**Regular Article**
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 35, No. 1, pp. 31-40, March, 2019
https://doi.org/10.7747/JFES.2019.35.1.31

JFES
Journal of Forest and Environmental Science

# Growing Environment Characteristics and Vegetation Structure of *Daphne Pseudomezereum* var. *Koreana* Native Habitats in Korea

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## Abstract

*Daphne pseudomezereum* var. *koreana* is an endangered deciduous shrub distributed in mountain areas that is vulnerable to climate change. The purpose of this study was to provide foundational data on the physical characteristics, soil environment, and vegetation structure of habitats of *Daphne pseudomezereum* var. *koreana* habitat in Korea in order to help with management decisions on ecosystem restoration. Rock exposure was 15 to 35%, with an average of 24%. The native habitat of *D. pseudomezereum* included 129 taxa consisting of 46 families and 95 genera. Two-way cluster analysis divided the habitat into three plant communities: Community I (dominaterd by *Tilia amurensis* and *Quercus mongolica*), Community II (dominaterd by *Fraxinus rhynchophylla* and *Acer pseudosieboldianum*), and Community III (dominaterd by *Ulmus davidiana* var. *japonica*). The diversity indices for Communities I, II, and III were 1.124, 1.047 and 0.932, respectively. The soils were loam or clay loam. Soil pH, organic matter content, and available phosphoric acid were 5.40, 14.38%, and 31.08 ppm, respectively. Ordination analysis resulted that most significant factors influencing *D. pseudomezereum* distribution were magnesium content of soil, shrub layer, and altitude.

**Key Words:** *Daphne pseudomezereum* var. *koreana*, vegetation structure, ordination analysis, soil characteristics, growth environment characteristics

## Introduction

When the Convention on Biological Diversity came into effect in 1993, increasing the awareness of the sovereign rights of biological resources, the value of biological resources became more important. Within the next 50 years, it is estimated that about 20 % of the 250,000 species of vascular plants will become extinct (Falk and Olwell 1992). With the expected increase in temperatures related to climate change, the distribution of evergreen broad-leaved forests will likely widen. However, much of the vegetation in alpine and sub-alpine ecosystems may decline or become extinct (Kong 1998; 2005).

*Daphne pseudomezereum* var. *koreana* Hamaya is a deciduous shrub distributed in Korea, Japan, and the Amur Oblast in Russia. In Korea, it is native to the high mountains of Mt. Halla, Mt. Jiri, and Mt. Taebaek in Gangwon province. *D. pseudomezereum* favors areas with strong

Received: November 5, 2018. Revised: January 7, 2019. Accepted: January 23, 2019.

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shade and well-drained soils that are rich in humus and moderately moist, but it is also able to withstand cold and dry conditions (Lee 1992). It grows rarely on the ridge-lines, top, and limestone areas (Gyeongbuk and Gangwon provinces) of mountainous sub-alpine areas. Unlike plants that are distributed in Japan [var. koreana (Nakai) Hamaya], *D. pseudomezereum* var. *koreana* leaves fall in autumn (Kim and Kim 2011). *D. pseudomezereum* has been designated as an endangered species by the Korea Forest Service and is described as a crisis plant, which is not an emergency but may be an endangered species in the near future (Korea National Arboretum 2013).

*D. pseudomezereum* has been relatively well studied. Jeong Eun-hee (2003) described the systematic relationship between external and internal forms and the anatomical traits and taxa of each species of *Daphne* spp. in Korea. Lee (2017) investigated the genome sequence of D. genkwa through the systematic study of *Daphne* spp. and *Wikistroemia* spp. Although these morphological and genetic studies have helped us understand more about the biology of *D. pseudomezereum*, there is a need to investigate the its growth environment in its native habitat.

Therefore, in this study, we investigated the physical characteristics, soil environment, and vegetation structure of native habitat of the *D. pseudomezereum*, which is distributed in the high mountains of Gangwondo region. These data will help with, restoration efforts.

## Materials and Methods

### Study sites and habitat survey

We installed eleven 20×20 m plots in five habitat areas on the Korea : four in Jeongseon, two in Pyeongchang, two in Taebaek, two in Gangneung, and one in Samcheok. We measured geographic information using GPS (Garmin, Montana 650) and Suunto Clino Compass (Fig. 1). The vegetation survey was conducted on all vascular plants that appeared in the quadrangle, and plant identification was made according to by Lee (1980) and Kim et al. (2011). Plant specimens from the vegetation survey were collected, and specimens were prepared using the calcite samples and the FAA solution. The plant specimens were stored in the Forest Medicinal Resources Research Center of the National Institute of Forestry Science.

