Microarthropods of a Desert Tabosa Grass (Hilaria mutica) Swale

YOSEF STEINBERGER[1]

and

WALTER G. WHITFORD[2]

Department of Biology, New Mexico State University, Las Cruces 88003

ABSTRACT: We examined soil microarthropod populations inhabiting a clay-silt soil of a tabosa grass (*Hilaria mutica*) swale in southern New Mexico. Maximum population densities of soil microarthropods occurred in September ($48,400.m^{-2}$) and lowest densities were in July ($1,250 \cdot m^{-2}$). These densities were 50% lower than those reported for well-drained soils on the upper parts of the same watershed. Prostigmatid mites made up 67% and cryptostigmatid mites, 26%, of the total microarthropod population. The ratio between prostigmatid and cryptostigmatid mites, approximately 4:1, was consistent throughout the year. Overall densities of microarthropod groups were correlated with soil moisture but many individual taxa were not. The most numerous and frequently occurring taxa [nanorchestid, tydeid and bdellid mites (Prostigmata); *Aphelacarus* sp. and *Cosmochthonius* sp. (Cryptostigmata)] are common in all Chihuahuan desert habitats examined to date and are common in other North American desert areas.

INTRODUCTION

Microarthropods constitute a numerically important component of the soil fauna. Microarthropods play an active role in breakdown of dead plant parts (Santos and Whitford, 1981), in vertical transport of organic material through the soil profile, in humus formation, and they may also increase microbial activity by disseminating fungal spores (Wallwork, 1970). Santos *et al.* (1978) and Franco *et al.* (1979) found that, in two North American desert areas, the microarthropod fauna was dominated by prostigmatid mites rather than the oribatid mites that feed on dead plant material in more mesic environments. Loots and Ryke (1967) working in different South African biotopes found that the soil moisture content was not always the most important factor determining the composition of the soil microarthropod fauna. They found a significant correlation between the ratio of oribatei/trombidiformes (= prostigmata) and the percentage of organic matter in different soils.

Montane piedmonts, bajadas, in the desert Southwest of North America, drain onto clay basins or flats which form from the deposition of fine particles. The clay "pans" and "swales" are characterized by poor drainage and poor percolation. Following rains, they may be inundated for varying periods. Clay pans may be unvegetated or have sparse shrub and grass cover. Swales are characterized by a dense cover of tabosa grass, *Hilaria mutica*. Litter accumulation constitutes an important storage reservoir in desert ecosystems and may affect soil water, which is generally thought to affect the density of soil fauna. Because of the soil characteristics of swales, *i.e.*, poor drainage, low infiltration and percolation, high soil water content and relatively high vegetative cover, we hypothesized that the soil fauna would differ in taxonomic composition and exhibit less seasonal change in population size than microarthropod populations in better-drained desert soils. We further hypothesized that the population densities would be higher and numbers of taxa would be lower than those found in erosional soils.

Whitford *et al.* (1981) used simulated rainfall in comparison to natural rainfall to follow the responses of a number of taxa as the soils dried. They found marked shifts in

---

[1]Present address: Department of Biology, Bar-Ilan University, Ramat Gan, Israel.
[2]Address reprint requests to: W.G. Whitford, Department of Biology, New Mexico State University, Las Cruces 88003.

microarthropod taxa and density during drying after a rain. Rainfall results in movement of organic matter and varying levels of water storage in desert soils depending upon the position of the soil on the landscape. Because swales are run-on areas, we hypothesized that (1) soil microarthropod populations would increase in the wet season during periods of high soil moisture content and (2) the numbers of taxa and numbers of individuals would rapidly decrease during drying following rain.

METHODS

The study was conducted on a tabosa grass (*Hilaria mutica*) swale on the U.S. Dep. Agric.-ARS Jornada Experimental Ranch 30 km N of Las Cruces, Dona Anna County, New Mexico. The climate of the Jornada range is characterized by long-term average precipitation of 225 mm·year^{-1}, with approximately two thirds of the rainfall from summer convectional storms. Summer temperature maxima reach 40 C and freezing temperatures occur between October and March (Table 1). The swale receives run-off from a portion of the watershed of the Jornada desert LTER (Long Term Ecological Research) site. At each sampling period nine soil samples were taken at random near the base of the grass clumps (*H. mutica*) with a core sampler 9 cm in diam to a depth of 9 cm. We did not sample deeper than 9 cm because we have found few arthropods below that depth. The samples were collected in the early morning before sunrise, placed in plastic Ziploc (TM) bags and transported to the laboratory. Total elapsed time from soil core collection to placement in extractors was less than 1 hr. Microarthropods were extracted from five samples; and four samples were used to measure gravimetric water and organic matter content. Soil cores were collected monthly. In late summer and in January, cores were collected at 5-day intervals following a heavy rain.

