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Abundance and Distribution of Soil Micro-Arthropods in Rock Valley, Nevada

E.B. Edney

P.J. Franco

J.F. McBrayer

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ABUNDANCE AND DISTRIBUTION OF SOIL MICROARTHROPODS IN ROCK VALLEY, NEVADA

E. B. Edney (Project Leader), J. F. McBrayer, P. J. Franco and A. W. Phillips
Laboratory of Nuclear Medicine and Radiation Biology
University of California, Los Angeles

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ABSTRACT

Weekly observations from January through June 1974 of the nature, densities and distribution of soil arthropods in Rock Valley are reported. These show that densities decrease vertically and horizontally away from the base of the shrubs. There was a seasonal change of relative abundance with position; arthropods in the lower layer (20-30 cm) becoming relatively more abundant in June than in January. There was a pronounced increase in total numbers from a mean of 2.04 x 10^3 m^{-2} in January to 4.30 x 10^3 m^{-2} in March. Highest densities up to 10^4 m^{-2} occurred near the base of shrubs in March. No effect of size or species of shrub on arthropod density was observed.

INTRODUCTION

Work carried out during 1974 was a continuation of the program started in 1973 and reported in last year's Research Memorandum (Edney et al. 1974).

Once again the overall aim has been to investigate the nature, biomass, distribution and phenology of soil arthropods at the Rock Valley site of the Mohave Desert ecosystem in relation to four main species of desert shrubs, and to temperature and soil moisture.

METHODS

Soil samples were taken essentially as before; at the base, at the periphery and at three radii away from the center of a shrub, and at three levels in each position; 0-10, 10-20 and 20-30 cm. Sample sets were taken in relation to four species of desert shrub once every week throughout the year. The species were *Larrea tridentata*, *Ambrosia dumosa*, *Lycium andersonii* and *Krameria parvifolia*, which together account for about 75% of the area covered by shrubs. One liter from each sample was used for other related studies. The remaining two liters were mixed and divided into four 500-ml aliquots. Each aliquot was extracted by our modification of Newell's (1959) technique and the arthropods stored in ethanol for subsequent identification and counting. In the early part of the year, all four aliquots were counted. However, statistical analysis showed that there was no significant difference between them, and for the rest of the year only two of the aliquots were counted. Sample position numbers were the same as in our last report. They are repeated here for convenience (Table 1). Each set of samples was replicated four times a week for a total of 144 samples per week.

Soil moisture was determined as before, as the mean water content at positions 1, 4, 7; 2, 5, 8; and 3, 6, 9 (i.e., at the three sample levels). Soil temperatures were measured just before taking each sample by inserting thermistor probes to depths of 5, 15 and 25 cm at the corresponding sample positions. Samples were taken about the same time, between 9:00 and 10:00 a.m. each day. At the time of writing, we have identified and counted samples through week 40. However, we report below our arthropod counts only for the first 26 weeks of the year, for only these have been collated, and analyzed statistically.

Table 1. 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

RESULTS

Faunal Composition

All the taxa recorded last year have been found again this year with the exception of *Eremaeus* sp., an oribatid mite. However, more mites have now been identified, and they are listed in Table 2.

Temperature and Moisture

Soil temperatures and moistures for the first 46 weeks of the year are shown in Table 3. Temperatures rose from about 0 to 30 C from weeks 0 through 27, and then fell off rather steeply to week 44. In the winter and fall, temperatures increased with depth, but in the spring and summer the reverse was generally true. The difference between depths seldom amounted to more than about 5 C and was usually less. Soil moisture was subject to more frequent, wider fluctuations; the large increases, of course, following each precipitation. After rains, the moistest sample was at the top, but for most of the readings, the reverse was true. Soil moistures are typically low in deserts, and these results are no exception; the highest reading was 16% by weight, but the large majority of readings fell between 1.5 and 6%.

