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Effects of simulated rainfall and litter quantities on desert soil biota: soil respiration, microflora, and protozoa

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With 6 figures

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1. Introduction

Water has been shown to be a limiting factor for microbial and protozoan growth and activity in some soils (Waksman 1916; Cutler & Dixon 1927). Noy-meir (1974) has proposed a trigger-pulse-reserve paradigm for processes in desert ecosystems. According to this model, rainfall acts to trigger a pulse of biological activity followed by formation of a reserve that is capable of surviving the subsequent dry period, e.g. seeds, spores, cysts, etc. During initial wetting the pulse in numbers (Waksman 1916) & activity (Birch 1960) is proposed to result in solubilization of soil organic matter and dead microbial cells (Birch 1960; Powlson & Jenkinson 1976). However, subsequent water amendments do not necessarily increase microbial numbers (Soulides & Allison 1961). Water is therefore not the only factor limiting microbial growth in non-desert soil.

Protozoan numbers, unlike bacteria, may not increase with the addition of water, however, the proportion of active forms can increase dramatically (Culter & Dixon 1927). Protozoa were generally considered to exist only in very low numbers (100 g^{-1}) in desert soils and litter due to water unavailability (Bamforth 1980). In the Chihuahuan desert, protozoa occur at much higher numbers than previously thought and therefore may play a major role in nutrient cycling processes in ecosystems (Whitford *et al.* 1981; Parker *et al.* in press).

In soils under a litter layer, pulses of nutrients can be leached into the soil during rain events. Dead leaves of *Larrea tridentata* (creosotebush), the dominant woody species on our study site, may lose 2.5—20 % of its mass by leaching based on laboratory studies (Comanor & Staffeldt 1978). However, in desert ecosystems, litter is not uniformly distributed (Santos *et al.* 1978). As a result of wind and water action, some shrubs have essentially no litter accumulation under the canopy while others have an extensive litter layer. Whitford *et al.* (1982) found a relationship between litter quantity and decomposition, suggesting that quantity of organic matter may be an important factor limiting desert soil biota. Therefore, in order to understand the effects of rain pulses on desert soil biota it is necessary to take into account litter quantity. We hypothesized that water-triggered pulses in microbial and protozoan activity and biomass would be minimal except under surface accumulations of litter. To test this hypothesis we designed a complete factorial experiment to examine relationships between rainfall litter quantity and populations of soil biota. Here we report the microbial responses and in Steinberger *et al.* (1984) we report the nematode and microarthropod responses.

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2. Material and methods

This study was conducted at the base of an alluvial plain approximately 5 km ESE of Las Cruces, NM. The soils are deep sandy loams *p*H 7.8, average EC of 0.98 mmhos and Na of 1.29 meg l^{-1} with a vegetation cover of creosotebushes *(Larrea tridentata)* and scattered mesquite *(Prosopis glandulosa)* along drainages.

We selected 36 creosotebushes of similar size (70 to 100 cm high and 100 cm in diameter). All leaf litter was cleared from a 1 m^2 area below the canopy of each shrub. The shrubs were assigned at random to one of the following litter replacement regimes: 0, 30, or 150 g m^{-2}. The litter was spread evenly around the shrubs on 1 m^2 plots. The litter treatments were further divided equally to receive supplemental water at a rate of 12 mm water at three day intervals or a control (natural rainfall). Water was applied at a rate equivalent to 50 mm · h^{-1}. Water was applied using a hose with a spray nozzle adjusted to give a large droplet size. This provided a complete factorial design for examining responses of desert soil biota to water and litter quantity.

Soil cores (4.5 cm diameter × 8 cm deep) were taken from each plot at six day intervals just prior to water amendment between 06.00 and 08.00. Five cores of each treatment were subsampled for direct counts of bacteria and fungi. Three of these 5 cores were sampled for cystic and total protozoa counts using the most-probable-number technique (Cutler 1920; Singh 1946). Cystic counts were made by mixing 1 g of soil with 20 ml of 2 % concentrated HCl and incubating for 24 h at 4 °C. The acid was then neutralized with NaOH.

Bacteria were counted by the FITC method (van Veen & Paul 1979). We blended the 1 g litter and 100 ml water in a water cooled blender for 5 min, removed four-10 ml aliquots and spread them evenly over four one cm^2 areas of a microscope slide and placed the slide on a hot plate (approximately 40 °C). After the slides had dried, they were heat fixed for 3 sec. Cell volume was multiplied by 0.33 to estimate biomass-C (van Veen & Paul 1979).

