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STUDY OF ANT-POPULATIONS IN VARIOUS GRASSLAND ECOSYSTEMS

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As regards the numbers of species and individuals, the mesophilous and xerophilous, moderately bound and loose-soiled grassland ecosystems, meadow land and pastures of the Great Hungarian Plain are in general rich insect-habitats. In the soil of these associations the density of the ant-nests too is high, and higher than in other plant ecosystems of different structures; for this reason they are particularly suitable for the study of ant-populations. The present paper reports investigations made during the seven years 1965—1971. The aim of the investigations was to establish the characteristic ant-species of plant ecosystem types, and the factors regulating their populations.

Methods and Materials

The samples were taken from 15 different habitats, on the basis of the zoogeographical atlas of MÓCZÁR L., from the Eupannonicum, in part from sandy pastures and clearings of the area between the Tisza and the Danube (Ásotthalom, Sasheverő, Balotapuszta), in part from the sides of the Tisza embankment, from the plant ecosystems *Alopecuretum pratensis* typicum *Arrhenatherum* facies, *poetosum angustifoliae, ranunculetosum acris Rumex* facies, *festucetosum pseudovinae; Cynodonti-Poëtum angustifoliae alopecuretosum; Salvio-Festucetum sulcatae; Astragalo-Festucetum sulcatae salicetosum rosmarinifoliae Stipa capillata* facies; and *Festucetum vaginatae salicetosum rosmarinifoliae* (BODROGKÖZY, 1957; 1966; 1968).

A total of 960 nests were sampled, and a study was made of 3191 individuals collected from these and from small squares, and a further 10,954 individuals collected on traps.

There are two important characteristics of ant-populations: (1) the number and distribution of the nests, and (2) the number and dispersion of the individuals. 1—9 m^2 squares were used to determine the density of the nests, the area of the squares being dug up in all cases. For the determination of the number of individuals per unit area, 625 cm^2 squares were sampled. Sugar-baited soil-traps were also used. It emerged during the sampling that the variation per square of the nests was the least, and thus the square-method for the nests was comparatively the most accurate. The dispersion of the individual number was less even, clearly because of this general organization in colonies, while the traps were not suitable for obtaining population-estimation samples. According to BRIAN (1964), the number of traps occupied by the ants in unit time can be described by an exponential equation. The results of the present investigations indicate that this number depends strongly on the temperature too; the bait-method is suitable for the determination of the relation between the feeding activity and the temperature, if the ants are also able to leave the buried plastic traps containing the bait.

Results and discussion

1. Factors stabilizing the population and determining the density of the nests

As regards the biotic factors stabilizing the population, a study was made of the effects of the interaction of the individuals and the nests.

Because of the colonialization, the ant individuals characteristically exhibit a „clumping form" dispersion (MC ARTHUR, CONNELL, 1967); the individual clumps are naturally indicative of the colonies and, as is well known, within the colony there is no competition. On the other hand, the intraspecific struggle for survival between the nests and colonies is more considerable that the interspecific interaction. This was proved by PONTIN (1961, 1963), who studied the interactions of populations of *Lasius niger* and *Lasius flavus*, primarily on the basis of the effect on the female production. Confirmation of this is provided by the situations of the colonies belonging to one species, in so far as the „orchard-like pattern form" dispersion (MCARTHUR, CONELL, 1967) is general in the relation of the colonies, and this presupposes competition between the neighbouring colonies. Such a feature of the dispersion of the colonies can also be shown numerically by means of the index

$$K = \frac{\sum_{i=0}^{n} z_i + x_i}{\sum_{i=0}^{n} x_i} \cdot \frac{1}{n \cdot c} \cdot \sum_{i=0}^{n} \frac{x_i(x_i - 1)}{z_i + 1}$$

where x_i is the number of nests or individuals of the species examined in the given square, z_i is the total number of other nests or individuals in the i-th square, n is the number of squares, and c is the constancy of the species (1—5). If the value of K is large (>3), then the competition between the neighbouring nests or individuals belonging to one species is very small (clumping form), while if $K < 3$ then the rivalry between the individuals or nests of the given species is greater than the interspecific competition towards individuals or nests of the other species (orchard-like). The K values are given in Table II. It can be seen that the value of K for the nests is < 1, and thus the uniform, orchard dispersion is very characteristic, while in all cases the K values of the individuals well known to form clumps, and used as controll, ware greater than three.

