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ABSTRACT

Work accomplished during 1973 was mostly preparative. During the period a satisfactory method of sampling desert soil arthropods was developed, using a modification of Newell's (1959) technique. Samples were taken in association with four species of shrubs, and the results for ten weeks during the summer are reported. Numbers were generally greatest near the soil surface at the bases of shrubs, and decreased with depth and distance from the shrub. Soil moistures and temperatures were obtained in association with the arthropod samples. Nearly all the taxa found have been identified at least to family. Mites contributed the greatest numbers and diversity, and prostigmatids were the dominant group of mites.

INTRODUCTION

Soil-inhabiting microarthropods are thought to be critical regulators of microbial decomposer activity. The study of desert populations, however, has been almost completely neglected, primarily for two reasons: (1) the populations are extremely small and aggregated, and (2) investigative procedures developed in other ecosystem types are generally unsuited to desert studies. We have been able to find only four publications dealing with numbers and distribution of desert soil microarthropods and two of these were conducted where the Mohave Desert grades into pinon-juniper scrub forest (Wallwork, 1972a, 1972b). Consequently, this study was forced to proceed on a trial-and-error basis with essentially no guidelines which could increase the probability of success.

OBJECTIVES

The objective of this study is to understand the nature, distribution and biomass of soil arthropods at the Rock Valley site of the Mohave ecosystem and to correlate the results with the distribution of four shrub species and with soil temperature and moisture.

METHODS

Soil in relation to four shrub species (*Larrea divaricata, Ambrosia dumosa, Lycium andersonii,* and *Krameria parvifolia*) was sampled. The soil was collected from depths of 0-10 cm, 10-20 cm and 20-30 cm at each of three distances from the shrub: the base of the shrub (samples 1, 2 and 3, starting at the surface), at the canopy margin or one mean-shrub radius (samples 4, 5 and 6), and at three shrub radii (samples 7, 8 and 9).

Sample frequency, replication and volume have changed during the progress of the study according to the dictates of the results. For the first ten weeks of the study, a single 1l sample was taken from each position at intervals allowing each shrub species to be sampled three times each month. Arthropods were extracted from the soil by means of a modification of Newell's (1959) technique, itself a modification of the familiar Tullgren funnel, and by Salt and Hollick (1944) flotation. Although other results (e.g., Bender et al., 1972) led us to expect greater utility from the second technique, our early results dictated abandonment of flotation in favor of the Newell method.

The number of samples was increased in order to improve the statistical properties of the sampling design. New sets of Newell funnels were designed which accepted a 500 cm^3 soil sample. This design was first tested using a sample frequency of one sample set per shrub each week. Results reported here are for the period of June 11 to September 28, 1973. The success of this program allowed us to complete an additional set of funnel extractors and we are now replicating each sample four times each week -- a total of 576 samples per month.

Samples are taken at about the same time each day so that soil temperatures are comparable. Temperature is recorded at each position by means of a YSI electric thermometer coupled with a 15 cm thermister probe. Soil aliquots are taken from each sampling position for gravimetric determination of soil moisture (105 C for 24 hr), and for root biomass and soil nematodes for other projects.

RESULTS

Faunal Composition

Most of the arthropods occurring in soil samples have now been identified at least to family (Table 1) and assigned to tentative trophic groupings based on taxonomic affinities. Only larvae of Diptera are considered here, for adult flies found in soil extracts most often have entered during the extraction process, attracted there by the preserving fluid. The Therevidae and Bombyliidae are considered to be predators and the Sciaridae are fungivores. The Mydidae probably are detritivores. The Phoridae need to be examined more closely, for members of that family may be either fungivores, parasites or both.

Phytophagous beetles present in soil samples include Chrysomelidae and Curculionidae. The former may be a root feeder and the latter a granivore. Predators include Staphylinidae and Cleridae and detritivore/omnivore habits are represented by Dermestidae, Tenebrionidae and Scarabaeidae.

Other insects present include *Arenivaga* sp. (Orthoptera: Polyphagidae), an omnivore, Lepismatidae (Thysanura) detritivores and Pseudocaecillidae (Psocoptera) fungivores. Pseudococcidae (Homoptera) and Thripidae (Thysanoptera) are present but may not be active in the soil. If active in the soil, the former is probably a root feeder and the latter a fungivore. Collembola are represented by Onychiuridae, Poduridae, Entomobryidae, and Sminthuridae, all of which are fungivores.

The Acari or mites are the most numerous and diverse of the soil groups. All of the mites encountered to date belong to the order Acariformes and predominantly to the suborder Prostigmata. The dominant prostigs, Nanorchestidae and Pachygnathidae, belong to a group (the Endeostigmata) having affinities with the suborder Cryptostigmata and

their feeding habits differ from the typical prostig predation. Both families are considered to be fungivores. Individuals of the Pymotidae may be fungivores, predators or phytophages. Feeding habits of the Tydeidae are similarly diverse. The tetranychoid Tuckerellidae are phytophagous, probably root feeders in this case. All of the remaining prostigmatid families are predators, feeding on mites, Collembola and, possibly, nematodes. The large number and diversity of predatory mites suggests the possibility of two or more predator trophic levels in the decomposer food web.

