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Ecological Attributes of Species Composition by Topographical Positions in the Natural Deciduous Forest

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ABSTRACT : Based upon the vegetation data of woody plants by plot sampling method in the natural deciduous forest of Mt. Jeombong, the study was carried out to examine importance value, rank abundance curve, and species abundance curve, and comparatively evaluate seven different species diversity indices for Shannon-Wiener index, Simpson index, McIntosh index, Log series, Margalef index, Berger-Parker index, and species richness, according to topographic positions. The minimal area which meant only few more species were increased was 3.48 ha in total. The dominant species of valley were *Carpinus cordata*, *Acer pseudo-sieboldianum*, *Quercus mongolica*, *Acer mono*, and *Abies holophylla*, and the dominant species of mid-slope were *Quercus mongolica*, *Acer pseudo-sieboldianum*, *Carpinus cordata*, *Tilia amurensis*, and *Fraxinus rhynchophylla*. Moreover, the dominant species of ridge were *Quercus mongolica*, *Acer pseudo-sieboldianum*, *Tilia amurensis*, *Fraxinus rhynchophylla*, and *Acer mono*. According to rank abundance curve and species abundance curve, species evenness was also low. All of Log series, species richness, Margalef, and Shannon-Wiener index discriminated that valley had the highest diversity, and ridge had the lowest diversity; but, Simpson index, McIntosh index, and Berger-Parker index represented that mid-slope had the highest diversity, and ridge had the lowest diversity. Uniquely, in Berger-Parker index, mid-slope was the higher value than total.

Keywords : Importance value, Species area curve, Rank abundance curve, Species abundance curve, Species diversity index

INTRODUCTION

The natural deciduous forest is composed of a variety of plant species, which have evolved thanks to its high adaptability to climatic and environmental conditions of a specific region. It is obvious that broad-leaved deciduous trees and shrubs are the most abundant growth form in the deciduous forest. Where there are enough trees to produce a more or less continuous canopy of leaves, the dominants are always trees. In some locations, especially where the dominant trees have sparse crowns, plants on the forest floor may share dominance. Deciduous trees in the forest sometimes let enough light through to the ground to produce a rich understory. The forest has a multilayered physiognomy with a number of growth forms, consisting of several strata and forming vertical structure (Kim, 2002).

Korean deciduous forests, developed mostly on rugged terrain, commonly show different species diversity of plants by microtopography. Generally, the species diversity tends to be higher in valley area than in mid-slope and ridge area, and higher on north facing slopes than on those of south. This variation is dependent on the difference of soil moisture regime controlled by climatic factors depending on microtopography. Compared to ridge area, valley area tends to have better moisture condition with higher water table and finer soil texture carried from upper position by wind, water, and gravity. Also north facing slopes receive less sunlight than south facing slopes, resulting in better moisture condition, which makes northern aspect higher species diversity. However, the larger amount of sunlight by disturbance may increase the species diversity. In a stand which has experienced any kinds of disturbance, a lot of plant species can migrate to take advantage of increased sunlight, which enhances the species diversity (Kang et al., 2000; Kang and Kim, 2000; Lee et al., 2000, Kim, 2002; Yang and Kim, 2002).

A forest community is said to have a high species diversity if many equally or nearly equally abundant species

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are present. On the other hand, if a community is composed of a very few species, or if only a few species are abundant, species diversity is low (Brower and Zar, 1977). High species diversity indicates a highly complex community because a greater variety of species allows for more variety of species interactions. Consequently, the concept of species diversity has been defined in many ways, and several different indices have been developed to express it.

Although there have been a lot of studies dealing with species diversity of natural deciduous forests, Shannon-Weiner index or Simpson index was mostly used. Other indices such as Log series, Margalef index, McIntosh index, and Berger-Parker index were seldom used in describing forest community attributes with species diversity indices.

This study was conducted to search the point where only a few more species were increased via species area curve, to understand stand structure through importance value, rank abundance curve, and species abundance curve, and to compare seven different diversity indices, Shannon-Wiener index, Simpson index, McIntosh index, Log series, Margalef index, Berger-Parker index, and species richness, according to topographic positions in the natural deciduous forest of Mt. Jeombong.

STUDY METHODS

1. Vegetation data from previous study

The study area of Mt. Jeombong (1424 m) is located in the middle of the Baekdudaegan Mts., on the south border of Sorak-San National Park. Except for small patches of pine stands, the hardwood forest classified as a mixed mesothytic type extends through most of the area. The area has a typical continental climate with average maximum temperature of 33℃ in the summer and average minimum temperature of -19℃ in the winter. The mean annual precipitation is 1,057mm. The predominant soils can be described well drained loams to clay loams with a high amount of organic matter. Major dominant genera are *Acer, Quercus, Fraxinus, Carpinus, Tilia, Ulmus,* and *Betula* (Korea Nature Conservation Association, 1984; Jin, 2002).

