

A PRELIMINARY NOTE ON THE FLORISTIC PHYTOGEOGRAPHY OF THE ALPINE FLORA OF JAPAN¹⁾

By

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(With 3 Plates, 1 Table and 2 Text-figures)

I. Introduction

Irrespective of its rather limited small land area, Japan possesses a lot of high mountains, and on those mountains there develop alpine zones where a number of beautiful alpine plants are growing. These charming *alpicolae* attracted botanists' attention gradually soon after botany, a branch of western natural sciences was introduced into Japan. And so early as in 1919, Dr. Gen'ichi KOIDZUMI presented a paper entitled "Genetic and Floristic Phytogeography of the Alpine Flora of Japan" (KOIDZUMI 1919), in which he, after having described a general feature of the alpine zone of Japan, analysed all the alpine vascular plants occurring on high mountains in Japan phytogeographically. Although not a few phytotaxonomists and phytogeographers had studied alpine plants in Japan before his work, the above mentioned paper, so far as the author is aware, is the first to report the floristic composition of the alpine flora of Japan statistically. Some sixty years have elapsed since the publication of his elaborate work, and during that period a number of new or novel species with their infraspecific taxa have been added to the alpine flora of Japan. On the other hand, however, not a few of the species that had been described as endemics in Japan revealed their natural systematic positions as to be included within infraspecific taxa of allied species in foreign countries or even as completely identical with foreign plants. In such current circumstances it became necessary to rediscuss on various problems in the floristic phytogeography of the alpine flora of Japan in its present status. Of course, this note is only of quite preliminary nature and appears to be far from complete, because the taxonomic positions of some vascular plants that are met with in the *regio alpina* in Japan have to receive further taxonomic examinations by the spe-

1) Dedicated to the late Dr. Hisayoshi TAKEDA and the late Prof. Gen'ichi KOIDZUMI who devoted themselves to the foundation of alpine botany in Japan.

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cialists of each plant group concerned and to be re-evaluated by virtue of modern taxonomic techniques including biosystematic comparisons of species in Japan with their allied ones in different parts of the world. However, the writer ventures to make this preliminary note public here, for it seems to the author that this paper would give students of the alpine flora of Japan a working basis on which they may extend their further researches.

II. General Aspect of the Alpine Zone

Much differing from high mountains in continents, no mountains attain a

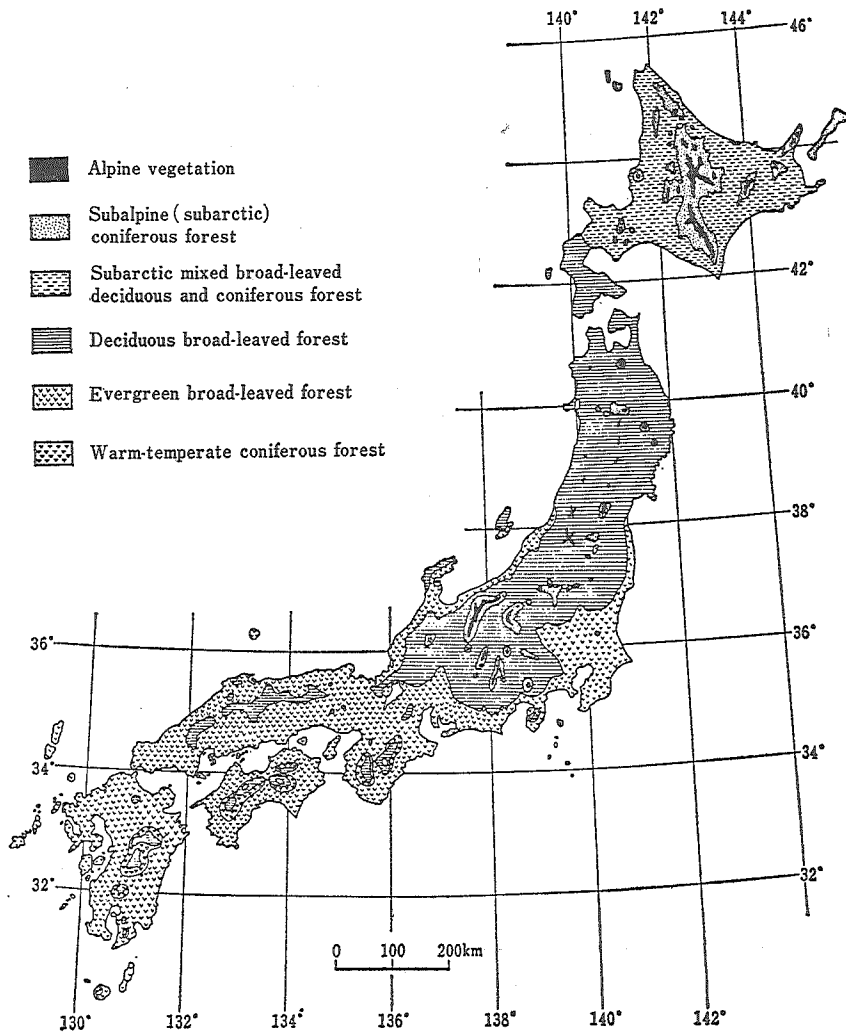


Fig. 1. Vegetation Map of Japan (YOSHIOKA 1973, 1974)

height of nival zone in Japan. Only some traces of glaciers in the Ice Age can be seen on the Hidaka Range in Hokkaido as well as in the Japanese Alps in Central Honshu where there are U-shaped valleys or "Kars" which were formed as a result of the Pleistocene glaciation. Figure 1 shows the distribution of the alpine zone in Japan (YOSHIOKA 1973 and in NUMATA 1974, modified).

The principal vegetation type observable in the alpine zone of Japan is the forest of *Pinus pumila* that appears in general above 2,500—2,600m in Central Honshu, gradually lowering to 1,900—2,000m in Northern Honshu, and to 1,300—1,500m in Hokkaido. On Mt. Fuji (3,776m), the highest mountain in Japan, however, there is no stand of *Pinus pumila*, and instead of the pine forest there occurs the stand of *Larix kaempferi*.

