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The Forest Vegetation of Mt. Jangan County Park in Jangsu-Gun, Jeonlabuk-Do, Korea

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ABSTRACT: Forest vegetation in Mt. Jangan County Park, Jeonlabuk-Do, Korea, was investigated by classification and ordination methods. By the cluster analysis (classification) method, nine groups were recognized as follows: *Quercus serrata* community, *Quercus serrata* - *Carpinus laxiflora* community, *Cornus controversa* community, *Fraxinus mandshurica* community, *Carpinus laxiflora* community, *Quercus variabilis* community, *Quercus mongolica* - *Sasa borealis* community, *Quercus mongolica* - *Symplocos chinensis* for. *pilosa* community and *Quercus mongolica* - *Rhododendron schlippenbachii* community. These groups showed differences in species composition and environmental characteristics, but *Quercus mongolica* - *Sasa borealis* community, *Quercus mongolica* - *Symplocos chinensis* for. *pilosa* community and *Quercus mongolica* - *Rhododendron schlippenbachii* community among them showed very similar floristic composition to each other. The interrelationship between the floristic composition of the vegetation and environmental factors was analysed by principal component analysis (PCA). *Quercus mongolica* community was distributed at a high altitude (900~1200 m above sea level). *Fraxinus mandshurica* community and *Cornus controversa* community were differentiated from the other communities with high contents of soil moisture and pH. On the other hand, *Carpinus laxiflora* community and *Quercus variabilis* community were distributed at places with adequate levels of soil moisture, soil organic matter, and at low altitude. In this study, the altitude and soil moisture were the main factors determining the forest vegetation. They were strongly correlated with the dominant compositional gradient at the localities examined.

Key Words: Altitude, Classification, Ordination, PCA, Soil moisture

INTRODUCTION

Community ecologists often analyze data by two methods consisting of classification and ordination. These two methods have the common goal of organizing data for purposes of description, discussion, understanding, and management of communities. Classification and ordination techniques organize community data on species abundances exclusively, apart from environmental data, leaving environmental interpretation to a subsequent, independent step (Gauch 1982).

The result of classification is the assignment of species and samples to classes; the classes may or may not be arranged in a hierarchy. The result of ordination is the arrangement of species and samples in a low-dimensional space such that similar entities are close by and dissimilar entities far apart. These two approaches are complementary. Classification basically involves grouping similar entities together in clusters. In hierarchical classification, variation in cluster analysis is related to the number of tie values in the similarity matrix (Tausch *et al.* 1995). Principal component analysis (PCA) as a semi-direct gradient analysis is the most usual way of combining a number of environmental factors into fewer uncorrelated components. PCA can be particularly sensitive to effects from relationships into data that are non-linear and non-monotonic (James and McCulloch 1990).

These classification and ordination methods have been advanced greatly since 1950 and have been used continuously up to now by many ecologists, such as Dooley and Collins (1984), Mueller-Dombois and Ellenberg (1974), Kim and Yim (1986a, 1986b), Kim and Kil (1991), and so on.

Mt. Jangan county park is largely coverged with oak (*Quercus*) forests in undisturbed area. Oak forests have been recognized as a distinct forest vegetation in cool-temperate zone in Korea. Among oaks, *Quercus mongolica* has been recognized as a dominant species in the middle part of cool-temperate zone (Yim and Baik 1985). The thermal distribution range of *Quercus mongolica* is much wider than that of *Carpinus* and *Cornus* (Yim 1977), and this species has been found in the more xeric-upper parts of the slope than *Carpinus* and *Cornus* (Song 1985). The deciduous broadleaf forest of Mt. Jangan county park are mixed with *Quercus, Carpinus, Cornus* and *Fraxinus.* Therefore, the mixed forests of Mt. Jangan county park have significance for recognition about characteristics of cool-temperate zone. Several studies on the mountain forest vegetation have been performed but these are on the flora and on the preliminarily surveys for phytosociology (Lee 1962, Park 1974, Kim 1986). *Quercus, Carpinus, Cornus* and *Fraxinus* forests of this area are not yet fully recognized in phytosociological viewpoints. To clarify this problems, to demonstrate the comlementarity of two methods, classification and ordination, and to understand the ecological relationship between the forest communities and the environment, a study on the forest vegetation of Mt. Jangan county park was carried out by classification and ordination techniques.