In previous work of Jin and Kim (2005; 2006), vegetation data were collected on one hundred and six 20 m x 20 m square sample plots of total 4.24 ha for the data of both tree and shrub species. They were evenly distributed from the lower to upper slopes of the Mt. Jeombong with reference to 1 : 25,000 topographic map of the study area. With identifying species, DBH and height were measured. All species of trees and shrubs collected were classified into 3 layers (overstory, midstory, and understory) in terms of vertical structure. Overstory was defined as trees which were dominant and co-dominant in the uppermost canopy, midstory was more than 3 m of height below overstory, and understory was less than 3 m of height. The overview of study area and the methods of data collection were mentioned in detail in the previous publication by Jin (2002). Botanical nomenclature of the species follows Lee (2003).

2. Data analysis

(1) Species area curve

A single measurement data is generally insufficient to obtain accurate conclusions about an ecological characteristic. This is because of the inability to know how reliably that characteristic had been estimated. Therefore, a series of repeated, or replicated data of the measurements should be taken. The cumulative number of species was plotted against the cumulative number of sample plots to produce species area curve as a preliminary guide for sample size.

(2) Compositional attributes of species

Since the natural forest is basically composed of many species, the dominance of a certain species may be represented by importance value which is sum of relative density, relative frequency, and relative coverage for the species in the community (Curtis and McIntosh, 1951). Scale is from 0 to 100; the larger the importance value, the more dominant a species in that particular community.

A rank abundance curve is a chart to display relative species abundance, which is a component of biodiversity. It also can be used to visualize species richness and evenness.

The species with the most individuals has a rank of 1 and the species with the next highest count of individuals has a rank of 2. Species richness can be indicated as the number of different species on the chart; how many species were ranked. Moreover, species evenness is shown from the slope of the line that fits the graph (Magurran, 2004).

Most biological communities contain many species of organisms, and the species may vary greatly in their abundance from very common to very rare. Preston (1948) suggested expressing the *X* axis (number of individuals represented in sample) on a geometric (logarithmic) scale rather than an arithmetic scale. Therefore, Preston chose grouping into what he called "Octave" as the most natural procedure; that is, the midpoint of each group was double that of the preceding group. In this study, octave scale of Preston (1948), equivalent to $\log_2$ scale, was used.

(3) Species diversity index

Species diversity, which is sometimes called species heterogeneity, is an expression of community structure. Also, it is one of the basic concepts of ecology that has been used to characterize communities and ecosystems and measured by species richness (the number of species present in a particular community) and species evenness (the relative abundance of the different species). In this study, seven different species diversity indices, they were Shannon-Wiener (Shannon and Wiener, 1948), Simpson (Simpson, 1949), McIntosh (McIntosh, 1967), Log series (Magurran, 1988), Margalef (Clifford and Stephenson, 1975), Berger-Parker (Berger and Parker, 1970), and species richness (Magurran, 1988), used for comparative evaluation.

RESULTS AND DISCUSSION

1. Species area curve

The species area curve for the collected vegetation data, plotting cumulative area sampled, was presented in Fig. 1. The minimal areas which meant the point on the curve where the slope most rapidly approached the horizontal or where only few more species were increased of total, over-story, mid-story, and under-story were 3.48 ha, 3.08 ha, 3.48 ha, and 2.36 ha, respectively; they were also 87th, 77th, 87th, and 59th sampling plots, respectively. Moreover, the numbers of species of total, over-story, mid-story, and under-story in the minimal area were 49, 42, 31, and 30, respectively. The species area curve indicated to have had enough sample size for analyzing the ecological attributes in the study area.

In fact, the number of species always increases with area up to the point where the area of the entire world has been accumulated (Williamson *et al*., 2001). However, plant ecologists have often used the species area curve to estimate the minimum size of a quadrat necessary to adequately characterize a community. The point on the curve where only few more species are increased is called the minimal area (Barbour et al., 1987).

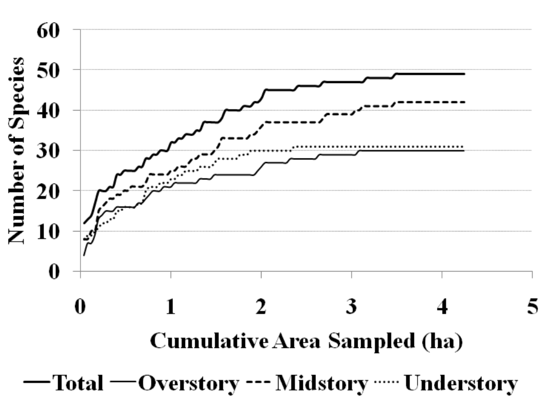

Fig. 1. Species area curve of Mt. Jeombong.