The alpine zone of Japan here defined is that in strict accordance with the delimitation in our historical usage, *i. e.*, the area of and above the forest of *Pinus pumila*.

However, as a result of a comparison of the vertical distributional patterns of the alpine plants of Japan with those of the Alps (TOYOKUNI unpubl.), it appears to be evident that most parts of *Pinus pumila* forests at high altitudes in Japanese mountains are still within the scope of the subalpine zone; the real alpine zone of Japan does start from the upper part of or even above the uppermost limit of this pine forest.

Discussions concerning the delimitation of the alpine zone of Japan are to be made in the author's another paper.

III. Floristic Composition of the Alpine Flora

In accordance with the system described in the writer's paper on the floristic phytogeography of the alpine flora of Hokkaido (TOYOKUNI 1980) with a little modification, all species of vascular plants indigenous to the alpine zone of Japan are divided into five elements by means of their distribution types, *i. e.*, (1) Asian Elements, (2) Asian-N. Pacific Elements, (3) Asian-N. American Elements, (4) Eurasian Elements and (5) Circumpolar and Cosmopolite Elements.

(1) Asian Elements

The species belonging to this category are divided into two minor groups: (i) Endemic or Japanese Species and (ii) Asiatic Species.

(1-i) Endemic or Japanese Species

The plants that belong to this group are restricted in their distributional area only to Japan, irrespective of the extent of distribution range, *e. g.*, *Salix paludicola* and *S. pseudo-paludicola* are met with only in a quite limited area on the Taisetsu Mts. in Hokkaido, but *Stellaria nipponica* is rather widely encountered on

high mountains in Honshu (var. *nipponica*) and in Hokkaido (var. *yezoensis*). The following 187 species belong to this group: *Athyrium melanolepis*³⁾, *Polystichum inanense*, *Struthiopteris castanea*, *Picea bicolor*, *P. koyamae*, *P. maximowiczii*, *Salix hidaka-montana*, *S. nakamuraana*, *S. paludicola*, *S. pseudo-paludicola*, *S. yezoalpina*, *Betula apoiensis*, *Bistorta hayachinensis*, *Pleuropteropyrum nakaii*, *Arenaria katoana*, *Cerastium schizopetalum*, *Dianthus shinanensis*, *Silene hidaka-alpina*, *S. keiskei*, *Stellaria nipponica*, *S. pterosperma*, *Aconitum apoiense*, *A. corymbiferum*, *A. hakusanense*, *A. ishizukai*, *A. kishidai*, *A. kitadakense*, *A. sakurii*, *A. senanense*, *A. septemcarpum*, *A. yuparense*, *A. zigzag*, *Callianthemum miyabeanaum*, *Pulsatilla nipponica*, *Thalictrum nakamurae*, *Trollius hondoensis*, *Glaucidium palmatum*, *Corydalis curvicalcarata*, *Papaver fauriei*, *Pteridophyllum racemosum*, *Arabis dentipetala*, *A. tanakana*, *Cardamine nipponica*, *Draba igarashii*, *D. japonica*, *D. kitadakensis*, *D. oiana*, *D. okamotoi*, *D. sakurii*, *D. shiroumana*, *Thlaspi japonicum*, *Rhodiola hidewoi*, *R. ishidae*, *Sedum cauticulum*, *Astilbe thunbergii*, *Boykinia lycoctonifolia*, *Parnassia alpicola*, *Ribes japonicum*, *Saxifraga japonica*, *S. nishidae*, *S. yuparenensis*, *Alchemilla japonica*, *Rubus pseudo-japonicus*, *R. yabei*, *Sanguisorba albiflora*, *S. obtusa*, *Sorbus matsumurana*, *Astragalus membranaceus*, *A. shiroumensis*, *A. yamamotoi*, *Oxytropis japonica*, *O. megalantha*, *Ilex sugerokii*, *Rhamnus ishidae*, *Hypericum erectum*, *H. samaniense*, *H. tatewakii*, *H. yamamotoi*, *Viola alliariiifolia*, *V. brevistipulata*, *V. kitamiana*, *V. yubariana*, *Epilobium shiroumense*, *Oplopanax japonicus*, *Angelica acutiloba*, *Bupleurum nipponicum*, *Coelopleurum multisectum*, *Tilingia holopetala*, *Pyrola alpina*, *Gaultheria adenothrix*, *Eubotryoides grayana*, *Phyllodoce alpina*, *P. nipponica*, *Rhododendron brachycarpum*, *R. nipponicum*, *Tripetaleia bracteata*, *Vaccinium shikokianum*, *Schizocodon soldanelloides*, *Primula hidakana*, *P. jesoana*, *P. macrocarpa*, *P. nipponica*, *P. sorachiana*, *P. takedana*, *P. tosaensis*, *P. yuparenensis*, *Gentiana makinoi*, *Gentianella yuparenensis*, *Gentianopsis yabei*, *Nepeta subsessilis*, *Euphrasia insignis*, *E. natsumurae*, *Pedicularis apodochila*, *Veronica nipponica*, *Pinguicula ramosa*, *Plantago hakusanensis*, *Galium nakaii*, *Lonicera tschonoskii*, *Scabiosa japonica*, *Adenophora nikoensis*, *A. takedae*, *Anaphalis alpicola*, *Artemisia kitadakensis*, *A. pedunculosa*, *A. sinanensis*, *Chrysanthemum rupestre*, *C. konoanum*, *Cirsium babanum*, *C. chokaiense*, *C. ganjuense*, *C. nambuense*, *C. nipponicum*, *C. ugoense*, *Erigeron miyabeanus*, *Hieracium japonicum*, *Hypochaeris crepidioides*, *Leontopodium fauriei*, *L. hayachinense*, *L. shinanense*, *Ligularia kaialpina*, *Saussurea brachycephala*, *S. chionophylla*, *S. franchetii*, *S. nikoensis*, *S. sagitta*, *S. tobitae*, *S. tripteron*, *S. yanagisawae*, *Scorzonera rebunensis*, *Senecio takedanus*, *Taraxacum alpicola*, *T.*

3) In analysing the alpine vascular plants phytogeographically, each plant is considered by the species level, the whole distribution area as the species being considered in accordance with the distribution type.



