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Comparison of the Structure of Grassland Communities and the Performance of Calcicoles and Calcifuges on the Limestone and the Granite Areas

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石灰岩과 花崗岩地帶에서 草地群落의 構造 및 好石灰植物과 嫌石灰植物의 成就度 比較

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ABSTRACT

Structure of grassland communities was investigated, and performance of populations of *Themeda triandra* var. *japonica* and *Miscanthus sinensis* were compared on limestone and granite soils. Forty three and forty taxa occurred on the limestone and granite grasslands, respectively, but their similarity was very low. Shoot height and number of hills per patch, as a measure of performance, of *Themeda* on the limestone grassland were higher than those on the granite grassland. In contrast, shoot height and number on hills per patch of *Miscanthus* were higher on limestone than granite grassland. Evidence shows that poor growth of *Miscanthus* population on the limestone soil was associated with higher content of insoluble divalent cations than soluble ones in shoot tissue.

Key words: Grassland, Performance, Calcicoles, Calcifuges, Limestone, Granite

INTRODUCTION

Through evolution, plant species have adapted to the varying soil pH and calcium conditions. For this reason, remarkable differences in the occurrence and abundance exist among plant species and even among varieties of a single species (Druce and Williams

1989, Ward and Jennings 1990, Kim *et al.* 1992). According to Gigon (1987), soil pH and calcium contents can be considered as important factors for the floristic difference between the limestone grassland and the granite one. In this respect plant species may be divided into calcicoles and calcifuges (Marrs and Bannister 1978, Kwak 1993). Calcifuges have often been characterized by having a low calcium optimum for growth and show severe growth inhibiton at high concentration, whereas calcicoles have a high calcium optimum for growth (Kinzel 1983). Studies on limestone community can be easily found in many ecological literatures. In Korea the works dealing with this subject have been swelled in number especially quite recently (Lee and Oh 1970, Chang and Mok 1981, Kim *et al.* 1990, 1991, 1992, Kwak 1993).

The purpose of this study is to investigate the structure of grassland communities and the performance of populations of calcicoles and calcifuges which are native to both the limestone and the granite soil.

MATERIALS AND METHODS

This study was conducted in limestone grassland at Maepo-myun, Tanyang-gun and in granite grassland at Gumseung-myun, Chewon-gun, Chungbuk Province. Study sites are at approximately 200 m altitude and 7.5 km apart from each other toward north-east (Kwak 1993). The limestone grassland was formed after clear-cutting of *Thuja orientalis* community, and the granite grassland was formed after clear-cutting of *Pinus densiflora* community. They are steep in slope (20~23°) and are facing east (60~70° in aspect). Soil pH and Ca^{2+} content of the limestone soil were pH 8.0 and 5.0 mg Ca^{2+}/g, and those of the granite soil were pH 6.0 and 1.0 mg Ca^{2+}/g, respectively. For vegetation analysis of the grasslands, the tape and quadrats were set within a 0.1 ha plot on both grasslands according to the Whittaker method (Barbour *et al.* 1987). Importance values of species were calculated at each stand by recording frequency and cover for species. The performance, i.e. shoot height and number of hills per patch, of *Themeda triandra* var. *japonica* population as calcicoles and *Miscanthus sinensis* population as calcifuges, which are commonly distributed throughout on both grasslands, was calculated in August, 1990. All the methods and procedures for classification of calcicoles and calcifuges and chemical analyses of samples were described by Kim *et al.* (1992).

RESULTS AND DISCUSSION

Community structure of grasslands

Forty three and forty taxa of plants were identified on the limestone and granite grassland communities, respectively (Table 1). Among them, species with the importance value $\geq$ 5 were 5 species including *Carex lanceolata* in the limestone communities, and those were 6 species including *Carex lanceolata* in the granite communities. Kim *et al.* (1992)

Table 1. The structure of grassland communities on the limestone and the granite areas

