpine chasmophyte communities

class	Asplenietea rupestria Br.Bl. 1934	
order	Potentilletalia dickinsii Ohba 1973	Juncetalia maximowiczii Ohba 1973
alliance	Potentillion dickinsii Ohba 1973	Juncion maximowiczii Ohba 1973
association		*Asplenium viride* community 1973

Table 2: Synoptic table of *Asplenium viride*-community

Asplenium viride community (Limestone)			
Running Nr.:	1	2	3
Location:	South.Alps	South.Alps	Sakhalin
Releve Nr.:	3	6	1
Number of species:	3	2,7	9
Asplenium viride	3(1-4)	IV(1-5)	1(1)
Woodsia glabella	·	II (1-2)	1(1)
Cystopteris fragilis	·	I (1)	1(1)
Asplenium ruta-muraria	·	·	1(+)
Gymnocarpium robertianum	·	·	1(+)
Woodsia subcordata	·	II (1)	·
Cryptogramma stelleri	·	II (1-2)	·
Lloydia serotina	1(+)	I (1)	·
Tilingia tachiroei	1(+)	I (1)	·
Artemisia pedunculosa	1(1)	·	·
Arenaria verna var. nipponica	1(+)	·	·
Poa sinanoana	1(+)	·	·
Viola biflora	1(+)	·	·
Sedum rosea	1(+)	·	·
Festuca rubra	1(+)	·	·
Potentilla nivea	1(+)	·	·
Cyrtomnium hemenophylloides	·	·	1(3)
Cirriphyllum cirosum	·	·	1(2)
Conocephalum conicum	·	·	1(+)

5.2 Dicentro-Stellarietea nipponicae Ohba 1969

Japanese class Dicentro-Stellarietea nipponicae, vicarious to European Thlaspietea, occurs on volcanic, steep slope, ultrabasic and dessert habitats (Table 3). The Saxifrago merckii-Cardaminetalia nipponicae occurs in Hokkaido, Sakhalin and Kamchatka. Northern Papaveretum fauriei occurs on volcanic dessert of Mt. Rishiri. The Minuartietalia vernae japonicae inclu-

Table 3: Syntaxonomical structure of alpine desert communities (Hokkaido: Ho; Japan Sea: JS; Pacific Ocean: PO)

class	Dicentro-Stellarietea nipponicae Ohba 1968
order-1	Saxifrago merckii-Cardaminetalia nipponicae Ohba 1969
alliance	Saxifrago merckii-Cardaminion nipponicae Ohba 1969 (Ho)
association	Carici-Saxifragetum merckii Ohba 1969
	Papaveretum fauriei Ohba 1969
order-2	Minuartietalia vernae japonicae Ohba 1968
alliance	Violo-Polygonion ajanensis Ohba 1969
association	Thalaspi-Polygonetum ajanensis Ohba 1969 (Ho)
(community)	Stellario-Polygonetum ajanensis Ohba 1969 (Ho)
	Arenarietum merckioidis chokaiensis Ohba 1969 (JS)
	Potentillo miyabei-Arenarietum merckioidis Nakamura 1988 (Ho)
	Dicentro-Violetum crassae Ohba 1969 (Ho, JS)
alliance	Stellariion nipponicae Ohba 1969
association	Merandrio-Cerastietum schizopetali Ohba 1969 (PO)
(community)	Sedo rosei-Saxifragetum bronchialis funstonii Nakamura 1986 (JS, PO)
	Arabido-Polygonetum weyrichii Ohba 1969 (PO)
	Deschampsia flexuosa community (Ho, JS, PO)
	Patrinia triloba-Ixeris dentata var. *alpicola*-community (JS)
alliance	Drabo-Arenarion katoanae Ohba 1968
association	Cerastio-Minuartietum vernae japonicae Ohba 1968 (JS)
(community)	Arenarietum lanceolatae Ohba 1968 (Ho)
	Saussuretum chionophyllae Ohba 1968 (Ho)
	Sanguisorbo-Minuartietum vernae japonicae Ohba 1968 (JS)
	Leontopodietum fauriei angustifolii Ohba 1968 (PO)

des three alliances, of which the Violo-Polygonion ajanensis is found in Hokkaido and Tohoku mainly in volcanic dessert.The Thlaspi-Polygonetum ajanensis occurs in Rebun Island, the Stellario-Polygonetum ajanensis in the alpine belt of Hokkaido, and Potentillo miyabei-Arenarietum merdkioidis on Mt. Meakan. Volcano Mt. Choukai in Tohoku has the endemic association Arenarietum merckioidis chokaiensis. Alpine desserts of rhyolite, quartz porphyry and structured soil provide habitats for Dicentro-Violetum crassae in Japan Sea side of Japan.