Fig. 2. Distribution Area of *Pinus pumila*

yatsugatakense, *T. yubarense*, *Youngia gymnopus*, *Sasa cernua*, *S. senanensis*, *Calamagrostis fauriei*, *C. gigas*, *C. longiseta*, *C. matsumurae*, *Elymus yubaridakensis*, *Festuca takedana*, *Helictotrichon hideoi*, *Hierochloe pluriflora*, *Poa hakusanensis*, *P. hayachinensis*, *Trisetum koidzumianum*, *Carex albata*, *C. angustisquama*, *C. aphyllopus*, *C. chinoi*, *C. doenitzii*, *C. podogyna*, *Rhynchospora fauriae*, *R. yasudana*, *Scirpus hondoensis*, *Eriocaulon nanellum*, *Juncus fauriensis*, *Luzula rost-rata*, *Aletris foliata*, *Heloniopsis orientalis*, *Japonolirion osense*, *Tofieldia okuboi*, *Veratrum longe-bracteatum*, *V. stamineum*, *Orchis fauriei* and *Pogonia minor*.

(1-ii) Asiatic Species

The species belonging to this group are distributed not only in Japan but also in other countries in Asia; some species have their distributional areas in Japan and Sakhalin, e. g., *Macropodium pterospermum*, *Fragaria iinumae*, *Pedicularis yezoensis*, etc., but some others have rather wide distribution ranges as in the case of *Pinus pumila* (Fig. 2). *Athyrium crenulato-serratum*, *A. pterorachis*, *A. rupestre*, *A. spinulosum*, *Cheilanthes kuhnii*, *Dryopteris amurensis*, *Polystichum lachenense*, *P. microchlamys*, *Picea jezoensis*, *Pinus pumila*, *Juniperus chinensis*, *Salix hidewoi*, *S. reinii*, *Betula ermanii*, *Thesium refractum*, *Pleuropteropyrum ajanense*, *P. weyrichii*,

Rumex gmelinii, *Arenaria merckiioides*, *Cerastium rubescens*, *Silene stenophylla*, *Stellaria fenzlii*, *S. ruscifolia*, *Aconitum sachalinense*, *Callianthemum insigne*, *Clematis ochotensis*, *Trautvetteria japonica*, *Trollius ledebouri*, *T. pulcher*, *Aquilegia flabelata*, *Dicentra peregrina*, *Arabis serrata*, *Draba sachalinensis*, *D. ussuriensis*, *Macropodium pterospermum*, *Sedum pluricaule*, *Saxifraga fortunei*, *S. laciniata*, *S. merkii*, *S. sachalinensis*, *Filipendula camtschatica*, *F. multijuga*, *Fragaria iinumae*, *F. nipponica*, *Potentilla matsumurae*, *P. miyabei*, *Prunus nipponica*, *Sanguisorba hakusanensis*, *S. tenuifolia*, *Sorbus sambucifolia*, *Hedysarum vicioides*, *Oxytropis retusa*, *O. revoluta*, *Geranium eriostemon*, *G. yesoense*, *Tithymalus sieboldianus*, *Ilex rugosa*, *Evonymus tricarplus*, *Acer tschonokii*, *A. ukurunduense*, *Hypericum kamtschaticum*, *Viola crassa*, *Epilobium fauriei*, *E. foucaudianum*, *E. dielsii*, *Conioselinum filicinum*, *Peucedanum multivittatum*, *Tilingia ajanensis*, *T. tachiroei*, *Pyrola faurieana*, *Arctericia nana*, *Bryanthus gmelinii*, *Menziesia pentandra*, *Rhododendron aureum*, *Vaccinium praestans*, *V. smallii*, *Primula modesta*, *Comastoma pulmonarium*, *Frasera tetrapetala*, *Gentiana jamesii*, *G. thunbergii*, *G. triflora*, *Gentianopsis contorta*, *Eritrichium nipponicum*, *Mertensia pterocarpa*, *Mimulus sessilifolius*, *Pedicularis resupinata*, *P. yezoensis*, *Veronica schmidtiana*, *V. stelleri*, *Lonicera alpigena*, *L. caerulea*, *L. chamissoi*, *Macrodiervilla middendorffiana*, *Viburnum furcatum*, *Patrinia sibirica*, *Adenophora pereskiaefolia*, *Peracarpa carnosa*, *Artemisia schmidtiana*, *Cirsium pectinellum*, *Crepis hokkaidoensis*, *Erigeron thunbergii*, *Ixeris dentata*, *Leontopodium discolor*, *L. japonicum*, *Ligularia hodgsonii*, *Saussurea acuminata*, *Senecio kawakamii*, *Taraxacum platypecidum*, *Potamogeton fryeri*, *Sasa kurilensis*, *Agrostis flaccida*, *Calamagrostis hakonensis*, *C. sachalinensis*, *C. sesquiflora*, *Glyceria alnasteretum*, *G. leptolepis*, *Poa macrocalyx*, *P. komarovii*, *P. sachalinensis*, *Carex augustiniowiczii*, *C. blepharicarpa*, *C. eleusinoides*, *C. flavocuspis*, *C. hakkodensis*, *C. hakonensis*, *C. kabanovii*, *C. lehmannii*, *C. melanocarpa*, *C. middendorffii*, *C. omiana*, *C. onoei*, *C. oxyandra*, *C. peiktusanii*, *C. pseudocuraica*, *C. scita*, *C. siroumensis*, *C. sachalinensis*, *C. subumbellata*, *C. stenantha*, *C. tenuiformis*, *C. vanheurckii*, *Eleocharis intersita*, *Scirpus maximowiczii*, *Juncus kamtschatcensis*, *J. potaninii*, *J. triceps*, *Luzula oligantha*, *Clintonia udensis*, *Hemerocallis middendorffii*, *Hosta rectifolia*, *Lilium medeoloides*, *Veratrum oxyspalum*, *Zygadenus sibiricus*, *Ephippianthus schmidtii*, *Listera nipponica*, *Myrmecis japonica*, *Neolindleya camtschatica*, *Platanthera ophrydioides* and *Pogonia japonica* belong to this category.

