한국환경과학회지 제21권(제2호), 135～144, 2012
Journal of the Environmental Sciences
http://dx.doi.org/10.5322/JES.2012.21.2.135

Analysis of Vegetation Structure of *Castanopsis sieboldii* Forest in the Warm-temperate Zone, Korea

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(Manuscript received 21 December, 2011; revised 4 January, 2012; accepted 22 February, 2012)

Abstract

This study aims at classifying and analyzing the vegetation structure of *Castanopsis sieboldii* forest, one of the evergreen broad-leaved forests found under the warm-temperate climate of Korea. It is also compared with the ones of the *Castanopsis sieboldii* forest in Japan where most similar such forest of Korea, to find unique vegetation structures of the only Korean forest. Vegetation structure of Korean *Castanopsis sieboldii* forest was divided into two units at the level of community units both of *Ardisia japonica-Castanopsis sieboldii* community and Ardisio-Castanopsietum sieboldii association. The association carries similar type with the vegetation system of Japan, but any subunits differentiated with the Japan were found vary much. Hierarchical cluster analysis brings in similar result with the analysis on the vegetation structure as well.

Key Words : Phytosociology, Evergreen broad-leaved forest, Jeju, Wando, Classification, Japan

1. Introduction

It conducted that the studies on the evergreen broad-leaved forests of the islands in the Korean Peninsula and Jeju-do Island in their flora and phytosociological studies (Kim, 1991, Kim and Oh, 1990, 1991; Park, 2007) and the studies on the vegetation structures (Han et al., 2007; Oh and Choi, 1993; Oh, 1994; Oh et al., 2007). Most of their studies were limited to analyzing the vegetation structures only by areas or their analysis was obtained by selecting only the trees, and very few data and information on analyzing the vegetation structures of the whole country are found. In particular, investigation on the vegetation structure of the *Castanopsis sieboldii* is insufficient.

This study, therefore, aims at analyzing and classifying the structure of *Castanopsis sieboldii* forest among the evergreen broad-leaved forests distributed in the warm-temperate zone of Korea. In addition, differences of the evergreen broad-leaved forests in Japan showing high similarity with the forests on the Korean peninsula were compared and analyzed. At the same time this study was conducted to collect and provide basic data and information required to analyze the vegetation structures of the peninsula as a whole.

2. Materials and methods

2.1. Climate

Most of the Korean peninsula is dominated by the deciduous broad-leaved forest in the temperate zone. That is to say, those are the regions of humid cool-temperate climate with significant frost every

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year and occasional temperatures significantly below -15 ℃, but the southernmost Korea and Jeju-do island are usually covered by evergreen broad-leaved forests in the warm-temperate zone, with light-to-moderate frost ever or nearly every year and absolute minima not under -15 ℃ (usually, leaf-changing seasonal broad-leaved evergreen forests can be tolerant and subtropical evergreen forests may not be) (Kolbek et al., 2003). This also includes the zones recognized on mid-latitude continental east sides by most global climate classification systems (Bailey, 1990; Walter and Box, 1976; Walter, 1984). This climate zone is also distributed in southern China. The study sites belong to the warm-temperate zone.

2.2. Study area

The studies were carried out at *Castanopsis sieboldii* forest of evergreen broad-leaved forest on Jeju-do Island and Southern islands, South Korea. The detail study sites are Bogil-do, Jin-do, Oinaro-do, Soan-do, and Wan-do Islands in the Korean peninsula and Mt. Sanbansan, Seonheul-ri, Eastern Gotjawal, and Gotjawal (Mt. dongbakdongsan) in Jeju-do Island. Fig. 1 shows the location of quadrates and topography of the study sites.

The field works carried out from 2005 to 2009.

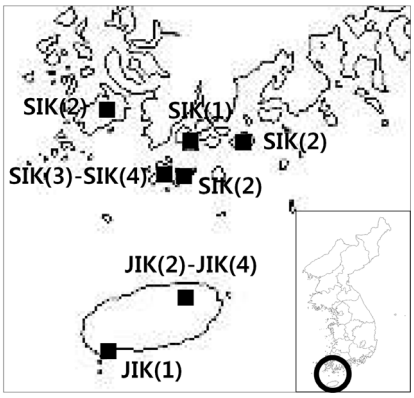

Fig. 1. Location of study sites.
SIK(1)-JIK(4) : study sites (refer to Table 1)

2.3. Vegetation research and analysis

Relevés were sampled in the typical evergreen broad-leaved forest, according to the Braun-Blanquet approach (Braun-Blanquet, 1964). The relevé sizes were set in such a way as to represent a vegetation's full floristic composition, from 120 m^2 to 500 m^2. All of relevés were taken from floristically and physiognomically on homogeneous stands. Data storage and a table work were carried out according to the phytosociological approach for vegetation classification (Mueller-dombois and Ellenberg, 1974). The relevés were classified and documented in a synoptic table. All vascular plants were recorded. An elevation, geographical coordinates, a slope aspect and a slope inclination were recorded at each relevé site. Scientific names of the plants investigated followed BGplants(2011) and Korean Plant Names Index (2007).