Table 2. Additional identifications of mites for Rock Valley

Acari (Prostigmata)	Acari (Cryptostigmata)
Linotetranidae	*Aphelacarus acarinus* (Berl.)
Caligonellidae	*Joshuella striata* (Wall.)
Eupodidae	*Eremaeus* sp.
	Multoribates sp.
	Belba sp.
	Trichthonius sp.
	Passalozetes sp.

Table 3. Soil temperatures and moistures in Rock Valley, Nevada. Weekly numbers begin January 1, 1974. Moistures were measured by drying at 105 C for 24 hr and are expressed as water content % of wet weight

	Soil temperature °C			Soil moisture		
Week	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm
1	—3.67	—0.67	+1.67	8.40	6.25	3.08
2	—1.67	+0.33	2.00	16.21	10.11	9.66
3	+2.58	3.25	4.33	11.04	11.09	9.92
4	1.33	3.58	5.00	11.16	12.05	12.63
5	1.42	2.67	4.42	8.27	10.64	11.65
6	1.66	3.33	5.58	6.01	8.22	8.75
7	6.42	7.75	10.00	5.61	7.19	7.24
8	4.58	5.08	8.58	5.14	6.21	6.67
9	8.67	7.75	9.25	4.24	6.16	6.37
10	4.08	6.00	8.50	6.82	7.62	7.94
11	13.25	11.92	12.50	7.00	8.66	8.93
12	13.42	13.58	15.50	4.18	5.31	5.88
13	13.33	13.33	15.17	2.80	4.79	5.76
14	13.58	13.08	14.67	2.61	5.12	5.84
15	18.00	14.83	16.00	1.80	3.71	4.96
16	18.08	15.75	16.33	1.75	4.26	5.51
17	17.58	15.58	16.92	1.49	3.53	4.95
18	19.08	17.58	17.92	1.75	4.69	6.55
19	24.00	21.75	21.17	1.22	2.55	3.80
20	24.67	22.00	22.67	1.33	2.46	4.16
21	25.08	19.42	20.67	1.46	2.75	4.48
22	28.67	25.08	25.67	1.41	3.33	5.21
23	26.08	26.17	26.67	1.16	2.11	3.42
24	30.08	27.00	26.92	0.86	1.25	1.90
25	28.33	26.17	26.33	1.26	1.79	3.22
26	30.25	29.00	29.33	1.00	1.46	1.83
27	35.50	31.33	30.25	0.98	1.20	1.41
28	29.33	29.50	30.00	0.98	1.14	1.34
29	30.92	31.17	31.25	1.41	2.45	3.04
30	25.92	25.92	28.42	10.54	8.23	2.91
31	31.17	30.00	30.92	3.79	5.63	4.30
32	28.42	27.58	28.42	2.62	4.55	4.43
33	27.00	27.00	29.17	1.96	4.63	4.50
34	26.42	26.83	28.42	1.41	3.07	3.46
35	24.50	26.00	27.83	1.18	1.98	2.79
36	30.08	28.92	29.08	1.11	1.61	2.16
37	25.33	26.92	28.25	1.13	1.61	1.92
38	22.92	24.58	27.00	1.00	1.21	1.66
39	24.75	24.75	26.75	1.17	1.48	1.84
40	19.50	21.08	24.33	4.29	1.90	2.32
41	16.42	18.25	21.42	2.88	2.29	2.18
42	16.25	18.33	21.50	1.96	2.97	2.81
43	17.33	18.33	20.92	1.48	1.79	1.92
44	8.67	9.33	14.25	9.74	3.91	3.75
45	8.92	9.08	12.08	7.98	6.31	2.81
46	12.42	11.75	13.08	4.58	5.47	3.53

Distribution of Soil Arthropods

We now have many more records than we had for our last report. Statistical analysis has been carried out in consultation with Dr. Dick Beckman of the Los Alamos Scientific Laboratory and Mr. Howard Kaaz of this laboratory, for all of the data for weeks 2-26.

An analysis of variance (Table 4) was carried out by the use of the University of California Health Science Biomedical Program P2V. Results show that the four species of shrubs are not significantly different as regards the density of arthropod populations beneath them ($p > 0.87$). This is important because it means that for future purposes all shrubs may be treated in the same manner. We have also been able to confirm our earlier suggestions about the ways in which populations are distributed in relation to the bases of shrubs. The effects of distance and depth from the bases on arthropod densities are highly significant, $p < 0.001$ in both cases.

