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Studies on the Floristic Composition and Succession of the Shrub Communities at the Summit of Mt. Halla, Cheju Island, Korea

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ABSTRACT: ***Empetrum nigrum*** dominant community or ***Rhododendron mucronulatum*** and ***R. yedoense*** var. ***poukhanense*** dominant shrub community are developing above 1,500m on Mt. Halla in Cheju Island, Korea. These communities were formed as a result of the forest of ***Abies koreana*** regression by grazing or erosion over a long period of time. This study was conducted using the phytosociological method and it clarified the floristic composition of the community in Cheju Island by comparing with a similar community in Japan. Also this study interpreted the development data of these communities and considered community succession. As a result of our interpretation, shrub community of Cheju Island is recognized as two associations, Festuco obinae-Empetretum nigrum ass. nov and Rhododendretum mucronulatum ass. nov. Each association of Cheju Island is composed of endemic species of Cheju Island, related to the Korean peninsula and to Japan. The two associations are divided into 8 sub-units but each community development has been created with longtime grazing and prescribed fire. Maybe the location stability by stoppage of interference and grazing will process community transition quickly. Comparing the shrub communities of Cheju Island with Maianthemo-Rhododendretum in Kyushu, Japan, which is close geographically, both areas have the species of Miscanthetea sinesis and Ericaceae in common. But Cheju Island has more abundant species and has higher ratio of appearance of alpine plants. The shrub communities of Cheju Island and Kyushu, Japan are identified as having a different rank over Alliance.

Key Words: *Empetrum nigrum*, Mt. Halla, Phytosociological method, *Rhododendron mucronulatum*, *Rhododendron yedoense* var. *poukhanense*, Shrub community, Succession.

INTRODUCTION

Cheju Island is a volcanic island that lies 130 km southwest of the Korean peninsula. The extinct volcano, Mt. Halla, in the central part of the island is 1,950m high. Cheju Is. also has many endemic species which show original adaptations, due to isolation from the continent (Nakai 1914). Lee (1985) reported that Cheju Is. has 74 endemic species, and most of them are distributed above 1,400 m altitude, where this study was conducted.

The vertical distribution of the vegetation is influenced strongly by mankind. Vegetation disturbance has occurred for a long time: large areas have been used as pasture in low land, meadows on the mountain sides, and grazing land on gentle slopes above 1,500m altitude. Natural forests of *Abies koreana* have been changed to grassland or scrub by prescribed fire and overgrazing for a long time. Depending on the intensity of grazing pressure and the level of soil erosion, various communities have formed like mosaics in these overgrazed areas. A succession of various communities is in progress because of recent prohibition of grazing. The object of this study is to clarify the floristic composition and habitat characteristics of shrub communities in potential *A. koreana* forest areas, and to compare shrub communities of Cheju Is. with those dominated by Ericaceae plants of Kyushu, Japan having a similar vegetation history.

DESCRIPTION OF SURVEYED AREA

Cheju Is. is located at Long. 126°10′E to 126°58′E, and Lat. 33°06′ to 33°33′N. The shape of the island is nearly elliptical and the area is 1,825 km^2. The base rock of this island is composed of volcanic rock, mainly including Basalts, Andesites and Trachytes (Won 1975).

Although primary vegetation of nearly all of the lowland was destroyed by inhabitants, vertical distribution of vegetation can be estimated by partially surviving plant communities in the area

below 500m altitude, where most of the land is on a gentle grade. These regions are occupied by evergreen broadleaved forests dominated by *Castanopsis cuspidata* var. *sieboldii* and *Quercus glauca* (Kim *et al.* 1994, Kim and Hukusima 1991). There are deciduous forests dominated by *Q. serrata, Q. mongolica*, etc. from 500m up to 1,400m altitude, including various steep slopes. Also, it is thought that were *Abies koreana* forests in gentle slope plateaus above 1,400m altitude (Kim and Nam 1985, Song and Nakanishi 1985). Above 1,750m altitude to the peak, shrubby *A. koreana* forests (Kim and Kim 1985) and *Diapensia lapponica* var. *ovovata* communities (Yoshikawa *et al.* 1999) are found in steep and exposed rock regions.

The regions of this study is from 1,400 to 1,650m altitude, where the slopes are gentle. *A. koreana* forests have survived at the areas which were not affected by forest fire. But most of these regions are covered with grassland of *Sasa quelpaertensis* and *Arundinella hirta*, and with shrub communities of *R. mucronulatum* and *R. yedoense* var. *poukhanense*, etc. due to prescribed fire and overgrazing in the past. The soil is composed of volcanic dark brown and black ash in the region (Yoo and Song 1984). Soil and rocks in some places have been exposed by erosion extending over a long time. The conditions were adequate for the forests to develop up to the summit judging from the climatological information of this island. The yearly precipitation of the lowlands is over 1,400mm. Uplands have more precipitation, moisture, and fog than lowlands, in general. But the greater part of the summit area of the mountain are exceedingly dry except partial slender slope area.