The samples were weighed immediately upon return to the laboratory, and afterward they were dried at 60 C for 72 hr to measure water content gravimetrically. The oven-dried samples were then burned in a muffled furnace at 700 C for 4 hr to estimate the total organic matter. Microarthropods were extracted by the Tullgren funnels described by Santos *et al.* (1978). Genera of cryptostigmatid mites were identified by J.A. Wallwork. The genera of prostigmatid mites for which we have identifications were identified by E. Lindquist and *Speleorchestes* sp. novo by R.W. Strandtmann. Voucher specimens and reference collections are maintained at New Mexico State University.

Microarthropods were counted on the basis of family characteristics. Identifications to lower taxonomic groupings were made at the end of the study. There were more than a single species in the following; Tydeidae—3 species, Stigmaeidae—2 species, Cunaxidae—2 genera, *Passalozetes*—3 species and *Cosmochthonius*—3 species. The other higher groupings presented were monogeneric or monospecific.

The common hydrometer method of determining particle-size distribution of the soils was used to classify the soils of the location (Bowles, 1978). Soil samples were collected once a month for 1 year. Unless otherwise stated, all data were analyzed by analysis of variance.

RESULTS

The soil, silt (32.0%), sand (30.8%) and clay (32.2%), was classified as a clay loam. There were significant temporal differences in soil moisture content. The soil moistures between September-February were significantly higher ($p<0.05$) than between March and August (Fig. 1). There were no significant differences in organic matter content during the year. The organic matter content of the surface 8 cm was ($\bar{x}=8.21\pm0.42$) (Fig. 1).

The yearly movement or activity of microarthropods in the top 8 cm of soil was related to the soil moisture. The highest population densities of microarthropods occurred in September ($\bar{x}=48,414\pm19,003$ m^{-2}) following the summer rain; the lowest population densities were found in July ($\bar{x}=1257\pm997$ m^{-2}) (Fig. 2). There was a significant correlation between soil moisture and microarthropod density ($r=0.79$, p. <0.001).

We found higher densities of Prostigmata than other orders of mites (Fig. 3, Table 1). Prostigmatid mites comprised 67% of the soil fauna while cryptostigmatids, mesostigmatids and astigmatids accounted for 26%, 4% and 2%, respectively. The Prostigmatid and cryptostigmatid mite populations fluctuated from 503 to 30,809 mites m^{-2} and 251 to 11,694 mites m^{-2} respectively (Fig. 3), while the mesostigmatid and the as-

TABLE 1.—Monthly average maximum and minimum air temperatures (C) and total monthly precipitation from the USDA-ARS Jornada station headquarters 6 km from the study site

	Maximum (C)	Minimum (C)	Precipitation (mm)
1980			
June	37.8	12.0	0.0
July	38.1	16.2	14.2
August	34.2	16.3	40.9
September	30.3	12.7	50.0
October	24.6	2.2	10.9
November	16.7	−4.1	2.8
December	17.0	−6.5	9.9
1981			
January	14.6	−4.5	13.7
February	17.7	−6.5	1.0
March	18.0	−1.0	10.9
April	25.7	5.1	4.6
May	28.7	9.2	28.7
June	35.9	13.6	26.4
			214.0