Of the abiotic factors regulating the ant-populations, measurements were made of the soil-temperature (important as regards the terricolous species), the turf-level temperature, the soil water-content, and the humidity (or evaporation). The factors mentioned affect the occurrence and the numbers of the species of a given habitat. Table III gives a correlation between the nest-density for various ant-species and some microclimatic factors. The data were obtained in the Middle Tisza region in 1970, and near Hódmezővásárhely on the southern part of the Great Hungarian Plain in 1971, at the same time in the two years on several biotopes of differing environmental effect. The minor differences between the coefficients for the two years can in part be explained by the differing bioclimatic indexes of the two regions: $I_{\text{Middle Tisza}} = 1.097$, and $I_{\text{Southern Great Plain}} = 1.227$, the difference being more than 10%. The

Table I

species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ponera coarctata LATR.	+	+	+				+	+	+						
Myrmica sulcinodis NYL.							+		+						
Myrmica scabrinodis NYL.			+	+											
Myrmica rugulosoides FOR.	+	+		+	+		+								
Myrmica sancta KARAW.							+		+						
Myrmica lobicornis NYL.		+													
Messor structor LATR.									+						
Solenopsis fugax LATR.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Myrmecina graminicola LATR.										+					
Leptothorax t. unifasciata LATR.												+	+		
Tetramorium caespitum LATR.	+	+	+	+					+	+	+	+			+
Tapinoma erraticum LATR.	+	+									+	+			
Plagiolepis pygmaea LATR.												+			
Plagiolepis vindobonensis LOMN.				+	+				+	+	+	+	+	+	+
Camponotus lateralis piceus LEACH.			+		+	+			+						+
Camponotus aethiops LATR.	+														
Camponotus c. fallax NYL.	+														
Lasius niger L.	+	+	+		+	+	+	+		+				+	
Lasius alienus FÖRST.						+		+	+	+		+	+	+	
Lasius emarginatus OL.												+	+		
Lasius flavus F.	+	+				+	+	+	+	+					
Lasius mixtus NYL.	+														
Lasius umbratus NYL.					+										
Lasius affinis SCHENCK.			+				+								
Cataglyphis c. aenescens LATR.													+		
Formica gagates LATR.				+											
Formica fusca L.	+		+												
Formica f. glebaria NYL.		+													
Formica rufibarbis F.	+	+	+		+	+									+
Formica cunicularia LATR.							+	+	+	+	+				
Formica sanguinea LATR.						+								+	
Formica rufa L.			+												
Formica pratensis RETZ.		+													
Polyergus rufescens LATR.	+	+	+												

Alopecuretum pratensis typicume: 5, 7; ranunculetosum: 1, 3, 6, 8; festucetosum: 2, 4, 11. Cynodonti—Poëtum angustifoliae: 6, 14; festucetosum: 15. Salvio—Festucetum sulcatae: 9, 10. Astragalo—Festucetum sulcatae: 12. Festucetum vaginatae salicetosum: 13.

numerical values of the coefficients show that with regard to the habitats examined *Lasius niger* is a species requiring less heat, and orients preferably towards the layers of wetter soil; *Myrmica sancta* is similar; *Plagiolepis vindobonensis* preferably lives with a greater abundance in the drier regions which heat up more readily; *Tetramorium caespitum* favours warmth (it exhibits a close positive relation with all the temperature values); the requirements of *Lasius alienus* for the water-content of the soil are much lower than those of

Table II

species	K_1	K_2
Myrmica sulcinodis NYL.	21.446	—
Solenopsis fugax LATR.	—	0.354
Tetramorium caespitum LAT.	4.202	0.673
Plag. vindobonensis LOMN.	3.215	0.526
Lasius niger L.	22.751	0.072
Lasius alienus FÖRST.	52.149	0.386

K_1 = K index values for the individuals;

K_2 = K index values for the colonies;

Measurements were not made for the values $K\,1_{Solenopsis}$ and $K\,2_{Myrmica}$

Lasius niger ($C_{Lasius\ alienus\ water\ content} = -0.987$), but it is less heat-demanding than *Tetramorium. Solenopsis fugax* is the ant-species occurring in greatest abundance in mesophilous grassland; the values of the coefficients too show that it is of wide ecological amplitude, and none of the factors investigated affect its spread significantly.