METHODS

Vegetation surveys were conducted with phytosociological methods (Braun-Blanquet 1964). Species composition tables were prepared with Ellenberg methods (Ellenberg 1956) from raw data, and vegetation units were discriminated and extracted. In order to examine the similarity and dissimilarity of species composition among the communities, the constituent species were compared with those of shrub communities of Kyshu, Japan which are physiognomically similar to this area (Ohda and Sumata 1966, Oita-Ken 1978, 1979, Suzuki 1969, Suzuki *et al.* 1970, Umezu and Suzuki 1970, Arakane *et al.* 1974, Kagoshima-Ken 1978, 1979, Miyawaki 1986, Miyawaki and Fujiwara 1978, Miyazaki-Ken 1978, 1979)

RESULTS AND DISCUSSION

Characteristics of species composition of shrub communities

Two new associations were divided from vegetation tables based on 145 relevés. Synthesis tables were provided in Table 1.

1) Festuco ovinae - Empetretum nigrum ass. nov.

Character species: *Empetrum nigrum* var. *japonicum, Festuca ovina*

Holotype: Stand No. 53 (Table 2). Mt. Halla, Cheju Is.

This association was an evergreen dwarf shrub community that was dominated by *Empetrum nigrum* var. *japonicum*. This community was composed of 80 species including 10 endemic and 8 alpine species. The dominance index of *E. nigrum* var. *japonicum* was over 4 and got into mat shape with small grasses and herbs. Although, the communities of *E. nigrum* var. *japonicum* also form in alpine gravel habitat in north to central Japan, this community in Mt. Halla was regarded as a new association because species composition was quite different from that of Japan. *E. nigrum* var. *japonicum* communities are commonly mixed with *Diapensia lapponica* var. *ovovata* in alpine zone of central Japan, but formed in rocks independently on Mt. Halla, Cheju Island (Yoshikawa *et al.* 1999).

Furthermore, this association was divided into the following three subassociations, and these corresponded with characteristics of their habitats. Festuco ovinae - Empetretum nigrum violetosum crassae was developed at some areas disturbed by erosion which were paths of grazing cattle. Both *Thymus quinquecostatus* and *Viola crassa* were abundant. The area is where *E. nigrum* var. *japonicum* can be developed by stabilization but the vegetation is demolished easily if eroded. Festuco ovinae - Empetretum nigrum typicum only was developed at flat rocky habitats having concluded poor soil. The number of composed species was mostly few, but it is estimated where *E. nigrum* var. *japonicum* was original habitats. Festuco ovinae - Empetretum nigrum deschampsietosum caespitosae was the community with various species as a result of *E. nigrum* var. *japonicum* growing on rocks and extending to stabilized habitats, and may be changed from the above two subassociations. In addition, there were various common species following Rhododendretum mucronulatum. It was estimated that Festuco ovinae - Empetretum nigrum deschampsietosum may shift to Rhododendretum mucronulatum because of inclusion of saplings of

Table 1. Summarized table of Festuco ovinae-Empetretum nigrum and Rhododendretum mucronulatum
A: Festuco ovinae-Empetretum nigrum nov.
a: Violetosum crassae
b: Typicum
c: Deschampsietosum caespitosae
B: Rhododendretum mucronulatum nov.
a: Geranietosum sibiricum
I. *Ligularia fiecheri* variant
1. Typical subvariant
2. *Prunus maximowiczii* subvariant
II. Typical variant
b: Caretosum metallica
I. *Rhododendron yedoense* v. *poukhanense* variant
II. Typical variant

	A			B				
	a	b	c	a			b	
				I		II	I	II
				1	2			
Number of Stands	13	35	14	18	20	8	24	13
Number of Species	15	24	79	106	134	56	31	12
Ch. species of Festuco ovinae - Empetretum nigrum								
Empetrum nigrum v. *japonicum*	V	V	V	III	II	IV	I	I
Festuca ovina	V	IV	I	+	I	II	I	I
Diff. species of Violetosum crassae								
Viola crassa	V	·	+	+	·	·	·	·
Diff. species of Deschampsietosum caespitosae and Geranitosum sibiricum								
Deschampsia caespitosa v. *festucaefolia*	·	·	IV	IV	IV	IV	·	·
Geranium sibiricum	·	·	IV	IV	III	II	·	·
Carex tenuiformis	·	·	II	IV	III	III	·	·
Cirsium japonicum v. *spinosissimum*	·	·	III	III	IV	I	·	·
Aster hayatae	·	·	III	II	II	I	·	·
Ch. species of Rhododendretum mucronulatum								
Rhododendron mucronulatum	+	II	II	V	V	V	IV	IV
Juniperus chinensis	·	·	II	IV	II	V	V	V
Rhododendron yedoense v. *poukhanense*	·	r	II	IV	IV	III	V	·
Diff. species of Geranietosum sibiricum								
Thymus quinquecostatus	IV	I	III	III	II	III	·	+
Galium pusillum	·	I	III	IV	III	IV	r	·
Euphorbia fauriei	II	I	II	III	III	III	r	·
Anaphalis sinica	II	I	III	III	II	IV	·	·
Aruncus aethusifolis	II	r	I	III	II	III	r	·
Sanguisorba officinalis	·	I	II	III	III	III	+	·
Solidago virgaurea v. *asiatica*	II	I	III	II	II	I	·	·
Trifolium lupinaster v. *alpinum*	·	I	II	III	II	II	·	·
Artemisia laciniata	·	+	+	III	II	II	·	·
Fragaria nipponica	·	·	+	II	III	I	·	·
Tilingia tachiroei	·	·	I	II	II	III	·	·
Saussurea gracilis	·	·	II	I	II	III	·	·
Primula modesta	·	·	II	II	II	II	·	·
Adenophora taquetii	·	·	·	II	III	II	·	·
Diff. species of *Ligularia fischeri* variant								
Liguraria fischeri	·	·	II	IV	IV	·	·	·