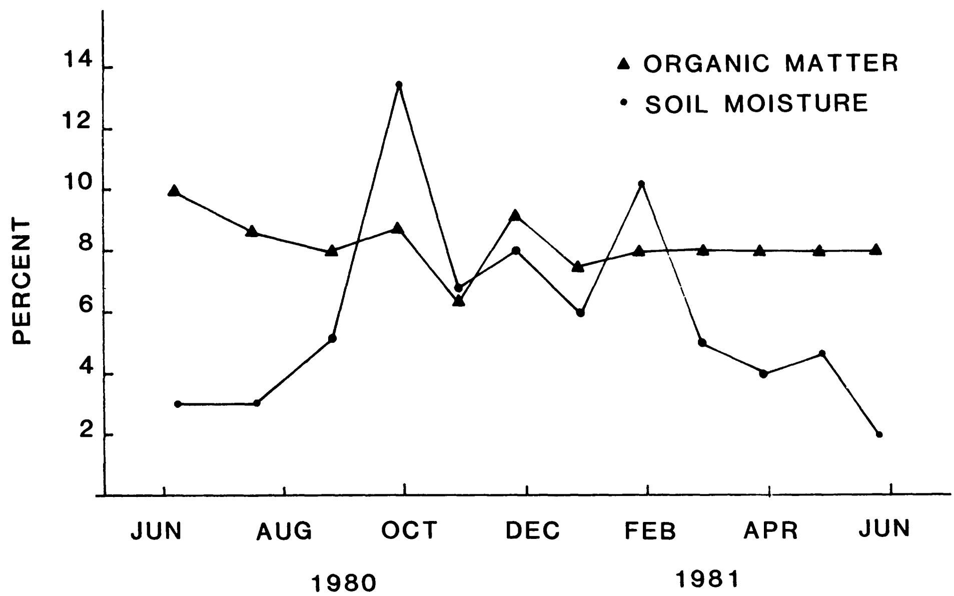

Fig. 1.—Variation in mean soil moisture and organic matter in a *Hilaria mutica* swale over a 1-year period

tigmatid mites occurred in very low numbers throughout the year. There was a significant correlation between the population densities of cryptostigmatid and prostigmatid mites, $r = 0.95$, $p < 0.01$ and between these mites and the soil moisture, $r = 0.79$, $p < 0.002$ and $r = 0.81$, $p < 0.001$, respectively.

Five families (Tydeidae, Nanorchestidae, Linotetranidae, Stigmaeidae, and Bdellidae) of the 12 prostigmatid families and two genera (*Cosmochthonius, Aphelacarus*) from a total of six genera of cryptostigmatids occurred at a frequency between 0.5 and 1.0 (Table 2). The population densities of the prostigmatid families, Tydeidae, Nanorchestidae, Pygmephoridae, Bdellidae and Scutacaridae, were significantly correlated with soil moisture content as were the cryptostigmatid genera, *Passalozetes, Joshuella,* and *Cosmochthonius* (Table 2).

The Mesostigmata and Astigmata were found nine and six times during the year, respectively, and there was no correlation between presence or abundance of these taxa and soil moisture or soil organic matter. Collembola, Diplura and Psocoptera were found occasionally during the year. There were no significant correlations between population density and soil temperature in any of the frequently encountered taxa.

The cryptostigmatid genus *Passalozetes* and Psocoptera that were present most of the time during August were absent from the soil fauna in January. The maximum soil moisture of 19.6% in August (Fig. 4) was significantly higher than the maximum soil

