Spatial Distribution Pattern of the Populations of *Cephalanthera erecta* at Mt. Ahop in Busan

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Cephalanthera erecta (Thunb. ex, Murray) is an herbaceous and a member of the genus *Cephalanthera* in the family Orchidaceae. The species is an herbaceous and has reputed Chinese medicinal value. It has been investigated the population density and spatial distribution of this species at Mt. Ahop in Korea during 2015. The spatial pattern of *C. erecta* was analyzed according to several patchiness indexes, population uniformity or aggregation under different sizes of plots by dispersion indices, and spatial autocorrelation. The mean crowding (M^*) and patchiness index (PAI) showed positive values except one small plot (2 m × 2 m). Most natural individuals of *C. erecta* for plots were not uniformly distributed in the forest community. The small plots (2 m × 2 m, to 8 m × 16 m) of *C. erecta* were uniformly distributed in the forest community and large plots (16 m × 16 m and 16 m × 32 m) were aggregately distributed. Significant aggregations by Moran's I of *C. erecta* were partially observed within IV classes (12 m). Dissimilarity among pairs of individuals could found by more than 18.0 m. In conclusion, the geographic distribution of *C. erecta* is not even with varying degrees of size of plots and human activities give rise to density effects in the plots at Mt. Ahop in Korea.

Key words : *Cephalanthera erecta*, Mt. Ahop, Moran's *I*, patchiness indexes, spatial distribution

Introduction

Plant survival and growth depend on local environments within a habitat [7, 11]. Spatial pattern (distribution of individuals in space) is an important characteristic of populations of sedentary organisms. Spatial configuration of suitable environments for plants is often patchily structured at various sizes within the habitat, like islands in a sea [22]. The spatial distribution pattern of plant populations exhibits scale dependence, e.g. a species may show an aggregated distribution at one spatial scale and may change to a random or uniform distribution at a different scale [12]. Botanists, ecologists, and population genetic researches have been interested in studying plant distribution patterns as they provide insight into the processes that facilitate diversification and speciation in plants and the factors that lead to reproductive isolation between closely related plant populations [25]. Many models of development of spatial patterns showed a trend of making regular distribution, when they were of nearly the same age and made densely closed canopy. Under their modeling assumptions they have shown that both random and aggregated spatial patterns of natural even-aged forest stands over time are preserved over time and a regular (lattice) spatial pattern tends to change into a random spatial pattern [13].

Analysis of the spatial distribution pattern of a plant population is helpful to determine the population's ecological preferences, biological characteristics and relationships with environmental factors [26]. Therefore, the analysis of the spatial distribution pattern of plant populations has always been a major focus for ecological research [2, 10].

Many ecologists have adopted several different major schools of spatial analysis from other disciplines [16]. The first of these comes from geography, and its methods include the use of statistics (e.g., Moran's *I*) to measure spatial autocorrelation [19]. It measures the extent to which the occurrence of an event in a real unit constrains, or makes more probable, the occurrence of an event in a neighboring areal unit.

Cephalanthera erecta (Thunb. ex, Murray) is an herbaceous and a member of the genus *Cephalanthera* in the family Orchidaceae. *C. erecta* is found in the far eastern Russia, Korea, Northern China, eastern Himalayas, Bhutan and

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Japan in open forests and thicket margins at elevations of 500 to 2,300 m. Several white flowers were occurred in May and June.

In this report, the several statistical tools of percentage distribution and population structure of the geographical areas are used to study the spatial distribution of *C. erecta* in Busan. Mt. Ahop locate in south of the Korean. A sample of a large (more than 330 individuals) natural population of *C. erecta* collected and was used in this study. It is expected to provide useful experimental conditions because of the large undisturbed and isolated site.