STUDY AREA

This study was carried out at Mt. Jangan county park located in Jeonlabuk-Do, Korea (35° 35′00″~35°40′00″N, 127°32′30″~127°35′30″E) (Fig. 1).

The Sadubong as the main peak of the study area is 1,014.8 m high and is located near Mt. Jangan (1,236.9 m high).

The forest vegetation in this area is largely characterized by *Quercus* spp., *Carpinus* spp., *Cornus* spp. and *Fraxinus* spp. Most study area of forest vegetation was influenced by men, so that secondary forest is now in various stages of regrowth. The area is meteorologically characterized as the cold-temperate deciduous broadleaf forest zone (Yim and Kira 1975).

According to Jeonju Meteorolongical Observatory (1996) the study area has an average rainfall of 1,288.6 mm/yr, and its mean annual temperature is 9.5℃ with minimum and maximum temperature of −22.1℃ and 33.7℃, respectively. In particular, the average monthly rainfall is over 100 mm from May to September and the average daily minimum temperature from December to March is below 0℃.

METHODS

Quantitative floristic data were obtained from April, 1997 to October, 1999 from 43 sample plots. The size of sample plots, with minimal area of 15 m×15 m, was set randomly at every relevé (Osting 1956). Representative plots were selected on the basis of homogeneity and visually checked for uniformity in floristic composition. All trees and shurbs of DBH (diameter at breast height) ≥ 3 cm in every relevé were measured for height.

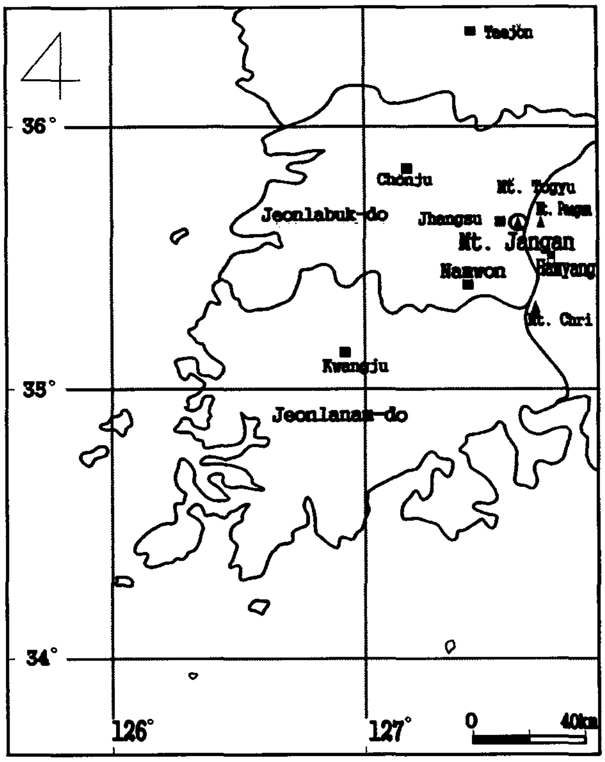

Fig. 1. The map showing study area of Mt. Jangan, Korea.

Soil samples were collected with a gouge auger (diameter 5.08 cm) from A horizon. Three cores were homogenized into one sample, and in each station three such samples were taken. Samples were air-dried and weighed (fresh weight and dry weight) prior to analysis.

The following chemical analyses were carried out. Soil moisture content was calculated as a percentage of loss water against dry weight at 105℃. Soil organic matter content was determined as a percentage of the loss-on-ignition against dry weight by Allen *et al.* (1991) method (Moore and Chapman 1986). Soil pH was determined in solution (Soil: distilled water = 1:5, W/V) by glass electrode. Cation exchange capacity was determined by Brown's method and potassium content by flame photometry. Other analyses of soil components were done following Rural Development Administration (1988). Soil analyses were carried out at the Soil Laboratory of the Rural Development Administration, Korea.