The Astigmata are represented only by the Acaridae, which are fungivores. The Oribatei are yet to be identified. Oribatids are either fungivores or detritivores.

Vertical and Lateral Distribution of Soil Microarthropods

Samples were taken in a manner that would yield information about differences in population densities with depth in the soil and with distance from the bases of shrubs. The sampling design is shown in Table 2, and is required for the interpretation of Tables 3-5. For example, sample 1 is taken from the top 10 cm of soil at the base of a shrub, and sample 8 is taken at a soil depth of 10-20 cm and at three mean-shrub radii away from the base. A mean radius is determined by half the average of the largest and smallest diameters of the shrub.

Table 1. Families of arthropods represented in soil samples from Rock Valley

Diptera	Acari (Prostigmata)
Sciaridae	Nanorchestidae
Therevidae	Pachygnathidae
Mydidae	Pymotidae
Bombyliidae	Tydeidae
Phoridae	Bdellidae
	Cunaxidae
Coleoptera	Caeculidae
Staphylinidae	Tuckerellidae
Dermestidae	Neophyllobiidae
Cleridae	Teneriffiidae
Tenebrionidae	Cheyletidae
Scarabaeidae	Erythraeidae
Chrysomelidae	Trombiculidae
Curculionidae	
Thysanura	Homoptera
Lepismatidae	Pseudococcidae
Collembola	Thysanoptera
Onychiuridae	Thripidae
Poduridae	
Entomobryidae	
Sminthuridae	Psocoptera
	Pseudocaecillidae
Orthoptera	
Polyphagidae	
Acari (Cryptostigmata)	Acari (Astigmata)
unidentified Oribatei	Acaridae

Mohave Desert soil arthropod populations are small, especially in summer (Table 3). Catches associated with *Krameria* in position 1 were significantly lower than those from other shrubs, but catches did not differ significantly between the other three species of shrubs, and no significant differences were found between *Krameria* and the rest at positions 3, 7 or 9. The variability between samples, however, was great (Table 4) because of the small number of samples and the low yields per sample. We expect this

Table 2. Sample position numbers with respect to soil depth and distance from the shrub base

Depth, cm	Distance from shrub base in radii		
	0	1	3
0-10	1	4	7
10-20	2	5	8
20-30	3	6	9

Table 3. Mean catches of soil microarthropods per sample for ten weeks within the period June 11 - Sept. 28 by shrub species and sample location (No./500 cm^3). Sample location is according to Table 2

Larrea			*Ambrosia*		
6.9	1.3	1.1	5.9	2.5	1.3
1.8	1.3	0.6	1.9	0.4	0.3
1.2	1.1	0.2	1.2	0.9	0.8
Lycium			*Krameria*		
5.1	1.1	0.9	1.4	1.6	0.2
2.4	0.3	0.1	0.6	0.2	1.1
0.7	0.3	0.1	0.9	0.6	0.2

Table 4. Variability of invertebrate catches expressed as the ratio of the standard deviation to the mean. Sample locations are according to Table 2

Larrea			*Ambrosia*		
0.68	1.23	1.55	0.73	0.80	1.15
1.39	2.23	1.33	0.95	2.00	1.67
1.33	1.64	2.00	1.17	1.11	2.75
Lycium			*Krameria*		
0.88	0.82	1.56	0.93	1.31	2.50
0.92	1.67	3.00	1.17	3.50	2.50
1.00	1.67	3.00	1.56	1.17	3.50

variability to be reduced in 1974 as we replicate samples and as seasonal changes produce greater numbers of arthropods per sample.

Trends are already evident, however. There is a reduction in numbers with depth and distance from the shrub, and an increase in variability in both cases. A t-test of significance showed that the population difference between positions 1 and 3 is significant for *Larrea*, *Ambrosia* and *Lycium*, but not for *Krameria* (Table 5.) Populations decreased significantly from position 1 to position 7 in all species. Unlike the other species, the maximum population density in *Krameria* was found at position 4, i.e., the top 10 cm at the canopy margin. There was no significant difference between populations at the extreme positions, either with depth at 3 radii distance (positions 7 vs. 9) or with distance at 20-30 cm depth (positions 3 vs. 9). The increased sampling program planned for 1974 may, however, reveal trends undetected in 1973.

Microarthropod Population Density and Biomass

Although the research was designed, initially, to examine the vertical and lateral distribution of arthropods around shrubs, ecosystem productivity studies require knowledge of population densities and biomass on unit areas of terrain. These data are being collected and more will be available at the end of 1974.