The Stellarion nipponicae occurs on high mountains of central Honshu with the Merandrio-Cerastietum schitzopetali characteristic of Southern Japanese Alps and Arabido-Polygonetum weyritchii of Mt. Fuji. The ultrabasic rock outcrops belong to the Drabo-Arenarion katoanae. The Arenarietum lanceolatum and Saussuretum chionophyllae are found on Mts. Apoi, Yubari, Hidaka. Mt. Hayachine in Tohoku has the endemic Leontopodietum fauriei angustifolii association. The Cerastio-Minuartietum vernae japonicae and Sanguisorbo-Minuartietum are widely distributed from Happo ridge to Mt. Asahi in Northern Japanese Alps.

5.3 Carici rupestris-Kobresietea bellardii Ohba 1974

The class Carici rupestris-Kobresietea bellardii in Northeast Asia includes Caricetalia tenuiformis order, which is represented by the Bupleuro-Caricion tenuiformis in Hokkaido and Oxytropidion japonicae in Honshu (Table 4). On Taisetsu Massive, the Salici-Oxytropidetum jezoensis occurs on the wind exposed site of the alpine belt. In the Japan Sea side of Japan, the wind exposed western slopes are occupied with the Kobresio-Oxytropidetum nigrescens japonicae. Typical vegetation profile of such slopes comprises the alternation of strips of the Kobresio-Oxytropidetum nigrescens japonicae and Dicentro-Violetum crassae.

The Kobresio-Oxytropidetum nigrescens japonicae includes species which mainly belong to circumpolar elements. However its race from Northern Japanese Alps is characterized by North Asian elements. In contrast, the race from Mt. Kitadake in Southern Japanese Alps is

Table 4: Syntaxonomical structure of alpine wind-exposed meadows (Hokkaido: Ho; Japan Sea: JS; Pacific Ocean: PO)

class	Carici rupestris-Kobresietea vellardii Ohba 1974
order	Caricetalia tenuiformis Ohba 1968
alliance-1	Bupleuro-Caricion tenuiformis Ohba 1968 (Ho)
association	Salici-Oxytropidetum yesoensis Tohyama 1971
alliance-2	Oxytropidion japonicae Ohba 1967 (Honshu)
association	Leontopodietum shinanensis Ohba 1974 (PO)
	Saussureo-Oxytropidetum japonicae Ohba 1981 (JS race)
	Saussureo-Oxytropidetum japonicae Ohba1981 (PO race)
alliance-3	Leontopodion hayachinensis Ohba 1974 (Honshu, Hokkaido)
association	Leontopodio hayachinensis-Caricetum tenuiformis Ohba 1967 (PO)
(community)	Saxifragetum nishidae Ohba 1974 (Ho)
	Hypochoerido-Caricetum tenuiformis Ohba 1968 (Ho)
	Caricetum meloanocarpae Nakamura 1988 (Ho)

characterized by Pacific Ocean elements (Table 5). The Leontopodion hayachinensis occurs on the ultrabasic rocks. The summit of Mt. Yubari is occupied with Saxifragetum nishidae and Caricetum melanocarpae. *Carex melanocarpa* occurs here at its southernmost in the isolated habitat. The Hypochoerido-Caricetum tenuiformis is also an endemic vegetation for Mt. Apoi.

