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Biology of Nematodes in Desert Ecosystems

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BIOLOGY OF NEMATODES IN DESERT ECOSYSTEMS

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ABSTRACT

The results of a 14-week sampling period (April, 1973-July, 1973) in which nematode trophic levels are related to depth and distance from four shrubs are reported. The greatest numbers of nematodes in all trophic levels occurred at the top 10 cm near the plant. Numbers of nematodes decreased significantly with increasing distance from all plants at all trophic levels. Of the plant hosts, *Ambrosia dumosa* (formerly *Franseria dumosa*) and *Krameria parvifolia* showed no significant differences in numbers of plant parasites with increasing depth and *Lycium andersonii* and *Larrea divaricata* had significant decreases at all trophic levels with increasing depth.

Preliminary sampling was begun at the three validation sites not previously sampled. Biomass and numbers of nematodes found at the Curlew Valley, Utah, and Tucson, Arizona, sites are discussed. Nematode biomass and density ranged from a low .034 g/m^2 and 308 nematodes/500 cm^3 soil at interspaces between plants at Rock Valley, Nevada, to a high of .310 g/m^2 and 3225 nematodes/500 cm^3 soil at Curlew Valley, Utah. Twenty-four nematode species thus far identified at the three sites are compared. Eleven of the 15 plant parasitic species identified occurred at Curlew Valley, Utah.

INTRODUCTION

Nematodes are major microfauna components of the below-ground ecosystem. All species of the soil nematodes are heterotrophic and depend upon organic food sources. To assess their importance in the desert soil biota, a weekly sampling program of four dominant plant shrubs began at Rock Valley, Nevada, in 1973, in conjunction with other below-ground investigators, Bamberg (1973) and Edney et al. (1974). The improved extraction methods for desert nematodes, determined in 1971-72, permitted increased sampling and handling of the Rock Valley soil. The 1973 study emphasized the functional roles, biomass and spatial distribution of the nematodes and their relationship to the dominant vegetation. The 1974 study will be expanded to relate abiotic factors and the activity of fungi, bacteria, soil microfauna, and actinomycetes to the desert nematodes.

Additional studies at the Jornada, Tucson and Curlew Valley Validation Sites were initiated to delineate the role of nematodes in undisturbed desert soils. Parameters measured at all four validation sites include nematode density, trophic and species diversity and geographical distribution.

OBJECTIVES

The specific objectives as defined in the proposal for 1973 were amended as a result of discussions with S. Bamberg and J. McBrayer. The development of an integrated, below-ground ecosystem study to characterize the trophic levels of the soil invertebrates was a primary objective of this program. The specific objectives of the research conducted during 1973 were:

1. The delineation of the trophic levels of the nematode community structure as determined by weekly sampling at Rock Valley, Nevada.
2. The characterization of this nematode community as to biomass, species, spatial distribution, density, and the influence of biotic and abiotic factors.
3. Periodic sampling of the other three validation sites to further establish the geographic distribution, functional role and characteristics of the nematode populations.

METHODS

The Desert Biome validation sites are diverse in several respects and the 1973 nematode sampling pattern reflects the variations encountered at each site. The purpose of the preliminary sampling at these sites was to: (1) estimate nematode biomass; and (2) determine species diversity and geographical species distribution. Each of the four validation sites was sampled in 1973; however, results from the Jornada site, Las Cruces, New Mexico, will not be reported until 1974.