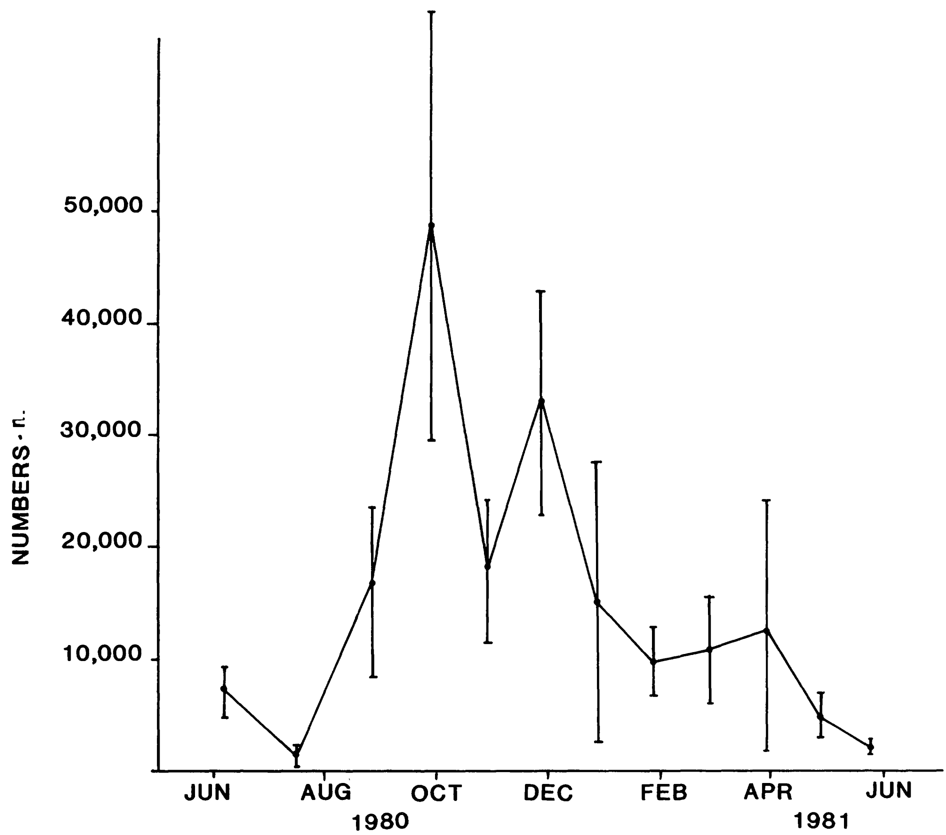

Fig. 2.—Annual variation in average population densities of microarthropods ± 1 SD (vertical lines) in soils from a *Hilaria mutica* swale in the northern Chihuahuan desert

moisture during January (13%). Despite this difference, the total microarthropod densities were similar (Fig. 4).

Comparing the composite total microarthropod population found in the 2 months of intensive sampling (Fig. 5), we found that during January prostigmatids comprised 74.5%, cryptostigmatids 19.0%, and the remaining 6.4% were collembolans. During August the microarthropod population was 38.5% prostigmatids, 13.6% cryptostigmatids and the remaining 47.9% were psocopterans, collembolans and japygids.

There was a high correlation between soil moisture and abundance of the genus *Passalozetes* and collembolans in August. In January the abundances of nanorchestids and the *Galumna* were correlated with soil moisture.

Fluctuations in abundance of the most frequently encountered taxa varied seasonally (Fig. 5). Increases in abundance of the predatory bdellids lagged 1-2 months in comparison to the other taxa. The fluctuations in abundance of the oribatids, *Cosmochthonius* and *Aphelacarus,* followed the same general seasonal pattern as the prostigmatids with the exceptions of a sharp drop in *Cosmochthonius* in mid-October and a sharp increase in *Aphelacarus* in mid-March (Fig. 5).

DISCUSSION

The hypothesis that the soil fauna of tabosa grassland swales would differ in taxonomic composition and change less in population size than microarthropod populations on well-drained desert soils was not supported by the data from this study. The seasonal fluctuations in population size of the soil microarthropods were similar to those reported by Steinberger and Whitford (1984) for soil microarthropod populations from sandy soils on a desert watershed. The magnitude of changes in abundances and taxonomic

