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Micro-Arthropods in the Surroundings of Nests of *Messor arenarius* Ants in the Negev Desert in Israel

Ittai Warburg, Yosef Steinberger*

The Mina & Everard Goodman Faculty of Life Sciences, Bar-Ilan University, Ramat Gan, Israel
Email: *Yosef.Steinberger@biu.ac.il

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Abstract

The present research investigated a segment of the micro-arthropod populations residing within nests of *Messor arenarius* ants in the Negev Desert of Israel. The total frequencies of micro-arthropods in the chaff of those ants' nests were found to be higher than in the surrounding soil of the same nests. Acari (mites) were observed to be more abundant during the spring season, whereas their presence decreased during the summer months. Springtails (Collembola) were found to follow the Acari pattern, commonly found within the nests of those ants during spring but were absent during summer. Psocoptera order inhabiting soil habitats were infrequently encountered during spring, but their prevalence increased significantly during summer, particularly within the chaff of the ants' nests, suggesting that chaff is their primary food source in the Negev Desert. Our research suggests that shifts in seasonality have important consequences on the distribution of soil invertebrate communities with implications on nutrient cycling.

Keywords

Ants, Arid Region, Harvesters, Micro-Arthropods

1. Introduction

Micro-arthropod populations occupy many habitats in the world, including hot deserts [1]-[3]. In these deserts, micro-arthropods can be found in the soil, as well as in plant litter, on the soil surface [2] [4]. Several research works were done, on the composition or the frequencies of micro-arthropod populations in desert litter or desert soil under or between plants [4]-[9]. The composition or the frequencies of soil micro-arthropods in nests of *Pogonomyrmex barbatus*

(F. Smith) ants was checked by Wagner *et al.* [10]. In that research, it was found that the frequencies of Acari or springtails in the soil of those nests were 30 - 40 times higher than in the surrounding soil of those ants' nests [10]. Desert harvester ants concentrate organic material near their nests, and also form biogeochemical spots in different places in the desert soil [11]-[13].

Ants of the species *Messor arenarius* (Fabricius) are harvester ants, which are distributed mainly in deserts of the Middle East, as well as in North Africa [14]. In Israel, those ants occupy arid habitats in the Negev Desert [15]-[19], as well as sandy areas in the Mediterranean Coastal Plain [14] [20]. Those ants are mainly granivorous [17] [18]. *M. arenarius* ants forage or collect their food mainly individually in radial sectors surrounding their nest [20]. Usually after the first rains in the winter season, these ants open new nest entrances (Ittai Warburg, unpublished data).

The main season of food collections by those ants in the Negev Desert is between March-September [21]. During that period, these ants collect mainly parts of plants that include seeds [18]. Inside their nest, those ants store the collected seeds in food granaries [22] [23]. Those ants put their food residuals, which include seed covers or other parts of plants, outside their nest near the nest entrance. These residuals of plant material accumulate during the foraging season, to form a nest mound, which has a shape of a crescent, or sometimes surround the nest entrance [24]. The total amount of chaff (plant material residuals) in *M. arenarius* ants' nests was found to be bigger in July than in April [18]. In those chaff piles of *M. arenarius*, there were found 108 different parts of plants that were collected by those ants from 74 different plant species [18]. Micro-arthropods in ants' nests or near those nests can affect the decomposition of the chaff surrounding those ants' nests [25]-[27].

In this research, the compositions or the frequencies of micro-arthropods in or near nest mounds of *M. arenarius* ants were determined. The primary aim of this research was to ascertain whether the compositions or frequencies of micro-arthropods exhibited temporal (seasonal) or spatial variations relative to their proximity to the nest entrance. This research was conducted, on both the chaff within the ants' nests and the surrounding soil, to assess the impact of chaff piles on micro-arthropod populations in these habitats.