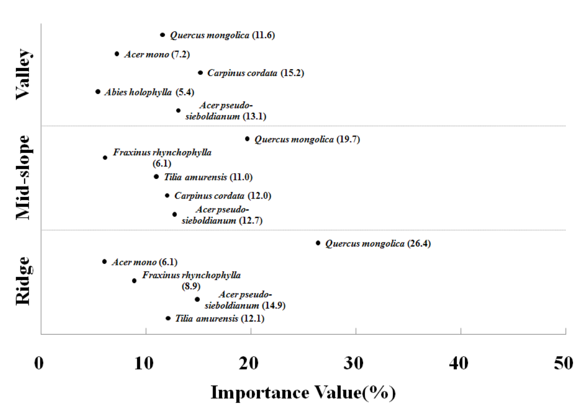

Fig. 2. Importance values by topographic positions

2. Classification by topographic position

(1) Compositional attributes of species

According to Fig. 2, the dominance species of valley was *Carpinus cordata* (15.2%), *Acer pseudo-sieboldianum* (13.1%), *Quercus mongolica* (11.6%), *Acer mono* (7.2%), and *Abies holophylla* (5.4%). Moreover, *Quercus mongolica* and *Acer pseudo-sieboldianum* were dominant species both of mid-slope and ridge.

The numbers of species, species richness, appeared in total, valley, mid-slope, and ridge were 49, 41, 39, and 30, respectively; the richest site was valley, and the poorest site was ridge (Fig. 3). A relative abundance of the most common species in total, valley, mid-slope, and ridge was 0.27, 0.27, 0.24, and 0.30, respectively. However, the graph certainly showed species evenness of all positions was low because of a steep gradient.

The number of species with octave 1 which had only one individual in valley, mid-slope, and ridge was respectively 11, 8, and 9; rare species were founded a lot in all of topographic position (Fig. 4). However, the number of common species in valley, mid-slope, and ridge was 2, 2, and 1, respectively.

There were also violent fluctuations in all of three topographic position as species-abundance curve by canopy layer and growth form.

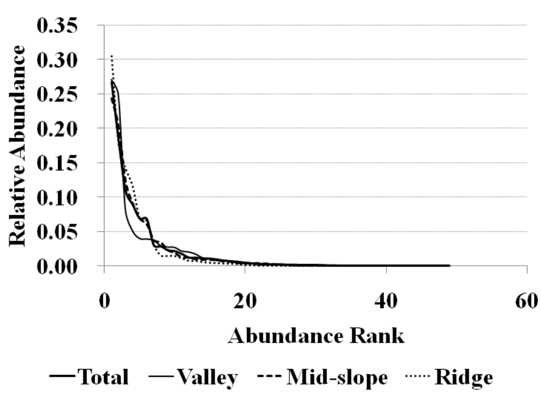

Fig. 3. Rank abundance curves by topographic positions

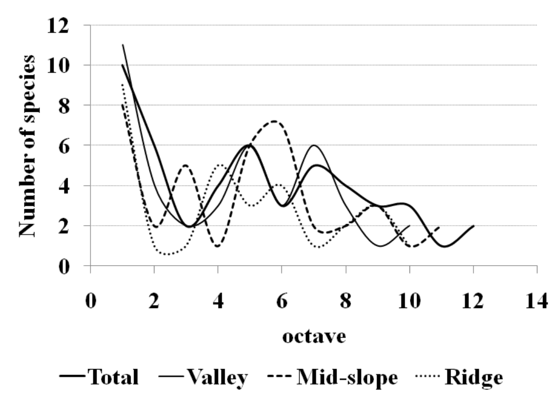

Fig. 4. Species abundance curves by topographic positions

Table 1. Species diversity indices by topographic positions

Species indices		Total	Valley	Mid-slope	Ridge
Shannon-Wiener	H'	2.44	2.41	2.40	2.14
	Hmax	3.89	3.71	3.66	3.40
	J'	0.63	0.65	0.66	0.63
	1-J'	0.37	0.35	0.34	0.37
Simpson	λ	0.14	0.15	0.14	0.17
	Ds	0.86	0.85	0.86	0.83
	Dmax	0.98	0.98	0.97	0.97
	Es	0.88	0.87	0.89	0.86
McIntosh	D	0.64	0.62	0.64	0.60
	E	0.74	0.72	0.75	0.72
Log series	α	6.57	6.57	5.74	4.67
Margalef	D	5.14	4.93	4.45	3.64
Berger-Parker	1/d	3.75	3.69	4.11	3.29
Species richness	S	49	41	39	30

(2) Species diversity index

All of Log series, species richness, Margalef, and Shannon-Wiener index discriminated that valley had the highest diversity, and ridge had the lowest diversity; but, Simpson's, McIntosh, and Berger-Parker index represented that mid-slope had the highest diversity, and ridge had the lowest diversity (Table 1). Uniquely, in Berger-Parker index, mid-slope was the highest value than total. It would be because of a feature of equation; it was weighted more towards dominance of species than to richness of species. Therefore, Berger-Parker index would be a good discrimination in the region with high evenness which meant a couple of species were dominant.

