Korean J. Ecol. 13(3) : 237~245, 1990

A Comparison of the Alpine Tundra Floras of the Alpine Tundra Zone on Paektusan with the Alpine and Subalpine Zone in Korea

Chang, Nam-Kee, Hae-Mee Yoo and Eun-Joo Eo
Dept. of Biology, College of Education, Seoul National Univ.

韓國에 있어서 白頭山의 高山툰드라대와 高山과 亞高山帶의 高山툰드라 植物相의 比較

張楠基 · 兪海美 · 魚銀珠
서울大學校 師範大學 生物敎育科

ABSTRACT

Ninety six plant species recorded at the alpine tundra zone on the Paektusan (Zhu and Rowe, 1987) were examined on the floras of alpine and subalpine zones in Korea. Among the 96 species, 59 (61%), 47 (49%) and 51 (53%) species in the alpine zone of Kwanmobong, Turyusan and Puksubaeksan were recognized respectively, and 24 (25%), 21 (22%), 21 (22%), 11 (11%) and 16 (17%) species in the subalpine zone of Myohyangsan, Kumgangsan, Soraksan, Chirisan and Hallasan respectively. The similarities between the alpine tundra zone of Paektusan and the alpine zones of other mountains in Korea showed high values than the values compared with subalpine zones.

INTRODUCTION

Few studies were reported on the species affinities of alpine and/or subalpine zone of Korea, based on the lists of alpine plants (Park, 1942; Chung, 1989). But, the many distribution maps were showed remarkable similarities of east and west for northern part of Pacific rim (Hulten, 1968). According to Zhu and Rowe (1987), the floras of the alpine tundra zone on Paektusan in northeastern China with several selected alpine and arctic floras of northwestern North America were compared in a primary way.

In this article the alpine tundra flora of the alpine tundra zone on Paektusan and the alpine and subalpine zone in Korea was investigated.

VEGETATION OF PAEKTUSAN

A volcanic peak of Paektusan (2, 744 m, 42° N and 128° E), which is the highest mountain in Korea, has erupted three times in 1597, 1668 and 1702 during the last 400 years (Fig. 1). The caldera is occupied by Cheonji (Heaven Lake) with the maximum depth of 300 m. Debris-covered basaltic and scoria cliffs surround the lake and rise some 400 m above lake level. Except for the active talus slopes, the cliffs and the truncated valley spurs indicate past glacial activity. Despite a history of volcanism that has produced areas of pumice-end-ash substrate unsuitable for plant growth near the caldera rim, Paektusan is well vegetated. Ascent of the mountain from the west side reveals the following zonation of communities on the deeper soils (Zhu and Rowe, 1987).

Below than 720 m in altitude

Scrub forest of *Quercus mongolica* and *Corylus heterophylla.*

Elevation zone 720 to 1100 m

Pine-Hardwood forest, with *Pinus koraiensis, Populus davidiana* and *Betula platyphylla* prominent on the drier sites, and with a rich mixture of temperate broadleaf species, such as *Tilia amurensis, Acer mono, Fraxinus mandshurica, Ulmus propinqua* and *Juglans mandshurica* occupying the moister sites.

Elevation zone 1100 to 1700 m

Coniferous forest, with pure or mixed species stands of *Larix olgensis, Picea jezoensis, Abies nephrolepis, Pinus sylvestris* var. *sylvestriformis,* plus several other spruce, fir and pine species. Some of the lower zone trees such as *Pinus, Populus* and *Betula* are conspicuous invaders after fire and other disturbance.