Table 1. Continued.

Sasa quelpartensis	+	I	III	II	IV	·	r	+
Stephanandra incisa	·	·	·	II	IV	·	·	·
Taxus cuspidata	·	·	+	II	III	·	I	·
Bistorta alopecuroide	·	·	II	II	I	·	·	·
Vaccinium japonica	·	·	·	II	III	·	·	·
Allium taquetii	·	·	+	II	II	·	·	·
Clematis chiisanensis	·	·	·	II	II	·	·	·
Achillea sibirica v. *discoides*	·	·	+	I	II	·	·	·
Weigela florida	·	·	+	I	II	·	·	·
Athyrium reflexipinnum	·	·	+	I	II	·	·	·
Diff. species of *Prunus maximowiczii* subvariant								
Rhamnus taquetii	·	·	·	·	III	·	·	·
Prunus maximowiczii	·	·	·	·	II	I	·	·
Scabiosa mansenensis f. *alpina*	·	·	+	·	II	I	·	·
Smilax sieboldii	·	·	·	·	II	·	+	·
Symplocos coreana	·	·	·	·	II	·	·	·
Ligustrum obtusifolium	·	·	·	·	II	·	·	·
Elaeagnus umbellata	·	·	·	·	II	·	·	·
Ilex crenata	·	·	·	·	II	·	·	·
Diff. species of Caretosum metallica								
Carex metallica	+	III	+I	·	·	·	IV	III
Lunathyrium viridifrons	·	·	·	·	·	·	II	II
Diff. species of *Rhododendon yedonensis* v. *poukhanense* variant								
Hosta minor	·	+	II	II	I	III	III	·
Berberis amurensis v. *quelpaertensis*	·	·	·	+	r	I	II	·
Lycopodium chinensis	·	·	·	I	·	·	II	·
Companions								
Cirsium rhinocerous	II	+	II	III	IV	II	I	I
Polygonum cuspidatum	I	+	II	IV	III	I	II	II
Thalictrum tuberiferum	·	r	II	III	II	·	II	·
Arundinella hirta	·	I	IV	III	II	II	r	II
Potentilla matsumurae	+	I	II	II	I	II	r	·
Euonymus alatus	·	r	+	I	III	II	r	·
Viola patrinii	+	+	II	II	I	·	r	·
Taraxacum hallaisanensis	·	·	III	I	I	II	·	·
Pedicularis verticillata	·	·	II	I	II	·	·	·
Prunella vulgaris v. *lilacina*	·	·	II	I	I	I	·	·
Geranium tripartitum	·	I	+	·	·	·	+	I
Gymnadenia conopsea	·	·	I	II	I	·	·	·
Senecio nemorensis	·	·	·	I	II	II	·	·
Gentian algida	·	·	+	II	I	·	·	·
Dianthus superbus v. *longiradiatui*	·	·	+	II	+	I	·	·
Sium sisarum	·	·	I	II	+	·	·	·
Viola verecunda	·	·	·	+	+	I	II	·
Bupleurum longiradiatum v. *longiradiatui*	·	·	·	+	II	I	·	·
Parnassia palustris	·	·	II	I	r	·	·	·
Libanotis coreana	·	·	·	II	+	I	·	·
Veratrum maackii v. *japonicum*	·	·	·	II	I	·	·	·
Patrinia scabiosaefolia	·	·	·	I	I	I	·	·
Abies koreana	·	·	I	I	+	I	·	·

Table 1. Continued.

Valeriana fauriei	·	·	·	II	r	I	·	·
Athyrium vidalii	·	·	·	II	+	I	·	·
Lespedeza bicolor f. *acutifolia*	·	·	I	I	·	II	·	·
Swertia tetrapetala	·	·	+	·	I	II	·	·
Scilla scilloides	·	·	·	I	I	I	·	·
Adenophora triphylla v. *japonica*	·	·	II	+	·	I	·	·
Tofieldia coccinea v. *kondoi*	·	·	I	+	+	·	·	·
Teucrium japonicum	·	·	·	I	I	·	·	·
Plantago asiatica	·	·	+	+	I	·	·	·
Milium effusum	·	·	I	·	I	·	·	·
Heracleum moellendorffii	·	·	·	I	+	·	·	·
Aster scaber	·	·	·	I	r	I	·	·

Other companions occurred less than 4 stands were omitted.