Fungal biomass was estimated using the same slides as for bacteria but counting 30 fields per 1 cm^2 area. Fungal lengths were measured by the method described by Olson (1950). Biovolumes were estimated by measuring the mean diameter per field. The biovolume was multiplied by 0.33 to estimate biomass C (van Veen & Paul 1979).

Soil respiration was measured on every plot (6 replicates) by base absorption of CO_2. The CO_2 traps (25 ml 1 *N* NaOH in 60 mm diameter baby food jars) were changed every three days. Translucent plastic containers (14 cm in diameter) were placed over the traps and forced 1 cm into the soils surface during CO_2 measurements. The traps were placed on the plots immediately after watering and collected just prior to the next water amendment. Blanks were maintained in the laboratory.

Soil moisture was measured gravimetrically and soil organic content was estimated by burning soil in a muffle furnace for 8 h at 490 °C. Data were analyzed by analysis of variance. When significance was observed at the P = 0.05 level, Tukey's Q values were calculated for mean separation (Sokal & Rohlf 1969). Data are presented as means of 5 replicates except for protozoa (3 reps.) and soil respiration and organic content (6 reps.).

3. Results and discussion

The experimental design was such that the soil underwent wet-dry cycles every 3 days in the wet treatment and was pulsed at days 9, 12 and 19 in the dry treatment by natural rain events of 20, 30 and 5 mm, respectively. The field capacity (330 hPa ≙ 0.33 bar)[1]) of this soil was 9 % water. Natural rainfall at the time of sampling on day 12 resulted in high soil moisture values (Table 1). Soil moisture of the wet treatments was higher than dry treatments only on days 3, 6, 21, 24, and 27.

Table 1. The effect of natural and simulated rain on desert soil moisture content under creosotebush canopies

Water	Days								
	0	3	6	12	18	21	24	27	30
Wet									
before	0.5^a	2.1^b	2.8^b	8.6^a	3.4^a	3.9^b	3.4^b	4.7^b	4.1^a
after	8.2^b	—	12.2^c	—	7.8^b	8.6^b	10.3^c	12.2^c	—
Dry	0.5^a	0.5^a	0.5^a	8.5^a	3.7^a	3.3^a	2.8^a	3.6^a	4.2^a

Note: Values in a column followed by the same letter are not different at the (P = 0.05) level.

[1]) 1 bar ≙ 1.10^5 Pa = 1000 hPa

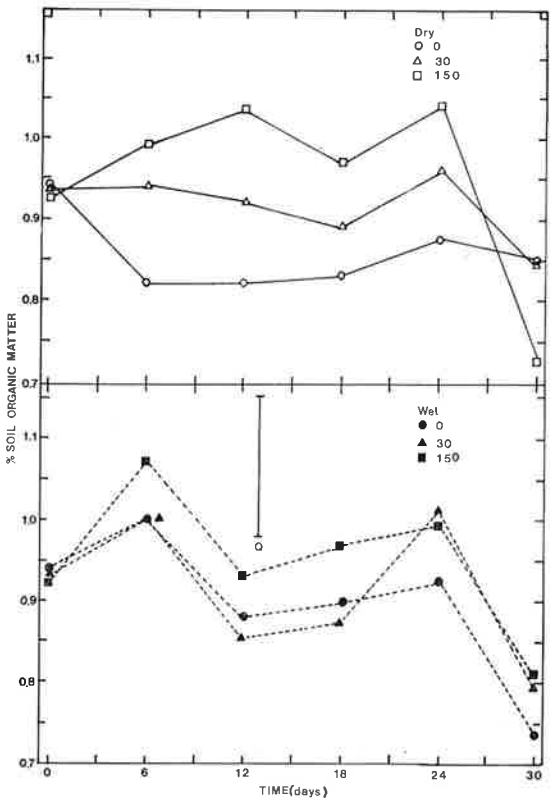

Fig. 1. The effects of natural (dry) and simulated (wet at 12 mm every 3 days) rainfall and surface creosotebush litter quantity (0, 30 and 150 g m^{-2}) on desert soil organic matter content under creosotebush canopies. The bar represents a Q_{36} for mean separation.

