Korean J. Ecol., 25(1): 33~39, 2002

Vegetation Structure of *Hovenia dulcis* Community in South Korea

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ABSTRACT: Objectives of this study are to make clear the vegetation structure of *Hovenia dulcis* community in the Korean Peninsula over ten mountains including 17 plots. The results were summarized as follows. Habitat of the community indicated that elevation ranged from 115 meter to 720 meter at the sea level, slope aspect in nearly all directions, bare rock from 0 to 90 percent, slope degree from 10° to 40 °, topography from valley to middle slope, the height of tree layer from 8m to 22m, the diameter at breast height from 12cm to 59cm and coverage from 65% to 95%. Vegetation physiognomy was mainly represented by a valley species such as *Cornus controversa, Quercus serrata, Carpinus cordata, Zelkova serrata, Torreya nucifera, Hovenia dulcis, Ulmus davidiana var. japonica, Quercus variabilis, Fagus crenata* var. *multinervis, Acer takesimense, etc.* Vegetation was largely divided into four types such as *Sorbus alnifolia* Type, *Acer palmatum* Type, *H. dulcis* typical Type and *Acer takesimense* Type. According to CCA, *H. dulcis typical* Type was positively correlated with disturbance, bare rock and altitude, *S. alnifolia* Type indicated a positive correlation with organic matter and *A. takesimense* Type showed a negative correlation with bare rock. Altitude and slope factors were significantly correlated on axes. Canopy profile of *S. alnifolia* Type was well developed, *H. dulcis* typical Type was open with about 55% cover under layer and *Acer takesimense* Type indicated the lowest canopy height of tree layer in four Types. According to importance value, *Hovenia dulcis, Cornus kousa, Quercus variabilis, Cornus controversa, Lindera erythrocarpa, etc.* indicated high value in the *H. dulcis* dominated plots, but in other plots, *Carpinus cordata, Hovenia dulcis, Torreya nucifera, Quercus serrata, Acer mono, Cornus controversa, etc.* showed high value caused by the differences of the floristic composition between them.

Key words: CCA, *Hovenia dulcis*, Importance value, Japanese raisin tree, Vegetation

INTRODUCTION

One of ecology' s utmost challenges is to understand how population diversity or community diversity regulates the structure and function of biological communities. Ecologists are also well aware that habitat heterogeneity exerts a strong influence on the distribution and abundance of species, on species interactions, and on the trophic structure of biological communities (Bradley *et al.* 2002, Shin 1995).

In Korea, there has been general consensus that forest ecosystem has been mainly classified into the community of valley type, slope type and the several other types along topography in many regions by many ecologists, especially by phytosociologists(Lee *et al.* 2001, Yun and Hong 2000, Cho *et al.* 1993, Oh *et al.* 1991, Kim and Yim 1988). But the community of valley type is naturally consisted of many kinds of populations, which represent a group of the same species, meaning habitat heterogeneity. This paper focuses only on the forest community including the individual or the population of *Hovenia dulcis* species regarded as a valley type in ecosystem around the country.

Hovenia dulcis Thunb. (Japanese Raisin Tree), which is a deciduous broad leaved tree species, belongs to the Family Rhamnaceae and the Order Rhamnales in taxonomic ranking (Lee 1999). It has been known up to now that the species is distributed just in eastern Asia including Korea, China and Japan in the world, it also thrives in sandy loam, and it is propagated by seeds, root cutting and cuttings of mature wood(KFRI 1990, Cornel university 1976).

Several studies on this worldwide rare tree have been largely concentrated on the development and use for an ornamental tree or a medicinal tree, that is, it has been reported that an ingredient making up this wood conducts the function such as hepatic detoxification activity and reducing serum alcohol concentration, and it is worth developing an ornamental tree or reforestation tree as well as a medicinal tree(Kim 2002, Lee 2001, KFRI 1990, An *et al.* 1999).

These several reports have dealt this tree as a subject or an article, but the ecological features for floristic composition, the

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population structure, the community structure and others have been scarcely dealt with, although those ecological studies could be regarded as one of the essential ones for the future forestry as well as for the researches interested in it. In south Korea, vegetation science, phytosociology, has been largely carried out to describe these features over the territory of several tens of mountain regions located in the country and a lot of data have been accumulated by phytosociologist so far(Lee *et al.* 2001, Yun and Hong 2000, Cho *et al.* 1993, Oh *et al.* 1991, Kim and Yim 1988). Objectives of this study are to make clear the vegetation structure of *Hovenia dulcis community* in Korean Peninsula and also to provide useful data to foresters, researchers, and the others concerned.

STUDY AREA AND METHODS

Fig. 1 shows the study area including the total of ten mountains such as Mt. Munsu(376m), Mt Geonbong(911m), Mt. Jugyeop(601m), Mt. Baegun(883m), Mt. Seonginbong(984m), Mt. Gaya(678m), Mt. Myeonbong(883m), Mt. Bangga(756m), Mt. Unmun(1,188m) and Mt. Naejang(763m) distributed in the Korean Peninsula.