In addition, soil samples were collected by the UCLA laboratory at Mercury, Nevada, in a weekly sampling study (DSCODE A3UMB36). Soil from each of four species of shrubs, *Lycium andersonii*, *Krameria parvifolia*, *Ambrosia dumosa*, and *Larrea divaricata* were sampled once per week in a random sampling pattern. Samples were collected by trenching to a depth of 30 cm and removing approximately 200 cm^3 soil at 10, 20 and 30 cm depths at three distances from the plant (position 1 = base of the plant, position 2 or r = edge of shrub canopy, position 4 or 3r = interspace or three times the mean radius of the shrub canopy). This design yielded nine samples/plant x four plant species/week = 36 soil samples/week from the Rock Valley site. Samples were placed in plastic bags and refrigerated during shipment to Riverside, California. Each sample was mixed in a split sample mixer, larger rocks discarded and 100 cm^3 subsamples processed by the modified sugar flotation method using Separan 2601 (Dow Chemical Co., Midland, Michigan) as a flocculating agent (Byrd et al., 1966; A3UMB32). The extracted nematodes from each of the 36 soil samples were allowed to settle in 25 ml pharmaceutical flasks for 1-2 hr and reduced in volume to 5 cc. One ml of this suspension was placed on a Hawksley counting slide and counted at 230 x magnification.

As the nematodes were counted they were placed in one of five trophic groups: (1) Microbial Feeders -- Cephalobidae; (2) Fungal Feeders -- *Aphelenchus avenae*, *Ditylenchus* sp., *Aphelenchoides* sp.; (3) Predators-Omnivores -- Dorylaimina; (4) Plant Parasites -- *Tylenchorhynchus* sp., Misc. Tylenchida; (5) Unidentifiable -- those damaged or unrecognizable. Results were expressed as number of

nematodes per 500 cc soil. Methods for processing nematodes to permanent mounts were the same as reported in 1973 (Mankau et al., 1973).

Parameters determined were species composition, vertical and horizontal distribution of species and trophic groups, density, biomass, time, and vegetation effects. Soil temperature, moisture and root biomass (June to September) were recorded for each sample by UCLA laboratories (Edney et al., 1974), and their relationship to the observed nematode populations in the soil samples will appear in the 1974 report. For purposes of this report, results of a 14-week sampling period (April to July, 1973) for *Larrea divaricata*, *Ambrosia dumosa* and *Krameria parvifolia* and a 12-week sampling period for *Lycium andersonii* will be reported. the 14 or 12 weekly samples were treated as replicates at each trophic level. Statistical analyses of the raw data were not possible because of high fluctuations in numbers of nematodes. To smooth out the distribution, the replicates were grouped and the unweighted averages were analyzed. Transformations to the log (X + 1), where X = the average number of nematodes, were made to stabilize the variances. Standard analysis of variance procedures were then run on the transformed numbers (Snedecor and Cochran, 1967).

Two of the validation sites, Silverbell at Tucson, Arizona, and Rock Valley, Nevada, were randomly sampled according to the transect pattern described in the 1972 progress report. Each of 21 soil samples were mixed and processed by the modified sugar flotation method. The nematodes extracted from each of the samples were counted and the samples combined for biomass analysis. One-hundred nematodes from the combined samples were randomly selected for the length and width measurements for use in calculating the average weight of nematodes (Mankau et al., 1973). Nematode biomass was calculated according to the formula of Andrassy (1956, as reported in Mankau et al., 1973).

Soil samples were collected in July, 1973,near the following plants at the Curlew Valley, Utah site (parentheses indicate the number of plants samples): *Agropyron* (3), *Atriplex* (4), *Bassia* (6), *Artemisia* (3), *Halogeton* (3), and *Chrysothamnus* (2). The plants represented dominant vegetation common to particular areas within the site. Nematodes were extracted as previously described and numbers in trophic groups were calclated per 500 cm^3 soil. Biomass for each trophic level was determined as previously described, with the understanding that these figures are preliminary and may be revised as more information on the distribution of the nematodes near the desert flora becomes available.

RESULTS

Distribution of Nematodes at the Rock Valley Site

Statistical analyses were run to determine differences in horizontal and vertical distribution of nematodes and differences between each individual sample. When the differences between positions were analyzed, there was a significant decline in the numbers of nematodes at all trophic levels as the distance from the plant increased (see Table 1, Figs. 1-16).

When depths were analyzed, there was a significant decline in the numbers of nematodes at each trophic level for all plants but *Ambrosia* and *Krameria*. These plants showed no significant difference in numbers of plant parasites at the three depths (see Table 2, Figs. 1-16).