2.4. Hierarchical cluster analysis

Hierarchical cluster analysis on the Relevé groups (study sites) estimated the similarities between the relevés after the constancy values were quantified by Yanai et al.(2007) and then group average method (UPGMA) based on the Bray-Curtis dissimilarity coefficient was applied to the analysis by the software of SYN-TAX 2000 (Podani, 2001). The estimation was made excluding companion species of floristic components that does not affect community classification.

3. Result

3.1. Vegetation analysis

Phytosociological table manipulation was applied to the field survey data, resulting in dividing broadly into one community and one association. The association was classified into 3 subassociations including typical subassociation and some of the subassociations were classified into 4 variants including typical variant (Table 1).

Table 1. Synoptic table of the communities of *Castanopsis sieboldii* forest in South Korea

Class	Camellietea japonicae							
Order and alliance			Quercion acuto-mysinaefoliae and Illicio-Quercetalia acutae					
Association and community	*Ardisia japonica-Castanopsis sieboldii*		Ardisio-Castanopsietum sieboldii					
Subassociation			Typical	*Quercetosum acutae*		*Arachniodo-Quercetum salicinae* f. *angustata*		
Variant				Typical	*Pourthiaea villosa* var. *villosa*	*Mallotus japonicus*	Typical	
Serial number	1	2	3	4	5	6	7	8
Study sites	SIK(1)	SIK(2)	JIK(1)	SIK(3)	SIK(4)	JIK(2)	JIK(3)	JIK(4)
Slope inclination (°)	20-35	15-25	30-42	5-23	16-28	0	0-5	0-10
Altitude (m)	10-20	30-120	365-390	50-85	90-315	187-250	196-230	160-219
Average no. of spp.	19	31	20	24	31	39	29	27
No. of releves	5	10	6	5	5	6	6	7
Character and differential species of Ardisio-Castanopsietum sieboldii Suz.-Tok. Et Hatiya 1952								
Castanopsis sieboldii	V 5	V 4-5	V 5	V 2-5	V 1-5	V 2-5	V 4-5	V +-2
Cymbidium goeringii	I +	III +	II +	II +	V +	I +	I +	
Dryopteris bissetiana	I +	V +-2		I +	III +-1	I +		I +
Callicarpa mollis		IV +-1			III +-2	I +	II +-1	
Viburnum erosum		III +-2		I +	IV +			
Differential species of Subunit(1)								
Dryopteris pacifica				IV +	I +			
Pinus densiflora				III 1	II 1			
Quercus acuta		+ 1		IV +-2	V 2-4			I 1
Differential species of Subunit(1-1)								
Pourthiaea villosa var. *villosa*		I +			V +-1			
Benthamidia japonica			II 1-2	I +	II +			
Carpinus laxiflora					II 1			
Daphniphyllum macropodum					II 1-2			
Dryopteris chinensis					II +			
Differential species of Subunit(2)								
Quercus glauca						III +-2	III 1	III 1-2
Arachniodes aristata						V 1-3	V +-2	V 2-3
Damnacanthus indicus						I +	III +	III +-1
Calanthe discolor					I +	III +	II +	II +-1
Differential species of Subunit(2-1)								
Cyrtomium fortunei						III +-1		
Polystichum lepidocaulon						II +		
Mallotus japonicus			I +		I +	IV +-1		
Dryopteris uniformis				I +		II +-1		
Character and differential species of Quercion acuto-mysinaefoliae K. Fujiwara 1981 and Illicio-Quercetalia acutae K. Fujiwara 1981								
Neolitsea aciculata			V +-2	II +	IV +-2	V +-1	V +	V +-1
Machilus japonica			III +	III +-1	III +	V +-1	V +-1	V +-1
Styrax japonica		I +	I +	I 1		II +-1	I 1	III +-1
Ophiopogon japonicus			I +	I +	III +	V +-2	III +-1	V +
Acer palmatum		+ +		I 1		III +-1	II 1	II +
Distylium racemosum			V +-1		I 1	IV +-2	V +-2	V +-2
Ardisia crenata			IV +	III +		V +	V +	V +-1
Quercus salicina f. *angustata*		I 1		V 2-4	II 1-2	V 1-4	V 1-3	V 4-5
Vegetation components of Southern islands in the Korean peninsula								
Pittosporum tobira	IV +	II +						
Rhaphiolepis indica var. *umbellata*	V 1-2	II +-1		I +	I +			
Liriope muscari	V +-1	II +-1						
Farfugium japonicum		II +						
Cyrtomium falcatum	I +							
Quercus serrata	II +-1	II 1		I 1				
Oplismenus undulatifolius var. *undulatifolius*		III +-1						
Carex lenta		III +			I +			

Character and differential species of Camellietea japonicae Miyawaki et Ohba 1963