Table 5: Element value of two races of Kobresio-Oxytropidetum nigrescens japonicae. ( ) show percentage

Phytogeographical element	South Alps (Kitadake-race)	North Alps (Shiroumadake-race)
Circumpolar	53.1(46.1)	57.0(46.7)
Pacific	20.3(17.6)	15.0(12.3)
North Asian	6.6(5.7)	11.0(9.0)
Northeast Asian	12.2(10.6)	26.0(21.3)
East Asian	8.8(7.6)	5.0(4.1)
Other Asian	2.6(2.3)	1.5(1.2)
Panarctic	3.1(2.7)	3.0(2.5)
Lower montane	5.8(5.0)	3.5(2.9)
Japanese endemic	2.7(2.3)	0.0(0.0)

5.4 Loiseleurio-Vaccinietea Eggler 1952

The Loiseleurio-Vaccinietea, which is composed of circumpolar elements distributed in Japan through the ice age and widely distributed in Northern Asia, reachs Japan at its southern distribution limit. There are no differentiations found between communities of Hokkaido and Honshu (Table 6). However Hokkaido communities include species like *Bryanthus gmelinii*, which occurs also in Sakhalin, Kamchatka and Siberia (SATO 2007). The representatives of alpine heath communities are evergreen Arcterico-Loiseleurietum procumbentis and

Table 6: Syntaxonomical structure of alpine dwarf-shrub heath (Hokkaido: Ho; Japan Sea: JS; Pacific Ocean: PO

class	Leuseleurio-Vaccinietea Eggler 1952
order	Arctericetalia Suz.-Tok. et Umezu 1964
allience	Arcterion Suz.-Tok. Et Umezu 1964 (Hokkaido, Honshu)
association	*Vaccinium ovalifolium-Ledum diversipilosum*-community
(community)	Arctoo-Vaccinietum ulginosi Yamazaki et Nagai 1961
	Arcterico-Loiseleurietum procumbentis Ohba ex Suz-Tok 1964

summergreen Arctoo-Vaccinietum uliginosi. The Arcterico-Loiseleurietum procumbentis occurs on the stable site and needs snow protection during the winter season, and the Arctoo-Vaccinietum uliginosi occupies the drier habitats.

5.5 Phyllodoco-Harrimanelletea Knapp 1954

Snow patch communities represented by Phyllodoco-Harrimanelletea, are characterized by Pacific Ocean elements and distributed widely in Hokkaido and Japan Sea side of Honshu. This class includes two alliances, Phyllodocion aleuticae and Faurion crista-galii (Table 7).

Table 7: Syntaxonomical structure of alpine snow patch (Hokkaido: Ho; Japan Sea: JS; Pacific Ocean: PO)

class	Phyllodoco-Harrimanelletea Knapp 1954
order	Harrimanelletalia Knapp 1954
alliense	Phyllodocion aleuticae Ohba 1967
association	*Pogonatum sphaerothecim*-community (JS)
(community)	Phyllodocetum yezoensi-aleuticae Nakamura 1988 (Ho)
	Anaphalido-Phyllodocetum aleuticae Ohba 1975 (JS,PO)
alliense	Faurion crista-galli Suz.-Tok. 1964
association	Primulo-Caricetum blepharicarpae Miyawaki et al. 1968 (JS)
(community)	Primulo nipponicae-Caricetum blepharicarpae Suz-Tok et al. 1956 (JS)
	Fauria crista-galli-community (JS,Ho)

The Phyllodocion aleuticae occupies the sites that become dry after snow melting and includes Phyllodocetum jezoensi-aleuticae in Hokkaido and Anaphalido-Phyllodocetum aleuticae in Honshu. In contrast, the Faurion crista-galii occurs on the sites with continuous wet conditions and includes the Primulo-Caricetum blepharicarpae in Hokkaido and Primulo nipponicae-Caricetun blepharicarpae in Honshu.