The purpose of this paper was to describe a statistical analysis for detecting a species association, which is valid even when the assumption of within- species spatial randomness is violated. The purpose of this study is addressed: is there a spatial structure within populations of *C. erecta?*

Materials and Methods

Study area

This study was carried out on the populations of *C. erecta*, located at Mt. Ahop (346.5 m) (35°16´ N/129°11´ E) in Busan-ci (Korea*)*. It has a temperate climate with a little hot and long summer. In this region the mean annual temperature is 14.7℃ with the maximum temperature being 29.4℃ in August and the minimum -0.6℃ in January. Mean annual precipitation is about 1519.1 mm with most rain falling period between June and August.

Sampling procedure

Many quadrats at Mt. Ahop were randomly chosen for each combination of site x habitat, so that, overall, 90 quadrats were sampled for the complete experiment.

Spatial ecologists use artificial sampling units (so-called quadrats) to determine abundance or density of species. The number of events per unit area are counted and divided by area of each square to get a measure of the intensity of each quadrat. I randomly located quadrates in each plot which I established populations. The quadrat sizes were 2 m × 2 m, 2 m × 4 m, 4 m × 4 m, 4 m × 8 m, 8 m × 8 m, 8 m × 16 m, 16 m × 16 m, and 16 m × 32 m. I mapped all plants to estimate *C. erecta* density per plot.

Index calculation and data analysis

The spatial pattern of *C. erecta* was analyzed according to the Neatest Neighbor Rule [3, 5] with Microsoft Excel 2014.

Average viewing distance (r_A) was calculated as follows:

$$r_A = \sum_{i=1}^{N} r_i / N \quad (i = 1, 2, 3 \dots N)$$

Where r_i is the distance from the individual to its nearest neighbor. N is the total number of individuals within the quadrat.

The expectation value of mean distance of individuals within a quadrat (r_B) was calculated as follows:

$$r_B = 1/2\sqrt{D}$$

Where D is population density and D is the number of individuals per plot size.

$$R = r_A / r_B$$

When $R > 1$, it is a uniform distribution, $R = 1$, it is a random distribution, $R < 1$, it is an aggregated distribution.

The significance index of the deviation of R that departs from the number of "1" is calculated from the following formula [15].

$$C_R = \frac{r_A - r_B}{\delta_{rB}}$$

$$\delta_{rB} = 0.2613/\sqrt{ND}$$

When $C_R > 1.96$, the level of the significance index of the deviation of R is 5%, and When $C_R > 2.58$, the level is 1%.

Many spatial dispersal parameters were calculated the degree of population aggregation under different sizes of plots by dispersion indices: index of clumping or the index of dispersion (*C*), aggregation index (*CI*), mean crowding (M*), patchiness index (PAI), negative binominal distribution index *K*, *Ca* indicators (*Ca* is the name of one index) [16] and Morisita index (*IM*) were calculated with Microsoft Excel 2014. The formulae are as follows:

Index of dispersion: $C = S^2/m$

Aggregation index $CI = \frac{S^2}{m} - 1$

Mean crowding $M^* = m + \frac{S^2}{m} - 1 = m + CI = m + C\text{-}1 - 1$

Patchiness index $PAI = \frac{m}{\frac{S^2}{m}-1} = \frac{M^*}{m}$

Aggregation intensity $PI = k = m^2/(S^2 - m)$

$$= \frac{m}{CI} = \frac{m}{C-1}$$

Ca indicators $Ca = 1/k$

$$IM = \frac{n\Sigma m(m-1)}{nm(nm-1)}$$

Where S^2 is variance and m is mean density of *C. erecta*.

When *C*, *M**, *PAI* > 1, it means aggregately distributed, when *C*, *M**, *PAI* < 1, it means uniformly distributed, when *CI*, *PA*, *Ca* > 0, it means aggregately distributed, and when *CI*, *PA*, *Ca* < 0 it means uniformly distributed.

The mean aggregation number to find the reason for the aggregation of *C. erecta* was calculated [1].

$$\delta = mr/2k$$

Where r is the value of chi-square when 2k is the degree of freedom and k is the aggregation intensity.