Rather unexpectedly, there is no effect of size of shrub. In other words, the density of arthropods in a 1-liter sample at the base of a small shrub is not significantly different from that of a large shrub ($p = .850$). Differences between individual samples are great, however, and may appear when further data are available.

For weeks 2-9, samples were taken from solitary shrubs only. Thereafter, in an attempt to approach the rather formidable problem of the effects of clumping, two of the species sampled per week were solitary shrubs and the other two were from clumps. A clump of shrubs usually consists of up to four shrubs, and for the present, each clump has been treated as a single (large) shrub, the "species" of the clump being determined by that of the largest shrub in the clump. From week 15 onwards, the procedure was again changed, and we took samples from solitary shrubs and from clumped shrubs on alternate weeks.

In order to express these results in terms of numbers per hectare, we modified our earlier procedure to conform with that of Bamberg et al. (1974) for root biomass work. This procedure assumes that zone A (positions 1, 2 and 3) is representative of one-third of the total area covered by a shrub. Similarly, numbers at positions 4, 5 and 6 are summed to give a measure of numbers per m^2 for the remaining two-thirds of the shrub area (zone B), and finally positions 7, 8 and 9 are summed to indicate arthropod densities for the areas between shrubs (zone C).

Knowing the proportion of the whole area covered by each species of shrub (totaling about 14.93%; Turner et al. 1973), the proportions assignable to zones A and B, and the total uncovered area (80%), one can multiply up and derive a value for total arthropods per hectare. We note the figures of Turner et al. (1973) indicate about 25% of the cover is due to species other than those we have sampled and if we assume that arthropod densities are the same for the unsampled species as for the four species sampled, our values should be multiplied by 4/3 to bring them closer to the best estimate.

Densities described in the above manner are shown in Table 5, both for solitary and for clumped shrubs. The data do not lend themselves to a valid comparison of solitary and clumped shrubs because there were large variations in density with time (perhaps in relation to temperature or moisture), but a cursory examination does not suggest any consistent difference. It is, however, apparent from Figure 1 that densities increased fairly consistently from weeks 5 through 14 (during a period of rather high soil moisture and rising soil temperature); beyond these, numbers decrease as soil moisture decreases and temperature continues to rise. It will be interesting to see the effect of the precipitation, and resultant high soil moisture, in weeks 29 onwards, although temperatures were then at their highest for the year and this may have had an inhibitory effect.

Table 4. F and p values for various factors and their interactions from a repeated measured analysis of variance and covariance

	Solitary shrubs		Clumped shrubs		Degrees of freedom
	f	p	f	p	
Mean	4.12426	0.043	0.02941	0.864	1
Plant species	0.23477	0.872	0.60976	0.609	3
Distance	46.84322	0.000	7.10310	0.001	2
Depth	98.21718	0.000	21.08092	0.000	2
Sp-distance	1.88793	0.081	0.70472	0.646	6
Sp-depth	0.66620	0.677	0.78930	0.579	6
Distance-depth	25.09581	0.000	2.23442	0.066	4
Sp-distance-depth	0.88179	0.566	0.45121	0.941	12
Plant radius	0.03586	0.850	0.33766	0.562	1

Table 5. Densities of soil arthropods in Rock Valley in numbers per hectare (10^6) for each of weeks 2-26 of 1974. Estimates are based on (s) solitary shrubs and (c) clumped shrubs

Week	Density	Week	Density
2	23.15 (s)	14	48.42 (s)
			53.97 (c)
3	24.82 (s)	15	37.39 (c)
4	15.52 (s)	16	27.16 (s)
5	17.99 (s)	17	12.25 (c)
6	19.04 (s)	18	28.16 (s)
7	26.48 (s)	19	24.13 (c)
8	12.31 (s)	20	29.76 (s)
9	29.49 (s)	21	17 67 (c)
10	24.69 (s)	22	28.61 (s)
	10.94 (c)		
11	24.97 (s)	23	24.63 (c)
	75.45 (c)		
12	42.88 (s)	24	20.82 (s)
	42.35 (c)		
13	76.30 (s)	25	26.85 (c)
	46.61 (c)		
		26	9.74 (s)