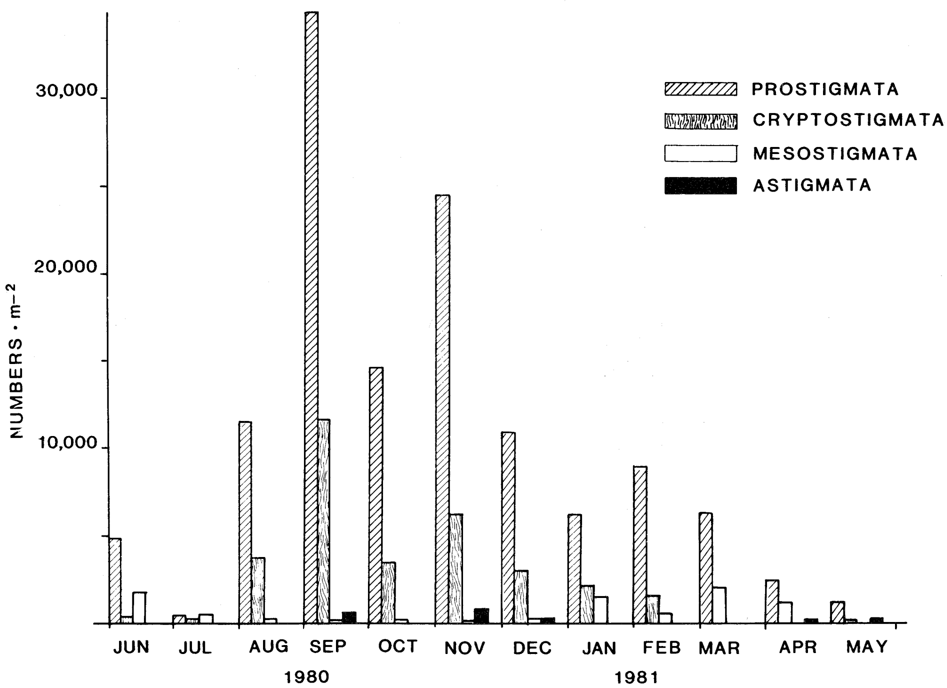

Fig. 3.—Annual variation in population densities of four orders of soil acari in soils of a *Hilaria mutica* swale

make-up of the soil microarthropod community in the swale, an area of water run-on, and soils with relatively high organic matter content was similar to those on erosional soils.

The most frequently encountered taxa included *Speleorchestes* spp. (Nanorchestidae), which probably feeds on cyanobacteria and possibly on other bacteria. *Speleorchestes* has been found in virtually every habitat and site that we have examined including gypsum dunes that are devoid of vegetation (Santos and Whitford, 1983). The other common family, the Tydeidae, is also characteristic of most Chihuahuan desert habitats (Santos and Whitford, 1981; Santos *et al.*, 1978; Santos and Whitford, 1983; Steinberger and Whitford, 1984). Tydeids may prey on nematodes (Santos *et al.*, 1981) but may also feed on fungi. The other abundant prostigmatid, bdellids, are predators and exhibited the time lag in peak population expected of a predator. The common oribatids, *Aphelacarus* sp. and *Cosmochthonius* sp., are generally the most abundant oribatid genera encountered in other Chihuahuan desert habitats (Wallwork *et al.*, 1984).

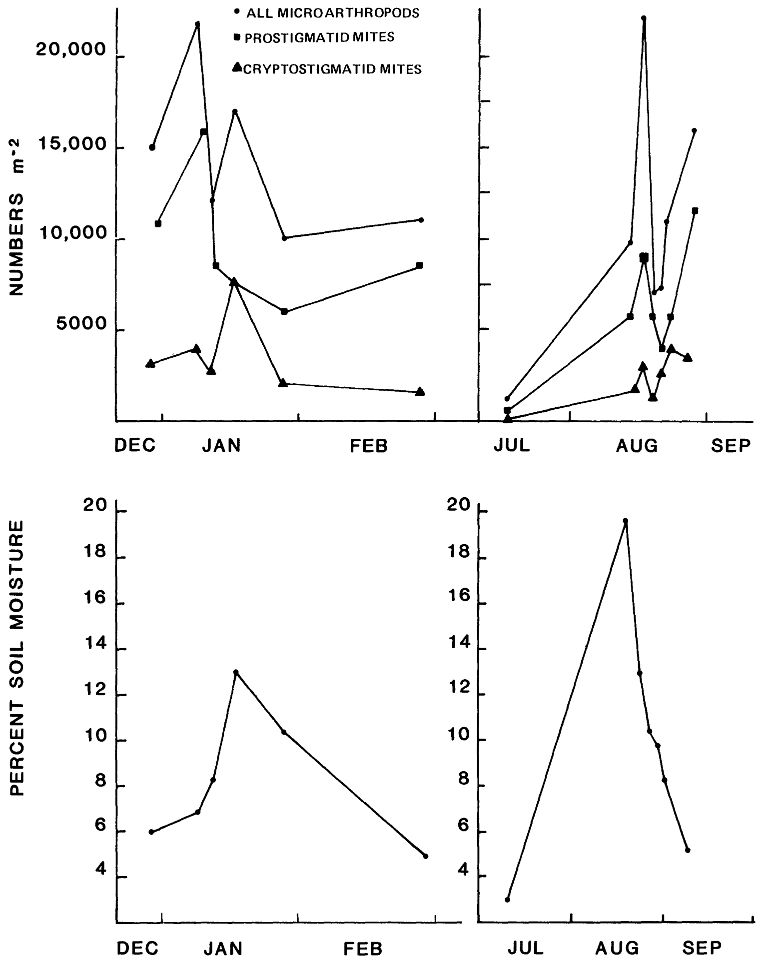

Fig. 4.—Variations in microarthropod population densities and population densities of the component abundant acari (cryptostigmatid and prostigmatid mites) following heavy rains in summer and winter. The lower panel presents the variation in soil moisture as a reference