Soil organic content: Soil organic content was extremely variable due to variations in surface litter accumulation patterns between creosotebushes before the initiation of the experiment. Simulated rain had no effect on soil organic content and only on day 12 in the dry plots was there a significant litter effect (Fig. 1). When the soil organic content data were averaged across time and water, 150 g m^{-2} was higher than 0 g m^{-2} but not higher than the 30 g m^{-2} and 0 g m^{-2} and 30 g m^{-2} were not different ($P = 0.05$). The means for decreasing litter content were 0.93, 0.91, 0.88 %. Since the soluble organic fraction of litter is readily mineralized (Williams & Gray 1974), we expect that a large fraction of that leached into the soil was evolved as CO_2.

Soil respiration: Soil respiration was initially stimulated by the addition of water; however, by day 12 there were no differences between wet and dry treatments due to natural rain events on days 9 and 12, (Fig. 2). The 150 g m^{-2} litter treatments always had the highest respiration. When averaged across time the 150 g m^{-2} dry litter simulated rainfall treatment was greater than either the 30 or 0 g m^{-2} dry litter simulated rainfall treatments. The same trend was observed in the unwatered treatments after day 9. Soil respiration after rain (either natural or simulated) was always higher than the 0 time watered soil respiration rates, however, by day 24, the 30 and 0 g m^{-2} litter amended treatments were not different from day 0. Soulides & Allison (1961) observed that the longer the drying period the greater the flush of CO_2 after wetting. In this study the unwatered treatments did not exhibit a higher soil respiration rate than the watered treatments after natural rain events. High temperatures and rapid drying of soils during the summer result in low soil respiration rates (Parker

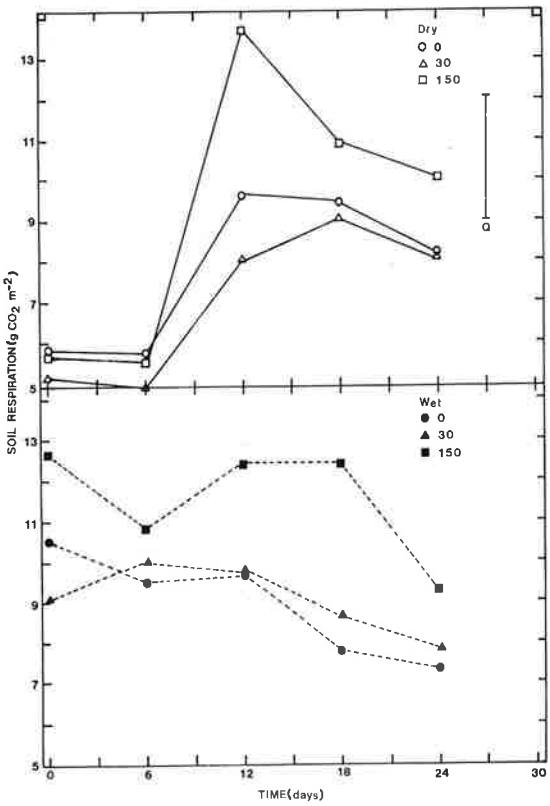

Fig. 2. The effects of natural and simulated rainfall and surface creosotebush litter quantity on desert soil respiration under creosotebush canopies. See Fig. 1 for a description of treatments.

et al. 1983). Nine days of drying of the unwatered was probably insignificant. These data indicate that soil respiration is pulsed by water, however surface litter is required to make the pulse significant and sustained for longer time periods. Leaching of nutrients appears therefore to be important in regulating soil microbial activity. However, the interpretation of desert soil respiration may be confounded by abiotic carbon fluxes. PARKER *et al.* (1983) have shown that the carbonate pool reestablishes the equilibrium after 48 h. Since we used an incubation time of 3 days in this study, the abiotic fluxes would have been neutralized.

Microbial biomass: Biomass of bacteria increased with the addition of water and the magnitude of the increase was dependent on litter quantity (Fig. 3). Bacteria in watered soils peaked on day 6 and then decreased until day 24 when they reached their lowest biomass. After natural rain events on days 9 and 12, bacteria responded differently in the unwatered soils than in the wet soils from days 0—6. The lack of response to litter in the unwatered soils at this time may have been a result of the magnitude of the natural rain event leaching soluble organics deeper into the soil. In the dry soils the clear cut response with respect to litter was not observed until days 24 and 30 when the highest biomass was found in the 150 g m^{-2} dry litter treatment. On day 24 the microbial biomass in all unwatered plots was greater than in the watered plots.