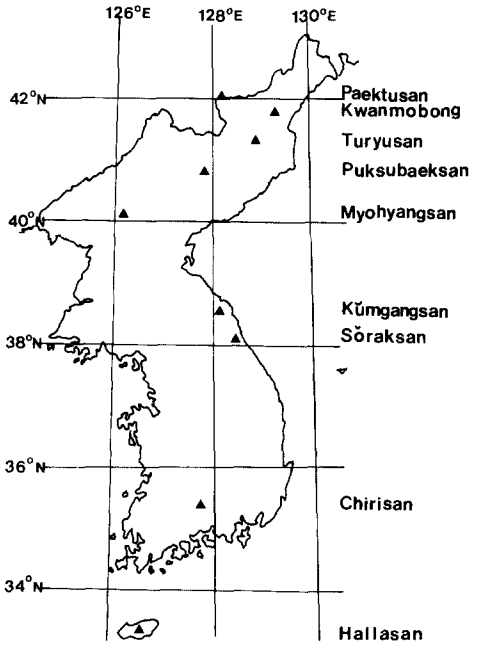

Fig. 1. Map showing studied mountains in Korea.

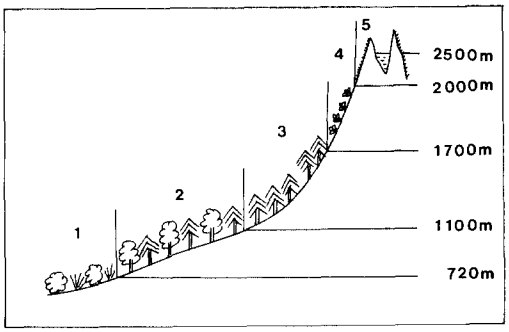

Fig. 2. Vegetation profile of western slope in Paektusan:

1. Scrub forests of *Quercus mongolica* and *Corylus heterophylla;*
2. Pine-Hardwood forests;
3. Coniferous forests;
4. Subalpine birch forests including birch krummholzt on the timber line;
5. Alpine "tundra" Ericaceae dwarf shrubs and alpine meadows.

Elevation zone 1700 to 2000 m

Subalpine birch forest, dominated by *Betula ermani,* with occasional *Pinus pumilia, Alnus fruticosa* var. *mandshurica* and *Sorbus decora.* At their upper limit, the birch groves assume the wind-trained krummholz form.

Elevation zone 2000 m

Alpine tundra, dominated by dwarf ericaceous shrubs, willows and many herbaceous plants. The flora of this fifth zone is the center of interst in the remainder of this article.

This general description of the vegetation of Paektusan is given by Hou (1983), and Zhu and Rowe (1987) who specifically refers to the Paektusan alpine vegetation as "Mountain Dwarf-Shrub Tundra" (Fig. 2).

METHODS

Studies on the vegetation of Soraksan, Chirisan and Hallasan have been carried out by the author from 1976 to 1990. The Paektusan alpine vegetation mountain dwarf-shrub tundra was investigated from July 23 to August 18, 1989.

In 1942, 197 plant species in the alpine zone on Paektusan was reported by Park, and in 1979, 96 plant species in the alpine tundra zone of Paektusan was published by Qiang and Chang. Their check lists of the alpine tundra zone of Paektusan were compared with several selected alpine and arctic flora of northwestern America by Zhu and Rowe (1987).

In this study the comparison of floras among nine mountains of Paektusan, Kwanmobong, Turyusan, Puksubaeksan, Myohyangsan, Kumgangsan, Soraksan, Chirisan and Hallasan was made along elevation change of 2,744, 2,451, 2,309, 2,522, 1,909, 1,639, 1,708, 1,915 and 1,950 m at altitude (Fig. 1). The floras by Qiang and Chang (1979) for Paektusan, Park (1943) and Chung (1965) of Korea, Chung (1989) for South Korea, Hulten (1968) for Alaska and the neighboring territories in Canada, Porsild and Cody (1980) for the Northwest territories, Moss and Packer (1983) for the Rocky Mountains of western Alberta, Chung (1989) for eastern North America, and Zhu and Rowe (1987) for northeastern China and northeastern North America were used for the comparison of floras among Paektusan, Kwanmobong, Turyusan, Puksubaeksan, Myohyangsan, Kumgangsan, Soraksan, Chirisan and Hallasan.