Table 2. Holotype stand of Festuco ovinae-Empetretum nigrum (Stand No. 53)

	D · S	Species
K	5 · 5	*Empetrum nigrum* v. *japonicum*
	+	*Festuca ovina*
	+	*Viola crassa*
	+	*Cirsium rhinoceros*
	+	*Thymus quinquecostatus*
	+	*Aruncus aethusifolius*

Table 3. Holotype stand of Rhododendretum mucronulatum (Stand No. R75)

	D · S	Species
S	3 · 3	*Rhododendron mucronulatum*
	1 · 1	*Rhododendron yedoense* v. *poukhanense*
	+	*Vaccinium japonica*
K	2 · 2	*Carex tenuiformis*
	1 · 2	*Arundinella hirta*
	1 · 1	*Juniperus chinensis*
	+ · 2	*Deschampsia caespitosa* v. *festucaefolia*
	+	*Empetrum nigrum* v. *japonicum*
	+	*Dianthus superbus* v. *longicalycinus*
	+	*Ligularia fischeri*
	+	*Cirsium rhinoceros*
	+	*Galium pusillum*
	+	*Euphorbia fauriei*
	+	*Geranium sibiricum*
	+	*Thymus quinquecostatus*
	+	*Anaphalis sinica*
	+	*Trifolium lupinaster* v. *alpinum*
	+	*Tilingia tachiroei*
	+	*Thalictrum tuberiferum*
	+	*Bistorta alopecuroides*
	+	*Athyrium vidalii*
	+	*Valeriana fauriei*
	+	*Heracleum moellendorffii*
	+	*Senecio flammeus*

various shrubs such as *R. mucronulatum*.

Festuco ovinae - Empetretum nigrum developed on fixed rocks, and extended from there. At first this association was restricted, but we concluded that their habitats were extended to bare and rocky areas by prescribed fire and overgrazing. Recovery of vegetation cover as a result of interruption of erosion and soil formation negatively affected the development of this dwarf association.

2) Rhododendretum mucronulatum ass. nov.

Character species: *R. mucronulatum*, *R. yedoense* var. *poukhanense*, *Juniperus chinensis* var. *sargentii*

Holotype: Stand No. R75 (Table 3). Mt. Halla, Cheju Is.

This association was dominated by one of three character species, and was a cushion-shaped community. It was composed of 163 species including 15 endemic and 8 alpine species. This community was divided into two subassociations and various subunits, and each vegetation unit corresponded with independent characteristics of their habitats.

Rhododendretum mucronulatum geranietosum sibiricum was classified by various differential species include 6 endemic species, and *R. mucronulatum* or *R. yedoense* var. *poukhanense* were dominant. The peculiarity of this subassociation was that *E. nigrum* var. *japonicum* grew in most parts. This subassociation developed where volcanic ash soil had accumulated. This was divided into *Ligularia fischeri* variant and typical variant, furthermore *L. fischeri* variant was divided into the typical subvariant and *Prunus maximowiczii* subvariant. The number of component species and shrub species increased in the order of typical variant, typical subvariant and *P. maximowiczii* subvariant of *L. fischeri* variant, and the soil profile with organic matter was deeply developed. These communities were

Table 4. Comparison of species composition between Maianthemo - Rhododendretum in Kyushu, and Rhododendretum mucronulatum on Mt. Halla.
A: Maianthemo - Rhododendretum Suz.-Tok. & T. Nakayama
a: Vaccinietosum
b: Typicum
c: Alnetsum
B: Rhododendretum mucronulatum nov.

