

SOIL MICROARTHROPOD FAUNA OF FOUR HABITATS OF
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ABSTRACT—A shrubland, a woodland, and two grassland habitats were compared for populations of soil microarthropods in a semiarid watershed of New Mexico. Densities of grass rhizosphere microarthropods were generally higher, and some taxa like sminthurid collembolans were essentially limited to the grama grassland habitat. However, the rhizosphere fauna was also not quantitatively or qualitatively different from fauna of unvegetated soil or soil below the litter layer except in the grama grassland habitat. The similarity in microarthropod faunas in the soils of the four major habitats shows soil microarthropod assemblages are more a function of the organic matter content of the soil and the microclimate of the upper 10 cm than of the individual plant species.

Soil microarthropods have been found to play important functional roles in soils of arid ecosystems (Santos et al., 1981; Parker et al., 1984). In soils that are dry for extended time periods, most taxa of soil biota are inactive with the exception of certain fungi and microarthropods (Whitford, 1989). Thus, in arid and semiarid ecosystems, during dry periods, microarthropods regulate decomposition and mineralization processes in litter and in soil and, possibly, in the rhizosphere of grasses.

There are numerous studies on the structure of microarthropod assemblages in desert soils (Santos et al., 1978; Franco et al., 1979; Santos and Whitford, 1981; Steinberger et al., 1984; Kamill et al., 1985; Silva et al., 1985; Steinberger and Whitford, 1985; Wallwork et al., 1985). There are few data on the microarthropod faunas of the slightly more mesic or cooler ecosystems that adjoin desert areas (Whitford, 1987). Seastedt's (1984) review of the literature on the role of microarthropods in decomposition and mineralization processes indicated that oribatid (cryptostigmatid) mites are dominant in forested ecosystems and prostigmatid mites are dominant in arid ecosystems. These community composition differences are reflected in qualitative and quantitative differences in the functional roles of microarthropods in these ecosystems (Seastedt, 1984).

The Rio Puerco watershed in northeastern New Mexico provides gradients of varying aridity and with vegetative cover dominants varying over blue grama (*Bouteloua gracilis*) grasslands, sagebrush (*Artemisia tridentata*) shrublands, juniper (*Juniperus monosperma*) grassland, and open ponderosa (*Pinus ponderosa*) and pinyon (*Pinus edulis*) woodlands. The grassland and juniper grassland habitats grade into desert shrublands, and the pine types may approach forest in physiognomy. On a gradient from shrubland to pine woodland, is there a shift in taxonomic composition of microarthropod communities toward a forest type assemblage? Do population densities of microarthropods increase along such a gradient? The answers to these questions will allow an assessment of the probable functional roles of these animals in such habitats and of the probable mechanisms of decomposition and nitrogen mineralization. We addressed these questions by comparing the microarthropod communities in four habitats in the Rio Puerco watershed in northwestern New Mexico.

MATERIALS AND METHODS—The study area, referred to as the Upper Rio Puerco Watershed, was 64 km northwest of Albuquerque, New Mexico. It comprised approximately 207,172 ha with an elevational gradient from 1,662 to 2,743 m. The climate was semiarid (Y. Tuan et al., in litt.) with annual precipitation

TABLE 1—Comparisons of population densities (number per squared meter) of soil and litter microarthropods from four habitats on the Rio Puerco watershed, northwestern New Mexico. BG = rhizosphere of the grass *Bouteloua gracilis*, BL = soil core below litter, UN = soil core from unvegetated area, and LI = core sample of litter layer and underlying soil.