2. Methods

2.1. Research Site

The research site was in Sede-Zin, which is located between the Institute of Desert Research at Sede-Boqer, and Kibbutz Sede-Boqer in the Negev Desert. Sede-Zin is a plain of alluvial loess soil, dominated by *Hammada scoparia* (Pomel) Iljin, *Zygophyllum dumosum* Boiss. and *Artemisia sieberi* Besser (*Artemisia herba-alba* Asso). Situated 600 meters above sea level, the area experiences an average annual rainfall of 100 mm, primarily occurring from October to late April, with the majority falling in scattered showers between December and February. Dew deposition, adds an additional moisture source, amounting to 35 mm annually, over approximately 210 nights during late summer and autumn. Annual evaporation reaches 2615.3 mm. Radiation levels can reach up to 3.14 × 104 $kJ \cdot m^{-2} \cdot d^{-1}$. Ground temperatures vary from −5˚C in winter to 70˚C in summer, with winter temperatures ranging between 5˚C - 14˚C in January and summer temperatures between 18˚C - 32˚C in June.

2.2. Sampling Procedure

Monthly samples of chaff and soil were collected from six nest mounds of *M. arenarius* ants, between February-September 1997 (**Figure 1**). At each nest, samples were collected as follows: a sample of chaff from the chaff pile (A), soil samples from underneath the chaff pile (B), the border of the chaff pile (C), outside the border of the chaff pile and near that border (D), and 1/2 meter outside the border of the chaff pile (E). Those soil samples were collected from the upper 10 cm of soil, with a metal corer of a diameter of 3 cm. Following the collection of chaff samples, the areas from which they were obtained were replenished, with additional chaff from the same nest. Similarly, after soil sampling, the sampled areas were refilled with soil sourced from the surrounding vicinity of the nest. This practice aimed to preserve the natural conditions within these nests. Those samples were collected in the morning hours, except those of 15 July 1997, which were taken in the late afternoon.

Figure 1. A nest mound of *Messor arenarius* ants at Sede-Zin in the Negev Desert in Israel. Photographed at a certain time during the 1990s' by Ittai Warburg.

2.3. Laboratory Work

The samples were brought to the laboratory and were kept refrigerated (4˚C). Within 1 - 5 days following the sample collection, micro-arthropods were extracted from each sample, using Tullgren funnels. The samples designated for extraction were as follows: for chaff extraction, 10 grams of chaff were utilized, while for soil

50 grams of soil were employed. Micro-arthropods were then extracted into plastic boxes partially filled with water, for a period of 48 ± 4 hours. After this period the samples were retrieved for identification and counting.

Micro-arthropods were identified and counted using a binocular microscope, following which they were preserved in 70% Ethanol. Classification of micro-arthropods was conducted based on the following groups: Acari, springtails, Psocoptera, and also other insects. All numerical data regarding the arthropod counts were standardized to represent quantities per 50 grams of sample.

3. Results

Table 1 shows the frequency data of micro-arthropods observed in the samples taken in that research. During the summer months, soil samples contained minimal micro-arthropods, in comparison to the spring season, when micro-arthropods were present in the soil samples and their density gradually decreased from the chaff pile towards the outer areas of the nest (**Table 1**). In the spring samples, the frequencies of Acari were notably high compared to the summer samples, where they were relatively lower. Acari were present in both the chaff and the soil samples during spring, but predominantly in the chaff during summer. Interestingly, no Acari were detected in the July 1997 sample, which was collected in the afternoon. Springtails (Collembola) were observed in both the chaff and the soil samples during spring but were absent in the summer samples. Psocoptera were seldom found in the spring samples but were considerably more prevalent in the summer samples, primarily within the chaff. When Psocoptera were present in the soil samples, they were typically found beneath the chaff. Other insects, aside from springtails or Psocoptera, were encountered in either the chaff or the soil during June and were not observed in the other sampling months of that research.

Table 1. Frequencies of different groups of micro-arthropods found in or near nest entrances of *Messor arenarius* ants at Sede-Zin in the Negev Desert during the 1997 observation period.

Location—See Details in the Methods Section	Month of Sampling / Systematic Group	February Nest No. 1	March Nest No. 2	April Nest No. 2	June Nest No. 3	July Nest No. 3	August Nest No. 3	August Nest No. 4	September Nest No. 3
A	Acari	30	50	13	-	-	-	35	30
	Springtails	10	3	-	-	-	-	-	-
	Psocoptera	5	1	1	10	20	500 - 750	45	150 - 200
	Other insects	-	-	-	15	-	-	-	
B	Acari	16	55	3	-	-	1	-	-
	Springtails	-	1	2	-	-	-	-	-
	Psocoptera	-	-	-	-	-	2	-	-
	Other insects	-	-	-	1	-	-	-	-