### Flora and vegetation

We conducted site surveys from August 2015 to March 2017, covering the leafing, flowering, and fruiting periods. We performed vegetation structure surveys using the Braun-Blanquet method (Braun-Blanquet 1964; Zurich-Montpellier School). Vegetation surveys were conducted on all vascular plants that appeared in the quadrangle. Plant specimens were collected and stored formaldehyde-acetic acid alcohol solution. The plant specimens were preserved in the National Institute of Forestry Science.

All plant species observed within the plots were recorded *in situ* and classified according to Engler's system (Melchior 1964). For plant taxonomy, we used the illustrated encyclopedias of plants by Lee (1980a; 2003b) and Kim et al. (2011), and the plants identified were classified according to the catalogs established by Kim (2017) for native plants and Lee et al. (2011) for naturalized plants. Scientific and common names were taken from the Korean Plant Name Index (Korea National Standard Arboretum and the Plant Taxonomic Society of Korea, 2013), and the collected samples and image data were stored in the sample room of the Forest Medicinal Resources Research Center of the National Institute of Forestry Science.

The plant species found within each plot were classified

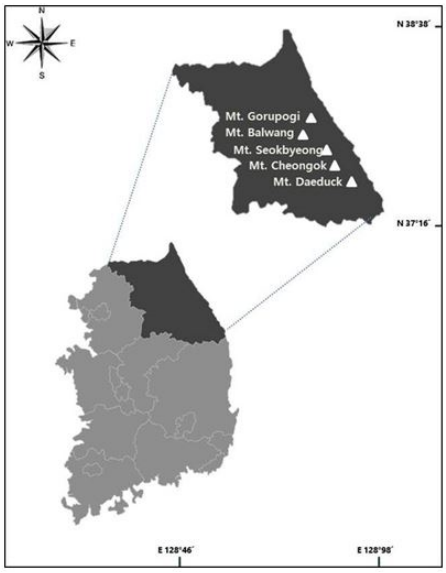


**Fig. 1.** Map of sites of *Daphne pseudomezereum* var. *koreana.*

as belonging to the tree layer (height ≥8 m), subtree layer (2 to 8 m), shrub layer (0.8 to 2 m), or herb layer (<0.8 m), and their relative frequency, density and coverage were calculated. These calculations were used to determine the importance percentage (IP) of each species, which represents the importance value proposed by Curtis and McIntosh (1951), to compare the inter-species dominance within each plot. The mean importance percentage was derived by assigning weight to each layer. Diversity and evenness of species of each layer were determined using the Shannon-Weaver Diversity Index (H′). The maximum H′, evenness (J′) and dominance (D) were obtained using the equations $H'max=logS$ (S denotes the total number of species), $J'=H'/H'max$ and $D=1-J'$ (Pielou 1975). Additionally, similarity indices at the community level were calculated using the similarity index formula of Sorensen (1948). We used two-way cluster analysis and detrended correspondence analysis (DCA) to determine similarities and differences among the vegetation structures of different habitats, thereby applying the weights of all clusters identified in the study sites. The 24 species with the highest emergence frequencies in *D. pseudomezereum* habitats were subjected to DCA. Additionally, we analyzed the relationships between the community characteristics, species, and environmental factors, such as habitat and soil characteristics, using Principal Component Analysis (PCA) ordination. These analysis were performed using PC-ORD v. 5.17 (McCune & Mefford 2006).

### Soil characteristic

We extracted three soil samples per plot at 10-20 cm depths after removing the organic matter layer. We then analyzed the chemical composition of the soil using the pipet method according to the U.S. Department of Agriculture classification system. We quantified the content of organic matter with the Walkley-Black method, available phosphate with the Lancaster method, total nitrogen with the Kjeldahl method, and exchangeable cations using inductively coupled plasma analysis with a 1N-NH4OAc (pH 7.0) leaching method. The cation exchange capacity was calculated with the NH4-N Kjeldahl distillation technique by leaching soil samples with 1N-NH4OAc solution buffered at pH 7.0. Electrical conductivity and pH of the diluted 1:5 soil samples were measured with an electrical conductively meter (HANNA, HI 98331) and a pH meter (HANNA, HI 99121).

