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BIODIVERSITY OF ANTS AT "EVOLUTION CANYON," NAHAL OREN, MT. CARMEL, ISRAEL

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ABSTRACT

The biodiversity and differentiation of ants into microclimatically contrasting habitats were investigated at the "Evolution Canyon" microsite, Nahal Oren, Mt. Carmel, Israel. The ant fauna consists of 17 species: 10 species occur on the south-facing slope, 10 on the north-facing slope, and 6 at the valley bottom. The two slopes differ by 30% of their species, out of which three species are restricted to the north-facing slope, two species are restricted to the south-facing slope and one species occurs on both the south-facing slope and the valley bottom. Four species were restricted to the valley bottom.

KEY WORDS: Formicidae, Israel, biodiversity, ecology, microsite.

INTRODUCTION

There are about 160 species of ants in Israel (Kugler, 1989), distributed across all terrestrial habitats. Ofer et al. (1978) studied 14 different ant habitats and established four different ant associations according to their ecological adaptations to the habitat. Ofer et al. (1978) compared two opposite slopes of a valley in the Judean hills: the south-facing slope (S-slope) and the north-facing slope (N-slope). Despite the short distance between the opposite slopes, they exhibited two distinct ant associations.

The objective of the present study was to compare the ant species on opposite slopes at "Evolution Canyon," lower Nahal Oren, Mt. Carmel, Israel (32° 43' N; 34° 58' E). Both slopes are composed of Upper Cenomanian limestone (Karcz, 1959) with terra rossa soil. The prime difference between the slopes is that the S-facing slope (S-slope) receives up to 300% higher radiation than the N-facing slope (N-slope) (Kutiel and Sher, unpublished). The S-slope dips 43°, whereas the N-slope dips 33°. Therefore, the "African" S-slope is warmer, drier (Kirkby et al., 1990) and less predictable (larger spatio-temporal changes in temperature and dryness than on the N-slope). It harbors an African-like xeromorphic vegetation, with an open park forest of *Ceratonia siliqua-Pistacia lentiscus,* and grass species of the genera *Hyparrhenia, Andropogon* and *Pennisetum.* By contrast, the "European" N-slope is cooler, wetter and more predictable, harboring a Mediterranean lush and dense green maquis-forest with *Quercus calliprinos* and *Pistacia palaestina* (Nevo, 1994,1995).

Our hypothesis was that biodiversity is generally higher on the S-slope (which is in accordance with its spatiotemporally higher heterogeneity) than on the N-slope. We expected this difference particularly for tropical taxa as compared to temperate ones because of the interslope microclimatic and biotic differentiation (Nevo, 1994, 1995). This study forms part of a research program focusing on the ecological determinants of biodiversity at a microsite in Nahal Oren. We have named this site the "Evolution Canyon" due to its extraordinary evolutionary theater and the rich ongoing evolutionary research program (Nevo, 1995).

MATERIALS AND METHODS

The survey was conducted between June 1990 and February 1991 by monthly visits that covered seven sample sites: three stations on the S-slope, one at the bottom of the valley, and three on the N-slope. We measured soil temperature and vegetation cover. We observed the activity of all ant species, and ant nests were counted according to species. Each monthly observation started with a measurement of the surface soil temperature with a contact thermometer before noon. At each of the seven sampling sites, an area of 400–500 m^2 was chosen. Each month an area of about 20 m^2 was randomly selected for study. The studied area was marked so that no area should be visited twice. During the 9 months of observation, 180 m^2 were studied at each sampling site. From each nest, a sample of ants was preserved in 50% alcohol for taxonomic identification.

RESULTS AND DISCUSSION

The average ground temperature was 30°C on the S-slope and 24°C on the N-slope. Plant cover on the S-slope varied between 50–83%, whereas it was 250% on the N-slope, reflecting the dense vegetation at several vertical levels.

We found 17 ant species in 80 recorded nests and calculated species composition (percentage) on each slope and at the valley bottom (Table 1). The differential distribution of species among the three habitats is highly significant ($\chi^2_6 = 33.86$, $p < 0.001$). In order to evaluate the χ^2, the distribution of four taxa were tested: Formicinae, *Monomorium*, *Messor* and the rest of Myrmicinae. The main contribution to χ^2 was made by the genus *Messor*, which is almost completely confined to the bottom of the valley. The divergence between the two slopes could not be tested, as the difference is based mainly on species with low frequency, whose effect is canceled when higher taxa, suitable for testing, were used. Additional sampling is necessary in order to substantiate the observed differences between the two slopes.

The species distribution between the various studied habitats indicates species restriction to slope — either the S-slope (two of ten species (20%)) or the N-slope (three of ten species (30%)) — or to the valley bottom (four of six species (67%) are habitat restricted). Moreover, the higher percentage of species restricted to the valley bottom holds also when calculations are based on the number of nests: 62% of the nests belong to species restricted to the valley bottom, whereas only 18% and 6% of the nests on the N- and S-slopes, respectively, belong to restricted species. Seven species occur on both slopes: some in similar proportions, others with interslope differences in abundance. Two S-slope species are shared with the valley bottom, and *Monomorium venustum*, the most common species on both slopes, is also common at the valley bottom (Table 1).