Green index (GI) is a modification of the index of cluster size that is independent of *n* [9].

Spatial structure

When a plant population or community is sampled, the samples have a spatial relationship with each other. To a certain extent, samples that are close to each other are more likely to be similar. Numerical simulations of previous analyses were performed to investigate the significant differences at various distance scales, i.e., 1.0 m, 1.5 m, 2.0 m, and so on. However, no significant population structure was found within the 3.0 m distance classes by means of Moran's *I*, and a significant population structure was revealed beyond 3.0 m. Thus, the distance classes are 0-3.0 m (class I), 3.0-6.0 m (class II), 6.0-9.0 m (class III), 9.0-12.0 m (class IV), 12.0-15.0 m (class V), 15.0-18.0 m (class VI), 18.0-21.0 m (class VII), 21.0-24.0 m (class VIII), 24.0-27.0 m (class IX), and 27.0-30.0 m (class IX).

The spatial structure was quantified by Moran's *I*, a coefficient of spatial autocorrelation (SA) [19]. As applied in this study, Moran's *I* quantifies the similarity of pairs of spatially adjacent individuals relative to the population sample as a whole. The value of *I* ranges between +1 (completely positive autocorrelation, i.e., paired individuals have identical values) and -1 (completely negative autocorrelation). Each plant was assigned a value depending on the presence or absence of a specific individual. If the *i*th plant was a homozygote for the individual of interest, the assigned pi value was 1, while if the individual was absent, the value 0 was assigned [20].

Pairs of sampled individuals were classified according to the Euclidian distance, dij, so that class k included dij satisfying k - 1 < dij < k + 1, where k ranges from 1 to 10. The interval for each distance class was 3.0 m. Moran's

I statistic for class k was calculated as follows:

$$I\ (k) = n\Sigma i \Sigma j(i \neq j)WijZiZj/S\Sigma Zi^2$$

where Zi is *pi* - p (p is the average of *pi*); Wij is 1 if the distance between the *i*th and *j*th plants is classified into class k; otherwise, Wij is 0; n is the number of all samples and S is the sum of Wij {$\Sigma i\Sigma j(i \neq j)$Wij} in class k. Under the randomization hypothesis, *I* (k) has the expected value u1 = -1/(n - 1) for all k. Its variance, u2, has been given, for example, in Sokal and Oden [19]. Thus, if an individual is randomly distributed for class k, the normalized *I* (k) for the standard normal deviation (SND) for the plant genotype, g (k) = {*I* (k) - u1}/u2$^{1/2}$, asymptotically has a standard normal distribution [4]. Hence, SND g(k) values exceeding 1.96, 2.58, and 3.27 are significant at the probability levels of 0.05, 0.01, and 0.001, respectively.

Results

The spatial pattern of individuals

Population densities (D) varied from 0.451 to 3.750, with a mean of 1.909 (Table 1). The values (*R*) of spatial distance (the rate of observed distance-to-expected distance) among the nearest individuals were higher than 1 and the significant index of CR was > 2.58. If by this parameter, the small plots (2 m × 2 m, 2 m × 4 m, 4 m × 4 m, 4 m × 8 m, 8 m x 8 m, and 8 m x 16 m) of *C. erecta* were uniformly distributed in the forest community (Table 1). However, *C. erecta* at Mt. Ahop were aggregately distributed in two large plots (16 m × 16 m and 16 m × 32 m).