## Results and Discussion

### Growth environment characteristic

*D. pseudomezereum* was distributed at relatively high altitudes in the range of 782 to 1,448 m above sea level, approximately 1,000 m on average. The slopes ranged from 10 to 40 degrees with an average of 24 degrees. Mean rock exposure rate was 24%, ranging from 15% to 35A%. The mean height of the upper stand was 12.7 m, and the mean diameter at breast height was 20.4 cm. Most areas with *D. pseudomezereum* are places where human access is difficult (Table 1). In

**Table 1.** General description of physical and vegetation of the studied site

| Plot No. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aspect | | SW230 | NE30 | NW300 | NE75 | W270 | NW330 | NE30 | NE60 | SW210 | NE40 | SW230 |
| Slope (°) | | 23 | 43 | 18 | 38 | 15 | 15 | 10 | 34 | 20 | 40 | 10 |
| Rock exposure (%) | | 35 | 28 | 45 | 55 | 30 | 40 | 45 | 50 | 30 | 30 | 35 |
| Topography | | Valley | Slope | Slope | Valley | Valley | Slope | Valley | Valley | Valley | Slope | Valley |
| Altitude (m) | | 978 | 1,051 | 1,448 | 1,000 | 1,090 | 1,437 | 782 | 950 | 954 | 1,000 | 1,108 |
| Tree layer | H[1] (m) | 14.5 | 13.2 | - | 12.5 | 13.5 | - | 10 | 13 | 12 | 13.2 | 13 |
| | DBH[1] (cm) | 26.5 | 24.1 | - | 21.1 | 20.7 | - | 14.8 | 15.3 | 14.8 | 22.4 | 23.8 |
| Shrub layer | H[1] (m) | 1.5 | 1.7 | 1.5 | 1.4 | 1.2 | 1.3 | 1 | 1.4 | 1.3 | 1.5 | 1.5 |
| | DBH[1] (cm) | 1.5 | 1.5 | 1.7 | 1.5 | 1.5 | 1.5 | 1 | 1 | 1 | 1.5 | 1.5 |

[1]H, hegiht; DBH, diameter at breast height.

case of Mt. Balwang in Pyeongchang, the *D. pseudomezereum* habitats were located at the top of the mountain. Most of the small communities were on northeast and northwest facing slopes. Most *D. pseudomezereum* habitats were located around the hilly climbing routes and wet rocky areas along mountain ridges.

### *Vegetation structure*

The DCA of the 24 species with the highest emergence frequencies in *D. pseudomezereum* habitats devided three community types (Fig. 2). Community I was dominated by *Tilia amurensis* and *Quercus mongolica*, consisting of five irradiated areas, and also included *Acer pseudosieboldianum*, *Carpinus cordata*, *A. pictum* subsp. *Mono*. Community II was dominated by *F. rhynchophylla* and *A. pseudosieboldianum* and also included *T. amurensis*, and *Cornus controversa*. Community III was dominated by *U. davidiana* var. *japonica*. Communities I and II appeared mainly in the valleys (maximum heights of 1,018 and 904 m, respectively), and Community III appeared on the slopes near the tops of mountains (maximum heights of 1,331 m).

### *Flora of each community type*

The native habitat of *D. pseudomezereum* included 46 families, 95 genera, and 129 species (Table 2). Rare plants included *Taxus cuspidata*, *Aristolochia manshuriensis*, *Paeonia japonica*, *Viola diamantiaca*, *Syringa wolfii*, *Parasenecio auriculatus*, *Cypripedium macranthos*. The endemic plants were *Aconitum pseudolaeve*, *Vicia chosenensis*, *Peucedanum insolens*, *Lonicera subsessilis*, *Weigela subsessilis*, *Saussurea calcicola*, and *Saussurea chabyoungsanica*.

Community I, which included five plots, had the highest number of taxa (41 families, 73 genera, 92 species), followed by Community II (31 families, 52 genera, 63 species), and Community III (30 families, 52 genera, 62 species).

### *Importance percentage*

The IPs of the plants in each vegetation layer revealed which species dominated the habitat of *D. pseudomezereum*. In the entire survey area, the dominant species of the tree layer was *T. amurensis* (IP: 22.29%), *Q. mongolica* (IP: 19.11%), and *F. rhynchophylla* (IP: 15.56%) was the dominant species, followed by three competing species: *A. pseu-*