Apart from actual density it is important to know how the relative abundance of arthropods at the different positions (depth and distance) changed throughout the year. So far as the first six months are concerned, these changes are shown in Table 6, where each entry is the percentage at that position of the total catch at all positions, averaged over all species for all samples for each month. These changes may be more readily appreciated from Figure 2, where the data are expressed as densities. From this it is clear that as the year progressed there were indeed changes in relative and absolute abundances at the various positions. For example there is a fairly consistent increase in relative abundance at positions 3, 6 and 9 from March through June, while the reverse is largely true for positions 1, 4 and 7.

Densities in numbers m^{-2} by zone and by month are shown in Table 7. Thus, in zone A (the center one-third of each shrub), with all three levels combined, absolute density increased from 6.68×10^3 m^{-2} in January to 17.95×10^3 m^{-2} in March, while total densities for the whole site (which are weighted means taking relative areas of zones A, B and C into account) rose only from 2.04×10^3 m^{-2} to 4.3×10^3 m^{-2} during the same period.

Finally, it is interesting to look at the numbers when these are broken down into approximate trophic groups which correspond to some extent to taxonomic groups. This has been done in Table 8. Collembolans, it appears, declined in numbers continuously during the first six months of the year. The other groups all showed the increase in March and subsequent decline, referred to above.

Table 6. Relative abundance of soil arthropods by month and position. Each entry is the percentage at that position of the total catch at all positions, averaged over all species for all samples in the month concerned. (Standard deviation of species means around the overall mean)

January			February		
49.32 (6.68)	23.35 (7.00)	12.26 (2.47)	47.71 (4.21)	19.42 (2.88)	14.93 (4.31)
5.70 (2.05)	1.65 (0.85)	1.68 (0.67)	7.76 (1.96)	2.66 (1.62)	2.31 (0.58)
2.29 (1.09)	3.35 (4.87)	0.40 (0.28)	2.83 (1.47)	1.23 (1.03)	1.10 (0.46)
March			**April**		
55.42 (12.55)	21.61 (9.58)	8.76 (2.98)	39.20 (8.44)	23.07 (4.27)	14.31 (4.58)
5.17 (1.07)	2.02 (1.10)	1.08 (0.47)	9.37 (5.28)	3.99 (1.56)	2.90 (1.26)
1.87 (1.13)	0.82 (0.36)	0.58 (0.28)	3.44 (1.48)	2.16 (0.81)	1.48 (1.56)
May			**June**		
30.16 (6.34)	13.26 (1.54)	7.74 (1.93)	35.14 (5.34)	11.63 (2.74)	4.93 (1.54)
14.70 (3.34)	11.62 (4.37)	8.60 (2.65)	14.64 (5.08)	7.84 (3.94)	5.02 (3.14)
6.24 (2.36)	3.80 (1.37)	3.83 (1.37)	12.16 (4.39)	6.71 (3.53)	4.92 (1.54)

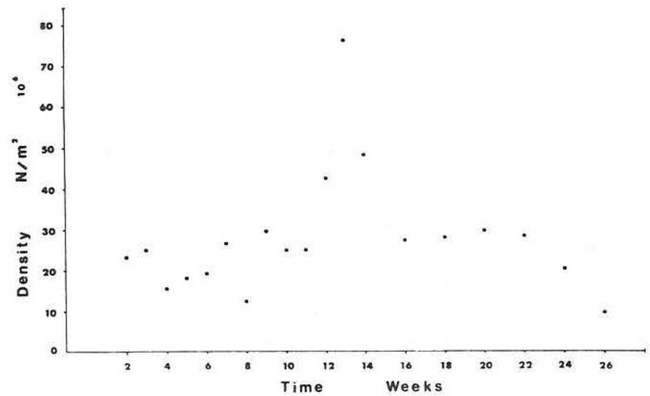

Figure 1. Density estimates of soil arthropods in Rock Valley during the first 26 weeks of 1974 (based on solitary shrubs only).