With increasing depth and distance from the plant there was a significant decline in numbers of nematodes with *Lycium* at all trophic levels but fungal feeders, and with *Ambrosia* and *Krameria* at the omnivore-predaceous trophic level (see Table 3, Figs. 7, 11, 14, 15, and 16).

Faunistic Composition

A partial listing of nematodes encountered at three validation sites is shown in Table 4. The composition of this list is preliminary due to the limited number of samples and the lack of periodic sampling at two of the sites, Silverbell and Curlew Valley, and to the lack of identification of many nematodes to the genus level. The available data show that species diversity within the plant parasitic trophic level at the Curlew Valley site was greater than that of the other

Table 1. Levels of significance for distance from the plant (1, 2 and 4)[a]

	Larrea	*Ambrosia*	*Lycium*	*Krameria*
Fungal Feeders	***	*	***	**
Microbial Feeders	***	***	***	***
Omnivore-Predator	***	***	***	**
Plant Parasites	**	***	***	**

[a] Analysis of variance of log (numbers of nematodes +1).

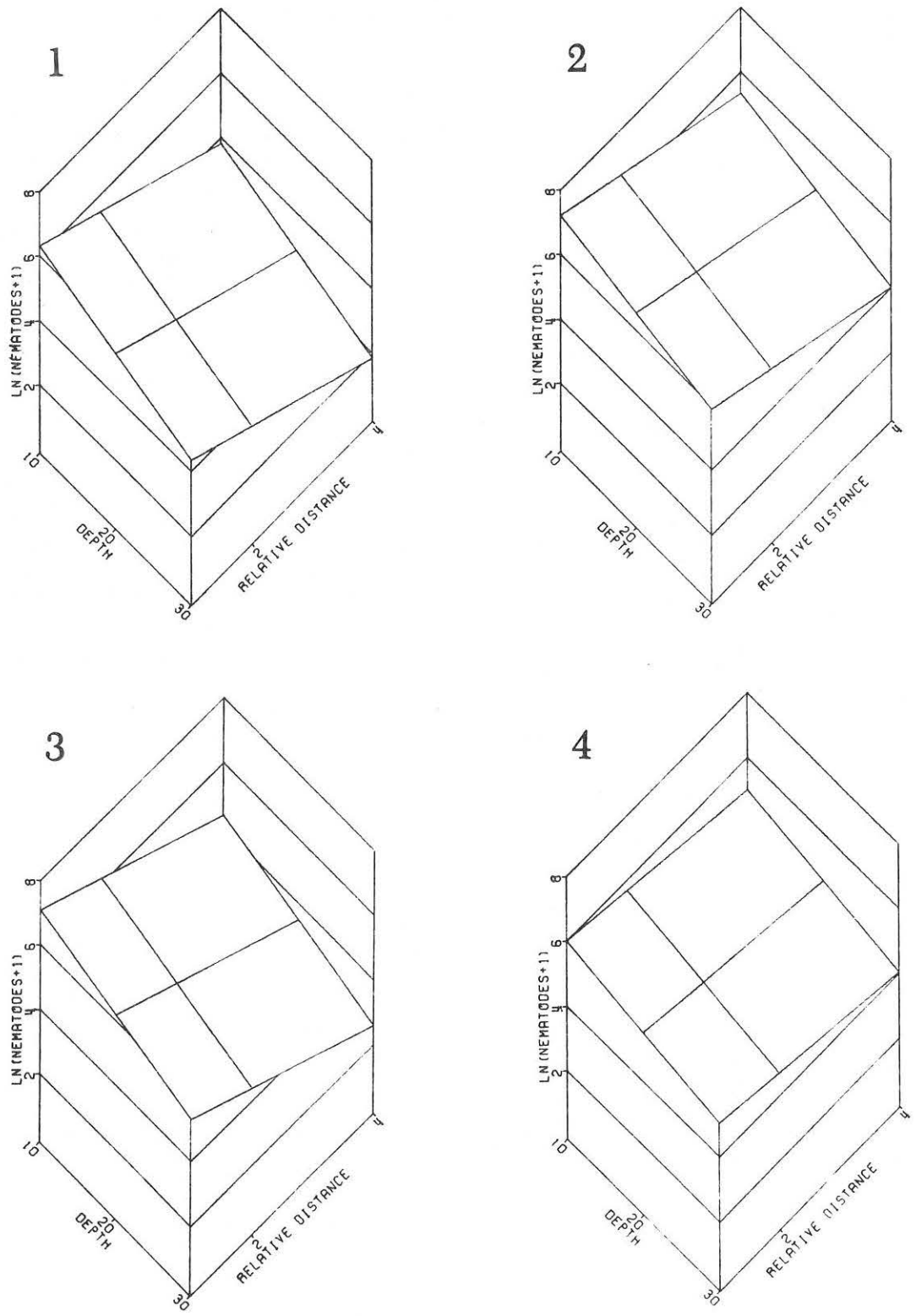
[b] * significant at P = .05

[c] ** significant at P = .01

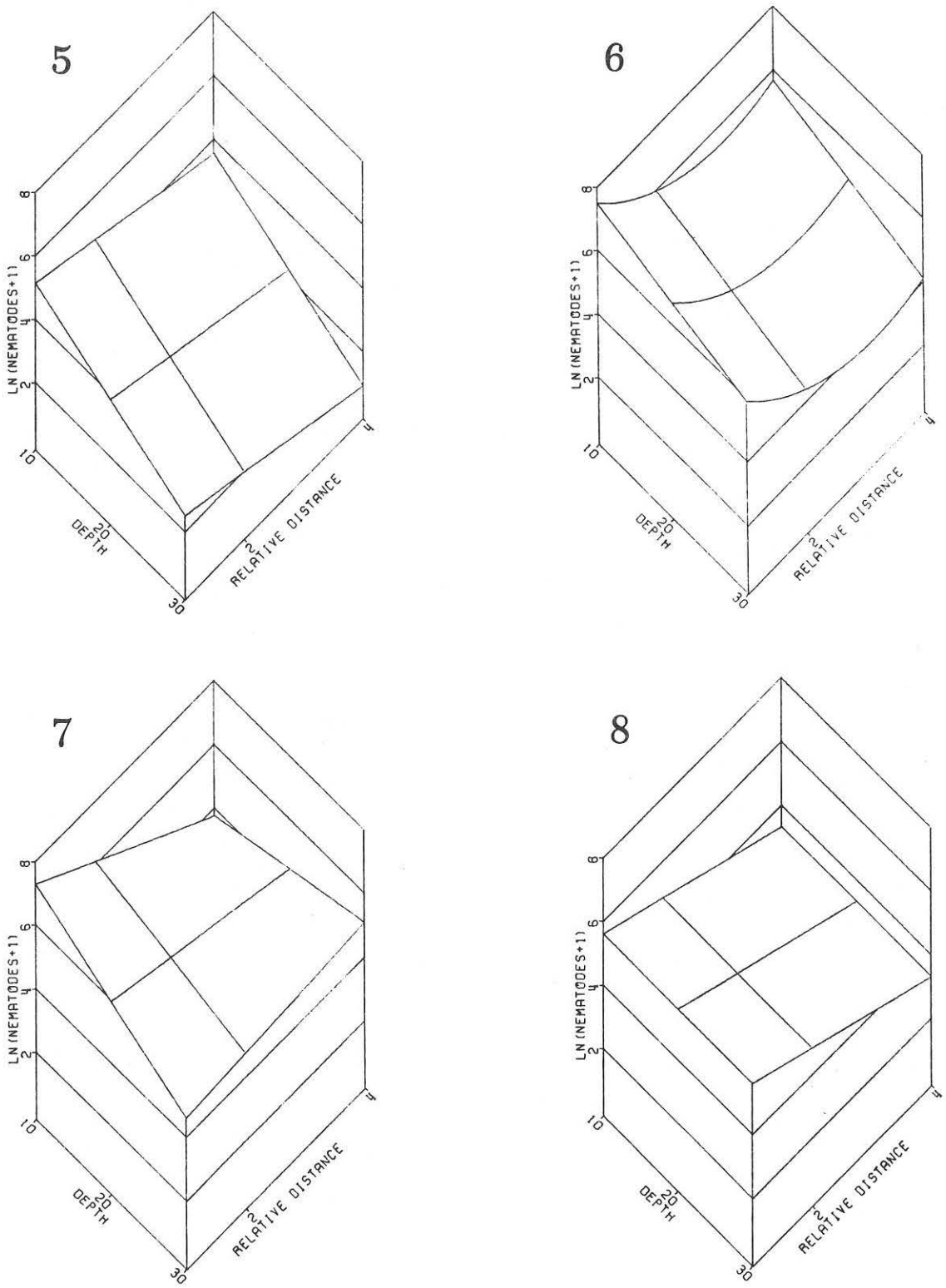
[d] *** significant at P = .001

Table 2. Levels of significance for depth; 10, 20, 30 cm (see Table 1 for footnotes)

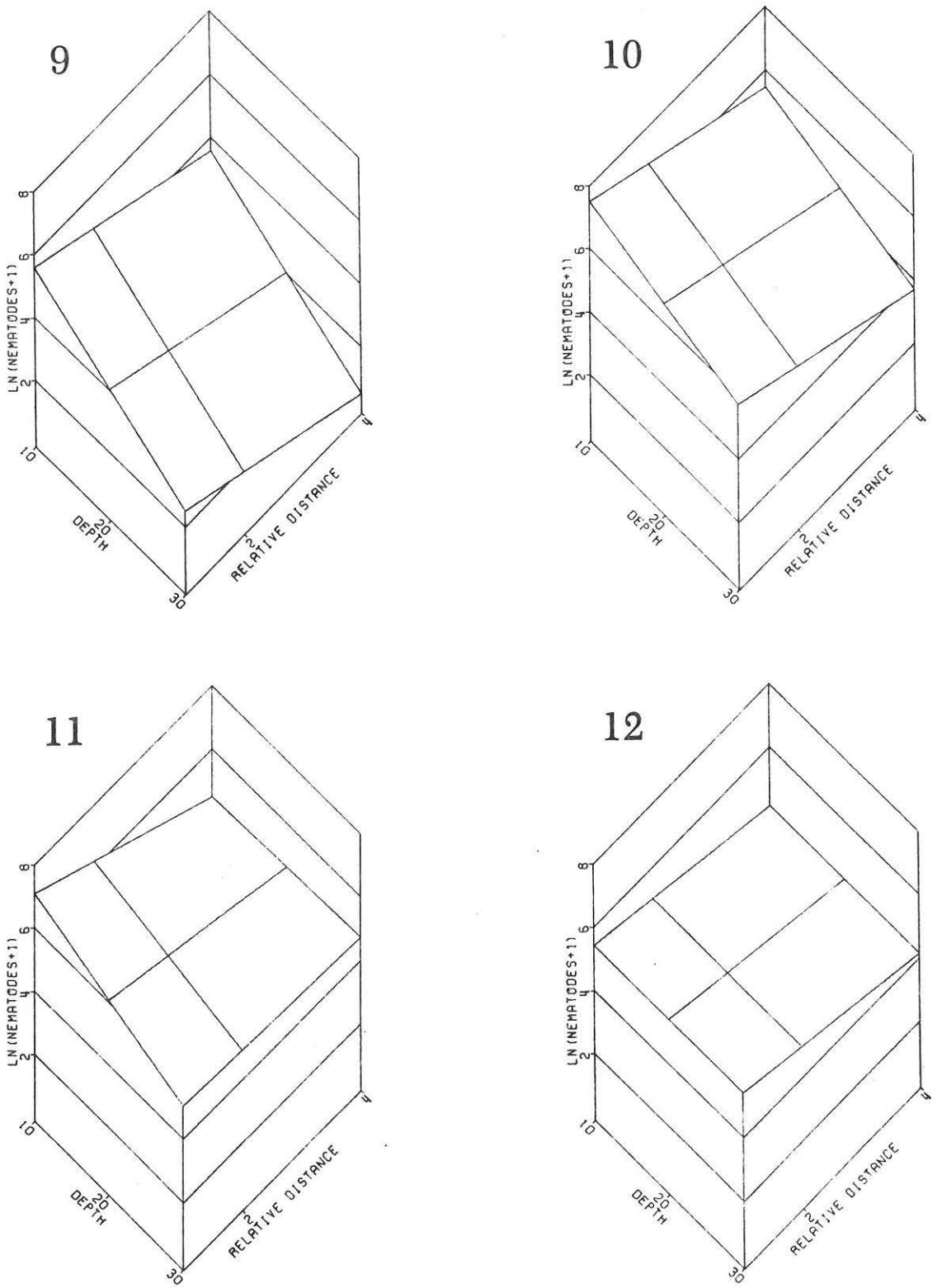
	Larrea	*Ambrosia*	*Lycium*	*Krameria*
Trophic Groups				
Fungal Feeders	**	**	*	***
Microbial Feeders	***	**	***	***
Omnivore Predators	**	*	**	***
Plant Parasites	**		**	