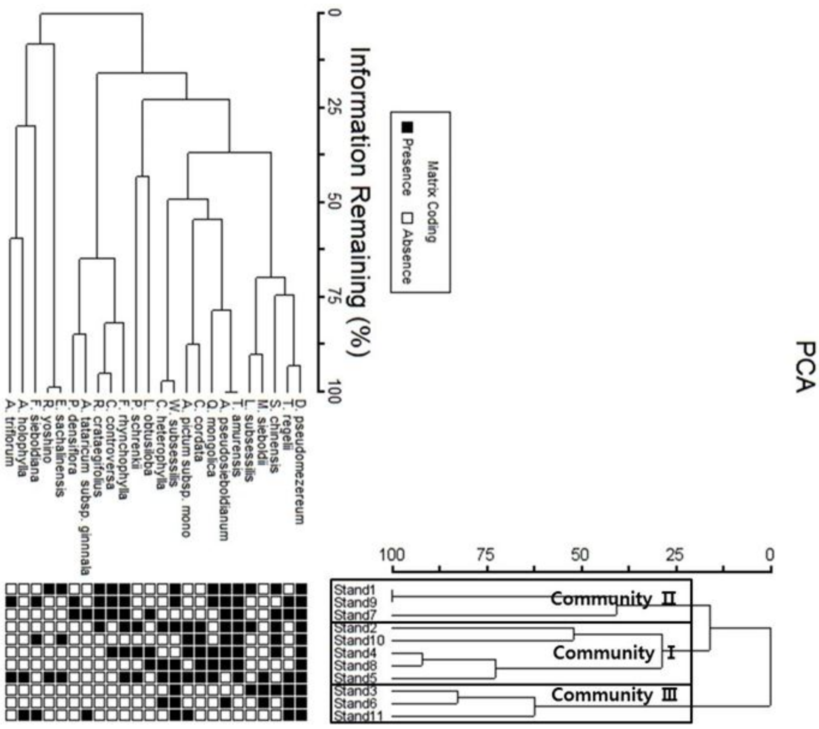


**Fig. 2.** Dendrogram of the plots and species based on cluster analysis.

**Table 2.** Vascular plants of *Daphne pseudomezereum* var. *koreana* native habitats

| System/Taxa | | Family | Genus | Species | Subspecies | Variety | Form | Total |
|---|---|---|---|---|---|---|---|---|
| Pteridophyta | | 1 | 2 | 2 | | | | 2 |
| Gymnosperms | | 2 | 3 | 3 | | | | 3 |
| Angiosperms | Monocotyledons | 5 | 10 | 15 | | | | 15 |
| | Dicotyledons | 38 | 80 | 109 | | | | 109 |
| Total | | 46 | 95 | 129 | | | | 129 |
| Community I[1] | | 41 | 73 | 92 | | | | 92 |
| Community II[1] | | 31 | 52 | 63 | | | | 63 |
| Community III[1] | | 30 | 52 | 62 | | | | 62 |

[1]Community I, *Tilia amurensis-Quercus mongolica*; Community II, *Fraxinus rhynchophylla-Acer pseudosieboldianum*; Community III, *Ulmus davidiana* var. *japonica*.

*dosieboldianum* (IP: 20.41%), *Fraxinus sieboldiana* (IP: 15.37%), and *T. amurensis* (IP: 9.49%). The dominant species in the shrub layer was *D. pseudomezereum* (IP: 11.23%), followed by *W. subsessilis* (IP: 6.81%) and *Lindera obtusiloba* (IP: 3.56%). The dominant species of the herb layer was *Carex siderosticta* (IP: 5.76%), followed by *Artemisia stolonifera* (IP: 4.00%) and *Rubia akane* (IP: 4.00%).

Table 3 presents the importance percentage (IP) of the plants of each vegetation layer identified in each community within the *D. pseudomezereum* habitat areas.

In Community I, the dominant species of the tree layer was *T. amurensis* (IP: 27.62%), and *Q. mongolica* (IP: 20.32%) was the dominant species in the subtree layer, followed by three competing species: *A. pseudosieboldianum* (IP: 17.25%), *Carpinus cordata* (IP: 16.44%), and *Aristolochia manshuriensis* (IP: 13.73%). The dominant species in the shrub layer was *D. pseudomezereum* (IP: 9.26%), followed by *F. rhynchophylla* (IP: 6.38%), *L. obtusiloba* (IP: 5.31%), *A. pseudosieboldianum* (IP: 5.17%). The dominant species of the herb layer was *C. siderosticta* (IP: 7.53%), followed by *A. stolonifera* (IP: 2.29%) and *R. akane* (IP: 5.59%).

In Community II, the dominant species of the tree layer was *F. rhynchophylla* (IP: 29.73%), followed by *Q. mongolica* (IP: 20.90%). The dominant species of the subtree layer was *A. pseudosieboldianum* (IP: 44.68%), with *F. sieboldiana* (IP: 21.32%), *T. amurensis* (IP: 20.12%) and *Acer tataricum* subsp. *Ginnala* (IP: 13.87%) closely competing with it. In the shrub layer, *A. pseudosieboldianum* (IP: 12.59%) was dominant, and *D. pseudomezereum* (IP: 11.94%), *C. controversa* (IP: 7.96%) were also observed. In the herb layer, *A. stolonifera* (IP: 7.87%) was dominant.

In Community III, the dominant species of the tree layer was *Ulmus davidiana* (IP: 74.89%) and *Abies holophylla* (IP: 25.11%) were also observed. *F. sieboldiana* (IP: 23.95%) was dominant in the subtree layer, followed by *Acer tataricum* subsp. *Ginnala* (IP: 18.45%) and *Magnolia sieboldii* (IP: 14.62%). In the shrub layer, *D. pseudomezereum* (IP: 15.63%) was dominant, while *W. subsessilis* (IP: 14.44%) and *L. obtusiloba* (IP: 5.61%) were also observed. In the herb layer, *Cimicifuga dahurica* (IP: 8.19%) was dominant, followed by *R. akane* (IP: 17.87%) and *C. siderosticta* (IP: 5.25).