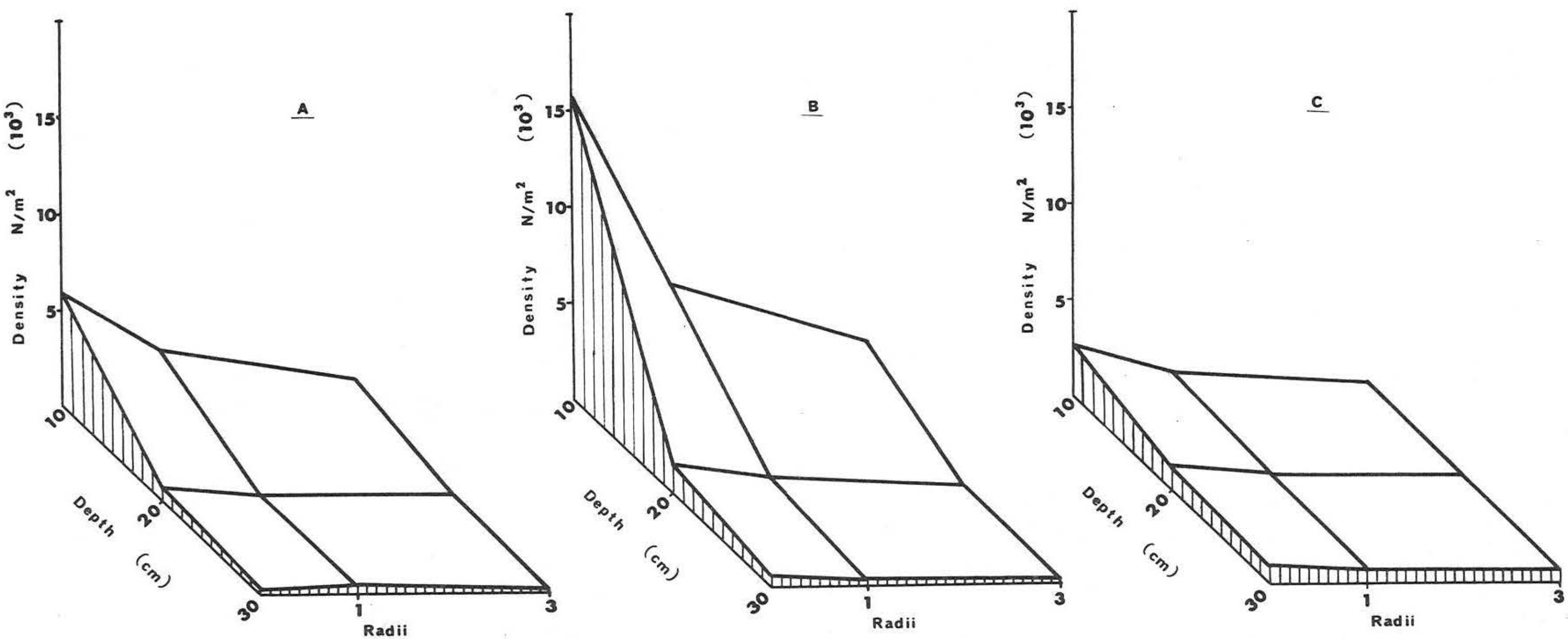

Figure 2. Three-dimensional graphs showing the densities of soil arthropods in relationship to depth and distance from desert shrubs. Means for all plant species; (A) the situation in January, (B) in March, (C) in June.

DISCUSSION

A disturbing aspect of this work is that we have not yet obtained any reliable data about the effectiveness of our extraction technique. Certainly, for the soils we have to deal with, our modification of Newell's (1959) modified Tullgren funnels do better than Salt and Hollick's (1944) flotation method as modified by Bender et al. (1972). But reliable figures are urgently needed, and we propose to obtain them.