	A								B		
	a			b	c						
Number of Stands	24	6	9	11	8	25	15	9	18	20	8
1. Ch. & Diff. species of Maianthemo - Rhododendretum											
Rhododendron kiusianum	V	V	V	V	V	V	V	V	·	·	·
Maianthemum dilatatum	Ⅳ	V	V	Ⅱ	Ⅱ	Ⅳ	V	Ⅳ	·	·	·
Hydrangea paniculata	Ⅱ	Ⅲ	V	Ⅳ	V	V	Ⅲ	Ⅲ	·	·	·
Miscanthus sinensis	Ⅱ	V	Ⅱ	Ⅳ	V	Ⅲ	Ⅲ	V	·	+	·
Miscanthus oligostachyus	Ⅳ	Ⅳ	Ⅳ	Ⅱ	·	Ⅱ	I	Ⅲ	·	·	·
Angelica longeradiata	Ⅳ	Ⅱ	Ⅳ	I	Ⅱ	Ⅱ	Ⅱ	Ⅱ	·	·	·
Carex chrysolepis	Ⅲ	Ⅲ	Ⅳ	Ⅲ	Ⅲ	Ⅱ	·	Ⅳ	·	·	·
Shortia soldanelloides	Ⅳ	Ⅲ	Ⅲ	Ⅱ	·	Ⅱ	·	Ⅲ	·	·	·
Aletris luteoviridis	Ⅲ	I	Ⅲ	+	Ⅱ	+	I	·	·	·	·
Gentiana scabra	Ⅱ	I	Ⅱ	+	Ⅱ	+	Ⅱ	Ⅱ	·	·	·
2. Diff. species of Vaccinietosum											
Vaccinium vitis-idaea	V	V	V	·	·	·	·	·	·	·	·
3. *Lycopodium obscurum*	V	·	·	·	Ⅱ	·	·	·	·	·	·
Deschampsia flexuosa	Ⅳ	·	·	+	·	I	·	·	·	·	·
4. *Festuca ovina*	+	·	V	Ⅱ	I	I	·	Ⅳ	+	I	Ⅱ
5. Diff. species of Alunetosum											
Abelia serrata	r	·	I	·	Ⅳ	I	Ⅳ	Ⅳ	·	·	·
Alnus firma	·	I	I	·	I	Ⅲ	Ⅲ	Ⅲ	·	·	·
Polygonum cuspidatum	r	·	Ⅱ	·	Ⅳ	Ⅲ	+	Ⅳ	Ⅳ	Ⅲ	I
Arundinella hirta	·	Ⅱ	·	·	V	I	I	V	Ⅲ	Ⅱ	Ⅱ
6. *Rubus palmatus*	·	·	·	·	·	I	Ⅲ	Ⅱ	·	·	·
7. *Picris japonica*	I	·	·	+	V	·	·	·	·	·	·
Saussurea scaposa	·	·	·	·	·	I	V	Ⅳ	·	·	·
Astilbe thunbergii	·	·	·	·	·	·	Ⅲ	Ⅳ	·	·	·
Carex blephricarpa	·	·	·	·	·	·	Ⅱ	V	·	·	·
8. *Symplocos coreana*	·	·	·	·	·	I	Ⅲ	·	·	Ⅱ	·
Carex sachalinensis	·	·	·	I	·	I	Ⅲ	·	·	·	·
Ilex crenata	+	·	·	Ⅱ	·	I	Ⅱ	·	·	Ⅱ	·
9. *Ligularia fischeri*	·	·	·	·	I	·	·	V	Ⅳ	Ⅳ	·
Saussurea gracilis	Ⅱ	·	·	+	Ⅱ	r	·	Ⅳ	I	Ⅱ	Ⅲ
Adenophora triphylla v. *japonica*	Ⅱ	·	·	·	Ⅱ	r	·	Ⅲ	+	·	I
Potentilla fragarioides	·	·	·	·	·	r	·	Ⅲ	·	I	·
Lespedeza cyrtobotrya	I	·	·	+	I	·	·	Ⅲ	·	·	·
10. *Solidago virgaurea* v. *asiatica*	Ⅲ	I	I	+	Ⅳ	Ⅱ	Ⅱ	Ⅲ	Ⅱ	Ⅱ	I
Sanguisorba officinalis	Ⅱ	I	·	Ⅱ	·	I	·	·	Ⅲ	Ⅲ	Ⅲ
Sasa quelpaertensis	Ⅱ	I	·	+	·	·	·	·	Ⅱ	Ⅳ	·
Sasa asoensis	Ⅲ	Ⅲ	I	Ⅱ	·	+	·	·	·	·	·
Prenanthes acerifolia	Ⅲ	Ⅱ	I	·	·	+	I	·	·	·	·
Athyrium yokoscense	I	I	Ⅱ	·	Ⅱ	I	·	Ⅱ	·	·	·
Lyonia ovalifolia	r	·	I	I	V	r	+	Ⅱ	·	·	·

Table 4. Continued.