The clustering technique of classification method applied to the species on site data used the CA (cluster analysis) method of Lance and Williams (1967). To determine the correlation of vegetation to environmental factors, principal component analysis (PCA) of ordination method was used (Austin and Orloci 1966, Orloci 1966, 1967, 1973, 1978).

RESULTS AND DISCUSSION

Classification by cluster analysis

The pattern of clustering for the 43 stands was summarized in the dendrogram (Fig. 2). The three arbitrary dashed lines, at chord distances of 11.0, 17.0, and 18.0, were used as reference points for identifying clusters. At a distance of 11.0, nine clusters emerge: A (stands 1, 2, 3, 4 and 5); B (6, 7, 8 and 9); C (10, 11, 12 and 13); D (14, 15, 16, 17, 18 and 19); E (20, 21, 22, 23 and 24); F (25, 26, 27 and 28); G (29, 30, 31, 32, 33, 34 and 35); H (36, 37 and 38); I (39, 40, 41, 42 and 43). Also at the higher chord distance of 17.0, three clusters emerged: I (A, B, C and D); II (E and F); and III (G, H and I). The highest chord distance of 19.0 formed a single cluster.

Inspection of the dendrogram produced by a distance of 11.0 reveals that sites tend to cluster into nine groups: A (*Quercus serrata* community); B (*Quercus serrata* - *Carpinus laxiflora* community); C (*Cornus controversa* community); D (*Fraxinus mandshurica* community); E (*Carpinus laxiflora* community); F (*Quercus variabilis* community); G (*Quercus mongolica* - *Sasa borealis* community); H (*Quercus mongolica* - *Symplocos chinensis* for. *pilosa* community); I (*Quercus mongolica* - *Rhododendron schlippenbachii* community). These communities showed differences in species composition and environmental characteristics.

In these results, 15 stands dominated by *Quercus mongolica* (stands 29~43) form a cluster distinct from the remaining 28 stands (stands 1~28), which were characterized by *Quercus serrata*, *Cornus controversa*, *Fraxinus mandshurica*, *Carpinus laxiflora* and *Quercus variabilis*. From a comparison of each cluster analysis the major differences were in the clustering of cluster E and F (higher cluster II). These clusters, in fact somewhat intermediate between the higher cluster I and III, showed that they had similar species composition and environmental characters.

The floristic composition and environmental characteristics of each of the higher clusters (I, II and III), shown in Fig. 2, can be descibed as follows:

1. Cluster type I (cutoff distance of 11.0: A, B, C and D)

The habitats of this cluster type in the study area were mainly located in valley, mesic and nutrient rich slopes between 600 and 1,100 m above sea level.

Associated species in this cluster type included *Quercus serrata*, *Carpinus laxiflora*, *Cornus controversa*, *Fraxinus mandshurica*, *Acer mono*, *Tilia amurensis*, *Stewartia koreana*, *Deutzia parviflora*, *Alangium platanifolium* var. *macrophylum*, *Lindera erythrocarpa*, *Polystichum tripteron*, *Dryopteris crassiohozoma* and *Hydroangea serrata* for. *acuminata*.