Another urgent need is for data concerning the biomass (or perhaps carbon content) of the various species that occur in the area. We must bear in mind that, although they may be rare, one tenebrionid larva (which is probably omnivorous) may represent as much carbon as several thousand prostigmatid mites and have as much significance for energy flow (for a discussion of the faunal composition and its trophic components see our earlier report, Edney et al. 1974).

Table 7. Mean absolute densities ($\bar{N}/m^2$)(10^3) by zone and by month. The "total area" value represents a weighted mean based on proportional areas of the zones. $\bar{x}$ of the four plant species sample (one standard deviation)

Month	Zone A	Zone B	Zone C	Total area
Jan	6.68 (1.56)	3.59 (1.03)	1.67 (0.39)	2.04
Feb	7.07 (2.27)	2.66 (1.21)	1.99 (0.86)	2.18
Mar	17.95 (8.71)	6.51 (2.94)	3.45 (1.68)	4.30
Apr	7.25 (2.39)	4.79 (3.05)	3.44 (1.84)	3.58
May	6.08 (1.44)	3.46 (0.68)	2.40 (0.51)	2.57
Jun	4.60 (0.56)	2.78 (0.99)	1.93 (0.95)	2.27

There is also need for improvement in our method for estimating the total number of arthropods present. To assume, as we do, that zone A represents one-third of the area covered by a shrub may lead to considerable error, as may the other two major assumptions. This problem is receiving attention, in consultation with Dr. Beckman.

As predicted last year, densities did increase in the winter and spring from the very low summer levels we then reported. The highest density observed so far this year is 17.95 x 10^3 m^{-2}, for zone A in March (Table 7). This is only marginally lower than Wood's (1971) figure for microarthropods in an Australian desert. It should be noted, however, that our weighted mean density for the same period above is only 4.30 x 10^3 m^{-2}.

These figures for arthropod densities compare to 1.54 x 10^5 to 8.34 x 10^5 m^{-2} in various forest ecosystems, and 3.20 x 10^4 to 2.98 x 10^5 m^{-2} for grasslands (Wallwork 1970). Krivolutsky (1968) reported about 250 cryptostigmatid mites m^{-2} while our highest numbers for the same group (again in March) were 950 m^{-2}.

We do not propose to comment at present on the possible causes of the fluctuation in absolute density and change in relation to positional abundance, because the data presented here are incomplete, save to point out that soil temperature and moisture will certainly be involved, but their interaction may prove to be complex -- at times complementary, at times conflicting.

EXPECTATIONS

We hope to have reliable data on extraction efficiency soon, and when we have further new detailed information about the shape of the distribution profile of arthropods in relation to the bases of shrubs, we should be in a position to improve our calculations of total numbers. We shall also aim at finding values for the biomass.

When all the samples for 1974 have been processed (some 7,500 samples will have been extracted and half this number counted) we believe that a more understandable picture will

Table 8. Mean monthly density (averaged for all positions and converted to numbers per hectare [10^6]) for five different taxonomic (and largely trophic) groups of soil arthropods

Month	Collembola	Cryptostigmata	Nonpredatory Prostigmata	Predatory Prostigmata
Jan	10.43 (7.75)	4.70 (1.18)	5.73 (2.75)	1.08 (0.39)
Feb	2.60 (0.99)	6.75 (2.40)	6.92 (2.40)	2.14 (0.74)
Mar	1.66 (0.73)	9.41 (4.35)	25.08 (11.32)	4.11 (1.97)
Apr	0.28 (0.14)	5.78 (4.10)	23.78 (17.46)	3.53 (2.31)
May	0.10 (0.03)	4.00 (0.92)	11.63 (2.48)	3.94 (0.86)

be visible -- at present we have presented only the first half-year's data. We believe the next important step will be to analyze the effects of the abiotic factors we have been measuring, and plans to do so by controlled experimental manipulation are already in hand. The work will be concerned, in the first place, with the effects of soil water activity and salt concentration, and experiments will be done partly on the Nevada Test Site, and partly in the laboratory at UCLA.

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