Eurya japonica	Ⅳ +	Ⅴ +-3	Ⅴ +-3	Ⅴ +-1	Ⅴ +-2	Ⅳ +-1	Ⅴ +-1	Ⅴ +-1
Trachelospermum asiaticum	Ⅴ 2-4	Ⅴ +-3	Ⅴ +-1	Ⅳ +-1	Ⅴ +-1	Ⅴ +-2	Ⅴ +-1	Ⅴ +-2
Camellia japonica		Ⅳ +-3	Ⅴ 1-3	Ⅴ 2-3	Ⅴ 1-3	Ⅴ +-2	Ⅴ +-1	Ⅴ +-2
Ligustrum japonicum	Ⅴ +-2	Ⅴ +-1		Ⅲ +-1	Ⅴ +-2	Ⅴ +-1	Ⅴ +	Ⅴ +-1
Ardisia japonica	Ⅴ +-2	Ⅴ +-3	Ⅴ +	Ⅴ +-1	Ⅳ +	Ⅲ +	Ⅴ +	Ⅳ +-1
Dryopteris erythrosora	Ⅰ +	Ⅱ +-2	Ⅴ +-1	Ⅴ +-1	Ⅴ +-2	Ⅴ +-1	Ⅴ +-2	Ⅴ +-2
Cinnamomum tenuifolium	Ⅴ +-1	Ⅳ +	Ⅴ 1-3	Ⅴ +-1	Ⅴ +-2	Ⅴ +-1	Ⅴ +-1	Ⅴ +-2
Lemmaphyllum microphyllum	Ⅱ +	Ⅱ +	Ⅴ +	Ⅰ +	Ⅱ +	Ⅳ +	Ⅴ +	Ⅳ +
Neolitsea sericea		+ +	Ⅱ +	Ⅰ +	Ⅴ +	Ⅱ +-1	Ⅰ +	Ⅲ +
Machilus thunbergii	Ⅴ +-2	Ⅴ +-2	Ⅰ +	Ⅴ +-1	Ⅲ +		Ⅱ +-1	
Hedera rhombea	Ⅰ +	Ⅴ +-1	Ⅲ +	Ⅱ +	Ⅰ +	Ⅴ +-1	Ⅴ +	Ⅴ +
Ilex integra	Ⅴ 2	Ⅳ 1-2	Ⅳ 1-2	Ⅲ +-1	Ⅱ +	Ⅱ +	Ⅱ +	Ⅱ +
Kadsura japonica		Ⅳ +-1	Ⅱ +	Ⅴ +-1	Ⅰ +	Ⅳ +	Ⅴ +	Ⅳ +
Stauntonia hexaphylla	Ⅱ +	Ⅱ +	Ⅳ +	Ⅱ +	Ⅴ +	Ⅴ +	Ⅴ +	Ⅲ +
Ophiopogon japonicus	Ⅴ +-1	Ⅴ +-1	Ⅱ +	Ⅲ +	Ⅴ +	Ⅰ +	Ⅰ +	Ⅲ +
Litsea coreana	Ⅴ 1-2	Ⅰ +	Ⅰ +	Ⅱ 1	Ⅳ +-1	Ⅱ +-1	Ⅲ +	Ⅱ 1
Ficus nipponica	Ⅳ +	Ⅱ +-1	Ⅴ +	Ⅱ +	Ⅲ +	Ⅴ +-1	Ⅳ +	Ⅰ +
Elaeagnus glabra	Ⅳ +-1	Ⅱ +		Ⅱ +	Ⅰ +	Ⅲ +	Ⅳ +	Ⅲ +
Liriope spicata		+ +				Ⅰ +		
Cleyera japonica							Ⅰ +	Ⅱ +
Euonymus japonicus		+ +	Ⅱ +					
Daphne kiusiana						Ⅱ +	Ⅰ +	Ⅰ +
Meliosma myriantha		Ⅱ +						
Elaeagnus macrophylla	Ⅲ +	Ⅲ +	Ⅴ +		Ⅰ +			
Dendropanax morbiferus	Ⅴ 1-2	Ⅲ 1-2		Ⅲ +-1	Ⅳ +-1	Ⅲ +-1	Ⅴ +-1	Ⅳ +-1
Meliosma oldhamii		Ⅰ +			Ⅱ +-1	Ⅰ 1		
Paederia scandens var. *scandens*		Ⅱ +				Ⅰ +	Ⅱ +	
Asplenium incisum	Ⅰ +	+ +				Ⅳ +	Ⅳ +	
Rhamnella frangulioides						Ⅱ +		
Callicarpa japonica	Ⅰ +	Ⅲ +				Ⅲ +	Ⅰ +	

* Study sites : SIK(1) : Wan-do island; SIK(2) : Oinaro-do, Soan-do, Jin-do islands; JIK(1) : Mt. Sanbansan, Jeju-do island; SIK(3), SIK(4) : Bogil-do island; JIK(2) JIK(3) : Seonheul-Ri, Gotjawal, Seonheul-ri, Jeju-do island; JIK(4) : Seonheul-Ri, Gotjawal(Mt. Dongbakdongsan), Eastern Gotjawal, Jeju-do island.