Thus, the most abundant taxa of microarthropods found in the heavy clay soils of a *Hilaria mutica* swale are the same taxa that are most abundant in other Chihuahuan desert soils including the gypsum dunes of the White Sands National Monument (Steinberger and Whitford, 1984; Santos and Whitford, 1983; Santos *et al.*, 1978). Many of these taxa were common in the Mojave Desert also (Franco *et al.*, 1979). Santos *et al.* (1984) reported similar taxa of microarthropods from buried litter in the North American hot deserts. Taxa extracted from litter bags are a subset of the soil fauna. The similarity of taxa in buried litter bags lends credence to the idea that the soil microfauna in North American hot deserts are dominated by the same taxa. In the cryptostigmatids we found the same genera in a variety of habitats, and these genera were also found in the Mojave Desert (Wallwork, 1972a; Franco *et al.*, 1979). Diversity of soil microarthro-

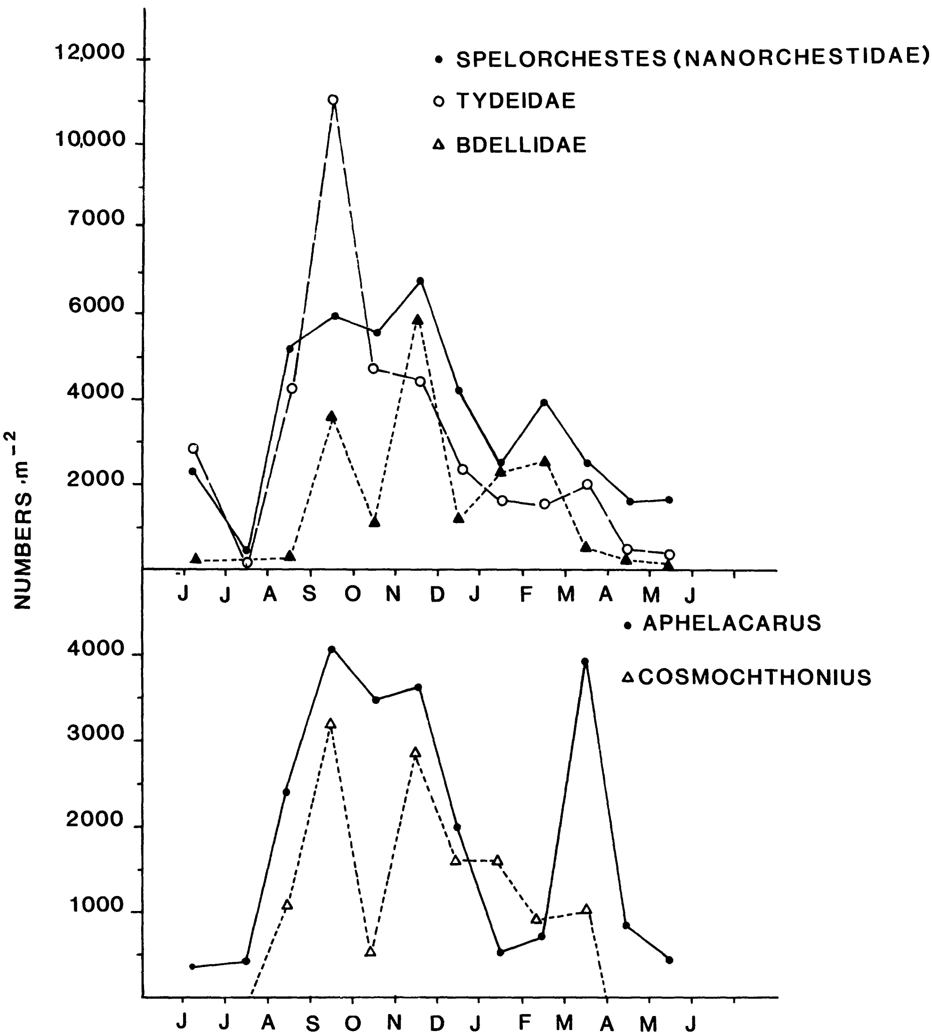

Fig. 5.—Annual variation in average population densities of the most frequently encountered Prostigmata and Cryptostigmata (oribatii)

