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DISPERSION OF HIGH DENSITY ANT POPULATIONS IN SANDY SOIL GRASSLAND ECOSYSTEMS

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Abstract

Dispersion of five ant populations was analysed on two grasslands, *Potentillo-Festucetum pseudovinae* and *Cynodonti-Poëtum angustifoliae* in Kiskunság National Park, Hungary. In contradiction to the results of estimating methods it was proved by Pielou's method being very useful for ant populations that in the case of the populations investigated the unit value of $s^2/\bar{x}$ doesn't mean a random dispersion.

Introduction

Many ecologists agree that the dispersion is one of the most important characteristics of the population-space relation. While density means the quantitative aspect of this relation, i.e. how many individuals or in the case of ants how many calies are in a unit of space, dispersion is a qualitative characteristic and it gives a lot of important information on populations such as presence or absence of competition within populations; ethological conditions of populations; homogeneity of environment; changes taking place in the environment etc. The knowledge of dispersion type is essential from the point of view of sampling method, as well.

Several methods were published for describing and identifying types of dispersion. BALOGH (1953) distinguished six types on the grounds of homogeneity of distribution and the size of animals. He numerically marked the homogeneity of dispersion by the "index of homogeneity":

$$H = \frac{n}{\sum x_i} \cdot 100 \tag{1}$$

where n is the number of samples; x the total number of individuals. The only condition of the application of this index is that samples should be as large as the minimiareal of population.

SCHWERDTFEGER (1968) distinguishes linear, horizontal, vertical and spatial dispersions. In practice only the horizontal types are used. Schwerdtfeger's horizontal dispersion types are: äqual, inäqual, cumular and insular. Analysing the types of dispersion the third and fourth types (cumular and insular) are usually drawn together, as two states of a cumular tendency and so three of dispersion types are used: (1) uniform (=äqual); (2) clumping (=cumular+insular) and (3) random (=inäqual).

For identifying the types the following methods are generally used:

(1) Index of dispersion:

$$V = \frac{s^2}{\bar{x}} \tag{2}$$

where s^2 is the variance of samples; $\bar{x}$ average density per sample. The theoretical basis of this index is that the variance of Poisson distribution regarded as a mathematical model of random dispersion is equal to mean, so if $V=1$ the dispersion is random, if $V>1$, clumping and if $V<1$, uniform.

(2) χ^2 test of the index V:

$$\chi^2 = \frac{s^2}{\bar{x}}(N-1) \tag{3}$$

where N is the number of samples (SOUTHWOOD, 1966). The basis of this method is that the form of the index of dispersion

$$V = \frac{\sum(\bar{x}_i - \bar{x})^2}{\sum x_i}$$

and the form of $\varkappa^2$ test

$$\varkappa^2 = \frac{(\mathrm{E}_i - \mathrm{o}_i)^2}{\mathrm{E}_i} \tag{4}$$

are similar and so V index presumably follows $\varkappa^2$ distribution.

(3) The "mean crowding" suggested by LLOYD (1967) is one of the important characteristics of populations:

$$\overset{*}{x} = \frac{\sum x_i(x_i - 1)}{\sum x_i} = \frac{\sum x_i^2}{\sum x_i} - 1 \tag{5}$$

Replacing this with the formulae of variance and mean:

$$\overset{*}{x} = \bar{x} + \frac{s^2}{\bar{x}} - 1 \tag{6}$$

On this basis Lloyd (1967) suggested the ratio $\overset{*}{x}/\bar{x}$, so called patchiness, to be a measure of dispersion.

(4) Fitting to the Poisson distribution by $\varkappa^2$ test basing on the samples taken (ANDREWARTHA, 1961, GALLÉ, 1973). If the result of this test isn't positive significantly, the type of dispersion of the population is identified from the value of index V or fitting tests to positive or negative bionomial distributions.

(5) The "k" of negative bionomial

$$k = \frac{\bar{x}^2}{s^2 - \bar{x}} \tag{7}$$

is used as a measure of aggregation of clumping dispersion, but its limits have recently been shown by TAYLOR et al. (1979).

