Kor. Turfgrass Sci., 9(2), 159~167, 1995

Studies on Some Indices of Species Structure of the *Arundinella hirta* Communities in Cheolwon Area

Cho, Doo-Han and Nam-Kee Chang

Dept. of Biology, College of Education, Seoul National University

鐵原地區 새 群集의 種構成指數에 關한 硏究

趙 斗 漢 · 張 楠 基

서울大學校 師範大學 生物敎育科

ABSTRACT

Some indices of species structure of the *Arundinella hirta* communities in Cheolwon area were studied and the following results were obtained.

The vegetational data was analyzed from six grass stands selected with the distance away from the DMZ in Cheolwon area.

Species diversity was higher in the stand away from the DMZ than in that near to it.

All six stands are not considered to be free of disturbance. Species composition of the stands might be related to the degree of disturbance. It can be said that the destruction of the vegetation by periodical fire or cutting simplifies the species composition.

In the rear district the human interference is supposed to be more frequent. But it is supposed to be slight in near the DMZ and that the degree of disturbance is not so destructive. This could be the explanation of high diversity in these stands.

Key words: *Arundinella hirta* communities, DMZ, Cheolwon area, Species diversity.

INTRODUCTION

It may be assumed that the productivity and species composition of the plant community are determined by environmental factors(Whittaker, 1965). The species composition of a community is the most important aspect in characterizing the community, and various indices of species structure provide the fundamental data in describing and analyzing the communities. Among these indices, the species diversity has been studied by many ecologists. This index is dependent on the species number and the relative abundance of species. Various formulas of species diversity have been proposed(Fisher *et al.*, 1943; Simpson, 1949; MacArthur, 1957; Margaleff, 1958; Krebs, 1985; Colinvaux, 1986; Ehrlich and Roughgarden, 1987), but the weakness of diversity as an ecological tool lies in its ambiguity(Hulbert, 1971). It has been suggested that species diversity be related to the environment or succession(Tramer, 1969 ; Nicholson and Monk, 1974). This index is thought to increase during the process of succession, enhance community stability, and relate to community productivity, evolution, niche structure, and competition(McIntosh, 1967).

Because the vicinity of DMZ is considered as undisturbed area for more than twenty years, this area has been thought to be a good reference to assess the difference between disturbed and undisturbed communities. Many studies have been accomplished in this area in various aspects of vegetation ecology(Chang *et al.*, 1969, Hong, 1968; Lee, 1968; The report of the Korean Association for Conservation of Nature, 1974; Chang and Yun, 1995).

In this study, six grass stands are selected in the distance away from the DMZ, in the north of Cheolwon, to investigate the effect of human disturbance to the vegetation.

METHODS

1. Study area and data

Six grass stands in Cheolwon area are selected with the distance away from the DMZ :

St. Ⅰ. Farming boundary line
St. Ⅱ. 1. 5 km from DMZ, north of Cheolwon
St. Ⅲ. Booheung-dong area, Hantan river side
St. Ⅳ. Soodowon-Seungilkyo, Cheolwon area
St. Ⅴ. Cheongyang-ri, Cheolwon-kun
St. Ⅵ. Keumhak Mountain, Cheolwon Area

The vegetational and environmental data used in this study were taken from the data of Chang(unpublished data) and Chang and Yun(1995). Using random samples of 6~7m^2 quadrat of each stand, they measured the number of individuals, frequency, cover degree, height of them. From these values, some parameters of species composition are calculated.

Arundinella hirta is the leading dominant species in all the stands. Species for each stand are shown in Table 1.

2. Species diversity indices

1) Simpson's index

Simpson introduced an index of diversity(Simpson, 1949).

$$D = 1 - \frac{\sum_{i=1}^{S} N_i(N_i-1)}{N(N-1)}$$

In this equation, S is the number of species, Ni the number of individuals belonging to the ith species, and N, the total number of individuals in the sample. This value varies from 0.0 to 1.0 in ascending order with increased diversity.