In the study area, the total of seventeen plots were largely obtained by qualitative and quantitative methods(Kershaw & Looney 1985, Braun-Blanquet 1964). The plot size was about 100m^2(10m × 10m), 200m^2(10m × 20m), 225m^2(15m × 15m) and 400m^2(20m × 20m) which were regarded as a minimum area of

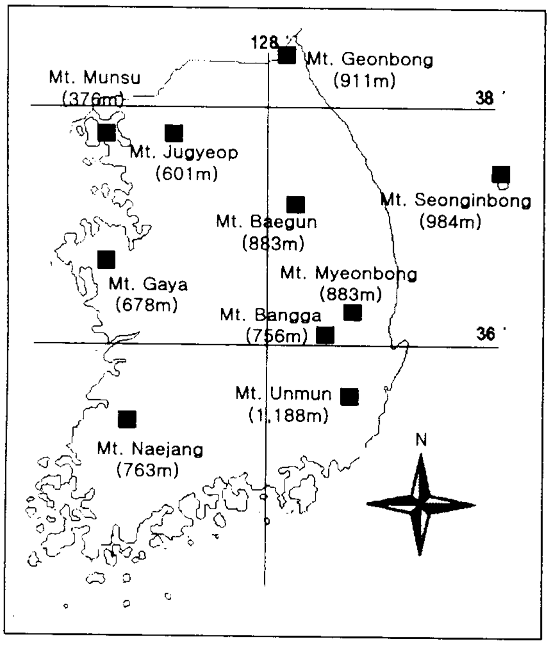

Fig. 1. Map showing the name and the location (with the peak' s altitude at the sea level) of the mountains containing the study site.

a homogeneous stand distributed by a particular tree species (Kershaw & Looney 1985). Although the plant species which we measured in order to manifest the structure and the characteristics of the community were homogeneously distributed, all the plots and their stand were not dominated just by *H. dulcis*. That is, the study area could divide into two groups such as the *H. dulcis* dominated stand and others. Vegetation type was classified by TWINSPAN, and canonical correspondence analysis ordination was conducted by PCORD computer package(Yun and Hong 2000, Lee *et al.* 1997, Ter Braak 1986). Canopy profile was drown along the method used by Lee *et al.*(1993). By the two groups and by four layers, we analyzed the occupying level of the major species and arranged the species along the value by the importance value(Curtis and McIntosh 1951). The importance value in this study was expressed in terms of 0 to 100 percent.

RESULTS AND DISCUSSION

Habitat

The physical and biotic features for the habitat of the plant communities is considered to play a basic role not just for the plant community itself but for the further related research. The altitude of the investigated area ranged from 115 meter to 720 meter at the sea level. Slope aspect distributed nearly all over the direction, but a little difference along the aspects was admitted like the order; the east, the south, the north and the west. Bare rock ranged from 0 to 90 percent, and slope degree was from 10° to 40 °. Topography of the study area was two valley sites, ten low slope sites and five middle slope sites in seventeen sites, which means that the habitat is mainly situated under the middle slope area in the Korean Peninsula. The height of tree layer ranged from 8 meter to 22 meter, the diameter of breast height of the layer was 12cm to 59cm and coverage of the layer was 65 percent to 95 percent.

Vegetation physiognomy

Dominant species in tree layer was represented by *Cornus controversa, Quercus serrata, Carpinus cordata, Zelkova serrata, Torreya nucifera, Hovenia dulcis, Ulmus davidiana* var. *japonica, Quercus variabilis, Fagus crenata* var. *multinervis* and *Acer takesimense*. The species in subtree layer *Cornus kousa, Carpinus cordata, Styrax japonica, Zelkova serrata, Torreya nucifera, Styrax obassia, Euonymus oxyphyllus, Acer mono, Lindera erythrocarpa, Hovenia dulcis* and *Acer okamotoanum*. Shrub layer was dominated by *Euonymus oxyphyllus, Ligustrum obtusifolium, Staphylea bumalda, Sasa borealis, Callicarpa japonica, Sapium japonicum, Parthenocissus tricuspidata, Quercus serrata, Hedera rhombea* and *Rubus parvifolius*. And Herb layer was dominated by *Oplismenus undulatifolius, Polys-*

tichum tripteron, Allium victorialis var. *platyphyllum, Calamagrostis arundinacea, Hedera rhombea, Disporum smilacinum, Syneilesis palmata, Parthenocissus tricuspidata* and *Carex ciliata-marginata.*

Vegetation type

Table 1 indicated the floristic composition classified by TWISPAN. Where the vegetation of the total of study area was largely divided into four types such as *Sorbus alnifolia* Type, *Acer palmatum* Type, *H. dulcis* typical Type and *Acer takesimense* Type.

Sorbus alnifolia Type was located at Mt. Jeogyeop having 4 releves(400m^2). The vertical range for the four sites was from 200 meter to 520 meter above sea level, the range of slope degree was from 11° to 18°, and the height and the diameter of breast height in the tree layer showed 18~22m and 32~46cm, respectively. The tree layer was dominated by *Cornus controversa, Quercus serrata* and *Carpinus cordata. Hovenia dulcis* was covered with + ~ 1.1 of coverage class in the four sites but it didn' t dominate any layer of the site.