In this comparison, only species names were used to overcome difficulties in determining subspecies and more lower taxa.

RESULTS AND DISCUSSION

A few species occuring in 2,000 m above area of Paektusan appear in the subalpine zone of Myohyangsan, Kumgangsan, Soraksan, Chirisan and Hallasan (Table 1). However a large numbers of alpine tundra species occur in northwestern America and the alpine zone of Kwanmobong, Turyusan and Puksubaeksan. The total listed complement of Paektusan's alpine tundra species is as much as 96 species (Zhu and Rowe, 1987). The number (and percentages) of those show 59 (61%) in Kwanmobong, 47 (49%) in Turyusan, 51 (53%) in Puksubaeksan, 49 (51%) in Alaska and neighboring territories, 39 (41%) in the Northwest territories in Canada and 32 (33%) in alpine zone of the Rocky Mountain in western Alberta. Those of the 96 species shared with the subalpine zone of Myohyangsan, Kumgangsan, Soraksan, Chirisan and Hallasan are 24 (25%), 21 (22%),

Table 1. Comparison of alpine tundra floras of the alpine tundra zone on Paektusan with the alpine and subalpine zone in Korea and the selected alpine zones in northwestern North America as a reference. KWA; Kwanmobong, TUR; Turyusan, PUK; Puksubaeksan, MYO; Myohyangsan, KUM; Kumgangsan, SOR; Soraksan, CHI; Chirisan, HAL; Hallasan, ANT; Alaska and neighboring territories, NTC; Northwest territories Canada and RMA; Rocky mountains Alberta, Canada

Alpine tundra species on Paektusan	Alpine zone			Subalpine zone					Reference area (Zhu & Rowe, 1987)		
	KWA	TUR	PUK	MYO	KUM	SOR	CHI	HAL	ANT	NTC	RMA
Lypodiaceae											
Lycopodium alpinum L.	+								+	+	+
L. chinense Christensen	+	+	+	+	+	+	+	+			
L. selago L.	+	+	+	+	+	+	+	+	+	+	+
Woodsiaceae											
Woodsia ilvensis R.Br.	+	+	+	+	+	+	+	+	+	+	+
Cupressaceae											
Juniperus sibirica Burgedorf.	+	+	+	+					+	+	+
Salicaceae											
Salix oblongifolia TR. & MEY											
S. polyadenia HAND-MAZZ.											
S. pyrolifolia LEDEB.											
S. rotundifolia Trautvetter	+	+	+	+	+	+	+	+	+	+	
Polygonaceae											
Bistorta ochotensis Komarov											
B. vulgaris HILL	+		+	+	+	+	+	+	+	+	+
Oxyria digyna Hill									+	+	+
Pleuropteropyrum ajanense Nakai											
Caryophyllaceae											
Cerastium baishanense Y.C. Chu											
Minuartia arctica (Fenzl) Ascherson & Graebner	+								+	+	
M. macrocarpa (Purch) Ostenf									+	+	
Silene oligantella Nakai	+	+	+		+	+					
S. repens Patr.	+	+	+	+	+	+			+	+	
Ranunculaceae											
Aquilegia japonica Nakai & Hara	+	+	+								
Ranunculus boralis Trautvetter								+	+	+	+
Papaveraceae											
Papaver coreanum Nakai	+										
Cruciferae											
Arabis coronata Nakai											
Cardamine resedifolia var. *morri* Nakai											