(2) Asian-N. Pacific Elements

The species of this group are distributed in Asia and up northwards as well as eastwards to the northern Pacific areas, e.g., the Commander Islands, the Aleutian Islands, etc., not attaining Alaska in the continent of N. America. They are *Trollius niederianus*, *Sieversia pentapetala*, *Penellianthus frutescens*, *Campanula*

dasyantha, *Arnica unalaschcensis*, *Artemisia unalaschcensis*, *Cacalia auriculata*, *Cirsium kamtschaticum*, *Saussurea riederi*, *Juncus beringensis*, *Platanthera chorisiana* and *P. tipuloides*.

(3) Asian-N. American Elements

The plants of this group are distributed both in Asia and in N. America; some species have rather wide ranges, but some others are restricted only to the westernmost Alaska on the N. American side. The following 63 species belong to this category: *Diphysium sabinaefolium*, *Selaginella sibirica*, *Cryptogramma stelleri*, *Polypodium virginianum*, *Alnus crispa*, *Minuartia macrocarpa*, *Diphylleia cymosa*, *Arabis lyrata*, *Barbarea orthoceras*, *Saxifraga bronchialis*, *S. punctata*, *Acomastylis calthifolia*, *Rosa acicularis*, *Rubus pedatus*, *R. spectabilis*, *Sanguisorba canadensis*, *S. stipulata*, *Spiraea betulifolia*, *Astragalus adsurgens*, *Geranium erianthum*, *Viola langsdorffii*, *V. repens*, *Coelopleurum lucidum*, *Chamaepericlymenum canadense*, *Cassiope lycopodioides*, *Gaultheria miqueliana*, *Harrimanella stelleriana*, *Phyllodoce aleutica*, *Therorhodium camtschaticum*, *Vaccinium ovalifolium*, *Primula cuneifolia*, *Gentiana algida*, *G. aquatica*, *G. glauca*, *Gentianella auriculata*, *Fauria cristagalli*, *Lagotis glauca*, *L. minor*⁴⁾, *Pedicularis chamissonis*, *Boschniakia rossica*, *Galium kamtschaticum*, *Campanula lasiocarpa*, *Achillea sibirica*, *Artemisia arctica*, *A. furcata*⁵⁾, *A. glomerata*, *Taraxacum trigonolobum*, *Agrostis trinii*, *Carex deweyana*, *C. mertensii*, *C. michauxiana*, *C. oligosperma*, *C. stipata*, *Eleocharis kamtschatica*, *Juncus ensifolius*, *J. mertensianus*, *Iris setosa*, *Fritillaria camschatcensis*, *Maianthemum dilatatum*, *Streptopus streptopoides*, *Tofieldia coccinea*, *Dactylorhiza aristata* and *Platanthera hyperborea*.

(4) Eurasian Elements

The species that belong to this group are distributed both in Asia and in Europe. They are *Selaginella helvetica*, *Isoetes setacea*, *Athyrium crenatum*, *Cryptogramma crispa*, *Cystopteris sudetica*, *Salix nummularia*, *Bistorta major*, *Rumex arifolius*, *Dianthus superbus*, *Silene repens*, *Thalictrum aquilegifolium*, *T. foetidum*, *Hedysarum hedysaroides*, *Oxytropis campestris*, *Anthriscus sylvestris*, *Pleurospermum austriacum*, *Cortusa matthioli*, *Thymus serpyllum*, *Picris hieracioides*, *Glyceria lithuanica*, *Carex caespitosa*, *Eriophorum vaginatum*, *Juncus triglumis*, *Veratrum album* and

4) *Lagotis minor* (WILLDENOW) STANDLEY in Publ. Field. Mus. Chicago Bot. 8: 325. 1931.

var. *yesoensis* (MIYABE et TATEWAKI) TOYOKUNI, comb. nov.

Syn. -

Lagotis Stelleri var. *yesoensis* MIYABE et TATEWAKI in Trans. Sapporo Nat. Hist. Soc. 13: 4. 1933.

5) *Artemisia furcata* BIEBERSTEIN, Fl. Taur.-Cauc. 3: 567. 1819.

var. *pedunculosa* (KOIDZUMI) TOYOKUNI, comb. nov.

Syn. -

Artemisia glomerata var. *pedunculosa* KOIDZUMI in Bot. Mag. Tokyo 32: 58. 1918.

Gymnadenia conopsea.