Acer palmatum Type was situated at Mt. Naejang and Mt. Geonbong having 3 releves(225m^2). The vertical range of the four plots was from 140 meter to 240 meter above sea level, the range of slope degree was from 10° to 30°, and the height and the diameter of breast height in the tree layer showed 12~16m and 20~59cm, respectively. The tree layer was dominated by *Zelkova serrata, Torreya nucifera* and *H. dulcis.*

H. dulcis typical Type was mainly located in Mt. Munsu, Mt. Gaegun, Mt. Myeonbong, Mt. Gaya, Mt. Bangga and Mt. Unmun. The number of observation was 9 releves(100m^2, 200m^2 and 225m^2) ranging 115 meter to 720 meter above sea level. The height and the diameter of breast height in the tree layer showed 11~15m and 20~30cm, respectively. *Hovenia dulcis* species was dominant in the tree layer or subtree layer for all releves of this vegetation unit.

Acer takesimense Type was distributed just in Ulleung-Do region in south Korea. The observation was two releves(100m^2). The vertical range was from 200 meter to 380 meter above sea level, aspects were NE and SE, the range of slope degree was from 20° to 35°, and the height and the diameter of breast height in the tree layer showed 8~9m and 12~18cm, respectively. The tree layer was dominated by *Fagus crenata* var. *multinervis* and *Acer takesimense*, the subtree layer by *Acer okamotoanum* and *Hovenia dulcis*, the shrub layer by *Hedera rhombea* and *Rubus parvifolius*, and the Herb layer by *Allium victorialis* var. *platyphyllum.*

CCA ordination

Fig. 2 showing canonical correlation analysis(CCA) ordination diagram indicated the correlation between plots(from P1 to P17) and major environmental variables(line). At first, study plots and their comprising species were divided into 3 types (indicated in circle in Fig. 2) that coincided approximately with the results classified by TWINSPAN. Based on the correlations between study plots and environmental factors, *H. dulcis* typical Type containing the plot numbers from P8 to P15 which were widely distributed around Mt. Gaya, Mt. Bangga, Mt. Myeonbong, Mt. Unmun, *etc.* was positively correlated with the three environmental factors such as disturbance, bare rock and altitude. And *S. alnifolia* Type containing the plot numbers from P1 to P4 located in Mt. Jugyeop indicated a positive correlation with the depth of organic matter, which was particularly showing a contrary tendency to the above typical type. On the other hand, *A. takesimense* Type only showed a negative correlation with bare rock. Table 2 indicated that altitude factor was significantly correlated on axis 1 at the level of 95 percent and slope factor was on axis 2 at the level of 99 percent. Those results on relationship between vegetation type and environmental factor were a little coincided with that of some other reports(Yun and Hong 2000, Lee *et al.* 1997, Song *et al.* 1995). However, much more things still remains to be solved with regard to the restricted growth of the species, which is considered to affect the ordination of the community.

Canopy profile

Fig. 3 showed the canopy profiles of four Types in *H. dulcis* community, where the canopy structure of each stratum for *S. alnifolia* Type was foremostly developed out of four Types. That of *H. dulcis* typical Type was also well developed, however subtree layer, shrub layer and herb layer was open with about 55% cover. *Acer takesimense* Type indicated the lowest canopy height of tree layer in four Types, which caused by the location, around Mt. Seonginbong, where the Type was only distributed and also there was a distinct properties of that habitat compared to other Types distributed in inland region of Korea. On the other hand, the typical Type showing low cover under layer was judged to be caused by the factors such as disturbance, bare rock and others. Therefore, we should give it more interest and awareness about this Type, so that we can detect and provide more explicit information to meet requirement for overall understanding of what such a cause is.

Floristic composition of the community

In the total research area, importance value(%) for the species occupying the tree layer in *Hovenia dulcis* community showed the order like this ; *Hovenia dulcis, Acer mono, Cornus controversa, Carpinus cordata, Fraxinus rhynchophylla, Cornus kousa, Zelkova serrata, Quercus variabilis, Quercus serrata, Torreya nucifera, Lindera erythrocarpa, Acer takesimense, Ulmus davidiana* var. *japoinca, Celtis jessoensis, etc.* In the plots dominated by *Hovenia dulcis*, Importance value indicated the order like this ; *Hovenia dulcis, Cornus kousa, Quercus variabilis, Cornus controversa, Lindera erythrocarpa, etc.* In the plots dominated by the

