The Community Structure of Plant at the Edge of the Oncheon River in Busan

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Community structure refers to the number of species in a community and the pattern of distribution of individuals among those species. The purpose of this paper was to describe a statistical analysis for detecting a ecological biodiversity which is valid even though the assumption at the different sampling points is not violated spatial randomness of species. Counts and cover were determined from 10 (20 m×20 m) plots in five sites of the Oncheon River which is located in Busan, Korea. Total 95 taxa (85 species, 9 varieties, and one form) were identified and measured in edge sides of this river. These were a total of present in the five sites. Overall across the fragments, mean number of species per plot differed significantly among the five sites (F=7.75, p<0.01). Shannon-Wiener functions differed significantly among plots (F=4.12, p<0.05), with the St. 1 having significantly higher value (2.380) than the others (2.206 for St. 2, 2.116 for St. 3, 2.069 for St. 4, and 0.637 for St. 5). The richness indices, R1 decreased from the upper stream of the Oncheon River to the lower stream. We used a novel way of representing community structure to show that abundance within closely related pairs of co-occurring species in the Oncheon River. The differences between the distributions for of congeners and pairs of non-congeners showed at the largest difference of the cumulative fractions of the data sets (x=0.85).

Key words : Community structure, the Oncheon River, congener pairs, non-congeners

Introduction

Humans convert forests to pastures, and agricultural fields into suburbs, with relatively little thought about the ecological consequences of these land-use changes [5]. But these changes in land use, hectare by hectare, are among the most serious impacts on global ecosystems, and they are difficult to quantify. The start of the industrial development in Korea brought with it a while new range of impacts and a new scale of human activity. The most direct threat to biodiversity comes from destruction of the habitat on which it depends [3].

When we think of urban landscape, we think of a number of separate elements such as trees, fields, rivers, buildings, roads and so on that combine to form a whole [1]. This essentially how it is viewed in conservation and ecology. A landscape is a heterogeneous area composed of a mosaic of patches with interacting elements. Some patches may be discrete with clear boundaries, whilst others grade into each other. Thus landscape ecology includes the study of the dynamics of these systems and movement and persistence of species within them [13]. This is relevant both to natural systems and those heavily influenced by human activity.

There has been increasing recognition among ecologists that landscape matrices surrounding remnants of fragmented habitat are important drivers of populations extinction within fragments [3,10]. While the influence of the matrix depends on species traits and the scale at which species perceive the landscape, the direct impacts of altering the matrix on the within-patch extinction risk are increasingly being considered [12].

Worldwide, urban areas are expending both in size and populations. As a result of urban expansion, native vegetation is reduced and fragment a landscape mosaic in which both the amount of impervious surface is increased, and the structure and comparison of the remaining vegetation is progressively altered [13].

Urbanization adjacent to natural areas and parks often results in simplification of habitats and a community of plant, which lead to fewer species dominated by habitat patch size to species richness, increasement of immigration and extinction rates, and have been applied to habitat patch dynamics in fragmented urban areas [6].

Many natural areas in Busan have been partly destroyed or degraded through the direct or indirect action of governments. However, this damage need not be total or

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permanent. To some extent habitats and ecosystems can be restored on a local basis provided that the materials (e.g. species) and expertise exist. Restoration is a positive process that can be used to great effect in conservation, but can be misused to seduce us into inappropriate use of resources.

In the present study, we measured the relative abundances of different species of flowering plants across five sites in the Oncheon River. We used these data to calculate species richness, evenness, diversity, and the measures of abundance on each plot and then correlated these variables with one another for each taxonomic grouping. In addition, we compared multiple taxonomic groups at the three different sampling points (upper, middle, and lower parts of the river).

The purpose of this paper was to describe a statistical analysis for detecting a ecological biodiversity which is valid even though the assumption at the different sampling points is not violated spatial randomness of species.