Pleioblastus chino v. *viridis*	I	·	·	+	Ⅳ	+	·	·	·	·	·
Spiraea japonica	r	I	·	+	·	I	I	Ⅱ	·	·	·
Clethra barbineevis	·	·	I	+	Ⅲ	I	+	Ⅱ	·	·	·
Viola pumilio	·	·	·	Ⅲ	Ⅳ	I	I	I	·	·	·
11. Ch. & Diff. species of Rhododendretum mucronulatum											
Rhododendron mucronulatum f. *cliatum*	·	·	·	·	·	·	·	·	V	V	V
Juniperus chinensis	I	·	·	·	·	·	·	·	Ⅳ	Ⅱ	V
Rhododendron yedoense v. *poukhanense*	·	·	·	·	·	·	·	·	Ⅳ	Ⅳ	Ⅲ
Empetrum nigrum v. *japonicum*	·	·	·	·	·	·	·	·	Ⅲ	Ⅱ	Ⅳ
Deschampsia caespitosa v. *festucaer*	·	·	·	·	·	·	·	·	Ⅳ	Ⅳ	Ⅲ
Geranium sibiricum	·	·	·	·	·	·	·	·	Ⅳ	Ⅲ	Ⅱ
Carex tenuiformis	·	·	·	·	·	·	·	·	Ⅳ	Ⅲ	Ⅲ
Cirisum japonicum v. *spinossimum*	·	·	·	·	·	·	·	·	Ⅲ	Ⅳ	I
Anapallis sinica	·	·	·	·	·	·	·	·	Ⅲ	Ⅱ	Ⅲ
Aster hayatae	·	·	·	·	·	·	·	·	Ⅱ	Ⅱ	I
Thymus quinquecostatus	·	·	·	·	·	·	·	·	Ⅲ	Ⅱ	Ⅲ
Galium pusillum	·	·	·	·	·	·	·	·	Ⅳ	Ⅲ	Ⅳ
Trifolium lupinaster v. *alpinum*	·	·	·	·	·	·	·	·	Ⅲ	Ⅱ	I
Artemisia laciniata	·	·	·	·	·	·	·	·	Ⅲ	Ⅱ	Ⅱ
Fragaria niponica	·	·	·	·	·	·	·	·	Ⅱ	Ⅲ	I
Tilingia tachiroei	·	·	·	·	·	·	·	·	Ⅱ	Ⅱ	Ⅲ
Primula modesta	·	·	·	·	·	·	·	·	Ⅱ	Ⅱ	Ⅱ
Adenophora taquetii	·	·	·	·	·	·	·	·	Ⅱ	Ⅲ	Ⅱ
Cirsium rhinoceros	·	·	·	·	·	·	·	·	Ⅲ	Ⅳ	Ⅱ
Euphorbia fauriei	·	·	·	·	·	·	·	·	Ⅲ	Ⅲ	Ⅲ
Aruncus aethusifolius	·	·	·	·	·	·	·	·	Ⅲ	Ⅱ	Ⅲ
Potentilla matsumurae	·	·	·	·	·	·	·	·	Ⅱ	I	Ⅱ
Euonymus alatus	·	·	·	·	·	·	·	·	I	Ⅲ	Ⅱ
Senecio nemorensis	·	·	·	·	·	·	·	·	I	Ⅱ	Ⅱ
Hosta minor	·	·	·	·	·	·	·	·	Ⅱ	I	Ⅲ
Viola patrinii	·	·	·	·	·	·	·	·	Ⅱ	I	I

estimated to be middle stage returned to *A. koreana* forest because many differential species of *L. fischeri* variant and *P. maximowiczii* subvariant were common in the adjacent *A. koreana* forest.

Rhododendretum mucronulatum caretosum metallica was classified by *Lunathyrium viridifrons* and *Carex metallica* dominated by *J. chinensis* var. *sargentii*. The number of constituent species was fewer than that of Rhododendretum mucronulatum geranietosum sibiricum. Habitats of the subassociation were around flat rocks. *J. chinensis* var. *sargentii* grew primarily in rocky habitats. The communities dominated by *J. chinensis* var. *sargentii* were commonly formed around *Pinus pumila* communities at rocky peaks in the alpine zone in north and central Honshu, Japan. The habitats of *J. chinensis* var. *sargentii*, as those of *E. nigrum* var. *japonicum*, may have spread in proportion to the expanding area of erosion on Mt. Halla. The Rhododendretum mucronulatum carietosum metallica was subdivided into two variants. Differential species of *R. yedoense* var. *poukhanense* variant were *Hosta minor*, *Berberis amurensis* var. *quelpaertensis*, and *Lycopodium chinense*, etc., distributed in habitats with some soil depth. The typical variant does not include *R. yedoense* var. *poukhanense*, and is distributed in rocky habitats.

The process of succession following prohibition of prescribed fire and grazing

As we have discussed above, *E. nigrum* var. *japonicum* grows in gravel habitats of collapsed sites, and *J. chinensis* var. *sargentii* grows in rocky habitats with little soil. And it was reported that *R. yedoense* var. *poukhanense* grows in riversides and cracks in rocks of rivulets, and *R.*

mucronulatum grows in shrub story of *Pinus densiflora* forests in Tsushima Is., Japan (Itow *et al.* 1993, Kim and Itow 1994). These species do not form extended pure stands in nature. But we concluded that the species dominating these communities developed at the top zone of Mt. Halla because of erosion by prescribed fire and overgrazing for a long time.