(6) Among the "nearest neighbour points" methods mostly used in plant ecology, one of the simplest is the CLARK's and EVANS' (1954)

$$\bar{x} = \frac{1}{4r^2} \quad (8)$$

where $\bar{x}$ is the density per unit area, $\bar{r}$ is the average distance between neighbour points. According to WALOFF and BLACKITH (1962) the dispersion is random if $r^2=0,25/\bar{x}$, and in the case of uniform-hexagonal dispersion r^2 was $1,154/\bar{x}$ on the population of *Lasius flavus F.*

(7) PIELOU (1969, 1974) has shown the mistake of these estimating methods: the unit value of σ^2/m is a characteristic of the Poisson series but not exclusively. Pielou's method based on nearest neighbour technique and fitting test is very useful to investigate the dispersion of ant populations because micromaps of sedentary ant nests can easily be made for further analysis. Pielou's method is based upon the equation:

$$F(r)=Pr \text{ (distance to nearest neighbour } \leqq r).$$

This means the probability that a circle of radius r centered on a randomly selected point will contain at least one individual. Therefore

$$F(r) = 1-e^{-mr^2} \quad (9)$$

where m denotes the mean number of individuals (nests) per circle. The fitting of data to the Poisson series can be tested by $\varkappa^2$ test in this case, too (PIELOU, 1974).

Among the works dealing with the dispersion of ant populations (TALBOT, 1943, 1954; BRIAN, 1956, WALOFF and BLACKITH, 1962; BARONI—URBANI, 1969; PETAL, 1972; GALLÉ, 1975, 1978) there are some in which it is shown that the dispersion of ant populations has a density dependent property (BRIAN, 1965; GALLÉ, 1975, 1978). When density is increasing the dispersion index is inversely proportional to density crosses decreasing from $V>1$ to $V<1$ (GALLÉ, 1975).

The basic hypothesis of the present paper is that the dispersion of ant populations is not random even in the temporary cases when $V\simeq 1$. Studying this problem it is also a purpose to investigate the applicability of indices based on estimation.

Methods

Samples were taken in two grasslands, sandy soil *Potentillo-Festucetum pseudovinae* (Bugacpuszta) and *Cynodonti-Poëtum angustifoliae* (near Tőserdő) with harder soil. Both of them are in the Kiskunság National Park.

Samples were contagious with size of one sq.m. One pattern consists of 20—39 samples. Since samples were dig up, all nests hidden in the soil were discovered. Therefore the density values got in this way are considerably higher than those published in the literature based only on the investigation of surface of soil.

Evaluating the data the following characteristics were estimated: density per 4 sq. m. ($\bar{x}$/4 m^2); density per sq. m. (x/m^2); index of dispersion (V); and its $\varkappa^2$ test ($\varkappa_v^2$). For Pielou's method micromaps were made on the position of nests and 50—50 points were chosen in a random way on them. The $\varkappa^2$ analysis was based on the number of ant colonies or nests being in the circles of „r" radius drawn from the points as centres. These $\varkappa^2$ values are marked $\varkappa_m^2$.

Results

In plant association *Potentillo-Festucetum pseudovinae*, in the research area of Zoological Department of Attila József University it was possible to identificate the dispersion of the nests of *Lasius alienus* FÖRST. and *Plagiolepsis vindononensis* LOMN.

Data of *Lasius alienus* population:

$$\bar{x}/4\,\mathrm{m}^2 = 4{,}4$$
$$s^2 = 2{,}3$$
$$V = 0{,}52$$
$$\chi^2_v = 2{,}09 \text{ on this basis } P_{RA} = +$$
$$\overset{*}{x} = 3.92$$
$$\overset{*}{x}/\bar{x} = 0{,}89$$
$$\chi^2_m = 12{,}87 \text{ on this basis } P_{RA} < 0{,}05$$

As it can be seen on the basis of χ^2_v test, the probability of RA (random) dispersion can't be excluded, although a uniform dispersion is more probable owing to the value of V being smaller than unit and values of mean crowding and patchiness. The probability of RA dispersion can significantly be rejected on the basis of micromapping method. In this respect there is a contradiction between χ^2_v and micromapping method.

Ecological data of population of *Plagiolepis vidobonensis:*

$$\bar{x}/4\,\mathrm{m}^2 = 1{,}2$$
$$s^2 = 1{,}2$$
$$V = 1{,}0$$
$$\chi^2_v = 4{,}0 \text{ on this basis } P_{RA} = +$$
$$\overset{*}{x} = 1{,}2$$
$$\overset{*}{x}/\bar{x} = 1{,}0$$
$$\chi^2_m = 12{,}87 \text{ on this basis } P_{RA} < 0{,}05$$

The estimating methods (V, χ^2_v, $\overset{*}{x}/\bar{x}$) support a random dispersion without doubt, but it must be rejected according to the micromapping method.