Microarthropod	Sub-habitat	Habitat			
		Sagebrush	Grama grassland	Juniper grassland	Pine woodland
Prostigmata	BG	1,192	3,475	1,324	1,092
Tydeidae	BL	1,854	1,291	1,357	1,721
	UN	1,192	3,343	2,151	1,456
	LI	4,180	1,210	5,225	5,528
	BG	364	1,059	794	910
Nanorchestidae	BL	103	1,059	430	364
	UN	1,456	860	894	430
	LI ¹	2,888 A	220 B	4,345 C	1,128 A
	BG	66	33	0	630
Tarsonemidae	BL	695	165	331	265
	UN	132	397	0	198
	LI	126	860	0	364
	BG	132	298	199	232
Predatory Prostigmata	BL	198	165	0	33
	UN	66	198	99	0
	LI	1,059	430	2,151	1,787
	BG	99	265	331	331
Cryptostigmata <i>Passalozetes</i> sp.	BL	331	22	99	0
	UN	0	397	99	199
	LI ¹	1,787 A	525 B	4,104 C	2,412 A
	BG	99	99	221	221
<i>Joshuella</i> sp.	BL	132	0	221	66
	UN	33	331	0	66
	LI ¹	467 A	0 B	2,860 C	495 A
	BG	66	827	0	529
<i>Aphelacaris</i> sp.	BL	165	132	33	430
	UN	132	563	0	232
	LI ¹	132 A	860 A	0 B	1,026 C
	BG	33	33	33	66
<i>Oribatula</i> sp.	BL	33	0	0	0
	UN	0	33	0	0
	LI	126	0	1,059	331
	BG	33	232	0	66
Other Cryptostigmata	BL	33	33	0	0
	UN	0	0	0	33
	LI	232	165	331	501
	BG	33	391	33	165
Mesostigmata	BL	165	66	33	66
	UN	0	66	0	198
	LI	688	138	55	165
	BG	0	66	0	563
Insecta	BL	265	0	0	662
Collembola	UN	0	0	33	33
	LI	2,173	358	798	3,245
Sminthuridae	BG	0	596	0	0
	BL	0	1,258	0	0

TABLE 1—Continued.

Microarthropod	Sub-habitat	Habitat			
		Sagebrush	Grama grassland	Juniper grassland	Pine woodland
	UN	0	0	0	0
	LI	0	83	438	0
Psocoptera	BG	0	33	0	0
Liposcellidae	BL	33	0	0	33
	UN	0	0	0	0
	LI	330	33	495	633
Total	BG	2,117	7,407	2,935	4,805
	BL	4,007	4,191	2,504	3,640
	UN	3,011	6,188	3,276	2,845
	LI	14,188	4,886	21,861	17,615

¹ Numbers within a row followed by the same letter are not significantly different. All were tested for significance by ANOVA followed by Tukey's procedure (Steel and Torrie, 1960). Means with heterogeneity of variances were compared by Welch's test (Milliken and Johnson, 1984) followed by Dunnett's T3 procedure (Dunnett, 1980). Differences at the 0.05 level of probability were considered significant.

ranging between 215.9 mm and 322.6 mm. Peak rainfall occurred between July and September as convective thunderstorms of high intensity and short duration. The mean summer maximum temperature was 38°C, and the mean minimum winter temperature -4°C. The soils were classified as Entisols and Aridisols with minor representation from Mollisols and units mapped as Complexes (Buol et al., 1973).

Forty-five plant communities have been quantified and classified in this area (Francis, 1986). From among these plant communities, eleven were considered the most representative of woodland, shrubland, and grassland formations. The soils of four habitats sampled in this study area were classified as follows: 1) pine woodland, silt clay loam soil; 2) juniper-grassland, clay loam soil; 3) sagebrush shrubland, sandy clay loam soil; 4) grassland, clay loam soil.

We sampled from three transects in each of the four plant habitats from 15 to 21 July 1987. Two random samples were taken for microarthropod extraction, soil water content, and organic matter content in each of four sub-habitats depending upon the dominant life form in the habitat being sampled. These were: a 36-cm² litter sample from mid-canopy of pine, juniper, or sagebrush plants and grass clumps to a depth of 7 cm; a 30.2-cm² soil core at mid-canopy beneath the litter of pine, juniper, or sagebrush to a depth of 10 cm; a 30.2-cm² soil core to a depth of 10 cm the mid-section of clumps of *B. gracilis*; and a 30.2-cm² soil core to a depth of 10 cm in an unvegetated area.