The process of succession after prohibition of prescribed fire and grazing was supposed based on the relationship between two associations including eight subunit communities and their habitats as in Figure 1. We concluded that succession proceeded from Festuco ovinae-petretum nigrum to Rhododendretum mucronulatum caretosum metallica and Rhododendretum mucronulatum geranietosum sibiricum. They will be *S. quelpaertensis* community or *A. koreana* community by degrees of stability. *A. koreana* forests as climatic climax have developed at top zone of Mt. Halla (Song and Nakanishi 1985). But the various communities were formed as a stage of retrogressive succession because the original communities were interfered with by prescribed fire and grazing for a long time. The differences in species composition of communities with spotted distribution were determined mainly by 1) degree and frequency of grazing and compaction by livestock, and 2) selection of adaptable species by degree of erosion. Consequently, many communities with various species were distributed in the area. In recent years, succession has proceeded because of prohibition of prescribed fire and grazing gave rise to interruption of retrogressive succession. Stabilization of habitats by prohibition of interference such as grazing brought about the change from herbal to shrub community. This process hindered enlargement of *E. nigrum* var. *japonicum* or *J. chinensis* var. *sargentii* communities in bare and rocky areas. Consequently, We concluded that habitats of these communities were restricted, and total area of the communities were rapidly reduced.

Comparison with Maianthemo-Rhododendretum Suz.-Tok and T. Nakayama in Kyushu, Japan

Rhododendretum mucronulatum is similar in physiognomy to Maianthemo-Rhododendretum in the top zone of mountainous districts in Kyushu, Japan. The two associations not only are similar externally to each other, because both had been affected by prescribed fire and overgrazing, but also have similar process of formation. Species compositions of the two associations through drawing up the species composition tables after the collection of data on 107 Maianthemo-Rhododendretum stands were investigated until to date (Arakane *et al.* 1994, Kagoshima-Ken 1978, 1979, Miyawaki and Fujiwara 1978, Miyazaki-Ken 1978, 1979, Oda and Sumata 1966, Oita-Ken 1978, 1979, Suzuki 1969, Suzuki *et al.* 1970, Umezu and Suzuki 1970). The results of the comparison show that the number of species of Rhododendretun mucronulatum with 163 species in 62 stands of Cheju Is. was much higher than that of Maianthemo-Rhododendretum with 117 species in 107 stands of Kyushu. Common features of the two associations are, firstly, they have factors of *Miscanthus sinensis* community such as *Sanguisorba officinalis*, *Solidago virga-aurea* var. *asiatica*, *Arundinella hirta*, *Saussurea scaposa*, etc. and *Ilex crenata* and *Symplocos coreana* as shrubs. Secondly, they have a two-storied vegetation structure with Ericaceae plants as the shrub layer and evergreen shrubs as the herb layer, that is to say, a combination of *R. mucronulatum* and *R. yedoense* var. *poukhanense* and *E. nigrum* var. *japonicum* in Cheju Is. and of *R. kiusianum* and *Vaccinium vitis-idaea* in Kyushu. The similarity of the two associations is due to the similarity of habitat environment. That is, the two regions are at the top zone and have volcanic ash soil. They easily become dry on account of windy weather, and have low temperatures in winter. We supposed as follows. As a result that they were interfered repeatedly by prescribed fire and overgrazing, the plants of composing current community should have been survived that livestock have not taste, herb and shrub species increased by formation of bare land and pressure of overgrazing.

In the contents of species composition of the two associations, Rhododendretm mucronulatum of Cheju Is. had 10 endemic species including *Circium japonicum* var. *spinosissimum* and *Gallium pisillum*. Also included were species common to central Honshu such as *J. chinensis* var. *sargentii* and *Carex tenuiformis*, but there was only *Vaccinium vitis-idaea* as an alpine species in Kyushu. Fig. 2 shows the geographical distribution of the composed species in the two associasions. Over 50 % of species that composing Rhododendretum mucronulatum of Cheju Is. were common to the Maianthemo-Rhododendretum of Kyushu, and 15 % were Korean peninsula and the northeast of Japan, respectively. The endemic species of Cheju Is. were about 15 % of total species of Rhododendretum mucronulatum. In contrast with that, the constituent species of Maianthemo-Rhododendretum of Kyushu was composed of common to nationwide in Japan.

The above conditions of association formation were similar but the two associations that developed in different floral regions were of different species