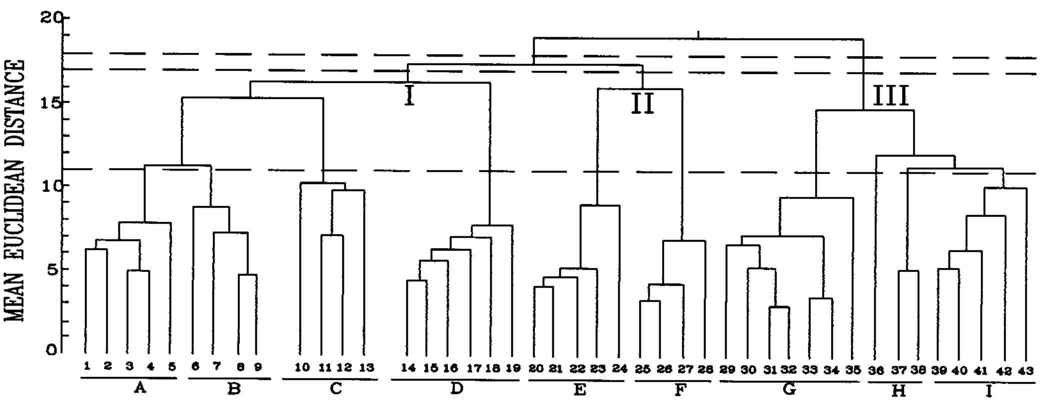

Fig. 2. Dendrogram of the clustering of nine groups using mean euclidean distance.
A : *Quercus serrata* community B : *Quercus serrata* - *Carpinus laxiflora* community
C : *Cornus controversa* community D : *Fraxinus mandshurica* community
E : *Carpinus laxiflora* community F : *Quercus variabilis* community
G : *Quercus mongolica* - *Sasa borealis* community
H : *Quercus mongolica* - *Symplocos chinensis* for. *pilosa* community
I : *Quercus mongolica* - *Rhododendron schlippenbachii* community

2. Cluster type Ⅱ (cutoff distance of 11.0: E and F)

In the study area, this cluster type was mainly located on middle/ low slopes below the 900 m above sea level.

The tree and shrub layers were mainly composed of *Quercus variabilis, Carpinus laxiflora, Carpinus tschonoskii, Betula costata, Styrax obassia, Maackia amurensis,* and *Sasa borealis.*

3. Cluster type Ⅲ (cutoff distance of 11.0: G, H and I)

Cluster type Ⅲ was widely distributed in the study area. This cluster type was distributed in mainly 900 and 1,200 m above sea level, but could descend to lower altitude along valley slopes.

Associated tree and shrub in this cluster type included *Quercus mongolica, Rhododendron schlippenbachii, Symplocos chinensis* for. *pilosa, Sasa borealis, Acer pseudo-sieboldianum, Fraxinus sieboldiana, Tripterygium regelii, Styrax obassia,* and *Lindera obtusiloba.*

Ordination by principal component analysis

Principal component analysis (PCA) is the most usual way of combining a number of environmental factors into fewer uncorrelated components. The results of the PCA are summarized by the eigenvalues and the eigenvectors.

Eigenvalues for the first three components of the 43 stands were 8.995, 4.368, 3.987 and the percentage of trace by each eigenvalue was 19.6%, 10.6%, 9.9% over 40% of the total variance. In a typical community study, the first three eigenvalues may account for 40 to 99% of the total variance (Gauch 1982).

The stand coordinates were used to graphically display the 43 stands within a coordinate system where the relative position of the stand reflects similarities (Fig. 3). Principal component I accounted for over 19.6% of the variation.

The results of stands ordination were given in Table 1 and Fig. 3. The ordination diagram of PCA was divided into 4 groups along the axes I and Ⅱ:

A group (*Fraxinus mandshurica* community), B group (*Cornus controversa* community, *Quercus serrata* community and *Quercus serrata* - *Carpinus laxiflora* community), C group (*Carpinus laxiflora* community and *Quercus variabilis* community) and D group (group of *Quercus mongolica* community, Fig. 2). In view of habitat conditions groups A and B were similar to each other. Group C was intermediate between groups B and D. Thus, the 4 groups were separated along the axes I and Ⅱ (Fig. 3).

The relationslip between PCA ordination axes and environmental variables could be observed from Fig. 4. Eigenvalues of the first three components of the nine environmental factors were 9.250, 0.726 and 0.022. Thus, since the first three components among them account for over 100% of the total variance, we regard these as the principal components (Table 1). This was convenient since it means that we could summ-

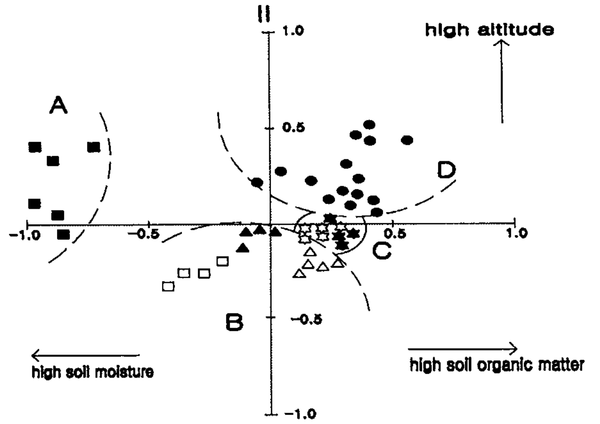

Fig. 3. Principal component ordination of 43 stands in the study area.
(△) : *Quercus serrata,*
(▲) : *Quercus serrata - Carpinus laxiflora,*
(□) : *Cornus controversa,*
(■) : *Fraxinus mandshurica,*
(☆) : *Carpinus laxiflora,*
(★) : *Quercus variabilis,*
(●) : *Quercus mongolica*