Table III

species (1970)	1	2	3	4
Myrmica sulcinodis NYL.	+0.132	−0.409	+0.276	−0.605
Solenopsis fugax LATR.	+0.090	+0.230	+0.488	−0.986
Tetramorium caespitum LATR.	+0.895	+0.868	+0.785	+0.129
Lasius niger L.	−0.645	−0.280	−0.908	+0.681
Lasius alienus FÖRST.	+0.092	+0.234	+0.498	−0.987
Lasius flavus F.	+0.049	−0.149	+0.131	−0.406
Plagiolepis vindobonensis LOMN.	+0.056	+0.197	+0.510	−0.687
species (1971)	1	2	3	4
Myrmica sancta KARAW.	+0.525	−0.115	−0.194	+0.801
Solenopsis fugax LATR.	+0.373	−0.006	+0.189	−0.144
Tetramorium caespitum LATR.	+0.908	+0.643	−0.708	−0.5316
Plagiolepis vindobonensis LOMN.	+0.463	+0.447	−0.985	−0.033
Lasius niger L.	−0.908	−0.486	+0.764	+0.529

1: temperature of turf-level;

2: temperature of soil;

3: evaporation (1970), humidity (1971);

4: soil water-content.

2. Feeding activity and its relation with the temperature

The use of sugar-baited traps permitted the measurement of the feeding activities of sugar-eating species. The sugar was put into plastic vessels so designed that the ants would not be confined but could freely leave the bait.

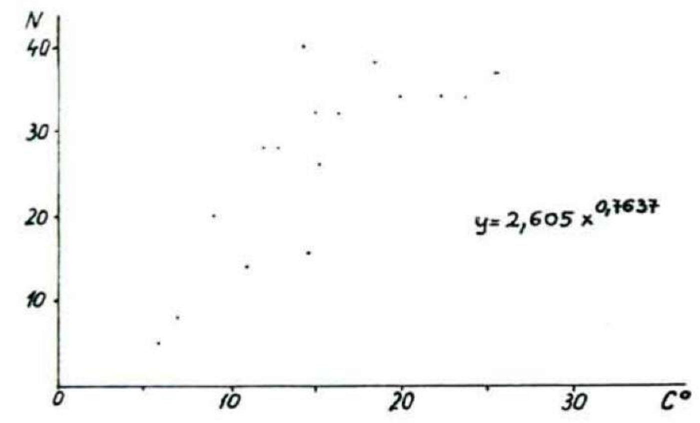

Figure 1. Relation between the food-seeking activity of *Lasius niger* and the temperature. N = the number of sugar-baited traps occupied. The relation is approximated to by the expression $y = 2.605\ x^{0.7637}$.

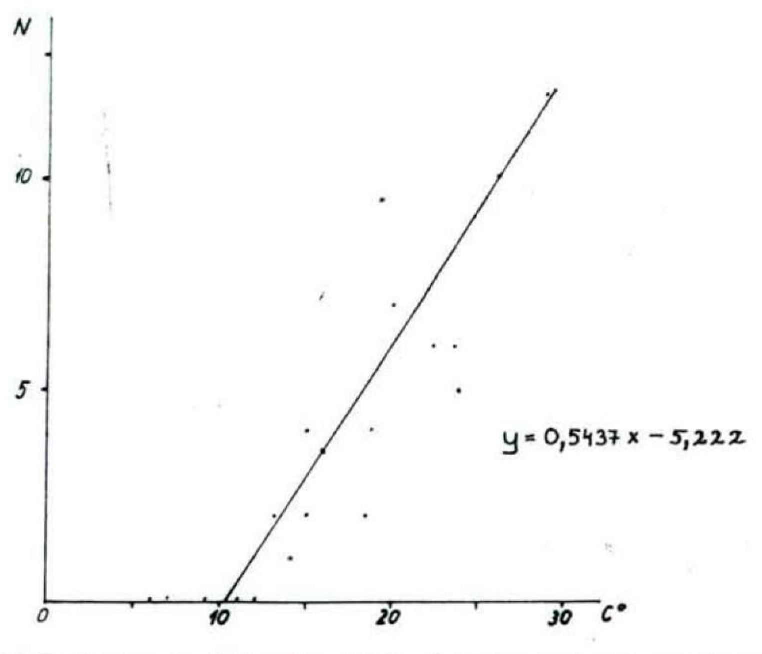

Figure 2. Relation between the food-seeking activity of *Formica cunicularia* and the temperature. The equation of the regression line is $y = 0.5437x - 5.222$.