Species	Limestone area			Granite area		
	Relative frequency	Relative cover	I.V. (%)	Relative frequency	Relative cover	I.V. (%)
Carex lanceolata	6.2	30.0	18.1	5.0	15.0	10.0
Isachne globosa	5.5	17.9	11.7	0.7	0.4	0.6
Pueraria thunbergiana	3.8	5.2	4.5	6.4	13.0	9.7
Arundinella hirta	3.8	2.1	3.0	7.1	7.4	7.3
Miscanthus sinensis	3.2	0.3	1.7	5.0	12.3	8.7
Quercus dentata	5.5	4.4	5.0	1.7	1.6	1.6
Themeda triandra var. *japonica*	3.2	4.1	3.7	2.1	0.8	1.4
Lespedeza cuneata	1.8	0.2	1.0	2.8	0.8	1.8
Cymbopogon tortilis var. *goeringii*	1.2	0.5	0.8	2.1	1.6	1.8
Leibnizia anandria	0.6	0.1	0.3	0.7	0.1	0.4
Patrinia rupestris	5.5	7.6	6.7	–	–	–
Cocculus trilobus	5.5	4.9	5.2	–	–	–
Spiraea chinensis	5.5	2.7	4.1	–	–	–
Abelia coreana	2.5	5.3	3.9	–	–	–
Euphorbia pekinensis	6.2	1.3	3.8	–	–	–
Spodiopogon sibiricus	3.2	1.9	2.6	–	–	–
Cynanchum paniculatum	3.8	0.7	2.3	–	–	–
Isodon inflexus	3.8	0.8	2.3	–	–	–
Ulmus macrocarpa	1.8	0.8	1.3	–	–	–
Indigofera kirilowii	3.8	0.8	2.2	–	–	–
Rubia cordifolia var. *pratensis*	2.5	0.8	1.7	–	–	–
Scabiosa mansenensis	2.5	0.5	1.5	–	–	–
Clematis mandshurica	1.8	0.3	1.1	–	–	–
Chrysosplenium japonicum	1.8	0.3	1.1	–	–	–
Viola rosii	1.8	0.3	1.1	–	–	–
Euonymus alatus	1.2	0.7	0.9	–	–	–
Thalictrum filamentosum	1.2	0.3	0.7	–	–	–
Securinega suffruticosa	1.2	0.2	0.6	–	–	–
Smilax nipponica	1.2	0.1	0.6	–	–	–
Fraxinus rhynchophylla	0.6	0.7	0.6	–	–	–
Pyrus ussuriensis	0.6	0.7	0.6	–	–	–
Rhapontica uniflora	0.6	0.7	0.6	–	–	–
Adenophora triphylla var. *japonica*	0.6	0.7	0.6	–	–	–
Pinus koraiensis	0.6	0.3	0.5	–	–	–
Ixeris chinensis var. *strigosa*	0.6	0.3	0.5	–	–	–
Thuja orientalis	0.6	0.3	0.5	–	–	–
Viola selkirkii	0.6	0.2	0.4	–	–	–
Lespedeza cyrtobotrya	0.6	0.2	0.4	–	–	–
Chrysanthemum zawadskii	0.6	0.2	0.4	–	–	–
Swertia japonica	0.6	0.2	0.4	–	–	–
Dioscorea batatas	0.6	0.2	0.4	–	–	–
Polygala japonica	0.6	0.1	0.3	–	–	–
Sanguisorba officinalis	0.6	0.1	0.3	–	–	–

Table 1. Continued……

Species	Limestone area			Granite area		
	Relative frequency	Relative cover	I.V. (%)	Relative frequency	Relative cover	I.V. (%)
Quercus serrata	–	–	–	5.0	12.3	8.7
Melampyrum roseum	–	–	–	4.9	10.3	7.6
Potentilla fragarioides var. *major*	–	–	–	5.0	3.7	4.3
Artemisia keiskeana	–	–	–	5.7	3.1	4.4
Spodiopogon cotulifer	–	–	–	4.3	3.5	3.9
Rhododendron mucronulatum	–	–	–	4.3	1.4	2.9
Melandryum firmum	–	–	–	3.5	1.1	2.3
Pinus densiflora	–	–	–	2.8	1.2	2.0
Scilla scilloides	–	–	–	3.5	0.5	2.0
Artemisia laciniata	–	–	–	2.8	1.1	1.9
Galium verum var. *asiaticum*	–	–	–	2.1	0.8	1.4
Solidago virga-aurea var. *asiatica*	–	–	–	2.1	1.4	1.7
Celastrus orbiculatus	–	–	–	1.3	1.4	1.3
Potentilla chinensis	–	–	–	2.1	0.5	1.3
Peucedanum terebinthaceum	–	–	–	2.1	0.2	1.1
Zoysia japonica	–	–	–	2.1	0.2	1.1
Artemisia capillaris	–	–	–	1.3	0.4	0.8
Artemisia japonica	–	–	–	1.3	0.4	0.8
Artemisia iwayomogi	–	–	–	0.7	1.0	0.9
Gypsophila oldhamiana	–	–	–	1.3	0.3	0.8
Chrysanthemum boreale	–	–	–	1.3	0.2	0.8
Setaria viridis	–	–	–	1.3	0.2	0.8
Dianthus chinensis	–	–	–	0.7	0.7	0.7
Pulsatilla koreana	–	–	–	0.7	0.2	0.5
Sedum aizoon	–	–	–	0.7	0.2	0.5
Atractylis lyrata	–	–	–	0.7	0.2	0.5
Erysimum amurense	–	–	–	0.7	0.2	0.5
Heloniopsis orientalis	–	–	–	0.7	0.1	0.4
Amethystea caerulea	–	–	–	0.7	0.1	0.4
Viola mandshurica	–	–	–	0.7	0.1	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