Table 1. Floristic composition table classified by TWISPAN

Species	abbreviation		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Pseudostellaria palibiniana	74	PsPa		3	3	2			2	-		-	-	-	-			-	-	000000
Osmorhiza aristata	82	OsA	-	3	5	-	2								-	-	-	-	-	000000
Disporum smilacinum	84	DiSm	-	6		5					3		-	-	-	-	-	-	-	000001
Sorbus alnifolia	17	SoAl	3	5	3	2			-	-	-	-	-	-	-			-	-	000001
Scutellaria insignis	18	ScIns		4	3	2				-		-	-	-	-	-	-			000001
Lonicera praeflorens	19	LoPr	3	2	2	2			-	-	-	-	-	-	-			-	-	000001
Pimpinella brachycarpa	21	PiBr	2	3		1							1	-	-	-	-	-	-	000001
Corylus heterophylla var. *thunbergii*	22	CoTh	3	-	2	3								-	-	-	-	-	-	000001
Scutellaria indica	23	ScInd		3	3	2				-	-	-	-	-	-			-	-	000001
Rubia akane	24	RuAk	-	2	3	2							-	-	-	-	-			000001
Viola orientalis	25	ViOr		2	3	3							-	-	-	-	-			000001
Hepatica asiatica	26	HeAs	3			3			1	-			-	-			-	-	-	000001
Deutzia coreana	27	DeCo	2		3	2			-	-	-	-	-	-	-			-	-	000001
Meehania urticifolia	28	MeUr	3	2	-	2								-	-	-	-	-	-	000001
Saussurea macrolepis	29	SaMa	3	2	-	-	-		-							-	-	-	-	000001
Prunus maackii	30	PrMa	-	3	-	3	-		-							-	-	-	-	000001
Viola kamibayashii	31	ViKa			4	1			-	-	-	-	-	-	-	-	-			000001
Ainsliaea acerifolia	32	AiAc		4		5	-	-	-	-	-	-	-	-	-	-	-		-	000001
Aconitum seoulense	33	AcSeo	-	4		2					-	-	-	-	-	-	-			000001
Carex siderosticta	34	CaSi	-	2	-	2									-	-	-	-	-	000001
Carpinus cordata	45	CaCo	-	7	5	6	3	-	-	-						-	-	-	-	000001
Kalopanax pictus	20	KaPi	4	2		1			2	-	-	-	-	-	-	-				000010
Euonymus oxyphyllus	40	EuOx	5	4	5	5	2		-	2	3	-	-	-	-	-	-			000010
Celtis jessoensis	44	CeJe	3	4	3	2	4								-	-	-	-	-	000010
Euonymus alatus for. *ciliato - dentatus*	47	EuCi	2	2	2	2	3	-	-	-	-	-	-	-		-	-	-	-	000010
Clematis trichotoma	50	ClTr	-	-	3	2	2						-	-	-	-	-			000010
Quercus serrata	67	QuSe	2	6	-	3	3	-	-	-	-	-	-			-	3	-	-	000010
Smilax sieboldii	46	SmSi	2	1	3	1	2	2	-	-						-	-	-	-	000010
Acanthopanax sessiliflorus	80	AcSes	2	2	-	-	-	-	-			3			-	-	-	-	-	000011
Asarum sieboldii	81	AsSi		2		1	-	-	-	2	-	-	-	-	-			-	-	000011
Vitis amurensis var. *coignetiae*	118	ViCoi	-		3				-	-	-	2	-	-	-			-	-	000011
Stephanandra incisa	48	StIn		2	2		-	2	2	-	-	-	-	-	-			-	-	000100
Synelesis palmata	49	SyPal		3		2	-	2	3	-	-	-	-	-	-				-	000100
Quercus aliena	110	QuAl	-	-	3	-	-	3	-						-	-	-	-	-	000100
Fraxinus rhynchophylla	8	FrRh	3	3	3	3	3	-	-	-	3	-	-	3	3	3	3	-	-	000101
Lindera obtusiloba	9	LinOb	2	2	3	3	2	2	2	-	2	-	-	-	3		2		-	000101
Alangium platanifolium var. *macrophylum*	64	AlMa	-	-	4	2	2	2					-	2	3	-	-	-		000101
Philadelphus schrenckii	66	PhSc	3	2	-	-	2						-	-	3	-	2	-	-	000101
Parthenocissus tricuspidata	69	PaTr		-	5	2	2	-	-	-	-	2	-	-	4			-	-	000101
Viola collina	70	ViCol		2		1			1	-	-	-	-	-	2	-	-			000101
Agrimonia pilosa	73	AgPi	-	2	-	2	-	2	-						2	-	-	-	-	000101
Rhus trichocarpa	87	RhTr				2	-	2	-	-	-	-	-	-	-	-	2		-	000101
Staphylea bumalda	5	StBu	4	2	2	2	3	3	3	3	2	2	-	3	3			-	-	000101
Acer pseudo - sieboldianum	60	AcPs	3	3	2	3	4		3	3		-	2	-	-	-	-	-	-	000101
Asparagus schoberioides	71	AsSch	-	2	1	-	2			2					-	-	-	-	-	000101
Polystichum tripteron	94	PoTr	4	-	-	-	2	-	-	-	3	-	-	-	-			-	-	000101
Acer mono	4	AcMo	5	3	3	3	3			3	3	3	3	4	3	4	-	-		00011
Callicarpa japonica	6	CaJa	2	2	2	4	2	2		3	3	3	4	3	-	-	-	-	-	00011
Arisaema amurense var. *serratum*	7	ArSe	2	1	4	2	2	2	-	2	2	2	2		3		-	-	-	00011
Polygonatum odoratum var. *pluriflorum*	43	PoPl	2		1	1	2	-	-	3	-	2	-	-	-					00011