2) Shannon's index

This index is a derivative of Shannon's information theory of communication(Shannon and Weaver, 1949). This index

$$H' = -\sum_{i=1}^{S} \frac{N_i}{N} \ln \frac{N_i}{N}$$

is a measure of uncertainty. It's value is independent of the sample size, and increases without limit ranges from 0.

3) McIntosh's index

The McIntosh's index (McIntosh, 1967)

$$D' = \frac{N - \sqrt{\sum_{i=1}^{S} N_i^2}}{N - \sqrt{N}}$$

yields values which are percentages of the maximum possible diversity for a sample of the same size.

3. Species eveness indices

The following equation

$$\text{Eveness} = \frac{\text{calculated diversity} - \text{minimum diversity}}{\text{maximum diversity} - \text{minimum diversity}}$$

is used as a general eveness formula for all diversity indices. From this equation, the eveness for each diversity index is invented(1972).

1) Eveness for D

The eveness "corollary" for Simpson's diversity index (Fager, 1972) is

$$SE = \frac{1 - \frac{\sum_{i=1}^{S} N_i(N_i - 1)}{N(N-1)} - \frac{(S-1)(2N-S)}{N(N-1)}}{\frac{N(N-1)}{S(N-1)} - \frac{(S-1)(2N-S)}{N(N-1)}}$$

2) Eveness for H'

In the similar manner, the eveness corollary for Shannon's index(Fager, 1972) is

$$J^* = \frac{[-\sum_{i=1}^{S} \frac{N_i}{N} \ln \frac{N_i}{N} - \ln N \frac{N-(S+1)}{N} \ln (N-(S+1))]}{\ln S - \{\ln N - \frac{N-(S+1)}{N} \ln [N-(S+1)]\}}$$

Table 1. Major species whose importance value is over 10. Importance value is obtained by adding four relative values of density, frequency, cover degree and height

St. I		St. II	
Species	Imp. V.	Species	Imp. V.
Arundinella hirita	134.1	*Arundinella hirita*	82.9
Cassia nomame	57.0	*Potentilla freyniana*	53.6
Spiraea simpliciflora	46.8	*Carex pediformis*	39.0
Artemisia japonica	42.5	*Festuca vulgaris*	33.3
Artemisia orietalis	35.3	*Athyrium nipponicum*	28.5
Artemisia asiatica	28.9	*Miscanthus purpurascena*	26.7
Amphicarpaea trisperma	16.5	*Hemerocalis minor*	23.7
Medicago dinticula	14.6	*Artemisia aurata*	17.9
Oxalis corniculata	13.5	*Sium latifolium*	13.8
Viola pachyrhiiza	10.8	*Sanguisorba officinalis*	13.5
		Artemisia orientalis	11.7
		Fimbristylis annua	10.4

St. III		St. IV	
Species	Imp. V.	Species	Imp. V.
Arundinella hirita	50.2	*Arundinella hirita*	57.9
Festuca vulgaris	41.1	*Festuca vulgaris*	33.7
Miscanthus purpurascena	18.5	*Aster scaber*	15.3
Thalictrum japonica	16.4	*Miscanthus purpurascena*	14.0
Scilla sinensis	16.2	*Artemisia keiskeana*	13.8
Calamagrostis arundinacea	14.2	*Potentilla freyniana*	13.5
Patrinia scobiosaefolia	13.1	*Carex siderostica*	13.0
Themeda japonica	13.1	*Artemisia japonica*	12.9
Galium verum	12.8	*Regnoutria japonica*	12.2
Hemerocallis minor	11.1	*Aster tataricus*	11.6
Aster tataricus	10.0	*Atractylodes coreana*	11.5
		Melempyrum typicum	10.7
		Themeda japonica	10.0

St. V		St. VI	
Species	Imp. V.	Species	Imp. V.
Arundinella hirita	57.0	*Arundinella hirita*	30.4
Miscanthus sinensis	40.9	*Carex nanella*	29.4
Carex nanella	25.4	*Festuca ovina*	27.2
Festuca ovina	12.0	*Miscanthus sinensis*	15.0
Cassia nomame	11.1	*Patrinia scabiosaefolia*	12.7
Patrinia scabiosaefolia	10.1	*Aster scaber*	12.5
		Potentilla freyniana	10.6