For analysing the dispersion of *Formica cunicularia* LATR., I investigated an area of several hundred sq. m., the number of nests was estimated and a micromap was made. The data of population:

$$\bar{x} = 0{,}14$$
$$s^2 = 0{,}12$$
$$V = 0{,}88$$
$$\chi^2_v = 35{,}80 \text{ on this basis } P_{RA} = +$$
$$\overset{*}{x} = 0{,}02$$
$$\overset{*}{x}/\bar{x} = 0{,}14$$

on the basis of χ^2_m $P_{RA} > 0{,}80$.

The V and patchiness are contradictory. The type of dispersion is random without doubt on the basis of micromapping analysis. Random dispersion is interesting in the case of *Serviformica* population with a relatively high density because the aggressive behaviour and probably also the ability for competition are very strong within the population.

On the basis of samples taken in a *Cynodonti-Poëtum* grass association near Tőserdő the dispersion analysis of *Tetramorium caespitum* L., *Diplorhoptrum fugax* LATR. and *Plagiolepis vindobonensis* can be made.

Characteristics of *Tetramorium caespitum* population:

$$\bar{x}/4\,m^2 = 1{,}4$$
$$\bar{x}/m^2 = 0{,}35$$
$$s^2 = 0{,}70$$
$$V = 0{,}50$$
$$\chi^2_v = 2{,}33 \text{ on this basis } P_{RA} = +$$
$$\overset{*}{x} = 0{,}98$$
$$\overset{*}{x}/\bar{x} = 0{,}70$$
$$\chi^2_m = 28{,}07 \text{ on this basis } P_{RA} < 0{,}001$$

The dispersion of this very dense population is uniform according to all indices.

Diplorhoptrum fugax:

$$\bar{x}/4\,m^2 = 2{,}4$$
$$\bar{x}/m^2 = 0{,}6$$
$$s^2 = 1{,}3$$
$$V = 0{,}54$$
$$\chi^2_v = 2{,}16 \text{ on this basis } P_{RA} = +$$
$$\overset{*}{x} = 1{,}94$$
$$\overset{*}{x}/\bar{x} = 0{,}80$$
$$\chi^2_m = 24{,}53 \text{ on this basis } P_{RA} < 0{,}01$$

Plagiolepis vindobonensis:

$$\bar{x} = 1{,}8$$
$$\bar{x}/m^2 = 0{,}45$$
$$s^2 = 1{,}70$$
$$V = 0{,}97$$
$$\chi^2_v = 3{,}77$$
$$\overset{*}{x} = 1{,}74$$
$$\overset{*}{x}/\bar{x} = 0{,}96$$
$$\chi^2_m = 7{,}39 \text{ on this basis } P_{RA} = 0{,}2-0{,}3$$

In opposition to χ^2_v test on the basis of χ^2_m random dispersion can be rejected significantly on the populations of *Tetramorium caespitum* and *Diplorhoptrum fugax* and most likely on *Plagiolepis vidobonensis*.

Discussion

The density dependent character of dispersion is doubtless. When dispersion is changing from clumping to uniform type, a homogeneous or nearly homogeneous environment is most suitable to study the case when $V \sim 1$. From the grasslands studied *Cynodonti-Poëtum angustifoliae* meets this requirement. *Potentillo-Festucetum* covers relatively homogeneous parts of an inhomogeneous sandy soil grassland. This homogeneous level is dissected by wind furrows with fragment of *Schoenetum nigricantis* and *Molinio-Salicetum* grass assotiations. In these furrows *Lasius alienus* is replaced by small and isolated populations of *Lasius niger* L. If random samples had been taken from the whole area, it would have resulted clumping dispersion for both *alienus* and *niger* populations because randomly situated samples result in a clumping dispersion for both clumping population and its complement (PIELOU, 1969). This is true for the population of *Plagiolepis vindobonensis*, as well, on which wind furrows cause "holes". In these cases clumping dispersion is caused by the inhomogeneity of environment. The populations of low density are also in a similar situation: a population can survive at those points of an area having unfavourable conditions for it, where conditions are relatively favourable. On these places clumps are formed within that there is a minimal distance between nests. In space going to a place more favourable for the population in question, the number and size of clumps are increasing and at last they cover the whole area and the dispersion type of population becomes uniform (GALLÉ, 1975). So the population has a well-defined, organized structure in space all the time and the nests aren't situated randomly. Results of the present paper show that only Pielou's micromapping method is sufficient to test that property, while on the basis of estimating methods (V, patchiness) we get random dispersion in all cases when $V \simeq 1$.

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