*Quercus mongolica* and Pinus densiflora were dominant in Community I and II. Community III differed from I and II, with *A. pseudosieboldianum* and *F. rhynchophylla* as dominant in the trees. In the subtree layer, the dominant species were *F. sieboldiana* and *A. pseudosieboldianum*. In the shrub layer, the three communities had different dominant species. Community I was dominated by the *Carpinus cordata*, a major species common to mature forests. *D. pseudomezereum* was also dominant, suggesting that it is able to photosynthesize in the lower light conditions of the understory by increasing the distribution of nitrogen to chlorophyll (Kitaoka and Koike 2005). *D. pseudomezereum* is considered to be closely related to climax deciduous broad-leaved forests in Korea. In summary, *D. pseudomezereum* grows in close association with other plant species, and it formed large populations in the regions with minimal human disturbance that we sampled.

**Table 3.** Importance percentage (IP) and mean importance percentage (MIP) of major species in each plant communities

| No. | Scientific Name | Total community | | | | | Community I | | | | | Community II | | | | | Community III | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $T^1$* | $T^2$* | S | H | M | $T^1$ | $T^2$ | S | H | M | $T^1$ | $T^2$ | S | H | M | $T^1$ | $T^2$ | S | H | M |
| sp1 | *Daphne pseudomezereum* | | | 11.23 | | 2.25 | | | 9.26 | | 1.85 | | | 11.94 | | | | | 15.63 | | 3.13 |
| sp2 | *Tilia amurensis* | 22.29 | 9.49 | 2.80 | | 12.32 | 27.62 | 10.00 | 3.71 | | 14.79 | 18.07 | 20.12 | 3.06 | | 13.88 | | | | | |
| sp3 | *Quercus mongolica* | 19.11 | | 1.73 | | 7.99 | 20.32 | | 1.08 | | 8.34 | 20.90 | | 4.26 | | 9.21 | | | | | |
| sp4 | *Fraxinus rhynchophylla* | 15.56 | | 4.96 | | 7.22 | 9.95 | | 6.38 | | 5.26 | 29.73 | | 6.11 | | 13.11 | | | | | |
| sp5 | *Carpinus cordata* | 9.05 | 8.81 | 1.40 | | 6.54 | 14.85 | 16.44 | 2.64 | | 11.40 | | | | | | | | | | |
| sp6 | *Acer pictum subsp. mono* | 5.62 | 7.39 | 2.71 | | 5.01 | 9.24 | 10.42 | 3.61 | | 7.55 | | | | | | | 7.59 | | | 2.28 |
| sp7 | *Ulmus davidiana* | 7.06 | 5.23 | | | 4.39 | 2.77 | 6.25 | | | 2.99 | | | | | | 74.89 | 7.82 | | | 32.30 |
| sp8 | *Pinus densiflora* | 7.61 | | | | 3.04 | | | | | | 22.81 | | | | 9.12 | | | | | |
| sp9 | *Betula costata* | 2.92 | | | | 1.17 | 4.86 | | | | 1.94 | | | | | | | | | | |
| sp10 | *Tilia manshurica* | 2.90 | | | | 1.16 | 4.78 | | | | 1.91 | | | | | | | | | | |
| sp11 | *Betula schmidtii* | 1.87 | 3.08 | | | 1.67 | 3.03 | 5.87 | | | 2.97 | | | | | | | | | | |
| sp12 | *Maackia amurensis* | 1.61 | | | | 0.64 | 2.56 | | | | 1.03 | | | | | | | | | | |
| sp13 | *Cornus controversa* | 2.71 | | 1.64 | | 1.41 | | | | | | 8.49 | | 7.96 | | 4.99 | | | | | |
| sp14 | *Abies holophylla* | 1.67 | | 0.58 | | 0.78 | | | | | | | | | | | 25.11 | | | | 10.04 |
| sp15 | *Fraxinus sieboldiana* | | 15.37 | | | 4.61 | | 6.10 | | | 1.83 | | 21.32 | | | 6.40 | | 23.95 | | | 7.19 |
| sp16 | *Sorbus commixta* | | 3.29 | | | 0.99 | | | | | | | | | | | | 13.98 | | | 4.19 |
| sp17 | *Acer pseudosieboldianum* | | 20.41 | 6.06 | | 7.34 | | 17.25 | 5.17 | | 6.21 | | 44.68 | 12.59 | | 15.92 | | 7.82 | | | 2.35 |
| sp18 | *Aristolochia manshuriensis* | | 7.14 | 0.58 | | 2.26 | | 13.73 | 1.08 | | 4.33 | | | | | | | | | | |
| sp19 | *Taxus cuspidata* | | 3.54 | 0.58 | | 1.18 | | | | | | | | | | | | 14.62 | 3.23 | | 5.03 |
| sp20 | *Magnolia sieboldii* | | 1.46 | 1.89 | | 0.82 | | | 1.56 | | 0.31 | | | | | | | 5.76 | 5.61 | | 2.85 |
| sp21 | *Lindera obtusiloba* | | 2.70 | 3.56 | | 1.52 | | 4.98 | 5.31 | | 2.55 | | | 3.98 | | 0.80 | | | | | |
| sp22 | *Acer tataricum subsp. Ginnala* | | 7.30 | | | 2.19 | | | | | | | 13.87 | | | 4.16 | | 18.45 | | | 5.54 |
| sp23 | *Acer tegmentosum* | | 2.03 | 0.58 | | 0.72 | | 3.88 | 1.08 | | 1.38 | | | | | | | | | | |
| sp24 | *Weigela subsessilis* | | | 6.81 | | 1.36 | | | 5.17 | | 1.03 | | | 5.19 | | 1.04 | | | 14.44 | | 2.89 |
| sp25 | *Carex siderosticta* | | | | 5.76 | 0.58 | | | | 7.53 | 0.75 | | | | 5.25 | 0.52 | | | | 5.25 | 0.52 |
| sp26 | *Artemisia stolonifera* | | | | 4.00 | 0.40 | | | | 2.29 | 0.23 | | | | 7.87 | 0.79 | | | | 7.87 | 0.79 |