* Companion species (scientific name : serial number (constancy value)) : *Smilax china* : 1 (Ⅰ), 2 (Ⅳ), 3 (Ⅴ), 4 (Ⅲ), 5 (Ⅳ), 6 (Ⅳ), 7 (Ⅱ); *Ficus erecta* : 2 (Ⅳ), 3 (Ⅳ), 4 (Ⅰ), 6 (Ⅴ), 7 (Ⅱ), 8 (Ⅱ); *Dioscorea tokoro* : 2 (Ⅱ), 4 (Ⅰ), 5 (Ⅰ), 6 (Ⅰ), 7 (Ⅰ), 8 (Ⅱ); *Pyrola japonica* : 1 (Ⅰ), 2 (Ⅰ), 4 (Ⅱ), 5 (Ⅳ), 6 (Ⅰ); *Cocculus trilobus* : 2 (+), 4 (Ⅰ), 5 (Ⅰ), 6 (Ⅲ), 7 (Ⅱ); *Gardneria insularis* : 3 Ⅱ(), 4 (Ⅰ), 5 (Ⅰ), 6 (Ⅱ), 7 Ⅱ(); *Parthenocissus tricuspidata* : 2 (Ⅰ), 4 (Ⅰ), 6 (Ⅰ), 7 (Ⅰ), 8 (Ⅱ); *Ampelopsis brevipedunculata* : 2 (Ⅰ), 6 (Ⅲ), 7 (Ⅰ), 8 (Ⅰ); *Euscaphis japonica* : 2 (+), 5 (Ⅰ), 6 (Ⅰ), 8 (Ⅰ); *Sorbus alnifolia* : 2 (+), 5 (Ⅰ), 6 (Ⅰ); *Viburnum dilatatum* : 2 (Ⅰ), 6 (Ⅲ), 8 (Ⅰ); *Viburnum odoratissimum* var.*awabuki* : 3 (Ⅰ), 6 (Ⅲ), 8 (Ⅱ); *Ficus erecta* var.*sieboldii* : 3 (Ⅱ), 6 (Ⅰ), 8 (Ⅰ); *Oplismenus undulatifolius* var.*japonicus* : 5 (Ⅰ), 6 (Ⅰ), 8 (Ⅰ); *Euonymus oxyphyllus* : 2 (+), 5 (Ⅱ); *Rhus tricocarpa* : 1 (Ⅱ), 2 (+); *Pinus thunbergii* : 1 (Ⅰ), 2 (+); *Symplocos chinensis* f. *pilosa* : 2 (+), 4 (Ⅰ); *Fraxinus sieboldiana* : 2 (+), 5 (Ⅱ); *Zanthoxylum piperitum* : 2 (+), 6 (Ⅱ); *Dryopteris lacera* : 2 (+), 6 (Ⅰ); *Albizia julibrissin* : 2 (Ⅱ), 8 (Ⅰ); *Carpinus tschonoskii* var.*eximia* : 2 (+), 8 (Ⅰ); *Arisaema ringens* : 3 (Ⅰ), 6 (Ⅰ); *Cerasus leveilleana* : 4 (Ⅰ), 5 (Ⅰ); *Pyrrosia lingua* : 6 (Ⅲ), 7 (Ⅰ); *Loxogramme salicifolia* : 6 (Ⅰ), 7 (Ⅰ); *Pourthiaea villosa* var.*zollingeri* : 6 (Ⅰ), 7 (Ⅰ); *Kalopanax septemlobus* : 6 (Ⅰ), 7 (Ⅰ); *Xylosma congesta* : 6 (Ⅱ), 8 (Ⅰ); *Celtis sinensis* var. *japonica* : 6 (Ⅱ), 8 (Ⅰ); *Idesia polycarpa* : 6 (Ⅰ), 8 (Ⅰ); *Arisaema serratum* : 6 (Ⅰ), 8 (Ⅰ); *Ainsliaea apiculata* : 2 (Ⅱ); *Desmodium podocarpum* var.*oxyphyllum* : 2 (Ⅱ); *Lindera obtusiloba* var.*obtusiloba* : 2 (Ⅱ); *Quercus variabilis* : 2 (Ⅰ); *Pueraria lobata* : 2 (Ⅰ); *Vaccinium bracteatum* : 2 (Ⅰ); *Milletia japonica* : 2 (Ⅰ); *Calamagrostis arundinacea* var.*brachytricha* : 2 (Ⅰ); *Lepisorus thunbergianus* : 2 (Ⅰ); *Carex oahuensis* var. *robusta* : 2 (Ⅰ); *Disporum smilacinum* : 2 (+); *Acer pictum* subsp.*dissectum* : 2 (+); *Carpinus turczaninovii* : 2 (+); *Maackia amurensis* var.*amurensis* : 2 (+); *Castanea crenata* : 2 (+); *Rhododendron mucronulatum* var. *mucronulatum* : 2 (+); *Lophatherum gracile* : 2 (+); *Cephalanthera longibracteata* : 2 (+); *Thalictrum actaefolium* : 2 (+); *Aster scaber* : 2 (+); *Phaenosperma globosa* : 2 (+); *Scutellaria indica* : 2 (+); : 2 (+); *Lespedeza maximowiczii* : 2 (+); *Prunus verecunda* f. *tomentella* : 2 (+); *Platycarya strobilacea* var. *strobilacea* f. *strobilacea* : 2 (+); *Phryma leptostachya* var. *asiatica* : 2 (+); *Chloranthus japonicus* : 2 (+); *Lonicera morrowii* : 2 (+); *Wisteria floribunda* : 2 (+); *Disporum sessile* var. *sessile* : 2 (+); *Lecanorchis japonica* : 2 (+); *Ainsliaea acerifolia* : 2 (+); *Lindera glauca* var. *glauca* : 2 (+); *Prunus serrulata* var. *spontanea* : 2 (+); *Galium pogonanthum* : 2 (+); *Pteridium aquilinum* var. *latiusculum* : 2 (+); *Blechnum niponicum* : 2 (+); *Zanthoxylum ailanthoides* : 3 (Ⅰ); *Ficus thunbergii* : 3 (Ⅰ); *Zanthoxylum schinifolium* : 4 (Ⅰ); *Menispermum dauricum* : 4 (Ⅰ); *Dryopteris nipponensis* : 4 (Ⅰ); *Thelypteris acuminata* : 4 (Ⅰ); *Cornus controversa* : 4 (Ⅰ); *Phyllostachys edulis* : 4 (Ⅰ); *Sapium japonicum* : 4 (Ⅰ); *Hosta longipes* var. *longipes* : 5 (Ⅰ); *Dioscorea nipponica* : 5 (Ⅰ); *Buxus microphylla* var. *insularis* : 5 (Ⅰ); *Celastrus orbiculatus* : 6 (Ⅲ); *Polygonatum macranthum* : 6 (Ⅱ); *Actinidia arguta* var. *arguta* : 6 (Ⅱ); *Ligustrum* sp. : 6 (Ⅱ); *Rhus succedanea* : 6 (Ⅱ); *Polystichum tsussimense* : 6 (Ⅱ); *Lindera erythrocarpa* : 6 (Ⅱ); Cudrania tricuspidata : 6 (Ⅱ); *Dryopteris saxifraga* : 6 (Ⅰ); *Akebia quinata* : 6 (Ⅰ); *Schizophragma hydrangeoides* : 6 (Ⅰ); *Celtis jessoensis* : 6 (Ⅰ); *Spodiopogon sibiricus* : 6 (Ⅰ); *Tylophora* sp. : 6 (Ⅰ); *Asparagus schoberioides* : 6 (Ⅰ); *Clerodendrum trichotomum* : 6 (Ⅰ); *Cornus macrophylla* : 6 (Ⅰ); *Lonicera japonica* : 6 (Ⅰ); *Teucrium japonicum* : 6 (Ⅰ); *Viola sieboldii* : 6 (Ⅰ); *Diplazium subsinuatum* : 6 (Ⅰ); *Smilax sieboldii* f. *sieboldii* : 6 (Ⅰ); *Morus bombycis* var.*bombycis* : 6 (Ⅰ); *Isodon inflexus* : 6 (Ⅰ); *Ternstroemia gymnanthera* : 7 (Ⅱ); *Cephalanthera falcata* : 7 (Ⅰ); *Fatsia japonica* : 7 (Ⅰ); *Liparis nervosa* : 7 (Ⅰ); *Prunus pendula* f. *ascendens* : 8 (Ⅰ); *Orixa japonica* : 8 (Ⅰ); *Maackia amurensis* var. *fauriei* : 8 (Ⅰ); *Polystichum tripteron* : 8 (Ⅰ); *Picrasma quassioides* : 8 (Ⅰ); *Quercus gilva* : 8 (Ⅰ).