Materials and Methods

Study site description and sampling design

We monitored aboveground standing species, abundance, and cover of plants in both side of the Oncheon River at Busan, from May 2005 through April 2007. Counts and cover were determined from 10 (20 m×20 m) plots in five sites (Table 1), allowing species-specific comparisons counts were of individual plants in noncloning species or distinct rosettes or clumps of stems.

The Shannon-Weaver index of diversity was used to characterize species richness and abundance [7]. It was calculated as:

$$H' = -\sum_{i=1}^{s} (pi)(\ln pi)$$

Where s is the total number of species and pi is the proportion of all individuals in a sample that belong to the ith species. N1 measures the number of abundant species in the sample and N2 is the number of very abundant species [15].

$$N1 = e^{H'}$$

$$N2 = 1/\lambda$$

λ is Simpson's index.

Species diversity may be thought of as being composed of two components. The first is the number of species in the community, which ecologists often refer to as species richness. Two well-known richness indices are as follows: R1 and R2 indices [4].

$$R1 = \frac{s-1}{\ln(n)}$$

$$R2 = \frac{s}{\sqrt{n}}$$

s: the total number of species in a community, n: the total number of individuals observed.

The second component is species evenness or equitability. The common evenness indices used by ecologists are E1~E5 [2].

Jaccard's coefficient (J) of similarity for twelve 20 m×20 m plots and five sites was used to compare the number of species shared between plots in different shared fragments.

J=(the number of shared species between plot A and plot B)/(the number of species in plot A+the number of species in plot B).

Table 1. The sites of invested area

Site	Plot	Location
St. 1	St. 1-A	Right side of river, Cheongrong-dong, Gyungjeong-gu
	St. 1-B	Left side of river, Cheongrong-dong, Gyungjeong-gu
St. 2	St. 2-A	Right side of river, Changjeon-dong, Gyungjeong-gu
	St. 2-B	Left side of river, Changjeon-dong, Gyungjeong-gu
St. 3	St. 3-A	Right side of river, Suan-dong, Dongrae-gu
	St. 3-B	Left side of river, Suan-dong, Dongrae-gu
St. 4	St. 4-A	Right side of river, Geoje-dong, Yeonje-gu
	St. 4-B	Left side of river, Geoje-dong, Yeonje-gu
St. 5	St. 5-A	Right side of river, Anlak-dong, Haeundae-gu
	St. 5-B	Left side of river, Anlak-dong, Haeundae-gu

Exploring the shape of the fractional abundance distribution

Kolmogorov-Smirnov statistic was evaluated at congeneric pairs and non-congeneric pairs (con-familial) for 10 (20 m×20 m) plots in five sites [9].

An analytic lognormal approximation can be used to explore the shape of the fractional abundance distribution as a function of width, δ_2, of the Preston plot, under the assumption that one species is as good as another [6]. For the analytic lognormal, the number of species with N individuals is represented by

$$S(N) \propto \exp[-(R-R_O)^2/\delta_2^2]$$

where R = og$_2N$ and the suffix on is a reminder that R is the logarithm to the base 2.

For a given pair, of fractional abundance is $r = n1/(n1 + n2)$ (where $n1>n2$ and r is between 0.5 and 1.0) and $\ln(n1) = \ln(n2) + \ln\{r/(1-r)\}$.

The probability of drawing a pair at random in unit intervals of $R1$ and $R2$ is proportional to

$$\exp[-(R1-Ro)^2/2\delta^2 - (R2-Ro)^2/2\delta^2]$$

and for fixed $n2$,

$$dR1 = d\log_2 n1 \propto dr/r(1-r)$$

The shape of the frequency distribution of the fractional abundance is, in this approximation, obtained by integrating out $R2 = \log_2 n2$ and the shape is then

$$\exp[-\{\log_2(-r/r(1-r)\}^2/4\delta_2^2]dr/r(1-r)$$

where ($\log_2 x = \ln x/\ln 2$) [6].