6. Historical study of Japanese alpine vegetation

Due to heavy snow accumulation in winter time in the Sea of Japan side, the edaphic climax vegetation belonging to the class Betulo-Ranunculetea is most developed in this area. The latter vegetation type was formed at the end of the Pleistocene maximum when the snowy climate developed in the eastern part of Japan. Before, there was a cold episode of climatic history, caused by the considerable lowering of sea level during ocean transgression which blocked the Tsushima warm current from entering the Sea of Japan (Fig. 5) (ONO & IGARASHI 1991). This period was characterized by predominance of continental climate in the coastal areas of Sea of Japan. Vegetation reconstruction for the late Pleistocene showed the occurrence of micro- and macrofossils of *Picea maximowiczii, P. koyamae*, the relatives of *Picea obovata*. Nowadays, these species occur in isolated areas of Yatsugatake, Chubu district. At the end of Pleistocene Maximum and early Holocene, 13,000-10,000 years BP, to-gether with the Sea level rise the Tsushima Sea current entered the Sea of Japan, and cold continental climate in the coastal areas during several hundred years changed to cool temperate climate with heavy-snow in wintertime. Japanese cedar-, *Cryptomeria japonica*-forests spread in the colline belt and *Fagus crenata*-forests belonging to Saso-Fagion crenatae in the montane belt. Continental conifer forests of *Picea maximowiczii* and *P. koyamae* disappeared from coastal areas and were replaced by *Abies mariesii*-forests belonging to the Abietetum mariesii and *Betula ermanii* forests in combination with tall forbs communities.

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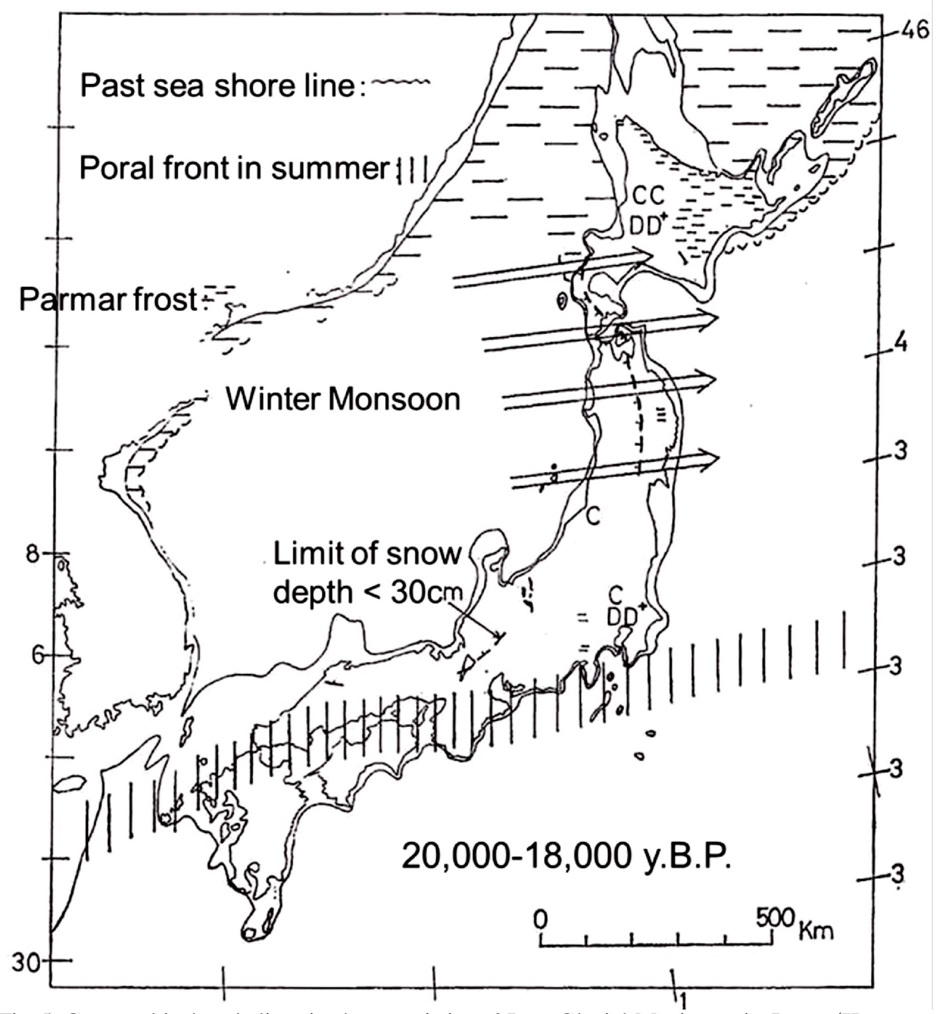

Fig. 5: Geographical and climatic characteristics of Last Glacial Maximum in Japan (KOIZUMI 2009)

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