* Contact to Corresponding author for Original data.

3.1.1. *Ardisia japonica–Castanopsis sieboldii* community

This community appears at Wan-do Island (SIK (1)) and other islands scattered in the southern parts of Korean peninsula (SIK(2)). It is distributed over east and west slopes around the southward aspect of slopes mostly except some relevés (such as Mira-ri in Soan-do Island, Oinaro-do Island: Northern aspect of slope). Most of it consists of brown forest soil being distributed at medium slope of 15~35 °. At Wan-do Island, the community was distributed at relatively low altitude (10~20 m) compared with other islands (30~120 m).

Tree layer in the *Ardisia japonica-Castanopsis sieboldii* community was dominated by *Castanopsis sieboldii* and some of the character and differential species of Camellietea japonicae such as *Ardisia japonica* were selected as such species of this community in addition to *Castanopsis sieboldii, Cymbidium goeringii, Dryopteris bissetiana, Callicarpa mollis* and *Viburnum erosum* (Miyawaki et al., 1994). At Wan-do Island, other differential species (*Cymbidium goeringii, Dryopteris bissetiana, Callicarpa mollis, Viburnum erosum*) were not found except *Castanopsis sieboldii* or they appeared in low constancy values.

The vegetation components of Southern islands in the Korean peninsula are *Pittosporum tobira, Rhaphiolepis indica* var. *umbellata, Liriope muscari, Farfugium japonicum, Cyrtomium falcatum, Quercus serrata, Oplismenus undulatifolius* var. *undulatifolius,* and *Carex lenta.* This vegetation components show the representative vegetation of *Castanopsis sieboldii* forest found at the only low areas of southern islands in Korea against the Ardisio-Castanopsietum sieboldii Suz.-Tok. et Hatiya 1952 (association) in Jeju-do Island and the other southern islands in Korea.