Cornus kousa	41	CoKo		3		3	-	-	-	4	5	3	-	-	-					001000
Clematis apiifolia	79	ClAp		2					-	2	-	2	-	-	-	-	-			001000
Akebia quinata	83	AkQu		3					-	-	-	3	2	-	-	-				001000
Adenophora remotiflora	119	AdRe	2	-						3		-	-	-	-	-	-	-	-	001000
Styrax japonica	61	StJa	-	3	5	-	3		-	4	4	4	3			-	-	-	-	001000
Oplismenus undulatifolius	10	OpUn		2	-	2	3	2	-	4	3	5	3	2			3	-	-	001001
Viola acuminata	63	ViAc	-	1	1		1	2	-	3	-	3	-	-	-	-	-			001001
Celtis sinensis	96	CeSi	-	-					2	-	-	3	-	2	-	-	-			001010
Lindera erythrocarpa	62	LiEr	-	-	-	-	3	2	-	4	3	4	3	4			-	-	-	001010
Viola rossii	68	ViRo			-	-	-	-	2	2	3	2	-	2				-	-	001010
Prunus sp.	122	PrSp	-	-						3	3	-	-	-	-	-	-	-		001010
Calamagrostis arundinacea	127	CaAr	-	-	-						3	3	-	-	-	-	-	-	-	001010
Ulmus davidiana var. *japonica*	89	UlJa	-	-	-	-	-		2						6	-	2	-	-	001011
Athyrium niponicum	111	AtNi		-	-	-	-	-	-	-	-	-	2		3		-	-	-	001011
Spodiopogon cotulifer	114	SpCo					-	-	-	3	-	-	-	-	-		3		-	001011
Quercus variabilis	88	QuVa	-	-	3	-	-						-	-	-	3	6	-	-	001100
Sambucus williamsii var. *coreana*	91	SaCo	1	-	-	-	2	-	-	-	-				3		-	-	-	001100
Ampelopsis brevipedunculata var. *heterophylla*	85	AmHe				-	2	-	-	2	-	-	-	-	-		2	-	-	001101
Sanicula chinensis	95	SaCh					-	2	-	-	-	-	-	2	2					001101
Cardamine leucantha	120	CaLe	-				3			-	-	-	-	-	2	-	-	-		001101
Aster scaber	130	AsSca	-	-	-	-	2	-	-	-	-				3	-	-	-	-	001101
Paederia scandens	75	PaSc					2	2	-	3	-	-	-	3	-					001101
Zelkova serrata	77	ZeSe					5	3		-	3	3	-	-	-	-	-			001101
Diospyros lotus	113	DiLo			-	-	3	-	-	-	-	-	-	3	-			-	-	001101
Sapium japonicum	123	SaJa	-	-	-	-	3			4					-	-	-	-	-	001101
Carpinus tschonoskii	86	CaTs	-	-	-	-	3	2	-	-	-			3			-	-	-	001110
Morus bombycis	92	MoBo	-	-	-	-	-	2	3	3						-	-	-	-	001110
Acer palmatum	35	AcPa	-	-	-	-	4	3	-					-	-	-	-	-	-	001110
Torreya nucifera	36	ToNu	-	-	-	-	3	7	-	-	-	-				-	-	-	-	001110
Diarrhena japonica	38	DiJa		-	-	-	3	2	-	-	-	-	-	-		-		-	-	001110
Galium trachyspermum	76	GaTr	-	-	-	-	2	2	1	2				-	-	-	-	-	-	001110
Smilax china	42	SmCh		-	1	-	2	-	2	-	2	-	-	-		-		-	-	001111
Ligustrum obtusifolium	72	LigOb		2	-	-	4	3	-	-	-	2	-	-				-	-	001111
Picrasma quassioides	78	PiQu	2	-	-	-	2	2					2		-	-	-	-	-	001111
Viburnum erosum	90	ViEr	-	-	2	-	3	2							-	-	-	-	-	001111
Hovenia dulcis	1	HoDu	2	3	3	3	3	2	5	6	6	6	6	6	5	6	4	3	5	01
Styrax obassia	2	StOb		2	-	3	3	-	3	2	3	-	-	3			3	3	-	01
Phryma leptostachya var. *asiatica*	65	PhAs	-	-				-	-	3	3	-	2	3	3	-	-	-	4	01
Cornus controversa	3	CoCo	5	-	3		3	3	3	-	-	-	-	4	-	-	-		4	100
Hedera rhombea	59	HeRh	-	-	-	-	-	4						-	-	-	-	3	-	100
Actinidia arguta	108	AcAr	-	-	-	-	-	-	-	-	-	-	-	-		3	-	3	-	101
Gynostemma pentaphyllum	109	GyPe	-	-	-	-	2							-	-	-	-	3	-	110
Cimicifuga heracleifolia	93	CiHe	2	-	-	-	-	-	2	-						-	-	-	4	1110
Acer takesimense	11	AcTa	-	-	-	-	-						-	-	-	-	-	3	5	1111
Allium victorialis var. *platyphyllum*	12	AlPl	-	-	-	-	-	-	-	-	-	-				-	-	5	6	1111
Tilia insularis	13	TiIn	-	-	-	-	-	-	-	-	-	-					-	3	3	1111
Taxus cuspidata var. *latifolia*	14	TaLa	-	-	-	-	-								-	-	-	3	3	1111
Dystaenia takeshimana	15	DyTa			-	-	-	-	-	-	-	-	-	-			-	2	2	1111
Arisaema negishii	16	ArNe	-	-	-					-	-	-	-	-	-	-	-	2	2	1111
Fagus crenata var. *multinervis*	51	FaMu			-	-	-	-	-	-	-					-	-	5	-	1111
			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
			0	0	0	0	1	1	1	1	1	1	1	1	1	1	1			
							0	0	0	1	1	1	1	1	1	1	1			