Result

Overall across the fragments, total 95 taxa were identified and measured in the 10 plots. These were a total of 85 species, 9 varieties, and one form present in the five sites (Appendix 1). There were 42 understory species in 10 plots of three sites. Two tree species were typical on almost all sites; *Pinus thunbergii* and *Prunus serrulata* var. *spontanea*, thus they were the dominant habitat type on most sites. The most common species in the site St. 1 was *Pinus densiflora* (Pinaceae), according for 17.1% of the individuals sampled in 20×20 m plots.

Average density (tree per plot) differed significantly among plots (F=9.96, p<0.001). Least significant differences (LSD) post hoc analysis revealed that the site St. 1 had significantly greater than densities than the remainder sites (St. 2, St. 3, St. 4, and St. 5). Mean number of species per plot differed significantly among the plots (F=7.75, p<0.01). Shannon-Wiener functions differed significantly among plots (F=4.12, p<0.05), with he site St. 1 having significantly higher value (2.380) than the others (2.206 for St. 2, 2.116 for St. 3, 2.069 for St. 4, and 0.637 for St. 5) (Table 2). The richness indices R1 decreased from the upper stream of the Oncheon River (site St. 1) to the lower stream (site St. 5). The evenness indices except E5 were not shown a significant differences among five sites.

Abundances of congeneric pairs were more similar to one another than are those of non-congeneric (con-familial) pairs for 10 plots (20 m×20 m) in five sites (Fig. 1). The differences between the distributions for of congeners and pairs of non-congeners was established with the two sample Kolmogorov-Smirnov test. The differences between the distributions for of congeners and pairs of non-congeners showed at the largest difference of the cumulative fractions of the data sets (x=0.85). Analyses of community structure were strongly dependent on species pool size. The species pool of all plant taxa decreased from the upper stream of the Oncheon River (plots St. 1-A and B) to the lower stream (plots St. 5-A and B).

The shape of the frequency distribution of the fractional abundance were obtained from the expression for δ_2 and it was simple to fellow the collapse of the bin 0.9-1.0 (Fig. 2). The quantity δ_2 had to be below 2.0 before the distribution function had flattened off. For even smaller values, fractional abundances near 0.5 were increasingly favored.

Table 2. Species diversity index at sites of the edge of the Oncheon River

Indices	Sites				
	St. 1	St. 2	St. 3	St. 4	St. 5
Richness					
R1	2.981	2.474	2.308	2.401	0.910
R2	1.737	1.622	1.591	1.701	1.155
Diversity					
H'	2.380	2.206	2.115	2.069	0.637
N1	10.808	9.076	8.293	7.919	1.890
N2	10.769	10.652	10.122	9.450	3.000
Evenness					
E1	0.928	0.958	0.963	0.942	0.918
E2	0.831	0.908	0.921	0.880	0.945
E3	0.817	0.897	0.912	0.865	0.890
E4	0.996	1.174	1.221	1.193	1.587
E5	0.996	1.195	1.251	1.221	2.247

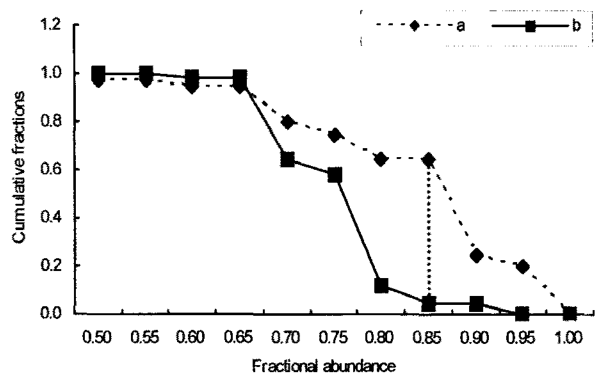

Fig. 1. Abundances of congeneric pairs are more similar to one another than are those of non-congeneric pairs (con-familial). The solid line shows the cumulative fraction of the number of congeneric pairs with fractional abundance, counting from a fractional abundance of 1. The dotted line shows the cumulative fractional abundance distribution for non-congeneric species pairs. The vertical dashed line (x=0.85) shows the point of greatest difference between the compared distribution.