The average bacterial biomass for this soil was 3.8 g carbon m^{-2} 8 cm deep or 7.6 g m^{-2} carbon 16 cm deep if we assume even distribution in the upper 16 cm. This is below the range (8.3 to 83 g C m^{-2} 15 cm deep) observed for most soils assuming the bacterial mass contains 50% carbon (ALEXANDER 1977). This low mass would be expected due to the low carbon content of desert soils. It is interesting that the values observed in this study are similar to

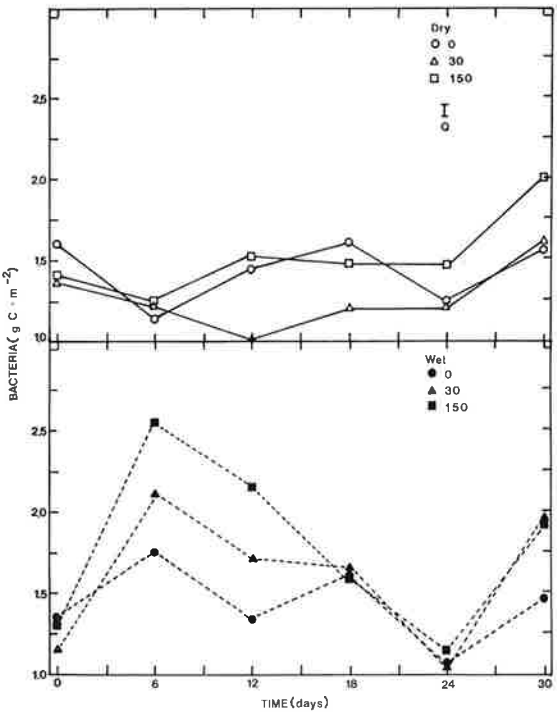

Fig. 3. The effects of natural and simulated rainfall and surface creosotebush litter quantity on desert soil bacterial biomass under creosotebush canopies. See Fig. 1 for a description of treatments.

those observed in peat (1.2—9.7 g C m^{-2}) which is at the opposite extreme in relation to soil organic carbon and moisture (Collins et al. 1970). Grassland soils have an average bacterial biomass of 28.5 g C m^{-2} 30 cm deep while the biomass of agricultural soils is 45 g C m^{-2} 15 cm deep (Clark & Paul 1970).

Fungal biomass responded differently than biomass of bacteria to water and litter quantity. While bacteria responded to rain, fungi did not. This is probably a result of their slower germination and growth rates than bacteria. Fungi were dependent on litter only at the last sample dates (Fig. 4). Fungal biomass at its highest was only 60% of the total microbial biomass and was generally only 30%. This is considerable lower than other ecosystems where fungal biomass comprises 60 to 85% of the soil microbial biomass (Alexander 1977). The low proportion of fungi as hyphae (40—60% of the total microbial biomass) is misleading in terms of fungal biomass because we did not distinguish between bacteria and yeasts, both of which are reported as bacterial biomass. In other studies, we have found unidentified yeasts to account for a large fraction of the cells counted as bacterial cells. The average fungal biomass in this study was 0.7 g C m^{-2} 8 cm deep. This, like bacterial biomass, was below the range for most non-desert soils (2.5 to 25 g C m^{-2}) assuming 50% in the fungal biomass (Alexander 1977). Fungal biomass in peat was higher (2 to 15 g C m^{-2}) (Collins *et al.* 1979) and grasslands was considerably higher (69 g C m^{-2} 20 cm deep) (Clark & Paul 1970).

Total microfloral biomass or the sum of bacterial and fungal biomass was dependent on water on day 6 but independent of water after that date (Fig. 5). Microbial biomass was generally independent of litter quantity until the latter sample dates. The positive litter response in bacteria on days 6 and 12 was counter-balanced by an opposite response by fungi. The total microbial biomass averaged 2 g C m^{-2} 8 cm deep or approximately 1.5 mg C 100 g^{-1} soil. This is much lower than observed by both Jenkinson & Powlson (1976) and