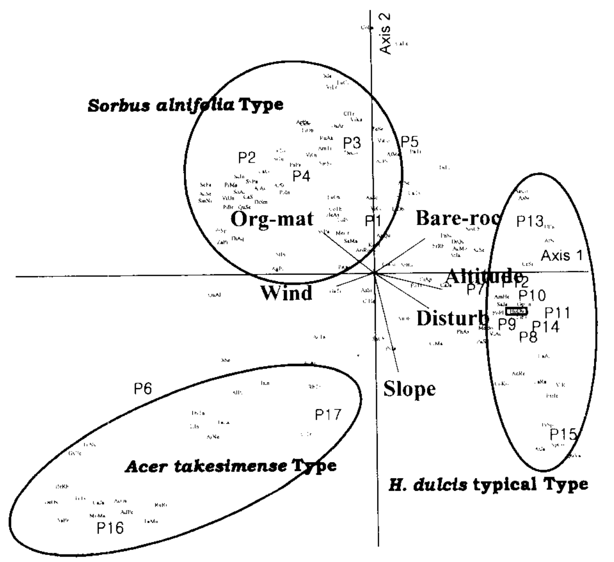

Fig. 2. CCA(canonical correspondence analysis) ordination diagram showing the correlation between plots(from P1 to P17) and major environmental variables(line) against the axis 1 and axis 2 (Cutoff R^2 value : 0.15 ; Vector scaling : 250%).

other species except *Hovenia dulcis*, Importance value showed somewhat different tendency as the order like this ; *Carpinus cordata, Hovenia dulcis, Torreya nucifera, Quercus serrata, Acer mono, Cornus controversa, etc.*

Table 2. Cannonical coefficients and inter-set correlations for 8 envirnment factors

Variable	Cannonical coefficients			Correlation coefficients		
	Axis1	Axis2	Axis3	Axis1	Axis2	Axis3
Altitude	-.119	-.274	.173	.585*	-.129	.084
Aspect	-1.035	-.756	.748	.066	-.190	.369
Slope	.110	-.957	-.291	.199	-.715**	-.215
Topography	.617	.107	1.167	.202	-.270	.313
Bare-rock	1.066	.682	-.197	.442	.258	-.100
Organic matter	-.892	.132	.629	-.433	.291	.200
Wind	-1.367	-.276	-.576	-.324	-.088	-.341
Disturbance	.387	.099	-.339	.461	-.264	.105
Eigenvalue	.642	.489	.426			

** $P < 0.01$, * $P < 0.05$.

In the subtree layer, shrub layer and herb layer, the species such as *Styrax japonica, Acer mono, Callicarpa japonica, Staphylea bumalda, Oplismenus undulatifolius, Allium victorialis* var. *platyphyllum, Phryma teptostachya* var. *asiatica, etc.* indicated high value.

Fig. 4 showed the importance value of *Hovenia dulcis* (Hodu) individual through the comparison of the stands dominated by *H. dulcis* or by the other species in 17 investigated stands. In the

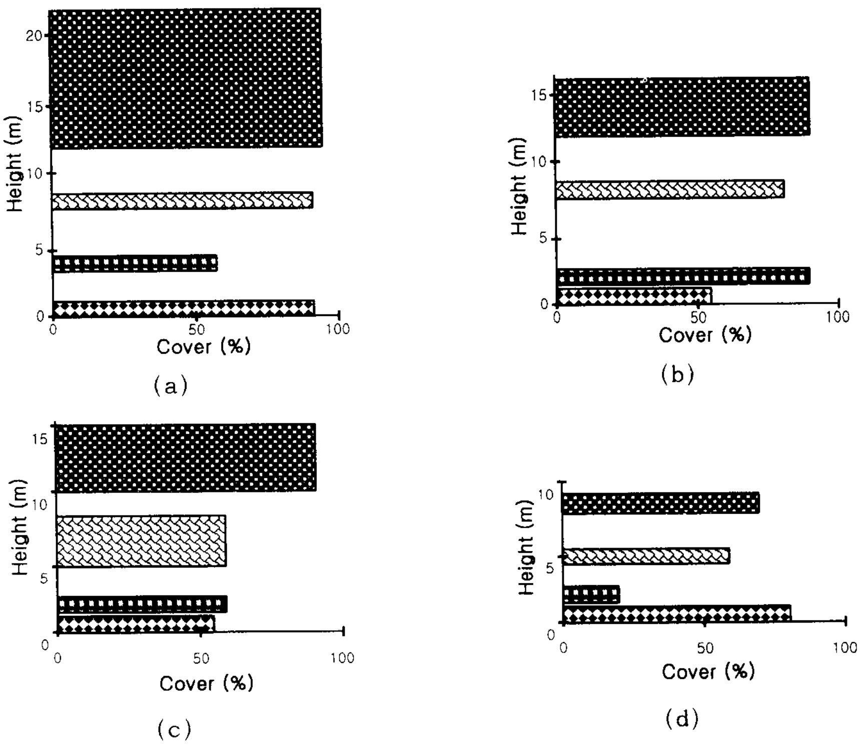

Fig. 3. Canopy profiles of *H. dulcis* community. The height of the horizontal bars represents the average span of canopy height and the length of each bar represents the total cover by all species in the height range. (a) shows *Sorbus alnifolia* type, (b) shows *Acer palmatum* type, (c) shows *H. dulcis* typical type and (d) shows *Acer takesimense* type.