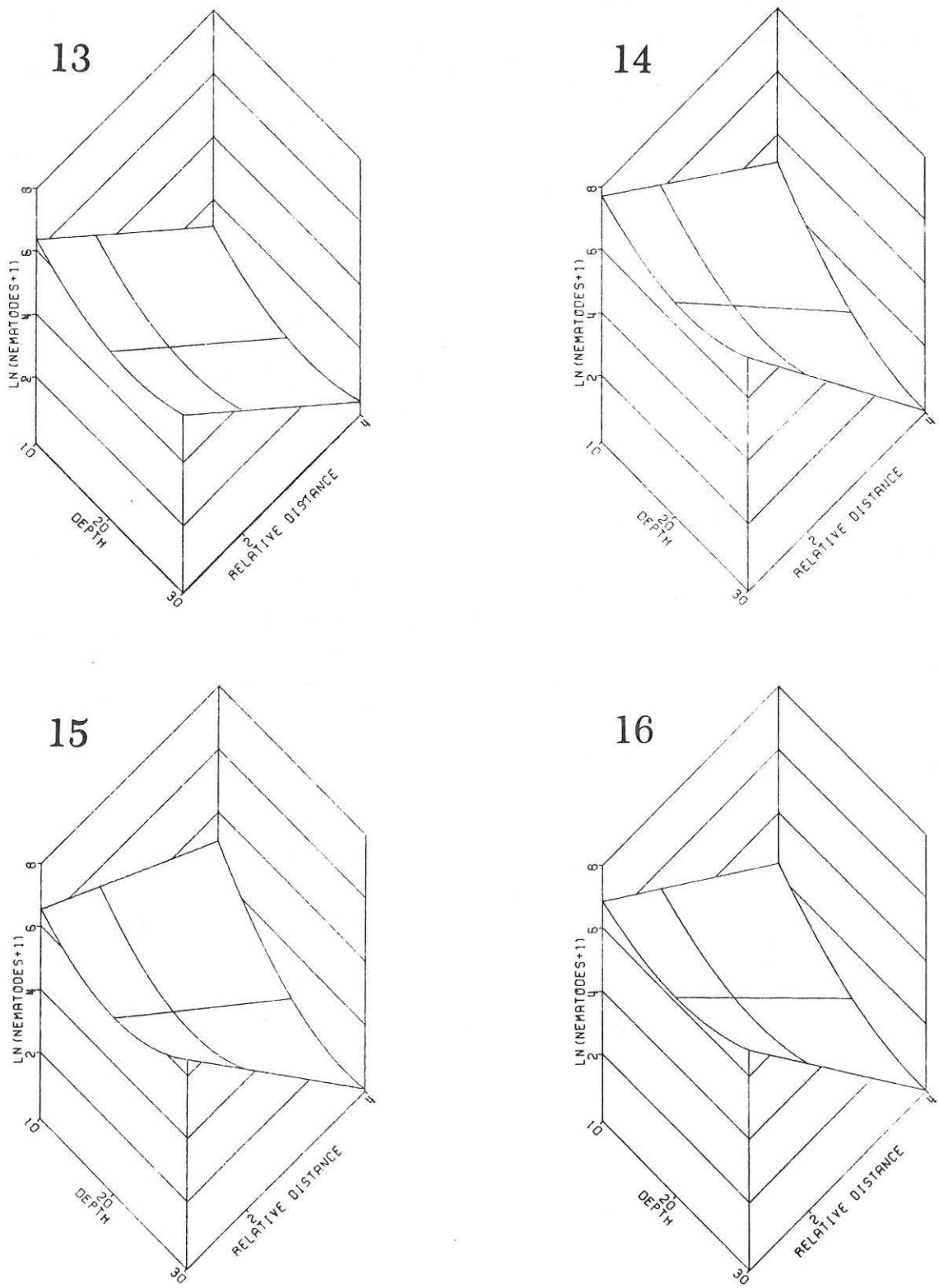
Figures 1-4. Distribution of logarithms of nematode numbers at Rock Valley in relation to *Larrea*: 1, fungal feeders; 2, microbial feeders; 3, omnivores-predators; 4, plant parasites.