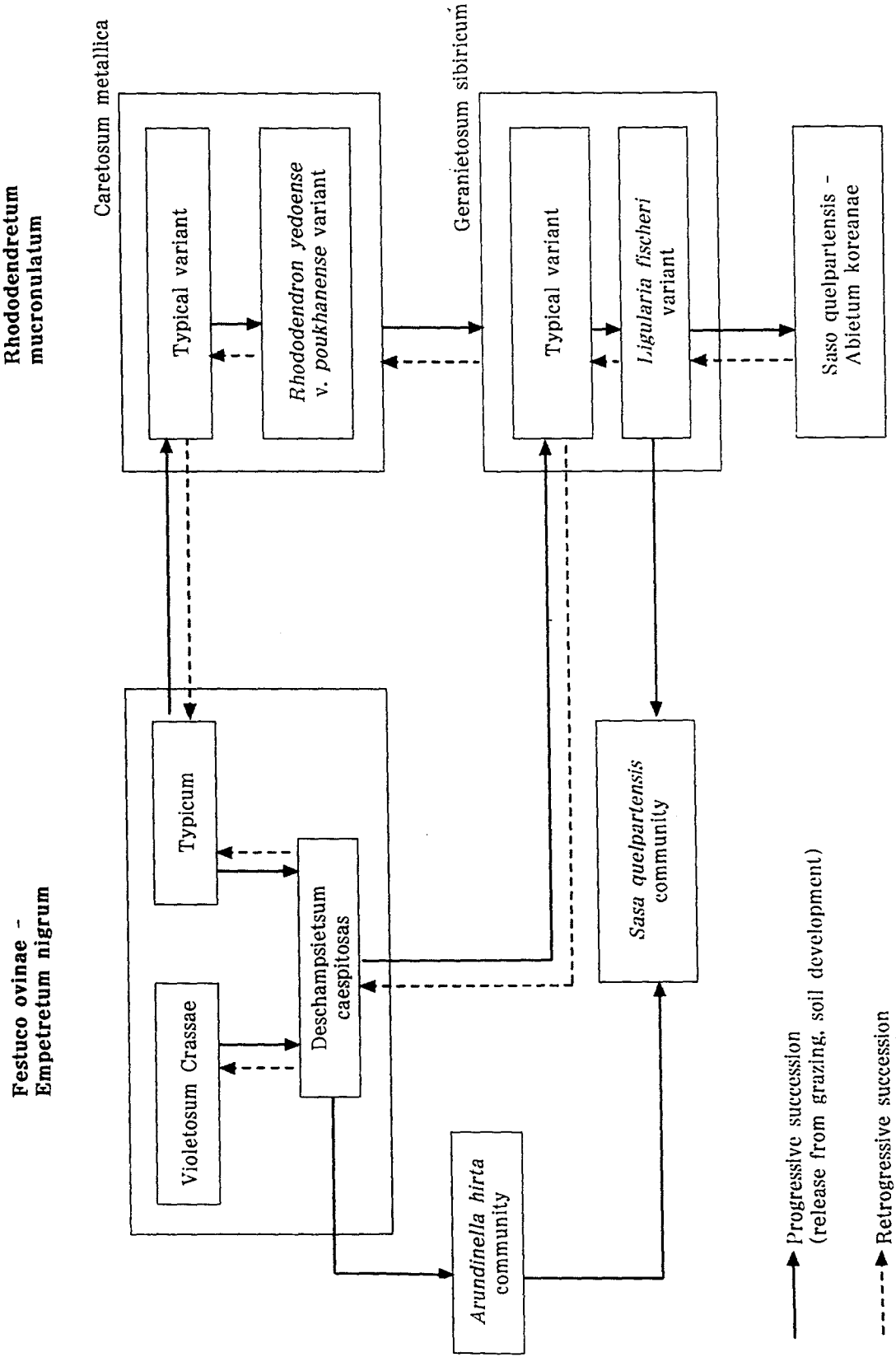
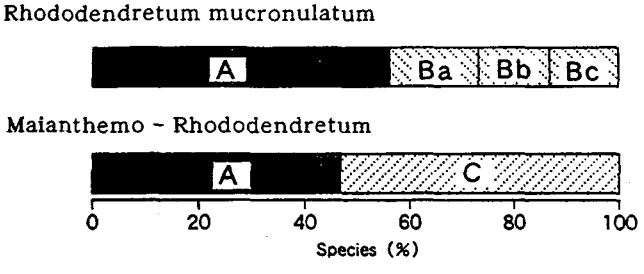


Fig. 1. Schematic diagram on succession of shrub communities in Mt. Halla.



A: Distribute both in Cheju and Kyushu
B: Distribute in Cheju, but not in Kyushu
Ba: Common species to continent
Bb: Common species to north-east Japan
Bc: Endemic species of Cheju
C: Distribute in Kyushu, but not in Cheju

Fig. 2. Geographical distribution of constituent species of Rhododendretum mucronulatum and Maianthemo - Rhododendretum.

composition. Therefore, there was dissimilarity as much as alliance unit. Rhododendrion kiusiani Suz.-Tok. et Nakayama 1970 have reported an upper unit of Maianthemo-Rhododendretum (Suzuki *et al.* 1970). Rhododendretum mucronulatum of Cheju Is. must be classified as an alliance *R. yedoense* var. *poukhanense*. Species group from *R. mucronulatum* to *Senecio nemorensis* in Table 4 will be differential or characteristic species of Rhododendorion kiusiani. On the other hand, species group from *R. kiusianum* to *Shortia soldanelloides* in *Rhodoendrion kiusiani* alliance of Japan has significance as a differential or characteristic species of Rhododendorion kiusiani. Furthermore, it is dissimilar to order level in the upper unit. Because of lack of data, we withhold establishment of order level until further studies are done on the Korean peninsula. But the class of the upper unit will belong to Miscanthetea sinensis because it includes various species of *Miscanthus sinensis* community.

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