The degree of population aggregation

The values dispersion index (*C*) at Mt. Ahop were lower at six plots (2 m × 2 m, 2 m × 4 m, 4 m × 4 m, 4 m × 8 m, 8 m × 8 m, and 8 m × 16 m) than 1 except two large

Table 1. Spatial patterns of *Cephalanthera erecta* individuals at different sampling quadrat sizes in Mt. Ahop

Quadrat size (m × m)	Density	R	CR	Distribution pattern
2 × 2	3.750	2.122	8.318	Uniform
2 × 4	3.125	3.097	20.064	Uniform
4 × 4	2.563	2.277	15.647	Uniform
4 × 8	2.031	1.640	9.878	Uniform
8 × 8	1.672	1.478	9.459	Uniform
8 × 16	1.055	1.218	4.838	Uniform
16 × 16	0.621	0.983	-0.406	Aggregation
16 × 32	0.451	0.759	-7.016	Aggregation

Table 2. Changes in gathering strength of *Cephalanthera erecta* at different sampling quadrat sizes

Quadrat size (m × m)	No. Quadrat	Aggregation indices						
		C	CI	M*	PAI	PI	Ca	IM
2 × 2	17	0.429	-0.575	-0.027	-0.050	-0.953	-1.050	-0.057
2 × 4	15	0.783	-0.217	0.659	0.753	-4.037	-0.248	0.788
4 × 4	10	0.791	-0.209	0.503	0.706	-3.408	-0.294	0.732
4 × 8	8	0.825	-0.175	0.349	0.665	- 2.989	-0.335	0.673
8 × 8	5	0.843	-0.157	0.414	0.725	-3.636	-0.275	0.737
8 × 16	3	0.894	-0.106	0.487	0.821	-5.594	-0.179	0.831
16 × 16	2	1.006	0.006	0.626	1.010	99.789	0.010	1.020
16 × 32	1	1.001	0.001	0.593	1.002	456.625	0.002	1.010

plots (Table 2). Thus these aggregation indices (*CI*) were negative at Mt. Ahop, which indicate a uniform distribution. Two large plots (16 m × 16 m and 16 m × 32 m) were positive. The mean crowding (*M**) and patchiness index (*PAI*) showed positive values except one small plot (2 m × 2 m). The three indices *C*, *M**, *PAI* were <1 and their values of *PI* and *Ca* except two plots were also shown smaller than zero, thus it means uniform distributed. In *C. erecta*, the two indices, *C*, *PAI* were >1 and their values of *PI* and *Ca* except four small plots were also shown greater than zero, thus it means aggregately distributed. Thus, most individuals of *C. erecta* at Mt. Ahop were clustered and the distribution pattern of the *C. erecta* was quadrat-sampling dependent. The values of δ were varied from 0.012 for 8 m × 16 m to 1.105 for 2 m × 2 m (Fig. 1).

Morisita index (*IM*) is related to the patchiness index (*PAI*) and showed an overly steep slope at the plot 16 m × 16 m in Mt. Ahop. When the area was smaller than 16 m × 16 m, the degree of aggregation increased significantly with increasing quadrat sizes, while the patchiness indices did not change from the plot 8 m × 16 m to 16 m × 32 m. Green index varied between -0.0008 to 0.0005 (Fig. 2).

Analysis of spatial autocorrelation

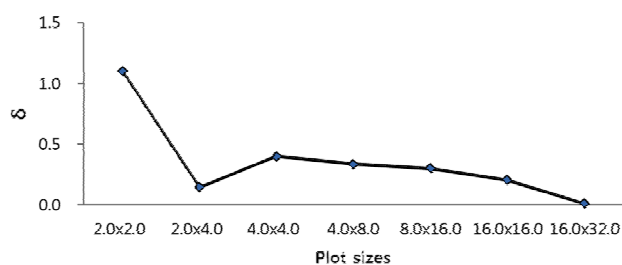The spatial autocoefficient, Moran's *I* is presented in

Table 3. Separate counts for each type of joined individuals and for each distance class of separation were tested for significant deviation from random expectations by calculating the SND. Moran's *I* of *C. erecta* significantly differed from the expected value in 7 of 10 cases (70%). Three of these values (30.0%) were negative, indicating a partial dissimilarity among pairs of individuals in the VIII distance classes (24 m). Four of the significant values (40.0%) were positive, indicating similarity among individuals in the first 4 distance classes (I~IV), i.e., pairs of individuals can separate by more than 15.0 m. Namely significant aggregations were partially observed within IV classes. As a matter of course, the negative SND values at classes VIII, IX and X. Thus, dissimilarity among pairs of individuals could found by more than 24.0 m.