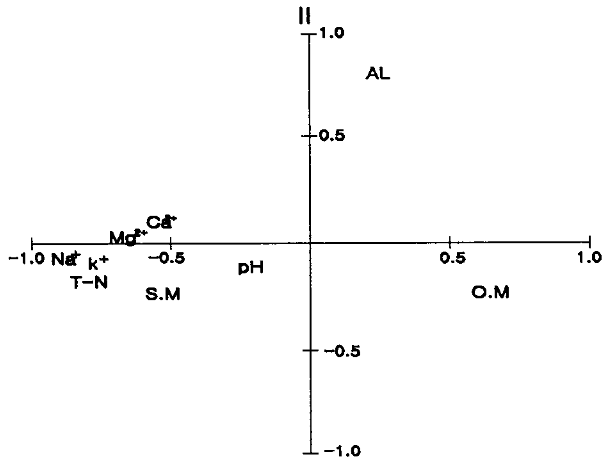

Fig. 4. Principal component analysis of nine environmental factors in the study area.
T-N : Total nitrogen, O.M : Soil organic matter,
AL : Altitude, S.M. : Soil moisture.

Table 1. Eigenvalues of the first three components of the nine environmental factors. The nine environmental factors are soil moisture, soil organic matter, pH, cation exchange capacity, total nitrogen, Ca^{2+}, K^{+}, Na^{+} and altitude

Components	Eigenvalues	Proportion of variability (%)	Cumulative proportion (%)
I	9.250	92.5	92.5
II	0.726	7.3	99.8
III	0.022	0.2	100.0

arize 100% of the total information furnished by these data on two-dimensional graphs (Causton 1988).

Soil moisture, Ca^{2+}, Na^{+}, K^{+}, T-N (total nitrogen), Mg^{2+} and soil organic matter were the environmental factors determining the variation in 43 stands along axes I.

Altitude was the major environmental factor along axis II. Soil moisure, Ca^{2+}, Na^{+}, K^{+}, T-N (total nitrogen) and Mg^{2+} were closely correlated with each other, but had strong negative correlation to altitude and soil organic matter (Fig. 3).

Along axis I, *Fraxinus mandshurica* community and *Cornus controversa* community with high soil moisture contents and pH were differentiated from the other communities.

The arrangement of stands along axes II was also topographically meaningful. The most important environmental variable along axis II was altitude.

As in Fig. 3 and Fig. 4, *Quercus mongolica* community was distributed at high altitude, and this community was found between 900~1,200 m high. Kim (1981) and Song (1990) distinguished *Quercus mongolica* group into mesic type, middle type and xeric type, but our result showed the highest important values in the middle moisture gradient. Although middle type was more suitable distribution area, mesic and xeric types also were significant types in the distribution of *Quercus mongolica*. On the other hand, *Carpinus laxiflora* community and *Quercus variabilis* community of group C were clumped together (Fig. 3). These communities were distributed at places with adequate levels of soil moisture, pH, and soil organic matter at low altitude. The above results are in a general correspondence with the results at Mt. Togyu (Kim 1992).

In this study altitude and soil moisture were strongly correlated with the dominant compositional gradient at the localities examined. They were the main factors determining the forest vegetation (Whittaker 1967, Peet 1981, Allen *et al.* 1991, Song 1990, Kim and Kil 1996, Kim and Kil 1997). The above results are congruent with the data of Song *et al.* (1987), Kim and Kil (1991), Kim (1992), Kim and Kil (1997) and Jeong *et al.* (1997).

The meaning of this study was shown not only in classifying the plant communities in the Mt. Jangan county park, Jeonlabuk-Do, but also in determining how they were related to one another and to the environmental factors.

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