The first part of the problem -- how populations change in relation to distance from individual shrubs -- has been tentatively solved. We have developed a distribution model which arbitrarily considers each of the lateral sampling distances (e.g. samples 1, 4 and 7) as representative of concentric rings of increasing area. Thus the inner ring, Zone A, extends from the shrub base to one-half the distance to sample 4, and has an area of $\pi(r/2)^2$, where r is one mean canopy radius. Zone B extends from that point to half-way between samples 4 and 7, and has an area of $\pi(2r)^2$ -Zone A. The final concentric ring, Zone C, extends to 1.5 radii beyond position 7 and has the area $\pi(4.5r)^2$ -(Zones A + B). Area calculatons are given in Table 6 for each shrub species, and approximate invertebrate densities are shown in Table 7.

Table 5. Statistical signifance of differences between soil microarthropod populations in relation to depth and distance from four shrubs. Positions are according to Table 2

Positions	*Larrea*	*Ambrosia*	*Lycium*	*Krameria*
1 vs 4	**	*	*	ns
1 vs 7	**	**	*	*
1 vs 3	**	**	*	ns
2 vs 5	ns	*	*	ns
3 vs 9	ns	ns	ns	ns
7 vs 9	ns	ns	ns	ns

** P < 0.01
* P < 0.05
ns-not significantly different

Summing the areas of influence from Table 6 and multiplying by the number of solitary shrubs per hectare (after Bamberg, 1973) yields an area of 1.3 ha, indicating at least 30% overlap of areas of influence. That overlap occurs primarily in Zone C, where population densities are lowest, and thus the estimate of total density (Table 7) probably is not a severe overestimate, particularly with respect to the inner zones. The zones of influence of solitary plants also overlap with those of clustered plants, again primarily in Zone C, where the influence is minimal.

The bigger problem, which we plan to investigate in 1974, concerns the effects of clustering. Individuals of all four shrub species occur more frequently as clusters than as solitaries. We are well aware of the fact that this has great significance for our density estimates, and plan to investigate the problem. For the present, however, the above considerations render any calculation of biomass premature. We have the resources necessary for determining the weights of individual microarthropods, and should have no difficulty in calculating biomass at the appropriate time.

DISCUSSION

No mesostigmatid mites have been observed so far in our studies, and indeed the group may prove to be absent from all arid areas. Wallwork (1972b) found no mesostigmatids, with the exception of samples from rotting *Nolina parryi* taken from a moist microhabitat. Wood (1971) also found

Table 6. Area of influence calculated for solitary shrubs

Species	radius, x (cm)	Area, m^2			
		Zone A	Zone B	Zone C	Total
Larrea	40.83	0.13	1.96	8.52	10.60
Ambrosia	29.32	0.07	1.01	4.39	5.47
Lycium	39.71	0.12	1.86	8.05	10.03
Krameria	23.44	0.04	0.65	2.80	3.50

Table 7. Calculated invertebrate densities (no./area to 30 cm depth) associated with solitary shrubs

Shrub	Zone A	Zone B	Zone C	Total	$\frac{\text{Total}}{m^2}$
Larrea	204	1151	2570	3925	370
Ambrosia	100	609	1672	2381	435
Lycium	156	502	1406	2064	206
Krameria	18	248	667	933	266

that Mesostigmata decreased in numbers with decreasing moisture, and became absent in sclerophyllous desert grassland. Wood speculated that the niche occupied by mesostigs in more moist habitats is occupied by various Prostigmata in arid soils. The abundance of prostigs in Rock Valley may be due in part to this effect.

Comparisons of densities remain tentative. Krivolutsky (1968) reported 250 Oribatei/m^2 of desert, which is at least an order of magnitude larger than the densities in Rock Valley. The paper is in Russian, however, and we have not yet compared the two sites. Wood (1971) reported 20 to 30 x 10^3 microarthropods/m^2 from an Australian desert; again far in excess of our apparent numbers. However, it must be remembered that we have so far been dealing with spring and summer samples, and numbers certainly increase in the winter.

EXPECTATIONS

We consider the work accomplished during 1973 to be essentially preparative. We now have satisfactory sampling procedures and we expect that these will be applied during 1974 to advance our knowledge of desert soil arthropods significantly. Early in the year we will carry out tests to determine the extraction efficiency of our equipment. This information will, of course, be essential when it comes to assessing total numbers and biomass.

Sampling at the increased frequency mentioned above (four replicates per locus for each of nine loci in association with four species once a week) will be continued throughout the year. Meanwhile we will try to generate information which will permit us to arrive at estimates of total biomass per hectare. So far we have sampled only from isolated bushes. We now hope to undertake separate studies on the effect of clustering on the numbers and distribution of our organisms.

Wet and dry weights will be obtained for each of the main constituent species at different times of the year for the purpose of developing an expression for biomass and its variations. Abiotic factors will also be measured and it should be possible to see the extent to which changes in biomass may be related to these variables. We are also beginning to look at relative population numbers and biomasses of the various trophic groups with a view, eventually, to getting a picture of the movements of energy and materials through soil arthropod systems.

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