classified *Themeda triandra* var. *japonica* as an obligate calcicole and *Miscanthus sinensis* as a facultative calcifuge. Both species occurred commonly on both grasslands, though the importance value of *Themeda* was higher in the limestone grassland than in the granite one and that of *Miscanthus* was higher in the granite grassland (Table 1).

In dominance-diversity curve, the species rank order was different for the species common to both grasslands (Fig. 1). Species diversity index in the limestone grassland was lower than that in the granite one (Fig. 1). Diversity tends to be reduced in stressed conditions of resource limitation by high calcium and pH on the limestone soil (Tilman

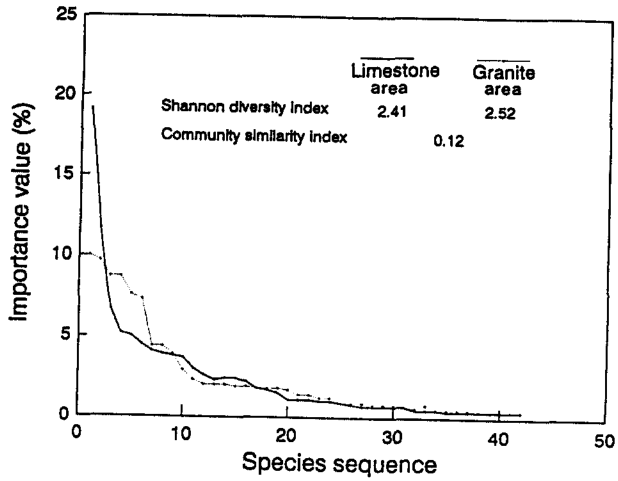

Fig. 1. Dominance-diversity curve and community indices in the limestone and the granite grasslands.

1988). Similarity index between the two grasslands was very low (0.12) (Fig. 1). This index value was lower than that of *Pinus densiflora* community (0.60) between the limestone and granite area (Kwak 1993). Our results suggest that the grassland communities of the limestone and granite areas showed a striking contrast in the abundance of common species and also in the occurrence of other species (Druce and Williams 1989, Kim *et al.* 1992).

Comparison of performance between the calcicoles and calcifuges

Performance of populations of *Themeda* as calcicoles and *Miscanthus* as calcifuges, which occurred commonly throughout on both limestone and granite areas, was compared between limestone and granite areas (Fig. 2). Mean shoot height of *Themeda* population on the limestone and granite grasslands was 140±28 cm and 100±38 cm, respectively. In contrast, mean shoot height of *Miscanthus* population was 130±42 cm and 180±30 cm on the limestone and granite, respectively (Fig. 2). Shoot height of *Themeda* population was about 30% higher on the limestone than on the granite soil, but that of *Miscanthus* was about 30% lower on the limestone than on the granite soil. Mean number of hills of *The-*