The effects of the conditions affecting the movements of the ants, their seeking for food, and their feeding activity can be measured via the number of traps occupied, and the numbers of ants per trap.

The studies were carried out on the species *Formica cunicularia* and *Lasius niger* in 1969, 1970 and 1971, with 60 traps put out in a *Cynodonti-Poëtum angustifoliae* grassland ecosystem near Szeged. The traps were left out for several months, and observations connected with the microclimatic examination were made weekly. From the factors studied, the occupation of the traps depends most of all on the temperature, while the results indicate that the effects of humidity and soil-moisture are not important, and do not cause significant differences.

As can be seen from Figure 1, the relation between the feeding activity of *Lasius niger* and the temperature is not linear, but is better approximated to by the expression

$$y = 2.605\ x^{0.763}.$$

The relation between the number of traps occupied by *Formica cunicularia* and the temperature is linear (Fig. 2), the regression equation being

$$y = 0.5437x - 5.222.$$

3. Characteristic ant-species of plant communities

The grasslands of various milieux also differ with regard to the plant communities. The various regions of the milieu-spectrum of the environmental factors can each be characterized by different plant-associations. This environmental spectrum-effect is also expressed in the compositions of the ant-groups. The ant-species occurring in the individual ecosystems can be found from Table I, and the factors affecting the extents of the species from the correlation Table. On the basis of these, the most important, constant-dominant species of the various ecosystems are the following:

(i) The polytype of the water-content of the substrate and medium, and at the same time the oligotype of the temperature, are represented by *Alopecuretum pratensis*. Its ants fall into the euryoecical hylophilous — hypereuryoecical intermediary range: *Lasius niger, Formica fusca, Myrmica* species, and rarely *Formica cunicularia*.

(ii) The mesotype is in all respects indicated by *Cynodonti—Poëtum angustifoliae* and *Salvio—Festucetum sulcatae*, while as regards moisture the lower limit of the mesotype is indicated by the *Astragalo—Festucetum* associations. Their ant-species fall into the intermediary — euryoecical eremophilous range: *Lasius alienus, Formica fusca glebaria, Formica cunicularia, Formica rufibarbis, Tapinoma erraticum, Plagiolepis vindobonensis, Camponotus lateralis piceus*, and even *Lasius niger* in places with damper soil.

(iii) With regard to the water-saturation of the soil and the air, the oligotype and the polytype of the temperature are represented by *Festucetum vaginatae* ecosystems which in general have a lower over all total cover. As a characteristic sandy grassland it can also be classified in the oligotype as regards the binding of the soil. Its ant-fauna is euryoecical eremophilous —

stenooecical eremophilous: the overwhelmingly predominant species are *Lasius emarginatus*, *Plagiolepis vindobonensis* and *Cataglyphis cursor aenescens*.

(iv) The weed ecosystems of similarly dry and warm, but more bound soil generally occur in places where the grassland has deteriorated as a result of an anthrapogenic effect. In the weed ecosystems the eremophilous *Tetramorium caespitum* and *Messor structor* are characteristic, and their appearance to all intents and purposes denotes intervention endangering the grassland too.

A generally common species of the grasslands is *Solenopsis fugax*, which due to its very wide valency can not be classified among the characteristic elements of any one ecosystem.

Summary

(a) The occurrence of 34 ant-species was confirmed from the grassland ecosystems.

(b) The intraspecific competition between the ant-colonies is larger than the interspecific; this can be proved from the K index values introduced to characterize the dispersion of the colonies.

(c) It can be established from the stoichastic connection between the density of the nests and the environmental factors that the ecological needs of the ant-species studied are different. In accordance with the milieu-spectrum of the abiotic factors, the grassland ecosystems can be divided into four different ant-fauna types.

(d) Of the autecological phenomena, the feeding activities of *Formica cunicularia* and *Lasius niger* were studied. The activity depends on the temperature, and the connection between the two can be determined numerically.

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