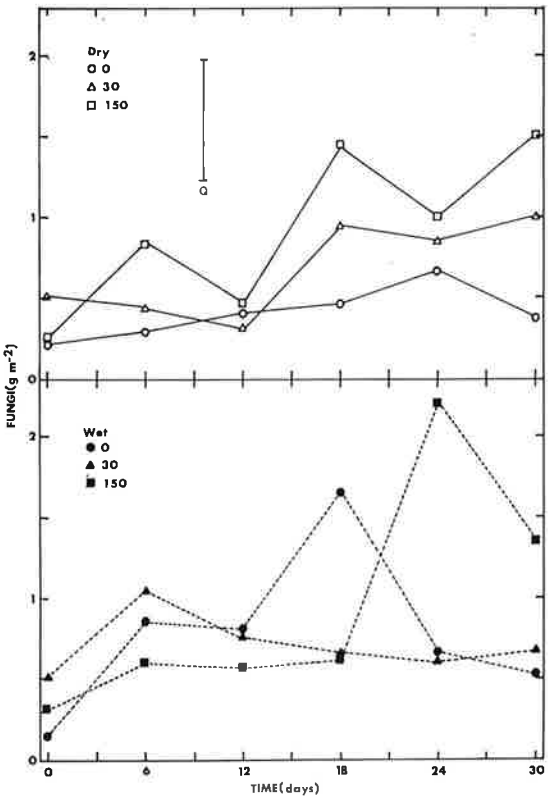

Fig. 4. The effects of natural and simulated rainfall and surface creosotebush litter quantity on desert soil fungal biomass under creosotebush canopies. See Fig. 1 for a description of treatments.

ANDERSON & DOMSCH (1979) for a variety of soils which ranged from 10—240 mg C 100 g^{-1} dry soil.

If we assume that the soil microflora has an efficiency of carbon utilization of 30 % with 70 % being evolved as CO_2 (ALEXANDER 1977; PARKER *et al.* 1983), we can estimate the total biomass produced (g C m^{-2}) and its turnover by the following relationship:

$$D = \frac{m_b}{0.3/0.7}$$

where D is the turnover in days, m_b is the microbial biomass (g C m^{-2}), 0.3 is the percent of carbon assimilated into microbial biomass (g CO_2-C m^{-2} d^{-1}) and 0.7 is the percent respired as CO_2.

Microbial turnover was relatively independent of both water and litter quantity; however, there was a significant date effect (Table 2). The average turnover for this soil was 6.97 $\pm$ 1.36 d^{-1}. CLARK & PAUL (1970) estimated that the microbial biomass at the Matador Grassland turned over only a few times a year. However, COLEMAN & SASSON (1980) estimated the turnover to be 41 d which is slower than that which we observed. Even if 50 % of the CO_2-Carbon evolved came from plant root respiration, the microbial population would turnover every 14 days. This study was conducted during August when the soils were generally warm and moist and therefore may not reflect the turnover during the rest of the year. Even though the turnover was the same, the standing biomass was larger in the 150 g treatments, indicating more carbon was flowing into the higher trophic groups during each turnover in the 150 g treatment. Surface litter accumulations therefore appear to be impor-

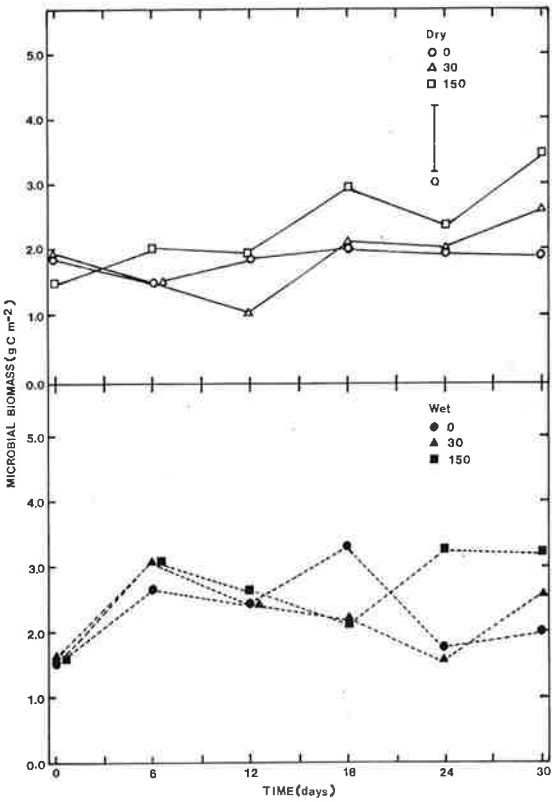

Fig. 5. The effects of natural and simulated rainfall and surface creosotebush litter quantity on desert soil microflora (sum of bacteria, yeast and fungi) biomass under creosotebush canopies. See Fig. 1 for a description of treatments.