3) Eveness for D

Eveness corollary to McIntosh's index(Fager, 1972) is

$$ME = \frac{\dfrac{N-\sqrt{\sum_{i=1}^{S} N_i^2}}{N-\sqrt{N}} - \dfrac{N-\sqrt{(S-1)+(N-(S-1))^2}}{N-\sqrt{N}}}{\dfrac{N-\sqrt{S\left(\frac{N}{S}\right)^2}}{N-\sqrt{N}} - \dfrac{N-\sqrt{(S-1)+(N-(S-1))^2}}{N-\sqrt{N}}}$$

4. Other indices

The probability of interspecific encounter and intraspecific competition(Hulbert, 1971) are calculated.

RESULTS

The vegetation of stand Ⅰ and Ⅱ which located close to the DMZ, are very simple. Stand Ⅲ-Ⅳ show quite complex vegetation relative to stand Ⅰ or Ⅱ. The dominant behavior of *Arundinella hirta* diminished as the diversity increases(Table 1 and 2).

The other importance value is calculated from four kinds of relative value including relative height.

Table 3 shows various species indices for each stand. For Shannon's index, H' is calculated using three kinds of different values(Table 4). In Table 3, it is evident that the farther stands are located from the DMZ, the larger and richer the species diversity index and the species richness become except stand Ⅳ. Shannon's indices calculated from the different quantitative values show some discrepancy(Table 4). When it is calculated from the number of individuals, stand Ⅳ is underestimated.

Table 2. Contribution of *Arundinella hirta* in each stand

Measures	STAND					
	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ
% frequency	56.2	81.2	62.5	81.8	100	71.4
Relative density	56.2	26.2	31.5	32.9	30.6	12.3
Total cover degree	4	4	5	7	16	13
Relative cover degree	28.7	15.4	6.6	10.1	10.7	7.0
Importance value	134.1	82.9	50.2	57.9	56.9	30.4
	(110.2)*	(70.3)*	(43.2)*	(48.4)*	(45.9)*	(22.6)*

* Calculated by adding 3 kinds of relative value.

DISCUSSIONS

Species diversity increased with the increase in species number rather than the number of individuals. Increasing pattern of Simpson's index is similar to Macintosh's index, but

Table 3. Indices of species composition for each stand

Measures	STAND					
	I	II	III	IV	V	VI
H′	1.4306	2.0646	2.5512	2.3279	2.7324	2.7954
D′	0.4083	0.6092	0.6266	0.5889	0.6237	0.6632
D	0.6372	0.8393	0.8469	0.8229	0.8479	0.8808
Δ_1	0.6377	0.8395	0.8477	0.8231	0.8488	0.8810
$1-\Delta_1$	0.3623	0.1605	0.1523	0.1769	0.1512	0.1190
J*	0.6101	0.7241	0.6079	0.5399	0.6148	0.6242
SE	0.7031	0.8905	0.8489	0.8263	0.8403	0.8885
ME	0.5769	0.7905	0.6892	0.6461	0.6770	0.7319
No. of species	10	17	52	74	61	81
Total No. of individuals	1369	3464	1110	3350	907	5650

* H′ is calculated from the number of individuals
Δ_1 : probability of interspecific encounter
$1-\Delta_1$: intraspecific competition

Table 4. Shannon's index calculated from three kinds of different value

H′	STAND					
	I	II	III	IV	V	VI
1	1.4306	2.0646	2.5512	2.3279	2.7324	2.7954
2	1.9321	2.4354	3.5228	3.6987	3.4761	3.9151
3	2.0014	2.5596	3.5717	3.7814	3.5873	3.9807

* Values used in diversity calculation are ;
1 ; No. of individual
2 ; Importance value (relative density+relative frequency+relative cover degree)
3 ; Importance value (above 3 values+relative height)