Table 1. Continued

Alpine tundra species on Paektusan	Alpine zone			Subalpine zone					Reference area (Zhu & Rowe, 1987)		
	KWA	TUR	PUK	MYO	KUM	SOR	CHI	HAL	ANT	NTC	RMA
Draba borealis DC									+	+	+
Crassulaceae											
Orostachys malacophyllus (Pallas) Fisch						+		+	+		
Rhodiola sachaliensis A. BOR									+		
Sedum rosea (L.) Scop.									+		+
Saxifragaceae											
Chrysosplenium kamtschatium Fish									+		
Parnassia palustris L.	+	+	+	+	+	+	+	+	+	+	+
Saxifraga laciniata Nakai et Takada	+	+	+								
S. punctata L.	+	+	+			+			+	+	
S. takedana Nakai											
Rosaceae											
Dryas octopetala L. var. *asiatica* Nakai	+	+	+					+	+	+	+
Potentilla nivea L.	+								+	+	+
Sibbaldia procumbens L.								+	+	+	+
Sanguisorba sitchensis C.A.MEY =*argutidens* Nakai	+	+	+						+	+	
Fabasceae											
Hedysarum alpinum L.	+	+	+						+	+	+
Oxytropis anertii Nakai	+	+	+								
Empetraceae											
Empetrum nigrum L. var. *asiaticum* Nakai	+	+	+					+	+	+	+
Violaceae											
Viola biflora L.	+	+	+						+		
Umbelliferae											
Bupleurum euphorbioides Nakai	+	+	+	+	+	+					
Coelopleurum nakaianum Kitagawa			+								
C. saxatile Drude											
Tilingia tachiroei (Fr. et. Sar.) Kitagawa	+	+	+	+			+	+			
Rhodoraceae											
Ledum palustre var. *angustum* Busch	+								+	+	+

Table 1. Continued

Alpine tundra species on Paektusan	Alpine zone			Subalpine zone					Reference area (Zhu & Rowe, 1987)		
	KWA	TUR	PUK	MYO	KUM	SOR	CHI	HAL	ANT	NTC	RMA
Phyllodoce coerulea Babington	+	+	+						+	+	
Rhododendron aureum Georgi	+	+	+			+					
R. confertissimum Nakai	+	+	+								
R. parvifolium Adams	+	+	+						+		
R. redouskianum Maxim	+										
Ericaceae											
Arctous ruber Nakai	+	+	+		+	+			+	+	+
Vaccinium uliginosum L.	+	+	+	+	+	+	+	+	+	+	+
V. vitis-idaea L.	+	+	+	+	+	+		+	+	+	+
Gentianaceae											
Gentiana algida Pallas	+	+	+						+		
G. jamesii Hemsley	+	+	+		+	+					
Labiatae											
Prunella asiatica Nakai	+	+	+	+	+	+	+	+			
Scrophulariaceae											
Pedicularis verticillata L.	+	+	+				+		+	+	
Veronica stelleri var. *longistyla* Kitagawa									+		
Caprifoliaceae											
Linnaea borealis L.	+	+	+	+					+	+	+
Compositae											
Aster alpinus L.									+	+	+
Chrysanthemum zawadskii var. alpinum Kitamura	+	+	+	+	+	+	+				
Ligularia deltoidea Nakai	+	+	+								
L. jamesii (Hemsley) Komarov	+	+	+								
Petasites saxatilis Komarov	+	+	+	+	+						
Saussurea alpicola Kitam.	+			+	+						
S. triangulata var. *alpina* Nakai		+	+	+							
Senecio phoeanthus Nakai	+	+	+	+	+	+	+				
Gramineae											
Agrostis flaccida var. *trinii* Turcz									+		
Anthoxanthum nipponicum Honda											
Deschampsia caespitosa Beauvois	+	+	+					+	+	+	+
Festuca rubra L.									+	+	+
F. subalpina Chang & Skv.											
Hierochloe alpina Roemer & Schultzes									+	+	+
Poa archica R.BR.									+	+	+