The comparison of Moran's *I* values to a logistic regression indicated that a highly significant percentage of individual dispersion in *C. erecta* populations at Mt. Ahop could be explained by isolation by distance.

Discussion

Aggregated spatial patterns with even-aged forest stands over time are preserved over time and a regular (lattice) spatial pattern tends to change into a random spatial pattern

Fig. 1. The mean aggregation number to find the reason for the aggregation of *Cephalanthera erecta*.
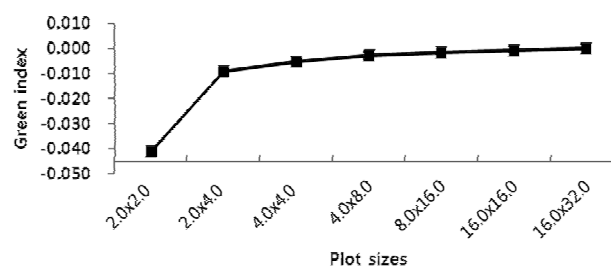

Fig. 2. The curves of patchiness in two areas of *Cephalanthera erecta* using values of Green index.

Table 3. Spatial autocorrelation coefficients (Moran's *I*) among plots of *Cephalanthera erecta* for ten distance classes

I	II	III	IV	V	VI	VII	VIII	IX	X
0.632[***]	0.539[***]	0.490[***]	0.326[**]	0.079	-0.013	-0.055	-0.218[*]	-0.365[**]	-0.707[***]

*: $p<0.05$, **: $p<0.01$, ***: $p<0.001$.

[13]. These results are given for a single generation of species and no new individuals are permitted to arise during the time of development. As a homogeneous area is considered, Mt. Ahop is as a relatively homogeneous area that differs from its surroundings. There is, however, a lot of field data indicating that even-aged population of trees, shrubs and herbs tend to decrease the intensity of aggregation in the course of self-thinning, being initially distributed in clumps [24] or tend to nearly regular distribution [17, 18].

When R = 1, it is a random distribution; R < 1, it is an aggregation; R > 1, it is a uniform distribution [15]. According to this rule, individuals within short distance plots of *C. erecta* at Mt. Ahop are uniform distribution (Table 1). According to dispersion indices of Llord [16], when *C*, *M**, *PAI* were > 1, it means aggregately distributed, when *C*, *M**, *PAI* were < 1, it means uniformly distributed. In addition to, when *CI*, *PI*, *Ca* were > 0, it means aggregately distributed, when *CI*, *PI*, *Ca* were < 0, it means uniformly distributed. The small plots (2 m × 2 m, 2 m × 4 m, 4 m × 4 m, 4 m × 8 m, 8 m × 8 m, and 8 m × 16 m) of *C. erecta* are not aggregately distributed (Table 2) and consistent with the Neatest Neighbor Rule [3, 15]. In only 2 large plots (16 m × 16 m and 16 m × 32 m), the three indices, *C*, *M**, *PAI* were >1, and the three indices, *CI*, *PI*, *Ca* were > 0, thus it means aggregately distributed. To find the reason for the aggregation at larger plots, the parameter δ was calculated. When δ > 2, the aggregation was mainly caused by both species characteristics and environmental factors [15]. When δ < 2, the aggregation was mainly caused by environmental factors. The values of δ were varied from 0.012 for 8 m × 16 m to 1.105 for 2 m × 2 m. Thus, aggregation of *C. erecta* populations at Mt. Ahop is mainly caused by the environmental factors. All plots had low δ < 2. I recognized that the important environmental factors might be considered competition, growth rate, little decomposition, light, and below-ground resources. The characteristics of the *C. erecta* concerned included primarily their life history, artificial disturbance, and population density. Life history theory seeks to understand the variation in traits such as growth rate, number and size of offspring and life span observed in nature, and to explain them as evolutionary adaptations to environmental conditions [21].