Table 5. Soil factors for each stand

Soil factors	STAND					
	I	II	III	IV	V	VI
Loss on ignition (%)	6.64	7.58	8.02	7.85	7.95	8.99
pH	4.82	5.06	5.40	5.06	5.32	5.36
Total nitrogen	0.26	0.29	0.32	0.28	0.31	0.46
Easily soluble P	3.64	3.21	3.58	3.23	3.52	4.00
Moisture content(%)	31.59	32.34	34.85	32.04	34.52	35.32
Available K	0.25	0.20	0.19	0.20	0.23	0.21

different from that of Shannon. Risser and Rice(1971) noted that Simpson's diversity is too strongly affected by the abundance of the two or three most abundant species in a community. So Simpson's index is more efficient when a few dominant species are evaluated. Stand Ⅳ has a low species diversity in spite of large number of individuals (Table 3). This fact is due to low species eveness. Eveness shows an irregular pattern with the increase in diversity. The result obtained conforms with the views that separate analysis of diversity component(species richness and eveness) is worthwhile(Shafi and Yarraton, 1973).

In stand Ⅵ(Table 2) the dominant species is changed when different values are used to calculate importance value. *Carex nanilla*(26.43) takes the leading dominant instead of *Arundinella hirta* when the importance value is obtained by adding relative density, relative frequency, and relative cover degree. *Festuca ovina* has an importance value of 26.05, which is still heigher than the *Arundinella hirta*. Whittaker(1965) said that the best single measure of species importance is its productivity. The importance value of the dominant species decreases as the diversity increases, so that the community seems to be more unstable in the rear district. This is thought to be the result that the succession in this area is in its developmental stage.

In the climate like this country, the grassland is reported to be formed as a secondary succession by fire and cutting and other disturbances(Hanson, 1939; Oosting, 1956). It seems to be true for the stand Ⅰ, which is consists of only ten species of herb but no tree species. This stand, however, seems to be a stable *Arundinella* community. From Table 5, stand Ⅰ is not appeared so infertile as to show such a small number of species.

Farming boundary line is under military control and for a military reason the vegetation is disturbed periodically by setting fire in the fall or cutting in the vigorously growing season. The fire might destroy the growing point of the tree species and as a result only herbaceous plant with perennial roots or rhizomes can survive. Iwanami and Izumi(1966) reported that herbs like *Arundinella* or *Miscanthus* received less damage than the tree because the growing point is 1.7cm above the earth surface. From this fact it can be said that a few tolerant species that can survive under this severe disturbances constitute the community in this considerably favorable environment. Therefore, intraspecific competition is greater than the other stands and the probability of interspecific encounter is low as shown in Table 3. The fact that the other stands show relatively high degree of species richness can be interpreted as a result of the occurrence of the new species which have been suppressed by the fire or cutting. The severe, unstable, and recent environment limits the number of species(Lorcks, 1970; Connell and Orias, 1964; Whittaker, 1965). From stand Ⅲ to Ⅵ, considerable number of shrubs and vines are found to exist. The stand is believed to show an unstable seral stage that tree species begin to invade the grass stand. On the one hand, this area is more frequently visited by men and domestic animals and becomes the habitat of many birds. Therefore, it is assumed that more chance of seed dispersion might contribute the formation of the more complicated vegetation

(Braun-Blanquet, 1932).

적 요

철원 지구 새 군집의 종구성지수에 관하여 연구한 결과는 다음과 같았다.

1. 철원 지구 비무장지대로부터 떨어져 있는 거리에 따라 선택한 6개 초지의 식생에 관한 자료를 분석하였다.
2. 비무장지대에 인접한 지소보다 멀리 떨어진 지소의 종 다양도가 높았다.
3. 6개 지소는 모두 인간의 방해를 전혀 안 받은 곳은 없는 것 같다. 각 지소의 종구성은 인간의 방해 정도와 관련되는 것으로 보인다. 정기적인 불이나 벌초에 의한 식피의 파괴 는 종구성을 단순하게 만드는 것으로 본다.
4. 후방 지역에서는 인간의 방해가 보다 자주 일어날 수는 있으나 그 정도가 약하여 비무장 지대 근처와 같이 심한 파괴는 받지 않았다고 볼 수 있다. 이것이 이 지소들의 높은 종 다양도에 대한 설명이 될 수 있을 것이다.