(5) Circumpolar and Cosmopolite Elements

The circumpolar plants are those that exhibit a circumpolar distributional pattern covering gyroflexously the arctic area around the North Pole. In this paper, however, the cosmopolite plants with more world-wide distribution ranges are also included. The following 127 species belong to this category: *Diphysium alpinum*, *D. complanatum*, *Huperzia selago*, *Lycopodium annotinum*, *Selaginella selaginoides*, *Botrychium lanceolatum*, *B. lunaria*, *B. multifidum*, *B. simplex*, *Woodsia glabella*, *W. ilvensis*, *Asplenium viride*, *Athyrium alpestre*, *A. felix-foemina*, *Carpogymnia dryopteris*, *C. robertiana*, *Dryopteris austriaca*, *Polypodium vulgare*, *Polystichum braunii*, *P. lonchitis*, *Phegopteris polypodioides*, *Thelypteris limbosperma*⁶⁾, *Juniperus communis*, *Oxyria digyna*, *Bistorta vivipara*, *Minuartia arctica*, *M. verna*, *Sagina saginoides*, *Silene apetala*, *Stellaria calycantha*, *Anemone narcissiflora*, *Coptis trifolia*, *Ranunculus acris*, *R. pygmaeus*, *R. sulphureus*, *Thalictrum alpinum*, *T. minus*, *Drosera anglica*, *D. rotundifolia*, *D. rotundifolio-anglica*, *Rhodiola rosea*, *Parnassia palustris*, *Saxifraga cernua*, *Aruncus dioicus*, *Dryas octopetala*, *Potentilla fruticosa*, *P. nivea*, *Rubus idaeus*, *Sibbaldia procumbens*, *Astragalus frigidus*, *Oxalis acetosella*, *Viola biflora*, *Circaea alpina*, *Bupleurum ranunculoides*, *Andromeda polifolia*, *Arctous alpina*, *Ledum palustre*, *Loiseleuria procumbens*, *Oxycoccus quadripetalus*, *Phyllodoce caerulea*, *Vaccinium uliginosum*, *V. vitis-idaea*, *Diapensia lapponica*, *Empetrum nigrum*, *Androsace chamaejasme*, *Trientalis europaea*, *Lomatogonium carinthiacum*, *Swertia perennis*, *Menyanthes trifoliata*, *Polemonium acutiflorum*, *Prunella vulgaris*, *Pedicularis verticillata*, *P. oederi*, *Veronica serpyllifolia*, *Pinguicula vulgaris*, *Galium triflorum*, *Linnaea borealis*, *Achillea ptarmica*, *Anaphalis margaritacea*, *Antennaria dioica*, *Erigeron acris*, *Solidago virga-aurea*, *Sparganium angustifolium*, *S. glomeratum*, *S. hyperboreum*, *Agrostis borealis*, *A. mertensianus*, *Anthoxanthum odoratum*, *Calamagrostis canadensis*, *C. deschampsiioides*, *C. neglecta*, *Deschampsia atropurpurea*, *D. caespitosa*, *D. flexuosa*, *Festuca ovina*, *Hierochloa alpina*, *Phleum alpinum*, *Poa glauca*, *Trisetum spicatum*, *Carex atrata*, *C. bigelowii*, *C. bipartita*, *C. brunnescens*, *C. capillaris*, *C. curta*, *C. lasiocarpa*, *C. limosa*, *C. livida*, *C. pauciflora*, *C. pauperula*, *C. pyrenaica*, *C. rupestris*, *Eleocharis mamillata*, *Eriophorum scheuchzeri*, *Kobresia bellardii*, *Rhynchospora alba*, *Trichophorum caespitosum*, *Juncus filiformis*, *Luzula arcuata*, *L. parviflora*, *Allium schoenoprasum*, *Lloydia serotina*, *Maianthemum bifolium*, *Streptopus amplexifolius*, *Coeloglossum viride*, *Listera cordata* and *Microstylis monophyllos*.

6) *Thelypteris limbosperma* (ALLIONI) H. P. FUCHS in Amer. Fern Jour. 48 : 144. 1958.
var. *fauriei* (H. CHRIST) TOYOKUNI, comb. nov.
Syn. -
Nephrodium montanum var. *Fauriei* H. CHRIST in Bull. Herb. Boiss. 4 : 671. 1896.

Table 1. The Floristic Composition of the Alpine Flora of Japan

DISTRIBUTION TYPE \ TAXON		Pter.	Spermat.		Total		
			Gym.	Angiosp.			
				Dicot.			Monocot.
Asian	Endemic (Japanese)	3	3	148	33	187(32.6%)	347 (60.5%)
	Asiatic	8	3	98	51	160(27.9%)	
Asian-N. Pacific		—	—	9	3	12(2.1%)	
Asian-N. American		4	—	43	16	63(10.9%)	
Eurasian		5	—	14	6	25(4.4%)	
Circumpolar and Cosmopolite		22	1	59	45	127(22.1%)	
Total		42	7	371	154	574	

Floristic composition of the alpine flora of Japan is summarised in Table 1. Learning from this table, it is evident that the Asian elements are the highest in number showing 347 species or 60.5%, of which the endemic or Japanese ones are 187 species or 32.6%. Next to the Asian elements follow the circumpolar and cosmopolite elements showing rather high species number, exhibiting 127 or 22.1%. The Asian-N. American elements are 63 species or 10.9%, while the Asian-N. Pacific ones are only 12 species or 2.1%. Such low species number shown depends on current data of plant distribution in northern parts of the continent of N. America where not a few Asiatic species have been discovered as natives, and if there is no clear cutline of demarcation between the Asian-N. American elements and the Asian-N. Pacific ones, the latter had better be included in the former under a new category. The Eurasian elements are 25 species or 4.4%. Species number and ratio in every one of the five elements mentioned come very near to those in the floristic composition of the alpine flora of Hokkaido (TOYOKUNI 1980). However, the number of endemic or Japanese elements much increased as compared with that in the above-mentioned paper, because many endemic species that are distributed on high mountains in Central Honshu and Tohoku district are added here in considering the alpine flora of Japan as a whole. Nevertheless, in the light of the above findings, the alpine flora of Japan as a whole and that of Hokkaido show a similar pattern in the floristic composition.

IV. On the Origin of the Alpine Flora

During the Pleistocene in the Quaternary period, Cainozoic era, glaciation occurred four times in the Northern Hemisphere. By the maximum advance of the glaciers in the Wisconsin Age, nearly 27 percent of the land area to-day is said to have been buried by ice (LEET and JUDSON 1962), and as glaciers came down southwards, the circumpolar plants that were growing in their homes in the arctic region gradually came down southwards around the terminal margin of the glaciers, and as the glaciers went back to the arctic, the circumpolar plants also went back gradually to the north. Many circumpolar plants, however, remained alive on high mountains, possessing their new homes there as becoming alpine plants. Such plants became to possess a new mode of living during the Interglacial period. By means of repeating those processes, many of the circumpolar plant species are distributed scatteredly on high mountains in the Northern Hemisphere. This view is supported by the fact that 22.1 percent of the plants growing in the alpine zone of Japan are of circumpolar and cosmopolite origin.