One result of spatial autocorrelation is that statistical tests performed give more apparently significant results than the data actually justify because the number of truly independent observations is smaller than the number used in the test [14, 23]. A significant positive value of Moran's *I* indicated that pairs of individuals separated by distances that fell within distance class IV had similar individuals, whereas a significant negative value indicated that they had dissimilar individuals (Table 3). The overall significance of individual correlograms was tested using Bonferroni's criteria. The results revealed that patchiness similarity was shared among individuals within up to a scale of a 12.0 m~15.0 m distance. Thus it was looked for the presence of dispersion correlations between neighbors at this scale.

In many real populations, there may not be any obvious individual populations or substructure at all, and the populations are continuous. The results from this study are consistent with the supposition that a plant population is subdivided into local demes, or neighborhoods of related individuals [5, 8]. Spatially distributed genetic populations that compete locally for resources and mate only with sufficiently close neighbors, may give rise to spontaneous pattern formation [6].

References

1. Arbous, A. G. and Kerrich, J. E. 1951. Accident statistics and the concept of accident proneness. *Biometrics* **7**, 340-342.
2. Baskent, E. Z. and Keles, S. 2005. Spatial forest planning: a review. *Ecolo. Modell.* **188**, 145-173.
3. Clark, P. J. and Evans, F. C. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. *Ecology* **35**, 445-453.
4. Cliff, A. D. and Ord, J. K. 1971. *Spatial autocorrelation*. Pion, London.
5. Ehrlich, P. R. and Raven, P. H. 1969. Differentiation of populations. *Science* **165**, 1228-1232.
6. Epperson, B. K., Chung, M. G. and Telewski, F. W. 2003. Spatial pattern variation in a contact zone of *Pinus ponderosa* and *P. arizonica* (Pinaceae). *Am. J. Bot.* **90**, 25-31.
7. Farley, R. A. and Fitter, A. H. 1999. Temporal and spatial variation in soil resources in a deciduous woodland. *J. Ecol.*

87, 688-696.

8. Garnier, L. K. M., Durand, J. and Dajoz, I. 2002. Limited seed dispersal and microspatial population structure of an agamospermous grass of West African savannahs. *Hyparrhenia diplandra* (Poaceae). *Am. J. Bot.* **89,** 1785-1791.

9. Green, R. H. 1966. Measurement of non-randomness in spatial distributions. *Res. Pop. Ecol.* **8,** 1-7.

10. Haase, P. 1995. Spatial pattern analysis in ecology based on Ripley's K-function: introduction and methods of edge correction. *J. Veg. Sci.* **6,** 575-582.

11. Huh, M. K. 2015. Spatial distribution pattern of the populations of *Carex siderosticta* at Mt. Geumjeong and Mt. Ahop. *J. Life Sci.* **25,** 369-375.

12. Kang, M. K and Huh, M. K. 2014. Spatial distribution pattern of the populations of *Camellia japonica* in Busan. *J. Life Sci.* **24,** 813-819.

13. Leps, J. and Kindlmann, P. 1987. Models of the development of spatial pattern of an even-aged plant population over time. *Ecol. Modell.* **39,** 45-57.

14. Legendre, P. 1993. Spatial autocorrelation: trouble or new paradigm? *Ecology* **74,** 1659-1673.

15. Lian, X., Jiang, Z., Ping, X., Tang, S., Bi, J. and Li, C. 2012. Spatial distribution pattern of the steppe toad-headed lizard (*Phrynocephalus frontalis*) and its influencing factors. *Asian Herpet. Res.* **3,** 46-51.