3.1.2. Ardisio–Castanopsietum sieboldii Suz.–Tok. Et Hatiya 1952

This association appears at Mt. Sanbang in Jeju-do Island (JIK (1)), Bogil-do Island (SIK(3), SIK(4)), Seonheul-ri and Gotjawal in Jeju-do Island (JIK (2), JIK(3)). This association was distributed over from flat land to various slopes according to the study sites. It is consisted mostly of brown forest soil and the soil of volcanic rocks and at various slopes ranging from 0 ° to 42 °. Some of the relevé of SIK(3) and SIK (4) were found at low sea level altitude (50-90 m) compared with other study sites(160-390 m) (Fig. 2). Upper unit of this association is Quercion acuto-mysinaefoliae and Illicio-Quercetalia acutae (alliance, order) and Camellietea japonicae (class). The class is also the highest unit of other community.

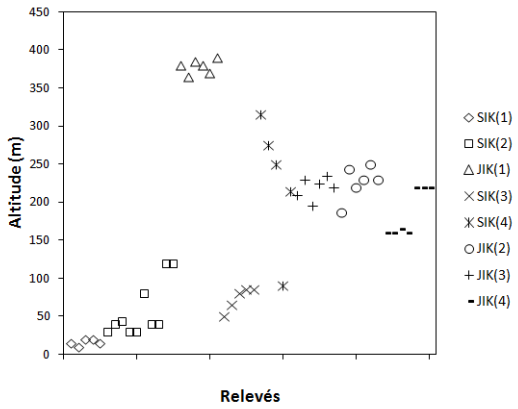

Fig. 2. Vertical distribution of each relevé in the study sites (relevé groups), South Korea.
SIK(1)-JIK(4) : study sites (refer to Table 1)

Tree layers of this Ardisio-Castanopsietum sieboldii were dominated by *Castanopsis sieboldii* as the case with Ardisio-Castanopsietum sieboldii of Japan (Miyawaki and Okuda, 1990) and *Quercus acuta, Quercus glauca,* and *Quercus salicina* f. *angustata* were found as well. In some parts of Jeju-do Island (JIK(4)), *Quercus salicina* f. *angustata* appeared in higher dominating extent in its relevé than *Castanopsis sieboldii.* Some of the character species and classify in species of Camellietea japonicae

(Miyawaki et al., 1994) like *Ardisia japonica* were selected as such species of this community in addition to *Castanopsis sieboldii, Cymbidium goeringii, Dryopteris bissetiana, Callicarpa mollis, Viburnum erosum*. This association was divided into lower units such as subassociations and variants by the character species of each lower unit.

3.1.2.1. Typical subassociation

This kind of typical subassociation appears at Mt. Sanbang in Jeju-do Island. It is found at various slope aspects, rapid slope of 30-42 ° (Fig. 3) and the slopes of the hill ridges at the highest altitudes of 365-390m compared with other communities (Fig. 2). Main Character and differential species such as *Dryopteris bissetiana, Callicarpa mollis,* and *Viburnum erosum* were not found there. This subunit belongs to relatively simple structure compared with others by low appearing numbers of species in average, and it is dominated mainly by *Castanopsis sieboldii* on the canopy.

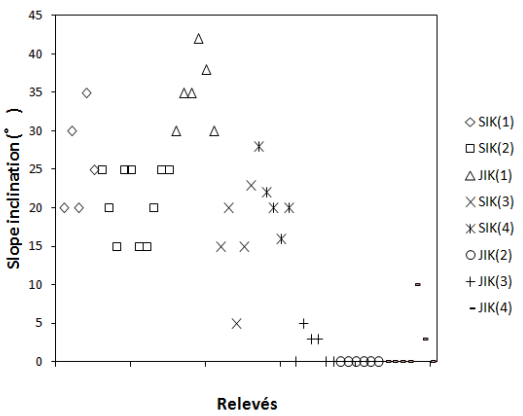

Fig. 3. Slope inclination of each relevé in the study sites (relevé groups), South Korea.
SIK(1)-JIK(4) : study sites (refer to Table 1)

3.1.2.2. Quercetosum acutae subassociation

The vegetation structure is distributed only at the Bogil-do Island in the southern part of Korea and it appears at various slopes ranging from 5-28 °, hill ridge slope, sea level altitude lower than 100 m and comparatively higher altitude of 200 m. (Table 1, Fig. 2). *Dryopteris pacifica, Pinus densiflora,* and *Quercus acuta* are the differential species of this association, which can be classified from other study sites. This subassociation is classified into two lower units: Typical variant and *Pourthiaea villosa* var. *villosa* variant.