According to geologists' view (*e. g.*, MINATO 1963), Japan was the easternmost margin of the continent of Asia during the Oligocene in the Tertiary period, but was completely separated from the continent during the Miocene. In the period between the late Pliocene and the early Pleistocene, the western side of Honshu was connected with the Korean peninsula. By virtue of such diverse geological conditions, many alpine and subalpine species of the continent origin became to have their new habitats in Japanese mountains as species common to Japan and the continent. This clearly indicates that Asiatic elements are now rich in Japan. But after the last glaciation, the Japanese Archipelago was again separated completely from the continent, and such a plant species that had been quite identical both in Japan and in the continent gradually changed its character on the Japan side or *vice versa*, differentiating as a subspecies or a quite distinct species (TOYOKUNI 1980); *Lomatogonium carinthiacum* (identical), *Gentiana aquatica* (identical), *Comastoma pulmonarium* subsp. *sectum* (race), *Primula yuparensis* (distinct species from *P. farinosa*), etc. are good examples in this connection.

For the origins of species common to Eastern Asia and to the N. Pacific islands or to N. America, the Behringia appears to have played an important rôle. Many species went to the continent of N. America from Asia through the Behringia or *vice versa*. It was pointed out by HULTÉN (1937) that all distribution areas of plants in the Northern Hemisphere could be well explained as radiating from an early Pleistocene refugium in the Behringia region with drastic reductions caused by virtue of changing climatic conditions.

By means of the combination of complicated processes mentioned above, the primary framework of the alpine flora of Japan appears to have been established. On such basis, further local differentiations have taken place in not a few species, giving rise to produce geographically or morphologically distinct varieties, races, or sometimes even distinct species also; *Gentianella yubarensis* and its race, subsp. *takedae*, *Gentiana aquatica* and its race, subsp. *laeviuscula*, *Leontopodium hayachinense* and its race, subsp. *miyabe anum*, etc. are good examples in this respect. The alpine flora of Japan was thus established.

V. Résumé

1. In this paper was dealt with the floristic phytogeography of the alpine flora of Japan.
2. All the vascular plants considered here as alpine plants are 574 species.
3. The above 574 species were analysed phytogeographically in accordance with their distribution types, and the results are shown in Table 1.
4. On the basis of these statistical data on the composition of the alpine flora of Japan, the origin of the flora was discussed.

VI. Main Literature

1. FITTER, A. 1978. An Atlas of the Wild Flowers of Britain and Northern Europe.
2. GOOD, R. 1966. The Geography of the Flowering Plants (ed. 3).
3. HARA, H. 1934-1939. Preliminary report on the flora of southern Hidaka, Hokkaido (Yezo) 1-36. in Bot. Mag. Tokyo 48-53.
4. HARA, H. 1952, 1956. Contributions to the study of variations in the Japanese plants closely related to those of Europe or North America 1, 2. in Jour. Fac. Sci. Univ. Tokyo, Sect. 3 (Bot.) 6: 29-96, 343-391.
5. HARA, H. and H. KANAI 1958, 1959. Distribution Maps of Flowering Plants in Japan, 1, 2.
6. HITCHCOCK, C. L. and A. CRONQUIST 1973. Flora of the Pacific Northwest.
7. HULTÉN, E. 1927-1930. Flora of Kamtchatka and the Adjacent Islands, 1-4.
8. HULTÉN, E. 1937. Outline of the History of the Arctic and Boreal Biota during the Quaternary Period.
9. HULTÉN, E. 1941-1950. Flora of Alaska and Yukon 1-10.
10. HULTÉN, E. 1960. Flora of the Aleutian Islands (ed. 2).
11. HULTÉN, E. 1964, 1971. The Circumpolar Plants 1, 2.
12. HULTÉN, E. 1968. Flora of Alaska and Neighboring Territories.
13. KARTESZ, J. T. and R. KARTESZ (ed.) 1980. A Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland. The Biota of North

America II.

14. KAWANO, S. 1971. Studies on the alpine flora of Hokkaido, Japan **1**. Phytogeography. in Jour. Coll. Liberal Arts, Toyama Univ. **4** (Nat. Sci.): 13-96.
15. KAWANO, S. 1973. Studies on the alpine flora of Hokkaido, Japan **2**. Systematic account-Pteridophyta. in Jour. Coll. Liberal Arts, Toyama Univ. **5** (Nat. Sci.): 89-127.
16. KITAGAWA, M. 1979. Neo-lineamenta Florae Manshuricae.
17. KITAMURA, S. *et al.* 1957-1964. Coloured Illustrations of Herbaceous Plants in Japan **1-3**.
18. KITAMURA, S. and G. Murata 1971, 1979. Coloured Illustrations of Woody Plants of Japan **1-2**.
19. KOIDZUMI, G. 1919. Genetic and floristic phytogeography of the alpine flora of Japan. in Bot. Mag. Tokyo **33**: 193-222.
20. KUDO, Y. 1925. The vegetation of Yezo. in Jap. Jour. Bot. **2** (4): 209-292.
21. LEET, L. D. and S. JUDSON 1962. Physical Geology.
22. MINATO, M. (ed.) 1963. Nippon-rettô no Oitachi (in Jap.) (The Origin of the Japanese Archipelago).
23. MIYABE, K. and Y. KUDO 1930-1934. Flora of Hokkaido and Saghalien **1-4**. in Jour. Fac. Agr. Hokkaido Imp. Univ. **26**: 1-79, 81-277, 279-387, 389-528.
24. MIYAWAKI, A., S. OKUDA and R. MOCHIZUKI 1978. Handbook of Japanese Vegetation.
25. NUMATA, M. (ed.) 1974. The Flora and Vegetation of Japan.
26. OHWI, J. 1965. Flora of Japan (ed. rev.).
27. OHWI, J. 1965. Flora of Japan (Engl. ed.).
28. SCOGGAN, H. J. 1978. The Flora of Canada **1-4**.
29. SHELTER, S. G. and L. E. SKOG (ed.) 1978. A Provisional Checklist of Species for Flora North America (Revised).
30. TAGAWA, M. 1959. Coloured Illustrations of the Japanese Pteridophyta.
31. TATEWAKI, M. 1933. The phytogeography of the middle Kuriles. in Jour. Fac. Agr. Hokkaido Imp. Univ. **24**(5): 191-363.
32. TATEWAKI, M. 1934-1938. Taxonomical study on plants growing in the alpine belt in Yezo **1-3**. in Jour. Sapporo Soc. Agr. & For. **26**: 241-285, **28**: 21-48, **30**: 1-26.
33. TATEWAKI, M. 1963. Alpine plants in Hokkaido. in Sci. Rep. Tohoku Univ. ser. Biol. **29**: 165-188.
34. TATEWAKI, M. and M. TOHYAMA 1975. Atlas of the distribution of alpine plants in Hokkaido. in Jour. Fac. Agr. Hokkaido Univ. **58**(1): 57-100.
35. TOYOKUNI, H. 1972. Notes on circumpolar elements in the alpine floras of the Hidaka-Yupari ranges, Hokkaido, Japan **1**. in Mem. Nat. Sci. Mus. **5**: 183-201.
36. TOYOKUNI, H. 1974-1978. Index plantarum in regionibus alpinis hokkaidoënsibus sponte crescentium **1-5**. in Jour. Asahikawa Univ. **2**: 121-126, **3**: 157-162, **4**: 173-179, **5**: 223-228, **6**: 115-124.
37. TOYOKUNI, H. 1979. Alpine plants of Hokkaido. in Bull. Bot. Soc. Nagano **12**: 6-11.