The litter and the soil samples from each of the locations were collected in the early morning, placed in individually labeled plastic bags, and stored in an insulated container for transport to the laboratory. The samples were placed on modified Tullgren funnels and

collected on water as described by Santos et al. (1978). The samples remained on the extractor for 48 h, after which the samples were wetted to field capacity and placed on the extractors to obtain samples of anhydrobiotic or cryptobiotic taxa. The re-wetted cores were extracted for another 48 h. The microarthropods were separated into the lowest identifiable taxonomic unit and counted. Identifications to lower taxonomic grouping were made at the end of the study.

A second set of samples was weighed immediately after return to the laboratory, and dried at 60°C for 72 h to measure gravimetric water content. The oven-dried samples were then burned in a muffle furnace at 700°C for 4 h to estimate total organic matter.

RESULTS—The microarthropod community in litter was dominated by prostigmatid mites with tydeids, nanorchestids, and tarsonemids representing the largest numbers. The ratio of cryptostigmatid to prostigmatid mites in litter was 0.5 in the grama grass litter, 0.3 in sagebrush litter, 0.45 in pine litter, and 0.75 in juniper litter. This ratio reflects the quality and quantity of the litter layer under these plants. The litter layer under *Juniperus* is thick, with a 2- to 3-cm deep layer of amorphous organic material. The litter layer under the pines has an amorphous organic layer of <1 cm. A litter layer is virtually absent in grasslands. Sagebrush litter accumulations tend to be thin and variable in structure. The cryptostigmatid mites that are dependent upon the partially decomposed litter include *Passalozetes* sp., *Joshuella* sp., and *Orbatula* sp. (Table 1).

TABLE 2—Comparisons of percent organic matter and percent water content from four habitats on the Rio Puerco watershed, northwestern New Mexico. BG = rhizosphere of the grass *Bouteloua gracilis*, BL = soil core below litter, UN = soil core from unvegetated area, and LI = core sample of litter layer and underlying soil. There were no statistically significant differences in organic matter and soil water content between vegetation types.

Component	Sub-habitat	Habitat			
		Sagebrush	Grama grassland	Juniper grassland	Pine woodland
Organic matter	BG	4.79 ± 1.91	9.65 ± 2.66	5.41 ± 2.36	5.25 ± 2.29
	BL	4.67 ± 1.89	11.54 ± 7.13	6.00 ± 1.74	7.50 ± 4.40
	UN	4.40 ± 1.85	7.21 ± 5.39	5.36 ± 2.76	4.56 ± 1.42
	LI	45.29 ± 20.50	65.77 ± 23.62	48.83 ± 24.99	84.21 ± 10.04
Water content	BG	11.50 ± 6.26	16.08 ± 8.46	4.38 ± 1.48	8.69 ± 4.59
	BL	8.07 ± 4.36	15.11 ± 7.03	6.34 ± 2.88	7.46 ± 3.75
	UN	10.48 ± 4.42	11.93 ± 4.12	5.05 ± 0.69	7.62 ± 2.96
	LI	58.88 ± 30.12	44.46 ± 31.27	8.33 ± 2.26	30.35 ± 15.91

There were a variety of predatory mite taxa in each habitat and locations within a habitat. The numerical abundance reflected the relative abundance of prey, with the highest numbers generally in the litter (Table 1). Densities of microarthropods were five to 10 times higher in litter than in the soil below litter or in the rhizosphere of grasses (Table 1).