Figures 5-8. Distribution of logarithms of nematode numbers at Rock Valley in in relation to *Ambrosia*: 5, fungal feeders; 6, microbial feeders; 7, omnivores-predators; 8, plant parasites.



Figures 9-12. Distribution of logarithms of nematode numbers at Rock Valley in relation to *Krameria:* 9, fungal feeders; 10, microbial feeders; 11, omnivores-predators; 12, plant parasites.



Figures 13-16. Distribution of logarithms of nematode numbers at Rock Valley in relation to *Lycium*: 13, fungal feeders; 14, microbial feeders; 15, omnivores-predators; 16, plant parasites.

Table 3. Levels of significance for interactions of depth and position[a]

	Larrea	*Ambrosia*	*Lycium*	*Krameria*
Trophic Group				
Fungal Feeders	NS	NS	NS	NS
Microbial Feeders	NS	NS	**	NS
Omnivore-Predators	NS	***	**	***
Plant Parasites	NS	NS	**	NS

[a]Analysis of variance of log (numbers of nematodes +1).

[b]* significant at P = .05

[c]** significant at P = .01

[d]*** significant at P = .001

Table 4. 1973 taxonomic list of desert nematodes

Trophic groups	Curlew Valley	Rock Valley	Tucson
FUNGAL FEEDERS			
Aphelenchus avenae	+	+	+
Aphelenchoides	+	+	+
Ditylenchus	+	+	+
PLANT PARASITES			
Apratylenchus belli	+	-	-
Heterodera	+	-	-
Leipotylenchus abulbosus	+	-	-
Megadorus	+	-	-
Merlinius grandis	-	+	-
Nacobbus	+	-	-
Tylenchorhynchus 106	-	+	-
Tylenchorhynchus 107	+	+	-
Tylenchorhynchus 167	-	+	-
Tylenchorhynchus acutus	+	-	-
Tylenchorhynchus canalis	+	-	-
Tylenchorhynchus capitatus	+	-	-
Tylenchorhynchus cylindricus	-	+	+
Tylenchorhynchus latus	+	-	-
Tylencholaimellus	+	-	-
PREDATOR-OMNIVORES			
Eudorylaimus sp.	-	+	+
Eudorylaimus monohystera	-	+	-
Pungentus	-	+	-
MICROBIVOROUS			
Acrobeles complexus	-	+	-
Elaphonema	-	+	-
Leptonchus	-	+	-

two sites. Species diversity within other trophic groups will be analyzed as to geographical distribution as more specimens are identified and as replications of samples from these sites are increased.