Table 3. Importance Value(%) of 81 major species in the *H. dulcis* community

	Tree layer			Subtree layer			Shrub layer			Herb layer		
	Other stand	Hodu stand	Mean	Other stand	Hodu stand	Mean	Other stand	Hodu stand	Mean	Other stand	Hodu stand	Mean
Hovenia dulcis	9.30	38.41	25.95	–	11.05	5.1	1.02	5.27	2.9	–	0.57	0.19
Acer mono	8.10	8.11	8.00	3.21	10.46	6.65	1.02	5.02	2.83	1.17	1.09	1.14
Cornus controversa	6.24	6.41	6.24	3.21	–	1.66	1.02	–	0.56	1.16	–	0.76
Carpinus cordata	13.52	–	5.93	17.63		9.66	0.51		0.29	–	–	
Fraxinus rhynchophylla	5.58	3.39	4.42	1.60	6.97	4.16	0.51	2.51	1.41	1.40	0.57	1.11
Cornus kousa	–	7.52	4.08	3.21	5.02	3.99	1.02	1.26	1.15		–	–
Zelkova serrata	4.38	3.39	3.69	2.78	–	1.50	1.53	–	0.85	1.63	–	1.06
Quercus variabilis	–	6.55	3.62	1.60	3.27	2.33	–	–	–	–	–	
Quercus serrata	8.20	–	3.62	1.60	1.74	1.66	–	1.26	0.56	1.46	–	0.96
Torreya nucifera	8.31	–	3.55	4.39	–	2.33	–	–	–	0.87	–	0.57
Lindera erythrocarpa	–	6.41	3.43	1.60	8.50	4.82	1.02	5.02	2.83	–		–
Acer takesimense	1.86	3.47	2.81	–	–	–	–	–	–	–	–	–
Ulmus davidiana var. *japonica*	–	4.85	2.74		1.74	0.83	–	2.64	1.15	–	–	
Celtis jessoensis	4.67		2.16	2.78	–	1.50	3.06		1.73	1.17	–	0.77
Sorbus alnifolia	4.38	–	1.92	3.21	–	1.66	0.51	–	0.29	0.29		0.19
Fagus crenata var. *multinervis*	4.38	–	1.92	–	–	–	–	–	–	–	–	–
Diospyros lotus	1.86	1.69	1.77	–	–		–		–		–	–
Acer palmatum	2.80	–	1.27	4.39	–	2.33	1.02		0.56	1.92	–	1.25
Quercus mongolica		2.36	1.27	–	3.27	1.50	–	0.69	0.29	–		–
Kalopanax pictus	2.80		1.27	–		–	0.51	0.69	0.59	0.78	–	0.52
Styrax obassia	1.86		0.88	3.21	3.49	3.33	1.02	3.90	2.29	–		–
Cornus walteri	–	1.69	0.88	–	1.74	0.83	–	1.26	0.56	–		–
Tilia insularis	1.86	–	0.88	–	1.74	0.83	–		–		–	–
Quercus aliena	1.86	–	0.88	–	–	–	1.02	–	0.56	0.29	–	0.19
Carpinus laxiflora	1.86	–	0.88	–	–		1.02	–	0.56	–	–	–
Juglans mandshurica	–	1.69	0.88		–	–	–	–			–	–
Camellia japonica	1.86	–	0.88	–	–			–	–	–	–	–
Styrax japonica		–	–	6.36	11.56	8.77	1.02	2.51	1.68	–	–	–
Euonymus oxyphyllus	–	–	–	9.14	–	4.94	16.84	1.95	9.81	0.88	–	0.58
Acer pseudo – sieboldianum		–	–	5.99	1.74	3.99	3.06	1.95	2.56	–	–	–
Staphylea bumalda	–		–	3.21	–	1.66	5.95	6.41	6.10	0.88	1.09	0.96
Sapium japonicum	–	–		1.60	1.74	1.66	0.51	2.76	1.57	–	–	–
Corylus heterophylla var. *thunbergii*	–	–	–	3.21		1.66	1.53	–	0.88	–	–	–
Morus bombycis	–	–	–	–	3.49	1.66	0.51	1.26	0.85	–		–
Carpinus tschonoskii	–	–		1.60	1.74	1.66	0.51		0.29	0.29	–	0.19
Lindera obtusiloba	–		–	–	1.74	0.83	4.08	3.34	3.73	0.29	1.09	0.57
Philadelphus schrenckii	–		–	–	1.74	0.83	2.04	1.95	2.00	0.29	0.57	0.39
Euonymus alatus for. *ciliato dentatus*	–	–	–	1.60	–	0.83	3.06	–	1.73	0.59		0.39
Viburnum erosum	–	–	–	1.60		0.83	2.04		1.15	–	–	–
Prunus maackii	–	–	–	1.60	–	0.83	2.04	–	1.12	–	–	–
Sambucus williamsii var. *coreana*	–	–			1.74	0.83	0.51	1.26	0.85	0.24	1.09	0.54
Celtis sinensis	–	–	–	–	1.74	0.83	–	1.39	0.59	–	–	–
Aralia elata		–	–	–	1.74	0.83	–	1.26	0.56	–	1.09	0.38
Prunus padus	–	–	–		1.74	0.83		1.26	0.56		–	
Lonicera mackii	–	–	–	1.60		0.83	–	–	–	–		–
Sambucus sieboldiana var. *pendula*	–	–	–	1.60	–	0.83	–	–	–	–		–
Morus bombycis var *maritima*	–	–	–	1.60	–	0.83	–	–	–	–	–	–
Acer okamotoanum		–		1.60	–	0.83		–			–	–
Callicarpa japonica	–	–	–	–	–	–	5.17	7.78	6.38		–	–
Sasa borealis	–		–	–	–	–	–	8.38	3.95	–	–	–
Alangium platanifolium var. *macrophylum*	–	–	–	–	–	–	3.91	1.95	3.01	0.24	0.57	0.36
Ligustrum obtusifolium		–			–		3.91	0.69	2.42	–	–	–
Parthenocissus tricuspidata	–	–	–	–	–	–	–	3.45	1.57	3.14	2.47	2.91
Stephanandra incisa		–		–	–	–	1.53	0.69	1.17	0.29		0.19
Picrasma quassioides		–			–	–	1.53	0.69	1.17	–		–
Lonicera praeflorens	–	–	–	–		–	2.04	–	1.15	0.29	–	0.19
Deutzia coreana	–	–	–		–		1.95	–	1.10	–	–	–
Smilax china	–		–	–		–	0.51	1.39	0.88	0.24	–	0.16
Ampelopsis brevipedunculata var. *heterophylla*	–	–	–	–	–	–	0.51	1.39	0.88	–	–	–
Rhus trichocarpa	–	–	–	–	–	–	1.02	0.69	0.88	–	–	–
Smilax sieboldii	–		–	–	–		1.02		0.59	1.36	–	0.90
Akebia quinata	–		–		–	–	0.51	0.69	0.59	0.58	1.09	0.76
Clematis apiifolia	–	–	–	–	–		–	1.39	0.59	0.29		0.19
Celtis choseniana		–		–	–	–	1.02	–	0.56	–	–	–
Securinega suffruticosa	–	–	–	–		–	–	1.26	0.56	–		–
Meliosma myriantha	–	–	–		–		1.02		0.56	–	–	
Abelia mosanensis	–		–	–	–		–	1.26	0.56	–	–	
Agrimonia pilosa	–		–	–	–	–		0.69	0.29	0.88	0.57	0.78
Clematis mandshurica		–		–	–	–	–	0.69	0.29	0.29		0.19
Pourthiaea villosa		–		–	–	–	0.51	–	0.29		–	–
Chionanthus retusa	–	–	–		–		0.51	–	0.29	–	–	
Rubus oldhamii		–		–	–	–	–	0.69	0.29		–	–
Oplismenus undulatifolius	–	–	–	–	–		–	–	–	1.41	11.08	4.81
Disporum smilacinum	–	–	–	–	–		–	–	–	6.80	1.09	4.77
Allium victorialis var. *platyphyllum*	–	–	–	–		–		–		2.61	7.64	4.39
Arisaema amurense var. *serratum*	–	–	–	–		–		–		2.76	3.39	2.96
Phryma teptostachya var. *asiatica*	–	–	–		–	–	–		–	–	7.41	2.57
Ainsliaea acerifolia		–		–	–	–	–	–	–	3.95	–	2.55
Osmorhiza aristata	–	–	–	–		–		–		3.48		2.26
Polystichum tripteron	–		–	–	–	–	–	–	–	1.63	1.09	1.44
Viola acuminata	–	–	–	–	–	–	–	–	–	1.02	2.18	1.43
Sum (%)	95.69	95.95	95.83	96.79	89.75	93.51	86.22	90.56	88.12	46.90	45.75	46.55
Others (%)	4.31	4.05	4.17	3.21	10.25	6.49	13.78	9.44	11.88	53.10	54.25	53.45
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