Table 1. Continued

Alpine tundra species on Paektusan	Alpine zone			Subalpine zone					Reference area (Zhu & Rowe, 1987)		
	KWA	TUR	PUK	MYO	KUM	SOR	CHI	HAL	ANT	NTC	RMA
P. shinanoana Ohwi											
Ptilagrostis mongolica (Turcz) Griseb.	+		+	+							
Trisetum spicatum (L.) Richter			+						+	+	+
Cyperaceae											
Carex atrata L.	+	+	+	+					+	+	+
C. bipartita All											+
C. changbaishanica Chou											
C. eleusinoidea Turcz									+	+	
C. sedakovii Meinsh											
C. sirounemsis Koidz											
Kobresia bellardii Degland	+								+	+	+
Scripus hudsonianus (Michx.) Fernald									+	+	+
S. maximowiczii C.B. Clarke	+	+	+	+	+						
Juncaceae											
Juncus maximowiczii Buchen	+										
Luzula oligantha Samuelsson	+	+	+	+	+	+					
L. pallescens (Wahlenb.) Bess.	+	+	+								
L. sudetica (Willdenow) D.C.	+	+	+								
L. wahlenbergii Ruprecht	+								+	+	+
Liliaceae											
Lloydia serotina (L.) Sweet	+		+						+	+	
L. triflora (Ledebour) Baker	+	+	+	+	+	+					
Tofieldia nutans Willd.											
Zygadenus sibiricus A. Gray	+	+	+								
Orchidaceae											
Coeloglossum viride var. *bracteatum* Richt.	+							+	+		+
Total species number (96 species)	59	47	51	24	21	21	11	16	49	39	32
Percentage, No. of species/96 species ×100 (%)	61	49	53	25	22	22	11	17	51	41	33

21 (22%), 11 (11%) and 16 (17%), respectively (Table 1). The decrease in numbers of species shared from Paektusan to Hallasan is that expected with increasing distance from Paektusan. The increase in numbers of species shared from Hallasan to Paektusan is also that expected with increasing above sea level height from subalpine zone to alpine.

The decreasing numbers of alpine tundra species toward Myohyangsan, Kumgangsan, Soraksan,

Chirisan and Hallasan is expected with subalpine zone as the reports by Zhu and Rowe (1987), which is the shared species decrease from Alaska to the Alberta Rocky Mountains because of increasing distance from Northeast Asia.

The Alpine tundra of Paektusan is dominated by ericoid vegetation in large area, including *Rhododendrons* with well-known arctic-alpine species such as *Empetrum nigrum*, *Arctous rubra*, *Ledum palustre*, *Phyllodoce coerulea*, *Vaccinium uliginosum* and *V. vitis-idaea*. This vegetation types are common in alpine and arctic North America, though lacking the richness of *Rhododendron* species. Similarities of this ericoid vegetation type might have been revealed on the alpine zone of Kwanmobong, Turyusan and Puksubaeksan. Zhu and Rowe (1987) said that it had been possible to carry out vegetational studies comparing the prevalence of dominant species on Paektusan with appropriate sample areas covered by the other alpine and arctic floras. There are parts of Hallasan dominated by Empetraceae and Ericaceae with the similarities in alpine tundra flora. Hallasan (1,950 m) is located at 33° N, 120° E. Ericaceae of the alpine tundra flora is shown on the subalpine zone of Myohyangsan, Kumgangsan, Soraksan and Chirisan, too.

Since Mesozoic time the Bering Sea had been land bridge, and only recently appered as a water barrier (Hopkins, 1967). Moreover, since the end of the Cretaceous the Bering Strait area has been close to the rotational north pole which means that the major control over migrating flora and fauna must have been largely climatic with cold temperature of the strongest selective influence (Mckenna, 1983). Zhu and Rowe (1987) suggested that cold-tolerant arctic and alpine species would be the most successful migrators between Asia and North America, particularly during the Pleistocene.

The glances at the topographic map of Korea and China show that there is a topographic barrier on the presumed migration route. The mountain ranges of which Paektusan is a part are isolated from other ranges farther north by the Manchurian Plain and the Amur River vally (Zhu and Rowe, 1987). And presumably elements of the arctic and alpine flora were able to cross these lowlands during glacial intervals close to the ice, when the forests retreated southward. The tundra vegetation with the return of forest during interglacials moved upward to survive on the high altitude of frost-stirred soils such as the present time.