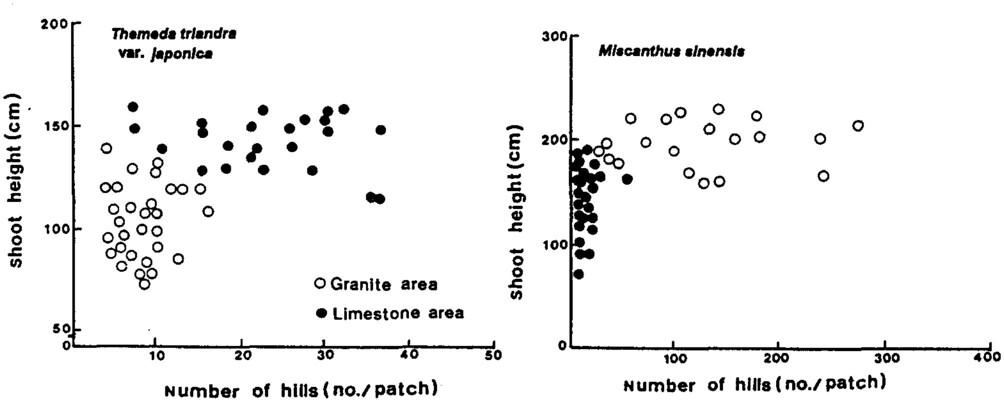

Fig. 2. Relationships between shoot height and number of hills per patch for *Themeda triandra* var. *japonica* (calcicoles) and *Miscanthus sinensis* (calcifuges) grown on the limestone (●) and the granite (○) grasslands.

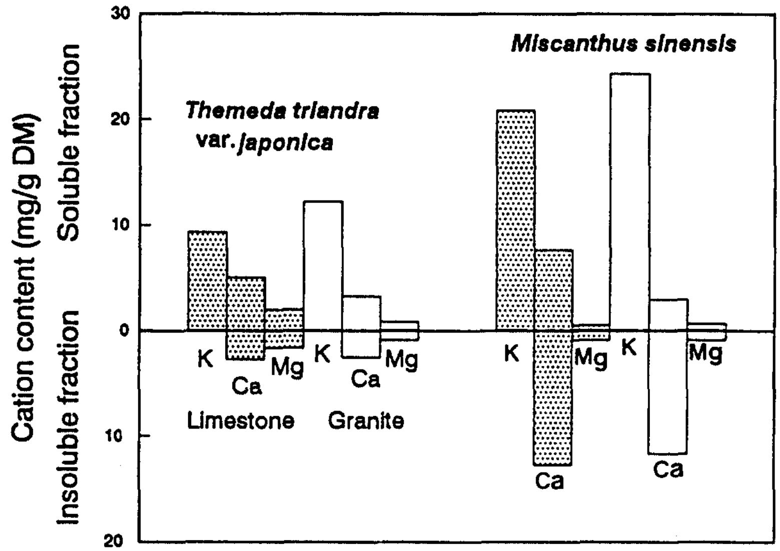

Fig. 3. Comparisons of the soluble and insoluble cation content (mg / g DM) in the shoot tissue of the populations grown on the limestone (▩) and the granite soils (□).

meda population was 23 (5~38 per patch) and 8 (4~18 per patch) on the limestone and granite soil, respectively. On the contrary, that of *Miscanthus* was 12 (3~36 per patch) and 90 (30~240 per patch) on the limestone and granite soils, respectively (Fig. 2). When performance was measured by shoot height and number of hills per patch, *Themeda* of the limestone grassland showed better performance than that of granite. In contrast, *Miscanthus* of limestone grassland had rather poor performance than that of granite grassland.

Ratio of soluble to insoluble divalent cations, i. e. Ca^{2+} + Mg^{2+}, in shoot tissue of *Themeda* on the limestone and granite grasslands was 1.5 and 1.1, respectively, and that of *Miscanthus* was 0.6 and 0.3 on the limestone and granite grasslands, respectively (Fig. 3).

These results indicate that *Themeda* as calcicoles contains larger amount of soluble divalent cations than insoluble ones in shoot tissue but the reverse is true for *Miscanthus* as calcifuges. The poor growth, therefore, of *Miscanthus* on the limestone soil was associated with higher concentrations of insoluble cations than soluble ones in shoot tissue. Many authors have suggested calcium toxicity and phosphorus and iron deficiency as reasons for the poor performance of calcifuges on the limestone soils (Anderson 1982, Haridasan 1985, Kim *et al.* 1992). Jeffries and Willis (1964) postulated that calcicoles are more selective than calcifuges with respect to ion absorption. Calcifuges have, therefore, apparently developed avoidance mechanisms (calcium exclusion or calcium precipitation) without developing as much resistance to the calcium stress as the more tolerant calcicoles (Levitt 1980).