pods is greater in microhabitats where there are substantial litter layers (Wallwork, 1972b, Santos *et al.*, 1978). In a tabosa swale a distinct litter layer is absent. The organic matter that provides the energy base for the swale microfauna is undoubtedly the dense mat of grass roots characteristic of perennial grass habitats. The production of organic matter by that root mat occurs during the growth of *Hilaria mutica,* a C4 grass, which occurs predominately in late summer. The phenology of most soil microarthropods also appears to be related to the predictable "wet" season of late summer. In most taxa, peak populations and presence of immatures occurred between late September and November, following the wet season and peak production of *H. mutica.*

The second hypothesis assuming higher population densities in the swale than in well-drained soils was rejected by this study. Maximum densities of microarthropods in the tabosa grass swale are only half of those reported from well-drained soils under mesquite on the upper slopes of the watershed (Steinberger and Whitford, 1984) but fall well within the range reported for other desert areas (Franco *et al.*, 1979). This may be a reflection of the lack of a distinct litter layer in this habitat as discussed previously.

The correlations of population size and soil moisture present some confusing pat-

TABLE 2.—Frequency of occurrence of soil microarthropod taxa in soil cores taken in a tabosa grass (*Hilaria mutica*) swale in the northern Chihuahuan desert. Cores were taken at monthly intervals. Correlation coefficients are given for the taxa in which there was a significant correlation between population densities and soil moisture over the 1 year of sampling

Taxon	Frequency	Correlation coefficient
Acari		
Prostigmata		
Tydeidae	1.0	$p<0.01$; $r=.81$
Nanorchestidae *Speleorchestes* sp.	1.0	$p<0.02$; $r=.67$
Linotetranidae	0.50	
Pygmephoridae *Siteroptes* sp.	0.33	$p<0.01$; $r=.74$
Tarsonemidae *Tarsonemus fusarii*	0.33	
Raphignathidae	0.16	
Stigmaeidae	0.75	
Bdellidae *Spinibdella* sp.	0.83	$p<0.05$; $r=.65$
Cunaxidae	0.42	
Scutacaridae *Imparipes* sp.	0.08	$p<0.01$; $r=.71$
Trombidiidae	0.58	
Teneriffidae	0.08	
Cryptostigmata		
Gymnonota	0.16	$p<0.01$; $r=.71$
Passalozetes sp.	0.25	$p<0.01$; $r=.71$
Joshuella sp.	0.08	$p<0.01$; $r=.71$
Cosmochthonius sp.	0.66	$p<0.01$; $r=.84$
Galumna sp.	0.42	$p<0.01$; $r=.75$
Aphelacarus acarinus	1.0	
Mesostigmata		
Rhodacaridae	0.75	
Astigmata		
Acaridae	0.50	
Insecta		
Diplura (Japygidae)	0.08	
Psocoptera	0.25	
Collembola	0.08	

terns. Some, but not all, of the most abundant and most frequently encountered taxa were correlated with soil moisture. Usher (1976) holds that the most important environmental factor acting on soil arthropods is the soil water. Clearly this is not the case with all of the soil microarthropods inhabiting a desert swale. If the lack of correlations with soil moisture were only among infrequently encountered taxa, we could attribute the lack of correlation to sampling error. However, since the densitites of several of the most frequently encountered taxa were not correlated with soil moisture, we must assume that other factors like seasonal patterns of movement within the soil are more important than soil moisture as determinants of abundance of these taxa. The large fraction of the soil microarthropod community made up of insects, psocopterans, collembolans and japygids in August probably reflects their reproduction and rapid growth in midsummer. Santos *et al.* (1984) found liposcelid psocopterans to be the most abundant microarthropods in buried litter in late summer in all of the North American hot deserts. Based on body size and numbers, these insects could be very important in breakdown of dead plant materials in desert ecosystems. Data on life history characteristics and feeding biology of these organisms are needed to examine such questions.