Considering the distances and the exigencies of migration for small plants, the similarities between Paektusan's complement of species and the floras of the northwest in North America raise intriguing questions about the rapidity of evolution, the stability of species, and the geological history of the Pacific rim continents. Kruckeberg (1983) suggested that much light might be thrown on the relationships of such vicariants and disjuncts through tests of genetic affinity by degree of crossability and interfertility.

According to Hamilton (1983), many of the ambiguities of geological history are more likely to be resolved by paleobiogeographic studies than by geologic and geophysical ones. As the basis for paleobiogeographic studies, much more ones should be known about the affinities of the Pacific rim floras, and particularly of the amphi-Pacific species.

要 約

Zhu and Rowe(1987)의 白頭山의 高山툰드라대에서 生育하고 있는 96종을 基準目錄으

로 하여 韓国의 高山帶와 亞高山帶의 植物相을 비교한 결과 冠帽峰, 頭流山, 北水白山의 高山帶에서 나타나는 種數(또는 %)는 각각 59(61%), 47(49%), 51(53%)였고, 妙香山, 金剛山, 雪岳山, 智異山, 漢拏山에 나타나는 種數(또는 %)는 각각 24(25%), 21(22%), 21(22%), 11(11%), 16(17%)로 백두산 고산툰드라 식물상 유사도가 기대한 바와 같이 고산대에서는 높고 아고산대에서는 낮았다.

LITERATURES CITED

Chang, N.K., S.T. Park and H.S. Lee. 1973. Phytosociological analyses of the forest on the elevational gradient in Mt. Halla. J. Education S.N.U. 3:167-180.

Chung, I.C. 1989. Eastern North America as seen by a botanist: Pictorial II. The wooded regions. Samhwa Publ. Co. Ltd. Seoul Korea pp. 113-368.

Chung, T.H. 1965. Illustrated encyclopedia of fauna and flora of Korea Vol. 5. Tracheophyta. Ministry of Education, Republic of Korea. 578 pp.

Chung, Y.H. 1989. Distribution pattern of alpine plants in South Korea. Nature Conservation 66:29-38.

Hamilton, W. 1983. Cretaceous and Cenozoic history of the northern continents. Annals of the Missouri Botanical Garden 70:440-458.

Hopkins, D.M. 1967. The Bering land Bridge. Stanford University Press, Stanford, California.

Hou, H.Y. 1983. Vegetation of China with reference to its geographical distribution.—Annals of the Missouri Botanical Garden 70:509-549.

Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, Califonia. pp. 103-230.

Kruckeberg, A.R. 1983. Temperate floras: the North Pacific connection. Annals of the Missouri Botanical Garden 70:591-596.

McKenna, M.C. 1983. Holarctic landmass rearrangement, cosmic events and Cenozoic terrestrial organisms. Annals of the Missouri Botanical Garden 70:469-489.

Moss, E.H. and J.G. Packer. 1983. Flora of Alberta. 2nd ed. University of Toronto Press, Toronto, Ontario, Canada pp. 23-110.

Park, M.K. 1942. A list of alpine plants in Korea. Journal of Chosen Natural History Society 9:1-12.

Porsild, A.E. and W.J. Cody. 1980. Vascular plant of continental Northeast Territories, Canada. National Museum of National Sciences, National Museum of Canada, Ottawa, Canada pp. 15-130.

Qiang, J.J. and W.Z. Chang. 1979. Distribution of plants of Chambai Mountain (In Chinese). Publishing House of the Northeast Normal University, Changchun, Jilim Province, People's Republic of China 50 pp.

Zhu, T.E. and J. S. Rowe. 1987. A comparison of alpine tundra floras: N.E. China and N.W. North America. Linzer Biol. Beitr. 19:29-41.

(Received 22 June 1990)