16. Lloyd, M. 1967. Mean crowding. *J. Ani. Ecol.* **36,** 1-30.

17. Phillips, D. L. and MacMahon, J. A. 1981. Competition and spacing patterns in desert shrubs. *J. Ecol.* **69,** 97-115.

18. Prach, K. 1981. Selected ecological characteristics of shrubby successional stages on abandoned fields in the Bohemian Karst. *Preslia* **53,** 159-169

19. Sokal, R. R. and Oden, N. L. 1978a. Spatial autocorrelation in biology 1. Methodology. *Biol. J. Lin. Soc.* **10,** 199-228.

20. Sokal, R. R. and Oden, N. L. 1978b. Spatial autocorrelation in biology 2. Some biological implications and four applications of evolutionary and ecological interest. *Biol. J. Lin. Soc.* **10,** 229-249.

21. Souza, A. F. and Martins, F. R. 2004. Microsite specialization and spatial distribution of *Geonoma brevispatha*, a clonal palm in south-eastern Brazil. *Ecol. Res.* **19,** 521-532.

22. Suzuki, R. O., Sujuki, J. I. and Kachi, N. 2005. Change in spatial distribution patterns of a biennial plant between growth stages and generations in a patchy habitat. *Ann. Bot.* **96,** 1009-1017.

23. Thomson, J. D., Weiblen, G., Thomson, B. A., Alfaro, S. and Legendre, P. 1996. Untangling multiple factors in spatial distribution: lilies, gophers, and rocks. *Ecology* **77,** 1698-1715.

24. Williams, D. G., Anderson, D. J. and Slater, K. R. 1978. The influence of sheep on pattern and process in *Atriplex oesicaria* populations from the Riverine Plain of New South Wales. *Aust. J. Bot.* **26,** 381-392.

25. Woodward, F. I. 1987. Climate and plant distribution. Cambridge Univ. Press, Cambridge, UK.

26. Zhang, Y. T., Li, J. M., Chang, S. L., Li, X. and Lu, J. J. 2012. Spatial distribution pattern of *Picea schrenkiana* population in the Middle Tianshan Mountains and the relationship with topographic attributes. *J. Arid Land* **4,** 457-468.

초록 : 부산시 아홉산의 은난초 집단의 공간적 분포 양상

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　　은난초(*Cephalanthera erecta*)는 난초과 은대난초속 초본이며 약용으로 쓰인다. 부산광역시 기장군 아홉산에서 은난초 식물 집단에 대해 개체군의 밀도와 공간분석을 실시하였다. 은난초의 공간적 분석은 여러 공간 분석 패치 척도를 사용하여 집단의 균질한 분포와 응집이 플롯의 크기에 따라 차이가 발생하는지 조사하였으며, 플롯의 크기에 따른 공관적 상관 분석을 실시하였다. 평균 운집 정도(*M**)와 패치 지수(*PAI*)는 가장 작은 플롯(2 m × 2 m)을 제외하고는 양의 값을 나타내었다. 많은 플롯에서 은난초의 개체들은 숲 군집 내 일정하게 분포하지 않았다. 작은 플롯(2 m × 2 m, to 8 m × 16 m) 내 은난초 군락은 숲 군집에서 일정하게 분포하고 있었지만, 큰 플롯(16 m × 16 m, 16 m × 32 m)에서는 은난초 군락에서 개체들의 응집이 발생하고 있었다. 공간적 상관관계 분석을 위해 Moran's *I* 척도를 이용한 결과 개체들의 응집은 등급 IV (12 m) 내에서 일어났다. 은난초 개체들은 18.0 m 이상 거리가 이격되면 이질성이 발생하였다. 결론적으로 한국 내 아홉산 집단에서 은난초의 지리적 분포는 플롯의 크기에 따라 변하며, 패치(patchy)구조를 보이며 패치의 크기는 인간의 활동에 의해서 밀도 효과를 유발한 것으로 판단되었다.