38. TOYOKUNI, H. 1980. Notes on the floristic phytogeography of the alpine flora of Hokkaido, Japan. in Jour. Fac. Liberal Arts, Shinshu Univ. Nat. Sci. **14**: 189-200.
39. TRALAU, H. (ed.) 1967-1973. Index Holmensis **1-3**.
40. TUTIN, T. G. *et al.* 1964, 1968, 1972, 1976, 1980. Flora Europaea **1-5**.
41. YOSHIOKA, K. 1973. Shokubutsu Chirigaku (Plant Geography).
42. ВОРОШИЛОВ, В. Н. 1966. Флора Советского Дальнего Востока.
43. ТОЛМАЧЕВ, А. И. 1960, 1964, 1966, 1963, 1966, 1971, 1975. Арктическая Флора СССР **1-7**.
44. Флора СССР **1-30**. 1934-1960.

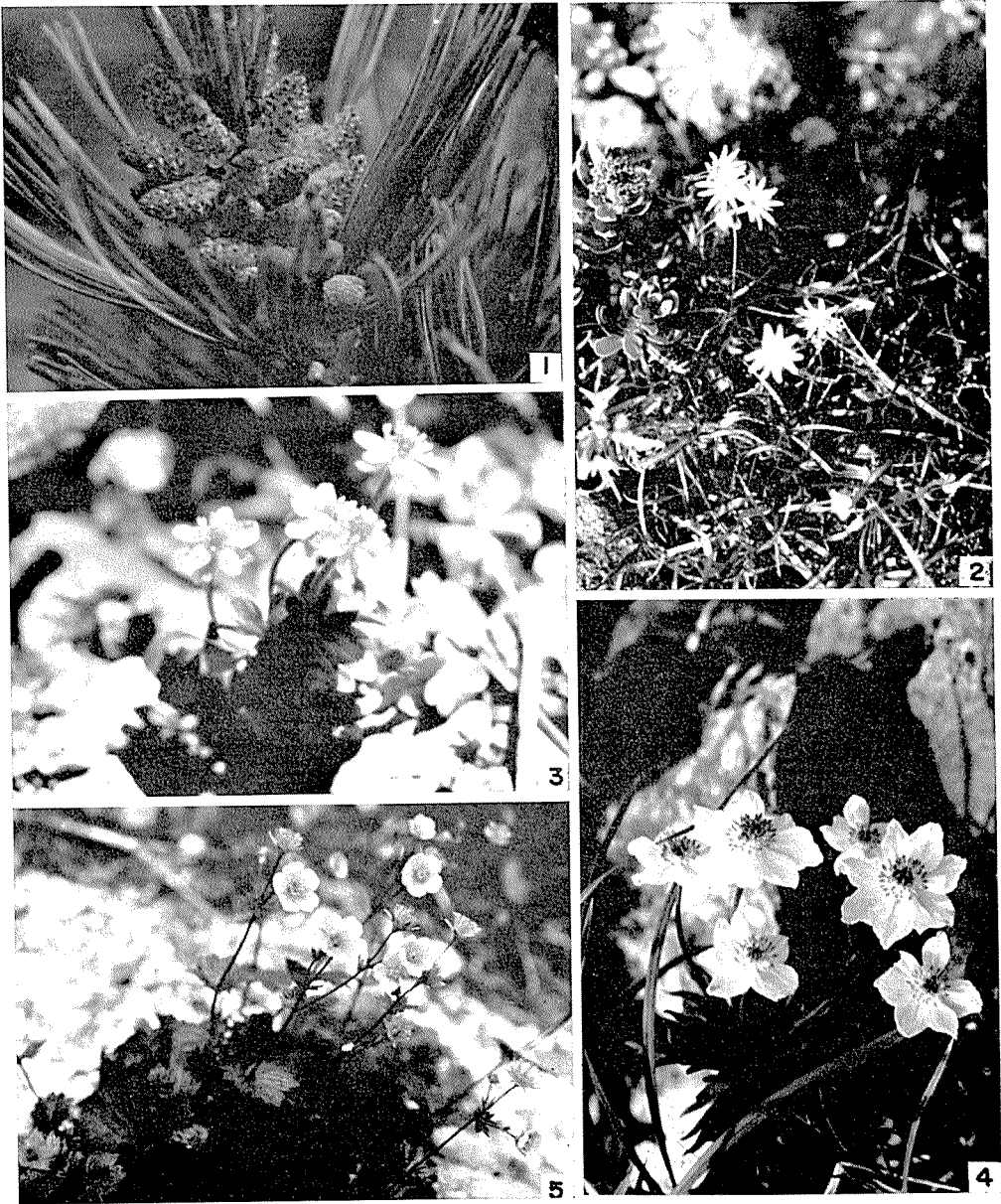


Plate I

- Fig. 1. *Pinus pumila* (Mt. Poroshiri, Hokkaido)
 Fig. 2. *Stellaria nipponica* (Mt. Shirouma, Central Honshu)
 Fig. 3. *Ranunculus pygmaeus* (Mt. Shirouma, Central Honshu)
 Fig. 4. *Anemone narcissiflora* (Mt. Shirouma, Central Honshu)