摘 要

석회암지대와 그에 인접한 화강암지대의 초지군락구조를 조사하고, 공통 출현종인 솔새(*Themeda triandra* var. *japonica*)와 참억새 (*Miscanthus sinensis*) 개체군의 성취도를 비교하였다. 석회암과 화강암 초지군락에서는 각각 43종류와 40종류가 출현하였는데 유사도지수(0.12)가 대단히 낮음으로써 종조성이 다름을 보였다. 솔새 개체군의 성취도, 즉 군반(patch) 당 이삭수와 초장은 화강암토양보다 석회암토양에서 우세하였고, 이와 대조적으로, 참억새의 성취도는 화강암토양보다 석회암토양에서 억제되었다. 석회암토양에서 호석회식물인 솔새는 액포속에 수용성 2가 이온농도를 높게 유지하고 Ca^{2+}을 선택적으로 흡수함으로써 성취도가 높지만, 혐석회식물인 참억새는 선택적 흡수능력이 적어서 성취도가 낮은 것으로 해석된다.

LITERATURES CITED

Anderson, C.A. 1982. The effect of calcium on the germination, growth and mineral nutrition of acidic and calcareous population of *Eucalyptus obliqua* L'Herit. Plant and Soil 69:213-223.

Barbour, M.G., J.H. Burk and W.D. Pitts. 1987. Terrestrial plant ecology. 2nd ed. The Benjamin/Cummings Publishing Company, Inc. 634p.

Chang, N.K. and C.S. Mok. 1981. Physiological and ecological studies of the vegetation on ore deposits. 2. Incidence of lime-chlorosis in the vegetation of Korea. Korean J. Ecol. 4:25-32.

Druce, A.P. and P.A. Williams. 1989. Vegetation and flora of the Ben More-Chalk range area of southern Marlborough, South Island. N. Z. J. Bot. 27:167-199.

Gigon, A. 1987. A hierarchic approach in causal ecosystem analysis: the calcifuges-calcicoles problem in alpine grasslands. *In* E.D. Schulze and H. Zwolfer (eds.). Potentials and limitations of ecosystem analysis. Springer-Verlag, Berlin, 435p.

Haridason, M. 1985. Accumulation of nutrients by *Eucalyptus* seedlings from acidic and calcareous soils of the Cerraddo region of central Brazil. Plant and Soil 86:35-46.

Jefferies, R.L. and A.J. Willis. 1964. Studies on the calcicole-calcifuge habit. Ⅱ. The influence of calcium on the growth and establishment of four species in soil and sand cultures. J. Ecol. 52:691-707.

Kim, J.H., H.T. Mun and Y.S. Kwak. 1990. Community structure and soil properties of the *Pinus densiflora* forests in the limestone areas. Korean J. Ecol. 13:285-295.

Kim, J.H., H.T. Mun and Y.S. Kwak. 1991. Community structure and soil properties of the Chinese cork oak (*Quercus variabilis*) forests in the limestone areas. Korean J. Ecol. 13:159-169.

Kim, J.H., Y.S. Kwak and H.T. Mun. 1992. Classification of calcicoles and calcifuges on the basis of the ratio of soluble to insoluble Ca and Mg in the leaves. Korean J. Ecol. 15:311-328.

Kinzel, H. 1983. Influence of limestone, silicates and soil pH on vegetation. *In* O.L. Lange, P.S. Nobel, C.B. Osmond and M.J. Ziegler (eds.). Physiological plant ecology Ⅲ. Responses to the chemical and biological environment. Springer - Velag, Berlin, pp. 210-244.

Kwak, Y.S. 1993. Productivity of plant communities and grouping of calcicoles and calcifuges in Tanyang limestone area. Ph. D. Thesis, Seoul National Univ., Seoul. 142p.

Lee, Y.N. and Y.C. Oh. 1970. Limestone flora of Todam, Province ChungBuk in south Korea. J.K.R.I.B.L. Vol. 5:101-115.

Levitt, J. 1980. Responses of plants to environmental stress - water, radiation, salt and other stresses. 2nd ed. Academic Press. N.Y. 607p.

Marrs, R.H. and P. Bannister. 1978. Response of several members of the Ericaceae to soils of contrasting pH and base-status. J. Ecol. 66:829-834.

Tilman, D. 1988. Plant strategies and the dynamics and structure of plant communities. Princeton Univ. Press. New Jersey. 360p.

Ward, L.K. and R.D. Jennings. 1990. Succession of disturbed and undisturbed chalk grassland at Aston Rowant National Nature Reserve: details of changes in species. J. Appl. Ecol. 27:913-923.

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