Table 2. The effect of natural and simulated rain and surface creosotebush litter mass on the turnover time (days) of desert soil microbial biomass under creosotebush canopies

Litter	Water	Days				
		6	128	18	24	30
g m^{-2}						
0	wet	6.38^{a}	5.79^{a}	7.63^{a}	5.77^{a}	6.91^{a}
	dry	6.22^{a}	8.31^{ab}	5.52^{a}	5.21^{a}	6.07^{a}
30	wet	8.89^{ab}	6.31^{ab}	7.50^{a}	5.40^{a}	8.67^{a}
	dry	7.79^{ab}	7.18^{ab}	6.86^{a}	5.76^{a}	8.24^{a}
150	wet	6.39^{a}	6.38^{ab}	4.39^{a}	6.94^{a}	8.97^{a}
	dry	9.46^{a}	9.10^{b}	6.87^{a}	5.54^{a}	8.89^{a}

Note: Values in a column followed by the same letter are not different ($P = 0.05$) $Q_5 = 3.02$ for date effects.

tant for the soil fauna that can move in to the litter under favorable conditions (Whitford *et al.* 1981).

Protozoa: Protozoan numbers, like bacterial biomass, increased initially in watered soils (Fig. 6) and were 95% active forms (Table 3) After day 6 there were essentially no differences among treatments in total protozoa numbers or the number of trophs except on day 24 where the protozoa in the were 150 g litter unwatered soils were 99% trophic and in the 150 g litter watered soils were 100% cystic. At this time bacterial biomass in the watered

Table 3. Effect of water and litter amendments on percent protozoa trophs in a desert soil from under creosotebush canopies

Litter	Water	Days					
		0	6	12	18	24	30
g m^{-2}							
0	wet	0[a]	96[b]	83[a]	95[b]	34[b]	—
	dry	0[a]	0[a]	64[a]	99[a]	0[a]	—
150	wet	0[a]	95[b]	73[a]	99[a]	0[a]	—
	dry	0[a]	0[a]	91[a]	99[a]	99[b]	—

Note: Values in a column followed by the same letter are not different (P = 0.05).

soils was lowest (Fig. 3). Since water was not a limiting factor, prey availability may have been regulating protozoa encystment in this treatment. HABTE & ALEXANDER (1975) have observed that when bacteria are depressed to a level where protozoans expend more energy in finding prey than is contained in the prey, then encystment can occur. In this study the encystment of protozoa in the 150 g litter watered soils may have resulted in reduced growth of nematodes when compared to the 150 g litter unwatered soils. (STEINBERGER *et al.* 1984). These data support the observation of ELLIOTT *et al.* (1980) in laboratory microcosms that protozoa are an important trophic link between bacteria and nematodes.

Results of studies by CUTLER & CRUMP (1920) and CLARHOLM (1981) indicate that after either a natural or simulated rain event bacterial numbers increase then decline after 3 days followed by a peak in protozoa numbers at approximately day 5. We observed cycles in both bacteria and protozoa, however, these cycles took longer to complete and were not as clear cut as those reported by these authors. This may be a function of the rapidity with which our soils dry after wetting because that allows only short periods of time for the soil biota to be active. Since we sampled every 6 day, it is possible that we missed some of the cycles. The lack of a second response by bacteria in the consecutive wet-dry cycles may be a result of protozoan predation such as that described by BRYANT *et al.* (1982) using gnotobiotic microcosms.

The numbers of protozoans in this study were greater than those observed by BAMFORTH (1980) in the Sonoran desert. In our study the most abundant protozoans were naked amoebae (X = 25,000 ind. g^{-1} dry soil) followed by flagellates (4,900 ind. g^{-1} dry soil) and ciliates (700 ind. g^{-1} dry soil) (Table 4). The dominance of naked amoebae in the Chihuahuan desert

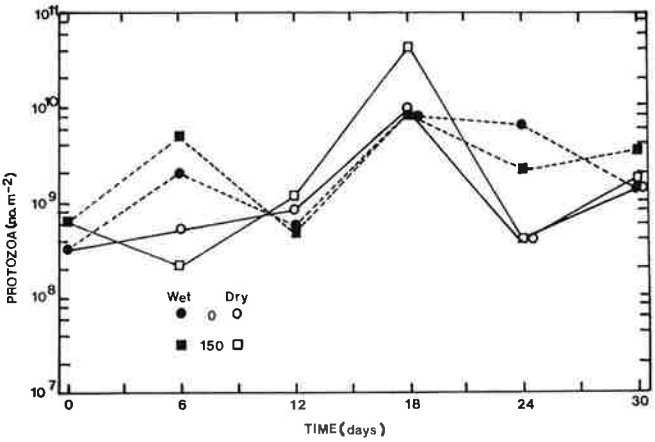

Fig. 6. The effects of natural and simulated rainfall and surface creosotebush litter quantity on desert soil protozoa under creosotebush canopies. See Fig. 1 for a description of treatments. The bar represents a Q_{24} for mean separation.