The data do not completely support the hypotheses concerning responses of microarthropods during drying following rain. Although the soil continued to dry in summer, the number of microarthropods increased after the initial drop in numbers. This increase was probably due to the addition of juveniles to the population as a result of reproduction that occurred during the rain pulse. The actual changes in numbers may have been greater than reported because we are not certain how effective our extraction method was for immature mites. The decrease in numbers of microarthropods as the soils dried in January is the expected pattern. The drying soil may result either in mortality or change in physiological state to a resting or desiccation resistant state (Greenslade, 1981; Poinsot-Balaguer, 1976).

Acknowledgments.—This research was supported by Grant DEB 8020083 from the National Science Foundation to W.G. Whitford.

LITERATURE CITED

BOWLES, J.E. 1978. Engineering properties of soils and their measurement, 2nd ed. McGraw-Hill, New York. 187 p.

FRANCO, P.J., E.B. EDNEY AND J.F. MCBRAYER. 1979. The distribution and abundance of soil arthropods in the northern Mojave desert. *J. Arid Environ.*, **2**:137-149.

GREENSLADE, P. 1981. Survival of collembola in arid environments: observations in South Australia and the Sudan. *Ibid.*, **4**:219-228.

LOOTS, G.C. AND P.A.J. RYKE. 1967. The ratio Oribatei: Trombidiformes with reference to organic matter content in soils. *Pedobiologia*, **7**:121-124.

POINSOT-BALAGUER, N. 1976. Dynamique des communantes de Collemboles en milien xerique mediterraneen. *Ibid.*, **16**:1-17.

SANTOS, P.F., E. DEPREE AND W.G. WHITFORD. 1978. Spatial distribution of litter and microarthropods in a Chihuahuan desert ecosystem. *J. Arid Environ.*, **1**:41-48.

——— AND W.G. WHITFORD. 1981. The effects of microarthropods on litter decomposition in a Chihuahuan desert ecosystem. *Ecology*, **62**: 654-663.

——— AND ———. 1983. Seasonal and spatial variation in the soil microarthropod fauna of the White Sands National Monument. *Southwest. Nat.*, **28**:417-421.

———, J. PHILLIPS AND W.G. WHITFORD. 1981. The role of mites and nematodes in early stages of buried litter decomposition in a desert. *Ecology*, **62**:664-669.

———, N. Z. ELKINS, Y. STEINBERGER AND W.G. WHITFORD. 1984. A comparison of surface and buried *Larrea tridentata* leaf litter decomposition in North American hot deserts. *Ibid.*, **65**:278-284.

STEINBERGER, Y. AND W.G. WHITFORD. 1984. Spatial and temporal relationships of soil microarthropods on a desert watershed. *Pedobiologia*, **26**:275-284.

USHER, M.B. 1976. Aggregation responses of soil arthropods in relation to the soil environments, p. 61-94. *In*: J.M. Anderson and A. Macfadyen (eds.). The role of terrestrial and aquatic organisms in decomposition processes. Blackwell Scientific Publ., Oxford.

WALLWORK, J.A. 1970. Ecology of soil animals. McGraw-Hill, London. 355 p.
_______. 1972a. Mites and other microarthropods from the Joshua Tree National Monument, California. *J. Zool. Proc. Zool. Soc. Lond.*, **168**:91-105.
_______. 1972b. Distribution patterns and population dynamics of the microarthropods of a desert soil in California. *J. Anim. Ecol.*, **41**:291-310.
WHITFORD, W.G., M. BRYANT, G. ETTERSHANK, J. ETTERSHANK AND P.F. SANTOS. 1980. Surface litter breakdown in a Chihuahuan desert ecosystem. *Pedobiologia,* **4**:243-245.
_______, D.W. FRECKMAN, N.Z. ELKINS, L.W. PARKER, R. PARMALEE, J. PHILLIPS AND S. TUCKER. 1981. Diurnal migration and responses to simulated rainfall in desert soil microarthropods and nematodes. *Soil Biol. Biochem.*, **13**:417-425.

SUBMITTED 30 APRIL 1984 ACCEPTED 22 APRIL 1985