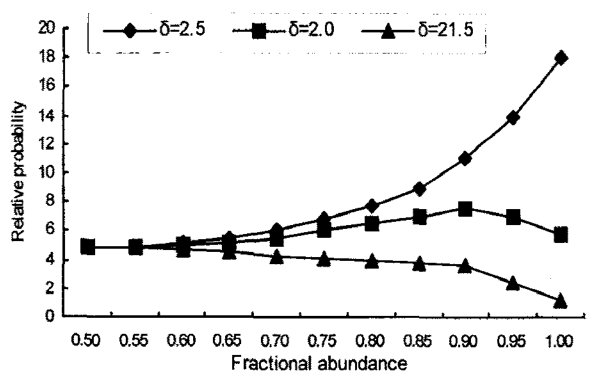

Fig. 2. Analytically derived shapes of abundances distribution for random sampling for selected values of δ_2, the standard deviation of a lognormal curve.

These probability distributions have not been normalized to the same (unit) plot, for clarity.

Mean Jaccard's coefficient of similarity between sites pairs was compared by the two-sample t-test (Table 3). The Jaccard's coefficient showed three distinct groups; St. 1, St. 2 - St. 4, and St. 5. St. 1 and St. 5 were well separated from the middle reaches (from St. 2 to St. 4) of the Oncheon River.

Discussion

From a mathematical viewpoint, the foremost requirement for a meaningful evenness index is that it must be independent of species richness [11,16]. This requirement is based on the assumption that species diversity can be partitioned into two components, species richness and evenness. If the separation is incomplete, so that evenness is affected by species richness, then differences in evenness values could result from differences in the species count rather than any fundamental difference in community's organization [8].

Entropy-related biodiversity indices deriving their conceptual basis from Shannon's information theory have a long history of use in ecology for quantifying community structure and diversity [16]. In addition, in the last two decades, numerous information-theoretical indices, such as the landscape dominance index, have been extensively applied to characterize landscape diversity in space and time.

Our primary result is that there is a community structuring process at riversides of the Oncheon River depend-

Table 3. Jaccard's coefficient of similarity (below diagonal) and t-tests (above diagonal) among ten plots of the Oncheon River

Plot	St. 1		St. 2		St. 3		St. 4		St. 5	
	St. 1-A	St. 1-B	St. 2-A	St. 2-B	St. 3-A	St. 3-B	St. 4-A	St. 4-B	St. 5-A	St. 5-B
St. 1-A	-	ns	ns	ns	*	*	*	*	**	**
St. 1-B	0.988	-	ns	*	*	*	*	*	**	**
St. 2-A	0.721	0.705	-	ns	ns	ns	ns	ns	*	*
St. 2-B	0.747	0.652	0.907	-	ns	ns	ns	ns	*	*
St. 3-A	0.581	0.623	0.810	0.824	-	ns	ns	ns	*	*
St. 3-B	0.605	0.621	0.789	0.714	0.812	-	ns	ns	*	*
St. 4-A	0.533	0.541	0.657	0.719	0.757	0.780	-	ns	*	ns
St. 4-B	0.524	0.589	0.699	0.645	0.711	0.748	0.883	-	ns	ns
St. 5-A	0.416	0.428	0.627	0.612	0.633	0.677	0.615	0.779	-	ns
St. 5-B	0.459	0.354	0.567	0.540	0.607	0.638	0.712	0.744	0.785	-

ns: Non-significant at the 5% level. $^{*}p<0.05$; $^{**}p<0.01$

ent upon species identity. The distribution of fractional abundance for congeneric pairs at the river is not more equitable than for random pairs (Figs. 1 and 2). From the observed differences among fractional abundance distributions, we conclude that the closely related members of congeneric pairs must interact with one another differently than do members of randomly selected species pairs. This observation is at odds with the assumption that species are interchangerable, which underpins neutral theory in any of its current forms [14]. If species were interchangeable, then any reasonable pairing algorithm would yield a fractional abundance distribution of pur paired congeners, comparing > 17.5% of the censused woody species at the Oncheon River and > 46.7% of all woody species with congeners, is notable different from random.