Those lower subunits are distinctively divided into two not only by the difference of differential species but also the altitude lower than 90 m (typical variant) and the one higher than 200 m (*Pourthiaea villosa* var. *villosa* variant). *Pourthiaea villosa* var. *villosa* variant is distributed over north-eastern slope and north-western slope while the typical variant is over various slope aspects. In the *Pourthiaea villosa* var. *villosa* variant, the differential species such as *Pourthiaea villosa* var. *villosa, Benthamidia japonica, Carpinus laxiflora, Daphniphyllum macropodum, Dryopteris chinensis,* are characterized as the only vegetation structure of Bogil-do Island against the other study sites. The canopy of the typical variant is dominated by *Castanopsis sieboldii* and *Quercus salicina* f. *angustata* while the *Pourthiaea villosa* var. *villosa* variant is dominated by *Quercus acuta* and *Castanopsis sieboldii* on the canopy.

3.1.2.3. Arachniodo-Quercetum salicinae f. angustata

The vegetation structure is distributed only Jeju-do Island, Korea and various size of rocks forms soil at flat land of 0 ° slope (Fig. 3) and it appears at adequate altitude(middle) of 160-315 m (Table 1, Fig. 2). *Quercus glauca, Arachniodes aristata, Damnacanthus indicus,* and *Calanthe discolor* is the differential species of this subassociation, which can be classified from the other study sites. This subassociation is classified into two lower units: *Mallotus japonicus* variant and Typical variant.

Those lower subunits do not show any significant

differences under basic environmental conditions and were classified by the difference of differential species (flora). *Mallotus japonicus* variant shows the highest appearing number of species in average, which is classified from other vegetation structures by differential species such as *Cyrtomium fortunei, Polystichum lepidocaulon, Mallotus japonicus,* and *Dryopteris uniformis.* The canopy of this variant is mostly dominated by *Castanopsis sieboldii* but *Quercus salicina* f. *angustata* dominates in some relevés. Typical variant is distributed in the study sites in Jeju-do Island. The canopy species are differentiated adequately between the two study sites, even though there is no adequate differences of the character and differential species between the two sites. The canopy of the study site JIK(3) is dominated by *Castanopsis sieboldii,* while the one of JIK(4) is dominated by *Quercus salicina* f. *angustata.*

3.2. Hierarchical cluster analysis

Hierarchical cluster analysis using SYN-TAX 2000 (Podani, 2001) revealed that two units of the community and the association were classified at the level of dissimilarity index 0.389939700E+00 (Fig. 4), and it corresponded with the result of the community units of the phytosociological classification. Low dissimilarities were found between the study sites (relevé groups) composing subassociation of Arachniodo-Quercetum salicinae f. angustata in Jeju-do Island. The index between typical variants of JIK(3) and JIK(4) was 0.129488600E+00, which was the lowest. The typical variants showed the second lowest dissimilarity index of 0.161286400E+00 with *Mallotus japonicus* variant (JIK(2)). Such index carries great gap between the indices of other study sites. The dissimilarity index between SIK(1) and SIK(2) which correspond with *Ardisia japonica-Castanopsis sieboldii* community was 0.340025100E+00, and the one between SIK(4) and SIK(5) which correspond with *Quercetosum acutae* subassociation was 0.340025100E+00. The one between JIK(1) which is the typical subassociation of *Ardisia japonica-Castanopsis sieboldii* community and the study sites of Arachniodo-Quercetum salicinae f. angustata was revealed to be 0.389939700E+00. The three indics were similar level. Final index between the study sites composing the association of Ardisio-Castanopsietum sieboldii was 0.389939700E+00 and the final dissimilarity index at the class level of this *Castanopsis sieboldii* forest was confirmed as 0.479710800E+00. The results described above are corresponding with those of phytosociological analysis and it proves justification of table manipulation by phytosociological Z-M methodology objectively.

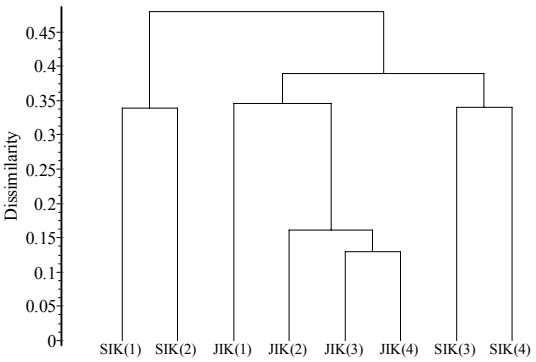

Fig. 4. Hierarchical clustering of *Castanopsis sieboldii* forest in South Korea.
(Sorting strategy : Average link (UPGMA); Dissimilarity coefficient : Bray-Curtis)

4. Discussion

Like the vegetation structure of Ardisio-Castanopsietum sieboldii of Japan (Miyawaki and Okuda, 1990), the fact that *Quercus acuta, Quercus salicina* f. *angustata* are mixed at the canopy (Quercetosum acutae) and it is distributed over the ridge, coincided with the structure of Japan. Consistency and similarity were also found in the Ardisio-Castanopsietum sieboldii of the two

neighboring countries in terms that the herbaceous layer such as *Dryopteris erythrosora, Dryopteris bissetiana, Hedera rhombea* and shrub layer like *Cinnamomum tenuifolium, Ilex integra* appear.