Table 3. Continued

| No. | Scientific Name | Total community | | | | | Community I | | | | | Community II | | | | | Community III | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $T^1$* | $T^2$* | S* | H* | M* | $T^1$ | $T^2$ | S | H | M | $T^1$ | $T^2$ | S | H | M | T1 | T2 | S | H | M |
| sp27 | *Rubia akane* | | | | 4.00 | 0.40 | | | | 5.95 | 0.59 | | | | 2.62 | 0.26 | | | | 2.62 | 0.26 |
| sp28 | *Dryopteris crassirhizoma* | | | | 3.29 | 0.33 | | | | 1.83 | 0.18 | | | | | | | | | 2.62 | 0.26 |
| sp29 | *Hepatica asiatica* | | | | 2.82 | 0.28 | | | | 4.12 | 0.41 | | | | 1.97 | 0.20 | | | | 1.97 | 0.20 |
| sp30 | *Prunella vulgaris* var. *lilacina* | | | | 2.59 | 0.26 | | | | 1.83 | 0.18 | | | | | | | | | 2.62 | 0.26 |
| sp31 | *Astilbe rubra* | | | | 2.35 | 0.24 | | | | 4.57 | 0.46 | | | | | | | | | 2.62 | 0.26 |
| sp32 | *Polygonatum odoratum* var. *pluriflorum* | | | | 2.35 | 0.23 | | | | 2.29 | 0.23 | | | | 1.97 | 0.20 | | | | 1.97 | 0.20 |
| sp33 | *Ainsliaea acerifolia* | | | | 2.12 | 0.21 | | | | 1.37 | 0.14 | | | | 8.19 | 0.82 | | | | 8.19 | 0.82 |
| sp34 | *Cimicifuga dahurica* | | | | 2.12 | 0.21 | | | | 2.75 | 0.27 | | | | | | | | | | |
| sp35 | *Angelica gigas* | | | | 2.12 | 0.21 | | | | 1.37 | 0.14 | | | | | | | | | 2.62 | 0.26 |
| sp36 | *Clematis heracleifolia* | | | | 2.11 | 0.21 | | | | 2.29 | 0.23 | | | | 2.65 | 0.26 | | | | 2.65 | 0.26 |
| sp37 | *Pimpinella brachycarpa* | | | | 1.88 | 0.19 | | | | 3.67 | 0.37 | | | | | | | | | | |
| sp38 | *Veratrum oxysepalum* | | | | 1.65 | 0.16 | | | | 3.20 | 0.32 | | | | | | | | | | |
| | Others | 0.00 | 2.76 | 52.89 | 60.87 | 17.49 | 0.00 | 5.08 | 53.96 | 54.94 | 17.81 | 0.00 | 0.00 | 44.91 | 69.47 | 18.32 | 0.00 | 0.00 | 61.09 | 58.97 | 18.12 |
| | Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

*$T^1$, importance percentage in overstory layer; $T^2$, importance percentage in understory layer; S, importance percentage in shrub layer; H, importance percentage in herbaceous layer; M, mean importance percentage.