Table 4. Effect of litter and water amendments on desert soil protozoa (no. x 10^4 g^{-1} soil) from under creosotebush canopies

Litter	Water	Flagellates			Ciliates			Amoebae		
		Day			Day			Day		
		12	18	24	12	18	24	12	18	24
g m^{-2}										
0	wet	0.025[a]	0.613[b]	1.144[b]	0.025[a]	0.128[b]	0.025[a]	0.580[a]	1.808[a]	5.897[a]
	dry	0.059[a]	0.718[b]	1.004[b]	0.035[a]	3.433[b]	0.036[a]	0.220[a]	3.433[a]	2.035[a]
150	wet	0.045[a]	0.684[b]	0.305[b]	0.038[a]	0.043[a]	0.253[b]	0.268[a]	5.313[b]	1.504[b]
	dry	0.071[a]	0.716[b]	0.515[b]	0.026[a]	0.030[a]	0.025[a]	0.447[a]	2.990[b]	1.807[b]

Note: Values for a particular protozoan group followed by the same letter are not different (P = 0.05).

soils corresponds to the relative abundances of protozoan groups observed in other terrestrial ecosystems (ELLIOTT & COLEMAN 1977; STOUT 1980; CLARHOLM 1981). The proportion of amoebae (74 ± 8 %) to flagellates (20 ± 8 %) and ciliates (6 ± 5 %) in the total protozoan population remained relatively constant and were independent of litter and water. The proportion of amoebae in the total population was about 20 % lower than that found in a short grass prairie (ELLIOTT & COLEMAN 1977).

The diversity of ciliates has been proposed to be an indicator of the soil moisture status of an ecosystem with the fewer species representing drier environments (BAMFORTH 1980). In our study among the abundant forms only two ciliate genera were observed: *Colpoda* and *Cyrtolophosis*. Other species may have been present but at densities too low to be detected by the method we employed. *Acanthamoeba* was the most abundant amoeba. The flagellates were predominately of the family Bodonidae; the genera *Bodo* and *Rhynchomonas* were most abundant.

We hypothesized that pulses in microbial biomass and activity in response to water would occur under large accumulations of litter. An initial rain event did pulse the microflora in the absence of litter; however, surface accumulations of litter were important in regulating the magnitude of this pulse during initial rain events. Protozoa, unlike the microflora, were independent of litter and dependent on water in regulating the proportion of active forms. The lack of a litter response in protozoa may have been a result of predation by higher trophic groups.

The loss of plant material from the soil surface involves a number of abiotic and biotic processes. The leaching of soluble organics into the soil below litter is important in an early pulsing of soil bacteria and yeasts and a retarded pulse in fungi. The importance in this bacterial yeast pulse is probably insignificant in terms of colonizing the surface litter and decomposing it. However, this pulse could be important in providing prey for higher trophic groups, which have the capability of moving into the litter from the soil under favorable conditions (WHITFORD *et al.* 1981; STEINBERGER *et al.* in press).

4. Acknowledgements

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Synopsis: *Original scientific paper*

PARKER, L. W., D. W. FRECKMAN, Y. STEINBERGER, L. DRIGGERS, & W. G. WHITFORD, 1984. Effects of simulated rainfall and litter quantities on desert soil biota: soil respiration, microflora, and protozoa. Pedobiologia **27**, 185—195.

We experimentally tested the hypothesis that simulated rainfall would trigger higher levels of activity in soil biota under large surface accumulation of litter in a Chihuahuan desert soil.

Bacterial biomass was highest on days 6 and 12 in plots receiving simulated rain and increased with increasing litter. The turnover of the microbial biomass was estimated as 6.97 days and was independent of either water or litter quantity. Soil respiration was higher in the wet treatments on days 0 and 6. When treatments were averaged across time, the highest soil respiration was in the 150 g m^{-2} litter, watered plots. The same pattern was observed in the dry treatments after natural rain events.

On day 6, protozoa were higher in the wet plots; protozoa in the dry plots were 100 % cystic while those in the wet plots were 100 % trophic. Protozoan numbers were independent of litter quantity and reached the maximum on day 18. Amoebae were the dominant protozoa with an average population size of 25,000 g^{-1}. Flagellates were intermediate in numbers (4,900 g^{-1}) while ciliates were the least abundant (700 g^{-1}).

Key words: Chihuahuan desert, trophic interactions, wet-dry cycles.