 Fig. 5. *Acomastylis calthifolia* var. *nipponica* (Mt. Shirouma, Central Honshu)

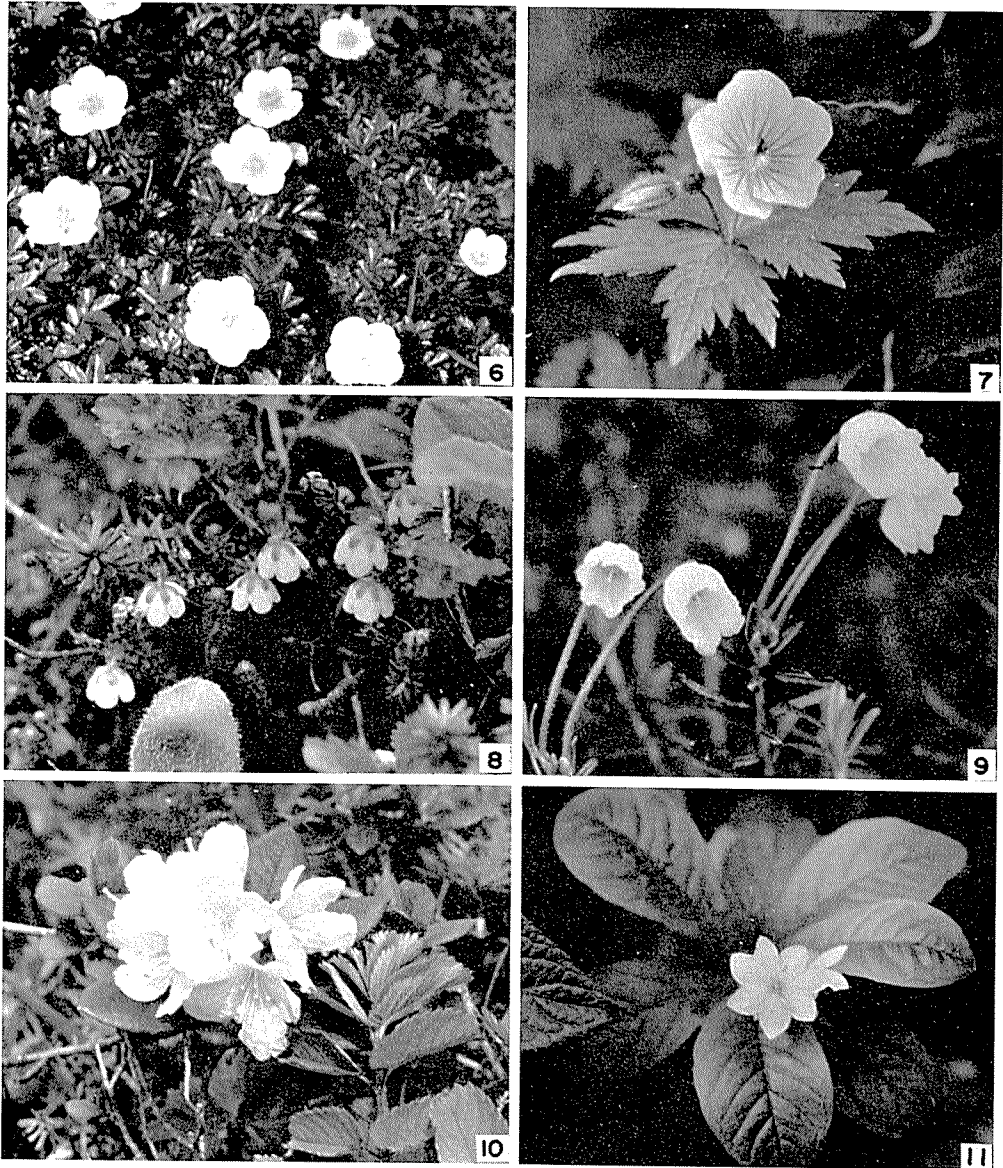


Plate II

- Fig. 6. *Sieversia pentapetala* (Mt. Poroshiri, Hokkaido)
- Fig. 7. *Geranium erianthum* (Mt. Poroshiri, Hokkaido)
- Fig. 8. *Harrimanella stelleriana* (Mt. Poroshiri, Hokkaido)
- Fig. 9. *Phyllodoce nipponica* var. *oblongo-ovata* (Mt. Poroshiri, Hokkaido)
- Fig. 10. *Rhododendron aureum* (Mt. Poroshiri, Hokkaido)
- Fig. 11. *Trientalis europaea* (Mt. Poroshiri, Hokkaido)



Plate III

- Fig. 12. *Gentianella yuparensis* subsp. *takedae* (Mt. Shirouma, Central Honshu)
 Fig. 13. *Lagotis glauca* (Mt. Shirouma, Central Honshu)
 Fig. 14. *Lonicera chamissoi* (Mt. Poroshiri, Hokkaido)
 Fig. 15. *Campanula lasiocarpa* (Mt. Shirouma, Central Honshu)
 Fig. 16. *Platanthera hyperborea* (Mt. Shirouma, Central Honshu)