### Species diversity analysis

Table 4 presents the Shannon-Weaver species diversity index (H′), maximum H′, evenness (J′), and dominance (D) values of the plant communities observed in the habitat of *D. pseudomezereum*. The highest Shannon-Weaver species diversity index value, 1.124, was observed in Community I (*T. amurensis* and *Q. mongolica*); for Community II (*F. rhynchophylla* and *A. pseudosieboldianum*) it was 1.047; and for Community III (*U. davidiana* var. *japonica*) it was 0.932. The evenness (J') of the native habitat of *D. pseudomezereum* ranged from 0.923 to 0.953 and dominance (D) ranged from 0.047 to 0.077. Evenness indicates the degree of distribution of each species, and values close to 1 indicate a uniform number of species (Brower and Zar 1977). A dominance index exceeding 0.9 suggests one species is considered dominant; a dominance index between 0.3 and 0.7 suggests two or three species are competing for dominance; and a dominance index less than 0.3 suggests that four or more species are competing for dominance (Whittaker 1956). The mean dominance of *D. pseudomezereum* was 0.0167, typical of a vegetation structure dominated by four or more species.

### Similarity index

Analysis of the community similarity of the native habitats of *D. pseudomezereum* (Table 5) revealed that Community I (*T. amurensis* and *Q. mongolica*) and Community II (*F. rhynchophylla* and *A. pseudosieboldianum*) were 41.29 % similar, while Community I (*T. amurensis* and *Q. mongolica*) and Community III (*U. davidiana* var. *japonica*) were 40.52 % similar. However, the similarity of Community II (*F. rhynchophylla* and *A. pseudosieboldianum*) and Community III (*U. davidiana* var. *japonica*) was 78.40%. Similarity indices suggest that communities are considered heterogeneous at less than 20% and are homogeneous when they are more than 80 % (Whittaker 1956). Overall, these similarity indices are high, considering that *D. pseudomezereum* is composed of small communities and grows with certain plants.

### Soil characteristics

Soil samples were collected from the native habitats of *D. pseudomezereum* (Table 6). Based on the grain size of the native soil of *D. pseudomezereum*, soil samples were mostly classified as loam or clay loam with silt and clay. The high levels of clay and silt indicate that the distribution of soil air (ventilation and drainage) is poor and that precipitation is high, which may adversely affect the growth environment of roots. Organic matter plays an important role in improving the physicochemical properties of soil, such as water holding capacity, air permeability, soil permeability, and soil structure change. At the same time, it is a reservoir for supplying microbial activity and supplying and storing nu-

**Table 4.** Species diversity indices of woody and herbaceous species in the surveyed plots

| Community | No. of species | H' (shannon) | H'max | J' (evenness) | D (dominance) |
|---|---|---|---|---|---|
| I[1] | 91 | 1.124 | 1.196 | 0.939 | 0.061 |
| II[1] | 62 | 1.047 | 1.134 | 0.923 | 0.077 |
| III[1] | 62 | 0.923 | 0.968 | 0.953 | 0.047 |

[1]Community I, *Tilia amurensis-Quercus mongolica*; Community II, *Fraxinus rhynchophylla-Acer pseudosieboldianum*; III, *Ulmus davidiana* var. *japonica*.

**Table 5.** Similarity index (%) between communities

| | | Community I[1] | Community II[1] | Community III[1] |
|---|---|---|---|---|
| Similarity index (%) | Community I[1] | | 41.29 | 40.52 |
| | Community II[1] | | | 78.40 |

[1]Community I, *Tilia amurensis-Quercus mongolica*; Community II, *Fraxinus rhynchophylla-Acer pseudosieboldianum*; III, *Ulmus davidiana* var. *japonica*.