The rhizosphere fauna of blue grama was qualitatively and quantitatively similar in all habitats except in the blue grama grassland habitats where there were qualitative differences. Densities of grass rhizosphere microarthropods were generally higher, and some taxa like sminturid collembolans were essentially limited to the blue grama grassland habitat. However, the rhizosphere fauna was also not quantitatively or qualitatively different from the fauna of unvegetated soil or soil below the litter layer (Table 1) except in the blue grama grassland habitat. Several taxa were recovered from samples re-wetted after the initial 48-h extraction. These were the cryptostigmatids: *Passalozetes* sp., *Joshuella* sp., *Aphelacarus* sp.; the prostigmatids *Speleorchestes* sp., Bdeliidae, and isotomid collembolans. All were taxa that were abundant in samples from the initial 48-h extraction, and most were recovered from re-wetted litter, not re-wetted soil cores.

The soil organic matter was similar among sites for each type of sampling unit (e.g., bare ground, below litter; Table 2) as was the soil water content. The large variance in soil organic matter and water content among samples from a sample unit resulted in a lack of statistically detectable differences among habitats (Table 2). The

differences reflect the large spatial heterogeneity of these habitats.

DISCUSSION—The similarity in microarthropod faunas in the soils of the four major habitats of the Rio Puerco supports the hypothesis that the species composition and population densities of soil microarthropod assemblages is more a function of the organic matter content of the soil and the microclimate of the upper 10 cm than of the plant species that provide the vegetation cover and organic matter resource (Wallwork et al., 1984; Whitford et al., 1986). These findings are consistent with the results of studies in a variety of desert habitats (Franco et al., 1979; Santos et al., 1981; Steinberger et al., 1984; Wallwork et al., 1985). The rhizosphere fauna of the blue grama was essentially the fauna of unvegetated soil or soil from under litter. The dominant species in blue grama rhizosphere were the same taxa as found associated with decomposing roots in the desert (Whitford et al., 1988). The seasonal precipitation pattern and hot, dry period of early summer in the Rio Puerco region produces desert-like conditions of the surficial soil layers where roots of annual plants and grasses are located. These abiotic conditions are known to affect the functional structure of the soil food webs (Whitford et al., 1981; Markay et al., 1987; Whitford, 1989). The functional soil food web in these habitats during the hot dry periods would be limited to fungi, fungus-feeding microarthropods, and assorted microarthropod predators, as described in the Chihuahuan Desert (Parker et al., 1984).

The most important difference in the four hab-

itats of the present study and the Chihuahuan Desert is the presence of large trees with their extensive litter layer that characterize the soils below the canopies in the present study. These organic rich patches provide habitat for Cryptostigmata, the mites characteristic of forest litter and soils (Seastedt, 1984). However, even in the desert where there are large trees and litter layers, cryptostigmatid mites are numerous and may be numerically dominant in the soil microarthropod community (Wallwork et al., 1985). Thus, this pattern is also consistent with the patterns characteristic of the desert.

Although the population densities of microarthropods in this study were lower than in some studies in deserts (Franco et al., 1979), they were equivalent to those reported in pinyon-juniper habitats (Whitford, 1987). The high densities and most diverse fauna are found at the end of the wet season from late August through October (Whitford, 1987). Because the sampling in this study was done before the recruitment of the young of the year in the populations, these density estimates probably represent the lowest densities for the year.

On the Rio Puerco watershed, average tree-canopy cover was 18.5% in the pine habitat and 6% in the juniper grassland. In the four habitats, grass cover ranged from 27.8% in the grama grassland to 0.8% in the pine woodland. In the four habitats sampled, unvegetated soil and cover of small shrubs and forbs represented most of the area. Based on these data, we conclude that the soil microarthropod fauna of the Rio Puerco habitats is essentially a desert fauna. Only in areas where the tree canopy is closed and the surface covered with a leaf litter layer will the microarthropod fauna be a "forest fauna." Thus, for the soil processes of decomposition and nutrient mineralization, the biological contribution will be essentially the same as in the Chihuahuan Desert.

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