Most views of New York City's Jamaica Bay come from overhead [3]. Moreover, as the city's biggest green space, it provides more than 325 birds species with a place to land and eat, or even nest, while the city's massive human population hums away in the background. However, according to some estimates, those wetlands may disappear entirely by 2015, as the stresses of the city take their toll on the area's vegetation and water quality [3]. The plant community of the Oncheon River is not exceptions and may be not imagination but reality as expectation of New York City's Jamaica Bay. A few dominant species often control communities through a combination of high population densities and large capita impacties. Considering just the most common species, the community comparison of the fragments is strikingly different. The site St. 1 is primarily a *Pinus thunbergii* - *Quercus aliena* forest and these species are not artificial populations, but natural forest. Whereas, the remainder sites are dominant by *Prunus serrulata* var. *spontanea*, *Euonymus japonica*, *Brassica campestris* ssp. *napus* var. *nippo-oleifera*, *Zoysia japonica*, or *Aster koraiensis*. For recently, their species were planted in St. 2, St. 3, St. 4, and St. 5 by human work and the pace of this process has increased with scenery decoration or development of the Oncheon River. In addition, These probability distributions have not been normalized to the same (unit) plot (Fig. 1). Namely, in some cases, artificial changes in species across population densities can lead to non-linearities in interaction strength; per capita impacts may decrease at low populations [1]. Understanding the nonlinear dependencies is critical for strongly interacting species as small changes in abundance can cause widespread ecological changes [11].

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References

1. Adams, P. A. 2001. Describing and quantifying interspecific interactions: a commentary on recent approaches. *Oikos* **94**, 209-218.
2. Alataro, R. V., A. Lundberg and K. Stahlbrandt. 1982. Why do pied fly catcher females mate with already-mated males? *Anim. Behav.* **30**, 585-593.
3. Gillespie, A. 2007. New plan to protect urban wetland. *Front. Ecol. Environ.* **10**, 517-518.
4. Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. *Ecology* **54**, 427-431.
5. Huh, M. K., J. S. Choi and S. G. Moon. 2006. Plant succession and changes on community at flooding area. *Kor. J. Life Sci.* **16**, 1097-1103.
6. Kelly, C. K., M. G. Bowler, O. Pybus and P. H. Harvey. 2008. Phylogeny, niches, and relative abundance in natural communities. *Ecology* **89**, 962-970.
7. Shannon, C. E. and W. Weaver 1949. *The Mathematical Theory of Communication*. pp. 326, University Illinois Press, Urbana, IL.
8. Sheldon, A. L. 1969. Equitability indices: Dependence on the species count. *Ecology* **50**, 466-467.
9. Siegal, S. and N. J. Castellan. 1998. *Nonparametric Statistics for the Behavioral Sciences*. Second edition, MaGraw-Hill, New York, USA.
10. Smith, L. M., R. L. Pederson and R. M. Kaminski. 1989. *Habitat Management for Migrating and Wintering Waterfowl in North America*. pp. 560, Texas Tech. University Press, Texas.
11. Smith, B. and J. B. Wilson. 1996. A consumer's guide to evenness indices. *Oikos* **76**, 70-82.
12. Soule, M. E., J. A. Esters, B. Miller and D. L. Honnold. 2005. Strongly interacting species: conservation policy, management and ethics. *BioScience* **55**, 168-176.
13. Swenson, N. G., B. J. Enquist, J. Pither, J. Thomson and J. K. Zimmerman. 2006. The problem and promise of scale dependency in community phylogenetics. *Ecology* **87**, 2418-2424.
14. Volkov, I., J. R. Banavar, S. P. Hubbell and A. Maritan. 2003. Neutral theory and relative species abundance in ecology. *Nature* **424**, 1035-1037.
15. Weaver, M. and M. Kellman. 1981. The effects of forest fragmentation on woodland tree biotas in Southern Ontario. *J. Biogeography* **8**, 199-210.
16. Wilson, J. B., J. B. Steel, W. King and H. Gitay. 1999. The effect of spatial scale on evenness. *J. Veg. Sci.* **10**, 463-468.