**Table 6.** The physical and chemical properties of soils by research sites

| Community | | OM | T-N | Avail. $P_2O_5$ (ppm) | Exchangeable $K^+$ | $Ca^{++}$ | $Mg^{++}$ | $Na^+$ | CEC | pH (1:5) | EC (1:5) | Sand | Silt | Clay | Base saturation (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (cmol$^+$kg) | | | | | | | | | | |
| [1]I | Mean | 13.68 | 0.47 | 29.96 | 0.41 | 20.27 | 1.73 | 0.56 | 38.88 | 5.51 | 0.20 | 36.53 | 35.49 | 27.54 | 68.85 |
| | | (5.02) | (0.20) | (9.27) | (0.13) | (5.92) | (0.70) | (0.53) | (3.12) | (0.53) | (0.10) | (6.54) | (6.66) | (2.39) | (8.98) |
| [1]II | Mean | 17.14 | 0.73 | 28.30 | 0.46 | 16.33 | 2.06 | 0.13 | 38.32 | 5.47 | 0.14 | 38.60 | 28.56 | 32.86 | 43.97 |
| | | (0.82) | (0.03) | (7.06) | (0.14) | (11.37) | (1.49) | (0.01) | (6.31) | (1.24) | (0.01) | (1.46) | (1.24) | (0.15) | (4.90) |
| [1]III | Mean | 14.09 | 0.52 | 37.77 | 0.41 | 11.12 | 1.07 | 0.10 | 35.32 | 4.95 | 0.15 | 34.95 | 33.52 | 31.54 | 29.85 |
| | | (4.69) | (0.28) | (1.11) | (0.01) | (6.26) | (0.48) | (0.01) | (4.08) | (0.54) | (0.02) | (6.53) | (1.71) | (0.54) | (18.92) |
| Total community mean | | 14.38 | 0.52 | 31.08 | 0.42 | 17.89 | 1.67 | 0.40 | 38.13 | 5.40 | 0.18 | 36.62 | 33.87 | 29.23 | 51.43 |
| Korea soil mean | | 4.49 | 0.19 | 25.60 | 0.23 | 2.44 | 1.01 | 0.22 | 12.20 | 5.48 | - | 37.30 | 44.80 | 17.90 | - |

[1]Community I, *Tilia amurensis-Quercus mongolica*; Community II, *Fraxinus rhynchophylla-Acer pseudosieboldianum*; Community III, *Ulmus davidiana* var. *japonica*.

trients of plants (Byun 2006). The organic matter content of the native soil of *D. pseudomezereum* was three times higher than the average of 4.49 in Korea. Higher organic content is considered to result from relatively low human intervention and soil exchange (Kim et al. 1988).

The average effective phosphorus was 31.08 ppm, which is higher than the average of forest soil in Korea (25.60 ppm). The soil pH was 5.4, which is similar to the average forest soil in Korea. The relatively high pH of the natural soil and the high effective phosphoric acid ratio are likely due to the high organic matter content and the effect of the substitutional cation and the high ratio of clay to phosphoric acid (Son et al. 2016). The degree of base saturation is closely related to pH. In general, the higher the base saturation, the higher the fertility of the soil. Most of the soil saturation in Korea is 30 to 40 % (Byun 2006). The degree of base saturation in the native forest of *D. pseudomezereum* is higher than that of the forest soils in Korea. These results suggest that the soil fertility is high, and that there has been active accumulation of nutrients in the valleys and slopes.

### PCA Ordination analysis

PCA ordination was used to determine the associations between the environmental and soil characteristics of the individual plots and *D. pseudomezereum* habitat characteristics

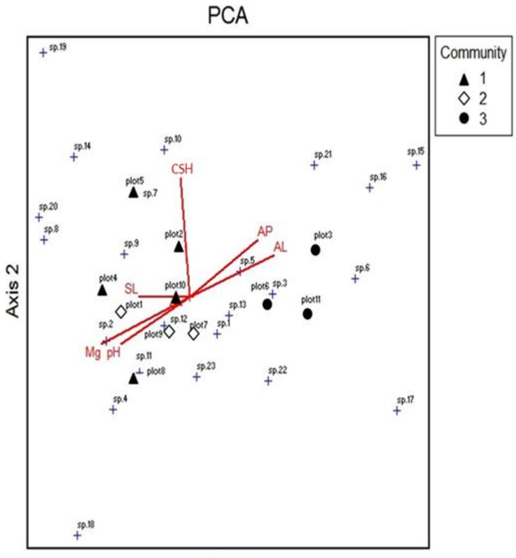


**Fig. 3.** PCA (principal component analysis) ordination diagram. (AP, available $P_2O_5$; AL, altitude; SL, slope; CSH, coverage of shrub layer; Mg, $Mg^{2+}$).

(Fig. 3), revealing that the most influential factors were magnesium content of soils, followed by effective phosphoric acid, pH, and slope. Community III was located on the right side of the axis, with high effective phosphate and elevation. Community I and Community II were associated with pH, magnesium content and slope in two axes. In the case of the marking species, Community III is located on the right side of axis I, centering on *Schisandra chinensis*, *W. subsessilis*, *Corylus heterophylla*, *Tripterygium regelii*, and *A. tataricum* subsp. *ginnala*. On the right side of axis II, Community I and II were located in the order of *F. rhynchophylla*, C. *cordata*, *T. amurensis*, *Rubus crataegifolius*. On the two axes, *F. rhynchophylla* and *C. cordata* Community II and community II are located. The magnesium content in the soil increased with increasing pH. In Communities I and II, the pH values were high, and the magnesium content was high due to the increase in magnesium availability.

## Acknowledgement

This work was supported by grant from National Institute of Forest Science in 2018.

This study was supported by Kangwon National University academic research promotion project.

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