TABLE 1
Ant species and nest distribution in "Evolution Canyon," Nahal Oren, Mt. Carmel, Israel, among three habitats: south-facing slope (S-slope), north-facing slope (N-slope) and valley bottom

Species	Number (%) of nests			Total no. of nests	Zoo-geographical element[1]	Thermo-hydro-phyly[2]
	S-slope	N-slope	Valley bottom			
Formicinae						
1. *Acantholepis bipartita* (Smith, 1862)	–	–	1 (4.8%)	1	EM	T-x
2. *Acantholepis* sp.	1 (3.2%)	1 (3.6%)	–	2	?	?
3. *Acantholepis splendens* Karawaiew, 1912	1 (3.2%)	3 (10.7%)	–	4	EM	T-x + h
4. *Camponotus lateralis rebeccae* (Olivier, 1791)	–	1 (3.6%)	–	1	EM[3]	H
5. *Camponotus sanctus* (Forel, 1904)	2 (6.5%)	3 (10.7%)	–	5	EM	H
6. *Cataglyphis viaticoides* (Andre, 1881)	–	–	3 (14.3%)	3	SEM	T-x
7. *Cataglyphis niger* (Andre, 1881)	–	–	1 (4.8%)	1	Er	T-x
8. *Paratrechina longicornis* (Latreille, 1802)	1 (3.2%)	–	–	1	C	T-x + h
9. *Plagiolepis ancyrensis* Santschi, 1920	2 (6.5%)	2 (7.1%)	–	4	EM	T-x + h
Myrmicinae						
10. *Aphaenogaster* sp.	–	2 (7.1%)	–	2	?	?
11. *Crematogaster lorteti* Forel, 1901	2 (6.5%)	3 (10.7%)	–	5	EM	H
12. *Messor ebeninus* Forel, 1910	–	–	8 (32.1%)	8	EM	T-x
13. *Messor semirufus* (Andre, 1882)	2 (6.5%)	–	3 (14.3%)	5	EM	T-x
14. *Monomorium dentiger* (Roger, 1862)	2 (6.5%)	1 (3.6%)	–	3	EM	T-x
15. *Monomorium venustum* (Smith, 1858)	17 (54.8%)	10 (37.8%)	5 (23.7%)	32	EM	T-x + h
16. *Pheidole pallidula* (Nylander, 1849)	–	2 (7.1%)	–	2	Cir M + IT	H
17. *Tetramorium lucidulum* Emery, 1909	1 (3.2%)	–	–	1	EM	T-x
Total number of nests	31 (100%)	28 (100%)	21 (100%)	80		
Total number of species	10	10	6	17		
Total number of restricted species	2	3	4	9		

[1]Zoogeographical element (Kugler, 1988): C = cosmopolitan or pantropical; Cir M = circum-Mediterranean; EM = east-Mediterranean; Er = Eremic; IT = Irano-Turanian; SEM = south- and east-Mediterranean.
[2]Thermohydrophyly (Bytinski-Salz, 1953): T = thermophylic species; H = hydrophylic species; x = living in xeric habitats; h = living in wet habitats.
[3]The species is Cir M, the subspecies is EM, appearing in the table.

The zoogeographical affinity of the ant species identified in this study is given in Table 1. More than half of the species belong to the east Mediterranean element (Kugler, 1988). The tropical trans-cosmopolitan species *Paratrechina longicornis* also occurs in "Evolution Canyon." The restricted species of the N-slope, *Camponotus lateralis* and *Pheidole pallidula*, belong to the circum-Mediterranean element.

Seven species (41%) are thermophilic living in xeric habitats (Bytinski-Salz, 1953): *Acantholepis bipartita, Cataglyphis viaticoides, C. niger, Messor ebeninus, M. semirufus, Monomorium dentiger* and *Tetramorium lucidulum.* Those species are found only on the dry S-slope or at the bottom of the valley. *Monomorium dentiger* is found on the S-slope and is apparently less frequent on the N-slope.

Four species (23.5%) are defined as thermophylic, but live in both xeric and wet habitats (Bytinski-Salz, 1953): *Acantholepis splendens, Paratrechina longicornis, Plagiolepis ancyrensis* and *Monomorium venustum.* In "Evolution Canyon" these species are distributed either on both slopes or only on the S-slope (*Paratrechina longicornis*).

Five species (29.4%) are defined as hydrophylic (Bytinsky-Salz, 1953): *Camponotus lateralis rebeccae, C. sanctus, Crematogaster lortei, Pheidole pallidula* and apparently also *Aphaenogaster* sp. The first, fourth and last species are found only on the N-slope and the second and third species are found on both slopes, but are more frequent on the N-slope.

The species that occur on both slopes are generalists, display adaptation and tolerance to a larger spectrum of conditions (deduced from the extreme difference of plant association), and are potential candidates for comparing genetic diversity on both slopes. The distribution of ant species demonstrates the interslope and valley bottom biotic differentiation, despite the short distance between the sites.

We found 10 ant species on each of the two slopes. Generally, we found a higher biodiversity on the S-slope in other terrestrial- and radiation-adapted taxa, such as Cyanophyta, angiosperm plants, landsnails, scorpions, beetles, drosophilids, reptiles and birds. The higher species richness overall on the S-slope is significant (sign test, $p = 0.004$; Nevo, 1995). The equality of ant species number neither supports nor contradicts that result. Theoretically, tropical habitats, including xeric savannas, are generally richer in species than temperate habitats (Schall and Pianka, 1978). This is consistent with the environmental theory, derived from Van Valen's (1965) niche-width variation hypothesis, that predicts a higher biodiversity in ecological niches with a broader span of conditions (Nevo, 1988). For some groups such as Euglenophyta, Baciliarophyta, mosses, micromycetes, lichens and Agaricales (Wasser et al., 1996), the opposite may be true, as they live primarily in wet and shaded habitats typical to the N-facing slope (sign test, $p = 0.016$; Nevo, 1995).

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