Buchbespechung

LEBRUN, PH., H. M. ANDRÉ, A. DE MEDTS, C. GRÉGOIRE-WIBO and G. WAUTHY (eds.), **New Trends in Soil Biology.** Proceedings of the VIII. International Colloquium of Soil Zoology, Louvain-la-Neuve, 30-VIII—2-IX-1982. 706 Seiten, Impr. Dieu-Bricharts, Ottignies-Louvain-la-Neuve.

Das VIII. Internationale Kolloquium der Bodenzoologie war, wie PH. LEBRUN als Generalsekretär eingangs darlegt, an der Zahl der Teilnehmer gemessen das bisher attraktivste (s. Bericht Pedobiologia **26**: 76). Der Umfang der Verhandlungen wurde nur von dem vorhergehenden (Syracuse 1979) übertroffen. Den Herausgebern und dem Verlag gebührt Dank, daß sie die Ergebnisse des Kolloquiums schnell, in guter Qualität, mit Verzeichnissen der Teilnehmer, der Autoren, der erwähnten Gattungen und der Stichwörter herausgebracht und so der Fachwelt zugänglich gemacht haben. Die Gliederung des Buches wird durch die 4 Sektionen des Kolloquiums bestimmt, die jeweils durch eine vom Sektionsvorsitzenden gegebene Übersicht eingeleitet werden: Rolle der Bodenfauna für den Kreislauf von Mineralen (J. A. WALLWORK); Funktionelle Beziehungen zwischen Bodenorganismen (D. PARKINSON); Ökophysiologie von Bodenorganismen (G. VANNIER) und Erholung gestörter Bodengemeinschaften (B. HEYDEMANN). Als Sektion 5 werden 41 von 73 dargebotenen Postern im Druck wiedergegeben; sie beziehen sich vorwiegend auf den genannten Rahmen der Sektionen 1—4. Wie der Präsident des Kolloquiums, P. BERTHET, mit gutem Recht abschließend bemerkte, wurden die Verhandlungen der Sektion 3 (Ökophysiologie) in besonders anregender Weise dem Thema des Kolloquiums gerecht, neue Wege und Arbeitsrichtungen der Bodenzoologie zu weisen. Bei einigen Beiträgen mögen Zweifel an der sachlichen Berechtigung ihrer vollen Berücksichtigung angebracht sein, die Mehrzahl der Artikel dokumentiert aber eindeutig das gestiegene, meist hochrangige Niveau der Arbeiten. Eine besondere Hervorhebung verdienen die erstklassigen Kompilationen, mit denen die Vorsitzenden in die Problematik ihrer Sektion einleiten. Die unzweifelhafte Nützlichkeit dieses Vorgehens sollte Anlaß zu einer verpflichtenden Tradition werden.

Mit der Einwirkung auf die Mineralzyklen der Bodenfauna befassen sich 12 Beiträge. Sie betonen die Notwendigkeit, die Laborergebnisse im Feldexperiment zu prüfen und stets das Gesamtsystem im Auge zu behalten, weil die Zugabe oder Konzentrationsveränderung nur eines Stoffes eine generelle Verschiebung des gesamten Ionengleichgewichts zur Folge haben kann. Die hohe Bedeutung, aber auch die Gruppenspezifik der Bodenfauna als Faktoren der Stickstoff-Dynamik sind Schwerpunkte der Diskussion. Wiederholt bekennen die Autoren, daß die Rolle der Bodenfauna (nicht nur der Termiten) im Mineralstoffkreislauf erst am Anfang der Aufklärung steht.

Die funktionellen Beziehungen zwischen Bodenorganismen werden in 13 Beiträgen als Netz von synergistischen und antagonistischen Leistungen dargestellt, von dem nur wenige Verknüpfungen bislang hinlänglich bekannt sind. Die Leistungen der saprotrophen Fauna wird durch die Faktoren der Parasitierung, der Predation, der Ausbildung der Darmflora und durch die Qualität der Bodenumwelt wie Gehalt an C-Verbindungen oder Tonmineralen weitaus mehr beeinflußt als bislang kalkuliert. Praktisches Interesse beanspruchen Beispiele, die auf die Frühindikation einer Störung des Systems Grüne Pflanze — Dekomposition (als Reaktion auf Überweidung) hinweisen, sowie Erfahrungen mit einer möglichen (sub) kompensativen Entwicklung von N-Fixierern bei N-Mangel bzw. fehlender N-Düngung. Auch die phytosanitäre Rolle mikrobiophager Bodentiere zählt zu den hier behandelten Themen.