REFERENCES

1. Braun-Blanquet. 1932. Plant Sociology. 1st ed. McGraw-Hill Book Co. N.Y.
2. Chang, N.K., Yun, I.S. 1969. A Study on the grassland types and plant succession in Korea. Kor. J. Anim. Sci. 11(2) 254~257.
3. Chang, N.K. and S.M. Yun. 1995. Studies on the composition, productivity, regrowth and soil properties of grasslands in Kimhwa and Chulwon areas. Kor. Turfgrass Sci. 9 (1):11~42.
4. Colinvaux, P. 1986. Ecology. John Wiley & Sons. pp. 18~683.
5. Connell, J.H. and Orias, E. 1964. The ecological regulation of species diversity. Am. Nat. 98 : 399~414.
6. Ehrlich, P.R. and J. Roughgarden. 1987. The Science of Ecology. Macmillan Publishing Company. New York. pp. 3~612.
7. Fager, E.W. 1972. Diversity : a sampling study. Am. Nat. 106 : 293~309.
8. Fisher, R.A., A.S. Corbett, and C.B. Williams. 1943. The relation between number of species and the number of individuals in a random sample from an animal population. J. Anim. Ecol. 12 : 42~58.
9. Hanson, H.C. 1939. Fire in land use and management. Am. Midl. Nat. 21 : 415~434.
10. Hong, S.W., Y.C. Hah, and Y.K. Choe. 1968. Some effect of fire on vegetation, soil, and soil microflora adjacent to DMZ in Korea. Kor. J. Bot. 11(4) 9~20.
11. Hulbert, S.H. 1971. The nonconcept of species diversity : A critique and altervative parameters. Ecology 52 : 577~586.
12. Iwanami, Y., and Izumis. 1966. Report on the burning temperature of Japanese lawn grass. Jap. J. Ecol. 16 : 40~41
13. Krebs, C.J. 1985. Ecology. The experimental analysis of distribution and abundance

Happer & Row, Publishers, New York. pp. 3~720.
14. Lee, I.K. 1968. Distribution of *Pinus densiflora* in DMZ. Kor. J. Bot. 11(4) 21~26.
15. Loucks, O.L. 1970. Evolution of diversity, efficiency, and community stability. Am. Zool. 10 : 17~25.
16. MacArthur, R.H. 1957. On the relative abundance of bird species. Proc. Nat. Acad. Sci. U.S. 43 : 293~295.
17. Margaleff, R. 1963. On certain unifying principles in ecology. Am. Nat. 97 : 357~374.
18. McIntosh, R.P. 1967. An index of diversity and the relation of certain concepts to diversity. Ecology 48 : 392~404.
19. Nicholson, S.A. and D. Monk. 1974. Plant species diversity in old-field succession on the Georgia Piedmont. Ecology 55 : 1075~1085.
20. Oosting, H.J. 1956. The study of plant communities. 2nd ed. W.H. Freeman and Co.
21. Risser, P.G. and Rice, E.L. 1971. Diversity in tree species in Oklahoma upland forests. Ecology 52 : 876~880.
22. Shafi, M.I. and Yarranton. 1973. Diversity, floristic richness, and species eveness during a secondary (post-fire) succession, Ecology 54 : 897~902.
23. Shannon, C.E. and W. Weaver. 1963. The mathematical theory of communication. Univ. Illinois Press, Urbana.
24. Simpson, E.H. 1949. Measurement of diversity, Nature 163 : 688.
25. The report of the Korean Association for Conservation of Nature. No. 7, 1974. Cultural properties Management Bureau, Ministry of Culture and Information.
26. Tramer, E.J. 1969. Bird species diversity : Components of Shannon's formula. Ecology 50 : 927~929.
27. Whittaker, T.H. 1965. Dominance and diversity in land plant communities. Science 147 : 250~260.