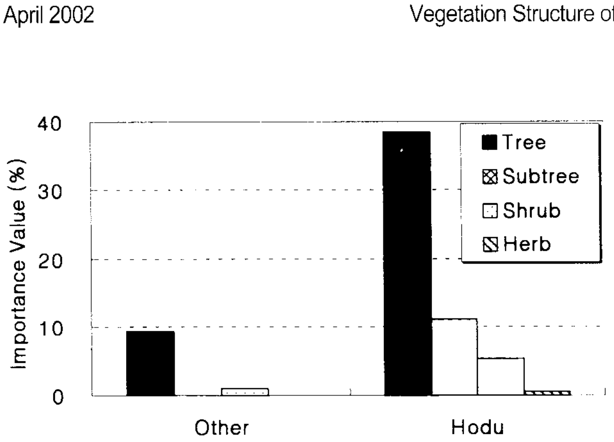

Fig. 4. Importance value (%) of *Hovenia dulcis* (Hodu) in the dominated stands by Hodu and in the other stands.

sites dominated by *H. dulcis*, all layers including tree layer, subtree layer, shrub layer and herb layer contained *H. dulcis* individuals, in which we could detect the fact that the vertical structure of the stand formed a reverse J-shape as going down from tree layer to herb layer. In the sites dominated by the other species, most of the *H. dulcis* individuals showed low level of the value that was 9.30 in tree layer and 1.02 in shrub layer, respectively. Expecially in shrub layer, it was absent.

Considering the above results, we could find the fact that the floristic composition in the sites dominated by *Hovenia dulcis* showed an apparently different tendency when it was compared with the sites dominated by the other species. Therefore, these species with high level of importance value were thought to be served as a guiding species in order to provide basic information for practical use and development and to manifest the vegetation structure.

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(*Received February 8, 2002, Accepted March 11, 2002*)