Appendix 1. The species list at the edge of the Oncheon River

Scientific name	Site	Life form
Ginkgoaceae		
Ginkgo biloba L.	4	M
Pinaceae		
Cedrus deodara (Roxb.) Loudon	3	M
Pinus desiflora Siebold *et* Zucc.	1	M
Pinus thunbergii Pal.	1	M
Cupressaceae		
Juniperus chinensis L.	3	M
Gramineae		
Digitaria sanguinalis (L.) Scop.	3, 4	Th
Echinochloa crusgalli var. *crusgalli*	3, 4	Th
Echinochloa crus-galli (L.) Beauv. var. *oryzicola* Ohwi	3, 4	Th
Eleusine indica (L.) Gaertner	3, 4	Th
Miscanthus sacchariflоruc Benth.	3, 4	Th
Oplismenus undulatifolius (Ard.) Roem. et Schult.	3, 4	H
Panicum dichotomiflorum Michx.	3, 4	Th
Phragmites communis Trin.	3, 4	G
Phragmites japonica Steud.	3, 4	G
Pseudosasa japonica (Sieb.) Makino	3	M
Setaria viridis (L.) Beauv.	3	Th
Zoysia japonica Steud.	4	H
Cyperaceae		
Cyperus amuricus Max.	3, 4	Th
Cannaceae		
Canna generalis Baily	4	H
Typhaceae		
Thpha orientalis Presl	3, 4	H
Liliaceae		
Disporum smilacinum Gray	1	G
Hemerocallis fulva L.	1	G
Liriope platyphylla Wang et Tang	4	G
Lilium tsingtauense Gilg.	4	G
Amarylidaceae		
Dioscorea tokoro Makino	3, 4	G
Commelinaceae		
Commelina communis L.	4	Th
Salicaceae		
Salix babylonica L.	4	M
Salix gracilistyla Miq.	1	N
Salix pseudo-lasiogyne Lev.	3	M
Betulaceae		
Carpinus laxiflora BL.	1	M
Polygonaceae		
Chenopodium album var. *centrorubrum* Makino	3	Th
Chenopodium serotinum L.	3	Th
Persicaria blumei Gross	3	Th
Persicaria lapathifolium subsp. *nodosum* (Person) Kitamura	3	Th
Persicaria hydropiper (L.) Spach	3	Th
Persicaria filiforme Nakai	3	H
Persicaria japonica (Meisn.) H.	3, 4	H
Polygonum aviculare L.	4	Th
Rumex crispus L.	4	H
Caryophyllaceae		
Stellaria aquatica Scop.	5	H
Amaranthaceae		
Achyranthes japonica (Miq.) Pax	4	H
Amaranthus lividus L.	4	Th
Amaranthus mangostanus L.	4	Th
Iridaceae		
Belamcanda chiensis (L.) DC.	4	G
Iris nertschinskia Lodd.	4	G
Cruciferae		
Brassica campestris L. ssp. *napus* var. *nippo-oleifera* Makino	4	Th
Brassica campestris L. ssp. *napus* Hook. fil. et Anders var. *pekinesis* Makino	1, 4	Th
Rosaceae		
Potentilla fragarioides var. *major* Max.	1	H
Prunus leveilleana Koehne	2, 3, 4	M
P. serrulata var. *spontanea* (Maxim.) Wils.	2, 3, 4	M
Rosa hybrida Hort.	3, 4	N
Rosa multiflora Thunb.	1	N
Stephanandra incisa Zabel	1	M
Saxifragaceae		
Hydrangea macrophylla for. *otaksa* (S. et Z.) Wils	4	N
Leguminosae		
Amorpha fruticosa L.	5	M
Astragalus sinicus L.	4	Th
Lespedeza maximowiczii Schneid.	1	N
Pueraria thunbergiana (Sieb. & Zucc.) Benth	1	M
Robinia pseudo-acacia L.	1	M
Trifolium repens L.	4	H
Wistaria floribunda A.P. DC.	1	M
Lemnaceae		
Arisaema amurense var. *serratum* Nakai	4	G
Cannabinaceae		
Humulus japonicus S. et. Z.	1	Th
Fumariaceae		
Corydalis turtschaninovii Bess.	4	G
Celastraceae		
Euonymus japonica Thunb.	3	M
Aceraceae		
Acer pseudo-sieboldianum (Paxton) Komarow	4	M
Vitaceae		
Cayrata japonica (Thunb.) Gagnepain	1	M