Upon the analytical results of this study, It was reviewed that, the most widely used index, Shannon-Wiener index was influenced more by richness and less by evenness than both Simpson and McIntosh index; that is, it was insensitive measure of the character of the species abundance distribution (evenness). Thus, Shannon-Wiener index would be a useful index for the community of which two or three species were dominant such as in the deciduous forest of Korea. It also showed a value of maximum diversity, dominance, and evenness as well as a diversity index at once. Simpson index was also one of the widely used index and simple to calculate, but heavily weighed towards the most abundant species in the sample. Therefore, it would result in a good discriminate ability in a community which was dominated by a couple of species because it was weighed towards species dominance. It also represented maximum diversity value, dominance value, and evenness value as well as a diversity index at once such as Shannon-Wiener index. McIntosh index was easy to calculate, but weighed towards species dominance. However, Log series had a good discriminant ability, but calculation was not that much easy. Species richness was easy to calculate, but too sensitive to sample size. The advantage of Margalef index also had a good discriminant ability as Log series, but weighed towards species richness. Berger-Parker index showed the almost same character of advantages and disadvantages (Magurran, 1988; Magurran, 2004).

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LITERATURE CITED

Barbour, M.G., Burk, J.H., and Pitts, W.D. 1987. Terrestrial Plant Ecology, 2nd edition. The Benjamin/Cummings Publishing Company, Inc. Menlo Park. California, USA.

Berger, W.H. and Parker, F.L. 1970. Diversity of *Planktonic foraminifera* in deep sea sediments. Science 168: 1345-1347.

Brower, J.E. and Zar, J.H. 1977. Field and Laboratory Methods for General Ecology. WM. C. Brown Company Publishers. 136pp.

Clifford, H.T. and Stephenson, W. 1975. An Introduction to Numerical Classification. Academic Press, London, UK.

Curtis, J.T. and McIntosh, R.P. 1951. An upland forest continuum in the prairie forest border region Wisconsin. Ecology 9: 161-166.

Jin, G.Z. 2002. The Analysis of Ecological Structure and Dynamics for Community Types in the Natural Deciduous Forest of Mt. Chumbong Area. Ph.D Dissertation. Dept. of Forest Management, Graduate School, Kangwon National University. 139pp.

Jin G.Z. and Kim, J.H. 2005. The analysis of successional trends by community types in the natural deciduous forest of Mt. Jumbong. Jour. Korean Fo. Soc. 94(6): 387-396.

Jin G.Z. and Kim, J.H. 2006. The estimation of succession index by community type in the natural deciduous forest of Mt. Jumbong. Jour. Korean Fo. Soc. 95(6): 723-728.

Kang, S.K. and Kim, J.H. 2000. The analysis of community structural attributes by topographic positions in the natural deciduous forest of Mt. Chumbong area (II)--Inter-species association and inter-community similarity. J. Res. For. Kangwon National University 20: 25-36.

Kang, S.K., Kim, J.H., Jin, G.Z., and Yang, H.M. 2000. The analysis of community structural attributes by topographic positions in the natural deciduous forest of Mt. Chumbong area (I)--Species composition, species diversity, life form. J. For. Sci. Kangwon National University 16: 93-104.

Kim, J.H. 2002. Community ecological view of the natural deciduous forest in Korea. In: Ecology of Korea. Bumwoo Publishing Company, Seoul, Korea. 93-104.

Lee, T.B. 2003. Coloured Flora of Korea. Hyangmoonsa, Seoul, Korea.

Lee, W.S., Kim, J.H., and Jin, G.Z. 2000. The analysis of successional trends by topographic positions in the natural deciduous forest of Mt. Chumbong. J. of Kor. For. Soc. 89(5): 655-665.

Magurran, A.E. 1988. Ecological Diversity and Its Measurement. Croom Helm, London, UK.

Magurran, A.E. 2004. Measuring Biological Diversity. Wiley-Blackwell, Oxford, UK.
McIntosh, R.P. 1967. An index of diversity and the relation of certain concepts to diversity. Ecology 48: 392-404.
Preston, F.W. 1948. The commonness and rarity of species. Ecology 29: 254-283.
Shannon, C.E. and Wiener, W. 1948. The mathematical theory of communication. Science 185: 27-39.
Simpson, E.H. 1949. Measurement of diversity. Nature 163: 688.
Yang, H.M. and Kim, J.H. 2002. Analysis and comparison of community structural attributes by topographic positions and aspects in the natural deciduous forest. J. For. Sci. Kangwon National University 18: 73-86.

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