Continued

C	Acari	-	17 - 20	4	-	-	-	-	-
	Springtails	1	3	1	-	-	-	-	-
	Psocoptera	-	-	-	-	-	-	2	-
	Other insects	-	-	-	1	-	-	-	-
D	Acari	1	2	1	-		-	-	-
	Springtails	1	2	-	-	-	-	-	-
	Psocoptera	-	-	-	-	-	-	1	-
	Other insects	-	-	-	-	-	-	-	-
E	Acari	1	-	6 - 7	-	-	-	1	-
	Springtails	-	-	-	-	-	-	-	-
	Psocoptera	-	-	-	-	-	-	-	-
	Other insects	-	-	-	-	-	-	-	-

Note: The data in this table refers to samples of 50 gr.

4. Discussion

Throughout that research, a spatial gradient of the micro-arthropod density from the chaff pile outwards to the nest surrounding area was discovered. This gradient appears to manifest, as a step function, rather than a gradual decline. The higher edge of this step function is observed within the chaff pile (sample A) or beneath it (sample B), while its lower edge is in the area outside the border of the chaff pile or its proximity (sample D). By comparing total micro-arthropod densities between the soil beneath the chaff pile (sample B) and outside the nest area (sample E), differences in the micro-arthropod densities were noted during the spring season, but not in the summer season. Those observations are consistent with what was found by Wagner *et al.* [10], who reported similar density discrepancies in the vicinity of nests of *Pogonomyrmex barbatus* ants, in arid grassland situated between the Chihuahuan and the Sonoran Deserts, approximately 3 - 4 weeks after the onset of the rainy season in their research area.

The temporal variations in the frequencies of micro-arthropods in those samples are monthly, reflected both in the frequencies of those micro-arthropods, as well as in their composition. As for those frequencies, there was no definite change in the micro-arthropods' frequencies during that observation period, although it is a known phenomenon in harvester ants, that the amount of chaff surrounding their nest's entrances accumulates gradually from the winter season towards the summer season [28]. As for the group compositions of those micro-arthropods, prominent differences can be observed between the spring and the summer seasons in this research.

During spring, Acari were abundant in both the chaff and the soil samples, but their presence dwindled significantly in summer. Analysis of abiotic data collected from the same geographic area and seasons suggests a positive correlation between Acari frequencies and the moisture levels in chaff or soil habitats. Consequently, during spring mornings, Acari populations were observed in both the chaff and the soil of those ants' nests. In summer mornings, when moisture levels were sufficient in the chaff but lacking in the soil, springtail activity was confined to the chaff, and not observed in the soil. In autumn, dew formation and accumulation overnight may extend Acari activity within the chaff piles. However, as moisture decreases, Acari activity diminishes significantly, both in the chaff piles and in the upper 10 cm layer of soil. This behavior is consistent with some findings of Steinberger and Wallwork [9], illustrating an effective adaptation of Acari in avoiding dry environments.

Springtails were found in the spring samples, but were absent in the summer samples, likely due to their dependence on humid conditions for activity. This behavior is consistent with other studies, indicating that springtails are active on the ground surface during rainy seasons [1] [29]. During dry periods, springtails burrow into the ground until they reach a layer with adequate humidity to sustain their activity [1] [29].

Contrary to the seasonal ecological behavior of Acari or of springtails in this research, Psocoptera in this research were hardly found in the spring samples, and they were very frequent in the summer samples. Like springtails, also Psocoptera, share a relatively narrow temperature or moisture range [29]. Contrary to springtails, which are typically active near the ground surface mainly in winter or early spring, Psocoptera exhibit activity near the ground surface primarily during summer in this research. This behavior is likely attributed to their feeding habits, as Psocoptera feed on chaff, which accumulates gradually from spring to summer. Psocoptera appears to display resistance to relatively high ground temperatures during summer. These findings are also consistent with those of Wallwork [29]-[31] from his research conducted in the Chihuahuan and Sonoran deserts.

Nutrient recycling through decomposition represents one facet of ecological dynamics, often pivotal in pulse-reserve systems where moisture variability, both spatially and temporally, serves as a driving force in soil biota community composition and function. These elements are vital in shaping primary production both above and below ground, as well as in directing the flux of organic matter towards nutrient cycling and supporting biotic communities, including food webs and ecosystem functions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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