Ardisio-Castanopsietum sieboldii of the two countries, on the other hand, was classified by the lower unit of subassociation type of *Quercetosum acutae* but some difference exits in their differential species. *Cymbidium goeringii, Quercus acuta* appeared in Korea as well but no *Osmanthus heterophyllus* var. *bibracteatus, Elaeagnus glabra* was found in Korea. But instead, the subassociation in Korea seemed to be under the edaphic influence according to the appearances of *Dryopteris pacifica* and *Pinus densiflora*. High constancy plants of shrub layer in the association of Japan such as *Dendropanax trifidus* including *Osmanthus heterophyllus* var. *bibracteatus* did not appear at Ardisio-Castanopsietum sieboldii in Korea. According to the appearances of the endemic species such as *Dendropanax morbiferus* appearing in the Korean associations to cope with *Dendropanax trifidus* in the Japanese associations, the Ardisio-Castanopsietum sieboldii of Korea shows floristic characteristics of only Korea.

Some of the species of the vegetation components found in the southern islands in the Korean peninsula are the character and differential species of Pittosporion tobira Nakanishi et H. Suzuki 1974 (Alliance; Miyawaki et al., 1994) of Myrsino-Castanopsietalia sieboldii K. Fujiwara 1981(Miyawaki et al., 1994) of Japan. In the alliance of Japan, there is no association to be named as *Castanopsis sieboldii* forest by *Castanopsis sieboldii* et al. dominating the canopy. In this regard, our study call edit as the vegetation components of southern islands in the Korean peninsula along with other components. The Pittosporion tobira is the alliance distributed in the wind confronting area at sea shore (Miyawaki et al., 1994), and some similarity is found considering the study sites with the species of the vegetation components are distributed at low altitude compared with other *Castanopsis sieboldii* forest of Korea (Fig. 2).

Yun et al.(2011) classified the *Castanopsis sieboldii* forest as a *Castanopsis*-Type and confirmed three communities (*Castanopsis cuspidata* var. *sieboldii-Rumohra aristata, Castanopsis cuspidata* var. *sieboldii-Ardisia japonica,* and *Castanopsis cuspidata* var. *sieboldii－Hosta minor* communities) in the forest communities of Jeju-do Island and one in the forest communities of Mt. Jiri region. Our study named all the *Castanopsis sieboldii* (*Castanopsis cuspidata* var. *sieboldii*) forest appeared in Jeju-do Island as Ardisio-Castanopsietum sieboldii association, while Yun et al.(2011) named four in their community unit. *Castanopsis cuspidata* var. *sieboldii-Ardisia japonica* community, similar with the association in our study, lacked in the character species. This result of Yun et al.(2011) was different from our study which found lots of species classifying and characterizing by the units of association, alliance, order and class and it may be reconsidered afterwards. On the other hand, some of the differential species of the other 2 communities corresponded with the character and differential species of the association of our study. The study made classification by an association unit and then classified it into its lower subunits instead of classifying into communities in detail as distinctive naming of upper units was available. *Castanopsis cuspidata* var. *sieboldii－Ligustrum japonicum* community is involved in Mt. Jiri region but it may cause misunderstanding in confirming correct distribution of the community because such community found in seashore is named after Mt. Jiri region located inland having different vegetation structures. On the contrary, it may be more precise to name such community after the name of Wan-do and Bogil-do Islands region where various typical evergreen broad-leaved forest of Korean Peninsula is distributed having specific environmental circumstances

as small islands. character species of above community such as *Eurya japonica, Ligustrum japonicum* and *Cinamomum jaonicum* are the character and differential species of the class unit in SIK (study sites) of our study and they were not used as character and differential species of certain community or association unit.

Kil and Kim(1999) analyzed the vegetation structures of the evergreen broad-leaved forest of Korea by arranging the thesis published previously. Unlike the analysis on the same by our study, they analyzed the vegetation structures of *Castanopsis sieboldii* forest by Querco-Castanopsion all. nov. and Dendropanaco-Castanopsion sieboldii all. nov.. *Quercus acuta* and *Castanopsis sieboldii*, however, carry independent vegetation structure respectively and difference of distributed location by altitudes. The naming with the two species in one community may cause misunderstanding on the vegetation structures of evergreen broad-leaved forest of Korea. Above assertion is proven by the Japanese practice that *Castanopsis sieboldii* forest does not apply to the names of association and community together even if *Quercus acuta* is appearing to some extent because the distribution area of two plant species are different. Validity of Dendropanaco-Castanopsion sieboldii needs to be verified by further analysis on its vegetation structure.

Analyzing the vegetation structure system based on those of Japan, this study regards that the one related to Korea carries similarity with Japan by showing difference in the character and differential species of upper units or no appearance but demonstrates unique vegetation structures of *Castanopsis sieboldii* forest of Korea.

Further vegetation structure analysis, therefore, is required on the distinctive association units for diversified analysis on the vegetation structures through the continuous vegetation investigation and structure analysis of pure *Castanopsis sieboldii* forest.

Acknowledgements

This study was partly supported by the National Research Foundation of Korea(NRF) Grant(F01-2009-000-10022-0).

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