Parthenocisus tricuspidata (S. et Z.) Planch.	1	M
Malvaceae		
Althaea rosea Cavanil	3	H
Hibiscus mutabilis L.	4	N
Hibiscus syriacus L.	3	M
Onagraceae		
Oenothera odorata Jacq.	3, 4	H
Lythraceae		
Lythrum anceps (Koehne) Makino	1	H
Theaceae		
Camellia japonica L.	3	M
Umbelliforae		
Ostericum stolonifera (Blume) DC.	4	H
Oleaceae		
Forsythia koreana Nakai	3, 4	N
Apocynaceae		
Trachelospermum asiaticum var. *intermedium* Nakai	1	M
Solanaceae		
Capsicum annuum L.	3	Th
Solanum nigrum L.	3	Th
Convolvulaceae		
Calystegia japonica (Thunb.) Chois.	5	H
Plantaginaceae		
Plantago asiatica L.	3, 4	H
Scrophulariaceae		
Veronica persica Poir.	1	H
Labiatae		
Salvia officinalia L.	4	H
Styracaceae		
Styrax japonica S. et Z.	1	M
Oleaceae		
Fraxinus rhynchophylla Hance	1	M
Compositae		
Ainsliaea acerifolia var. *elatior* Descourtils	3	Th
Ainsliaea priceps var. *orientalis*	3, 4	H
Aster subulatus Michx.	4	G
Aster koraiensis Nakai	4	G
Cosmos biqinnatus Cav.	3, 4	H
Eclipta prostrata L.	1	Th
Erigeron annuus (L.) Pers.	5	Th
Lactuca indica var. *laciniata* (O. Kuntze) Hara	4	Th
Taraxacum officinale Weber	4	Th
Taraxacum platycarpum H. Mazz.	4	Th

초록 : 부산광역시 온천변 식물상의 군집구조에 관한 연구

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군집구조란 군집에서 종 수와 이들 종 간 개체들의 분포 양상을 말한다. 본 연구는 다른 지점에서 생태학적 생물종다양성의 통계학적 방법으로 종이 임의로 분포하는지 평가하였다. 이를 위해 부산광역시 도심을 관류하는 온천천의 상, 중, 하류의 다섯 개의 지점을 선정하여 각 지점당 양쪽에 위치한 10개 정점에서 종수를 파악하였다. 95분류군(85종, 9변종, 1품종)이 온천천변에 분포하였다. 다섯 지점에 대해 종수는 유의하게 차이를 나타내었다 ($F=7.75$, $p<0.01$). Shannon-Wiener의 정보지수는 정점간 유의한 차이를 나타내었으며($F=4.12$, $p<0.05$), 지점 St. 1이 다른 지점(St. 2는 2.206, St. 3는 2.116, St. 4는 2.069, St. 5는 0.637)에 비해 가장 높았다(2.380). 풍부도 지수에서 R1값은 온천천의 상류에서 하류로 갈수록 낮았다. 공존하는 근연속내 식물종의 풍부도를 근연관계가 먼 그룹과 낮은 그룹 간 분석하는 새로운 군집구조 분석법을 시도하였다. 근연속과 그렇지 않은 속의 쌍 분포도에서 정점 간 유의한 차이를 역시 나타내었다. 축적값은 $x=0.85$일 때 가장 유의한 차이를 나타내었다.