Biomass

The nematode biomass for three desert sites (Table 5) is lower than the 0.7 g/m^2 reported by Wasilewska (1971) for undisturbed semi-desert steppe and is similar to the .09 g/m^2 nematode biomass reported for the Mohave desert site by Mankau et al. (1973). These figures do not reflect the many environmental factors that can influence biomass. The Rock Valley data do illustrate the effect of sampling soil near shrubs versus interspaces on nematode biomass. The clumping of animals near the shrubs resulted in a biomass four times greater than those of the interspaces. Variations in temperature, moisture and availabity of food sources affect the nematode populations and result in changes in biomass. These factors will be considered in 1974 and will be used to calculate more accurately nematode biomass at all sites.

A relationship between numbers of nematodes and their biomass at the trophic level is shown in Figure 17. A sampling of six plants at the Curlew Valley site indicated that microbial feeders (Cephalobidae) and omnivore-predators (Dorylaimina) had the largest numbers of nematodes and biomass on all plants except *Artemisia* and *Atriplex*. Contribution to biomass is not directly proportioned to population numbers in all nematode groups. The Dorylaimina are larger animals than the plant parasites and contribute more to biomass than to population numbers whereas the plant parasites make a greater contribution to number of nematodes than to biomass. The numbers and biomass of the fungal feeders were low on all plants examined. On undisturbed forest soils, the plant parasitic trophic level is about 40% of the nematode

Table 5. Nematode biomass of Desert Biome validation sites (A3UMB36)

	Biomass (g/m^2)	# of nematodes/500cc
Rock Valley, Nevada		
random samples	.115	1165
random interspaces	.034	308
Curlew Valley, Utah		
Agropyron	.164	1700
Atriplex	.180	1862
Artemisia	.310	3225
Halogeton	.189	1950
Chrysothamnus	.115	1187
Bassia	.146	1510
Tucson, Arizona	.078	1254

population and therefore their biomass and density are much larger than in desert soils (Johnson et al., 1973).

DISCUSSION

The studies conducted prior to 1973 dealt primarily with methodology and taxonomy of desert nematodes near Riveside, California. The expansion of our studies to the validation sites in 1973 allowed us to concentrate our efforts on interactions of the nematodes with dominant shrubs and abiotic factors (Rock Valley) and to establish preliminary data on the biomass and species composition of the other validation sites. The Rock Valley results showed that nematode density at each trophic level was greatest in the top 10 cm of soil. Presumably, the food sources required for each trophic level are greater at that depth and position from the plant. The microbial feeders, fungal feeders and omnivore-predators usually are found in association with organic matter where there is an abundance of fungi, bacteria and soil arthropods. The 10 cm soil sample (position 1) near the plant would seem to have more organic matter and be less subject to environmental extremes because of the protection of the shrub canopy. Wallace and Romney (1972) reported greater organic matter and biological activity in the top few inches of soil near *Lycium*. It is not surprising that nematode density is greatest at the top 10 cm near the plant. Nematodes require moisture and the top 10 cm depth farther from the plant would be more subject to high temperatures and drying than the 10 cm depth near the plants where there is some protection or at lower depths where there is less environmental fluctuation.

The plant parasites are associated with root systems and they declined significantly with increasing depth and distance on *Larrea* and *Lycium*; there was, however, no significant difference in numbers of nematodes on *Ambrosia* or *Krameria*. This might be related to susceptibility of plant hosts or differences in the root profiles of the plants. Wallace and Romney (1972) reported *Krameria* had a deep fibrous root system, *Larrea* and *Ambrosia* had a large, shallow extensive root profile, and *Lycium* had an intermediate fibrous root system.

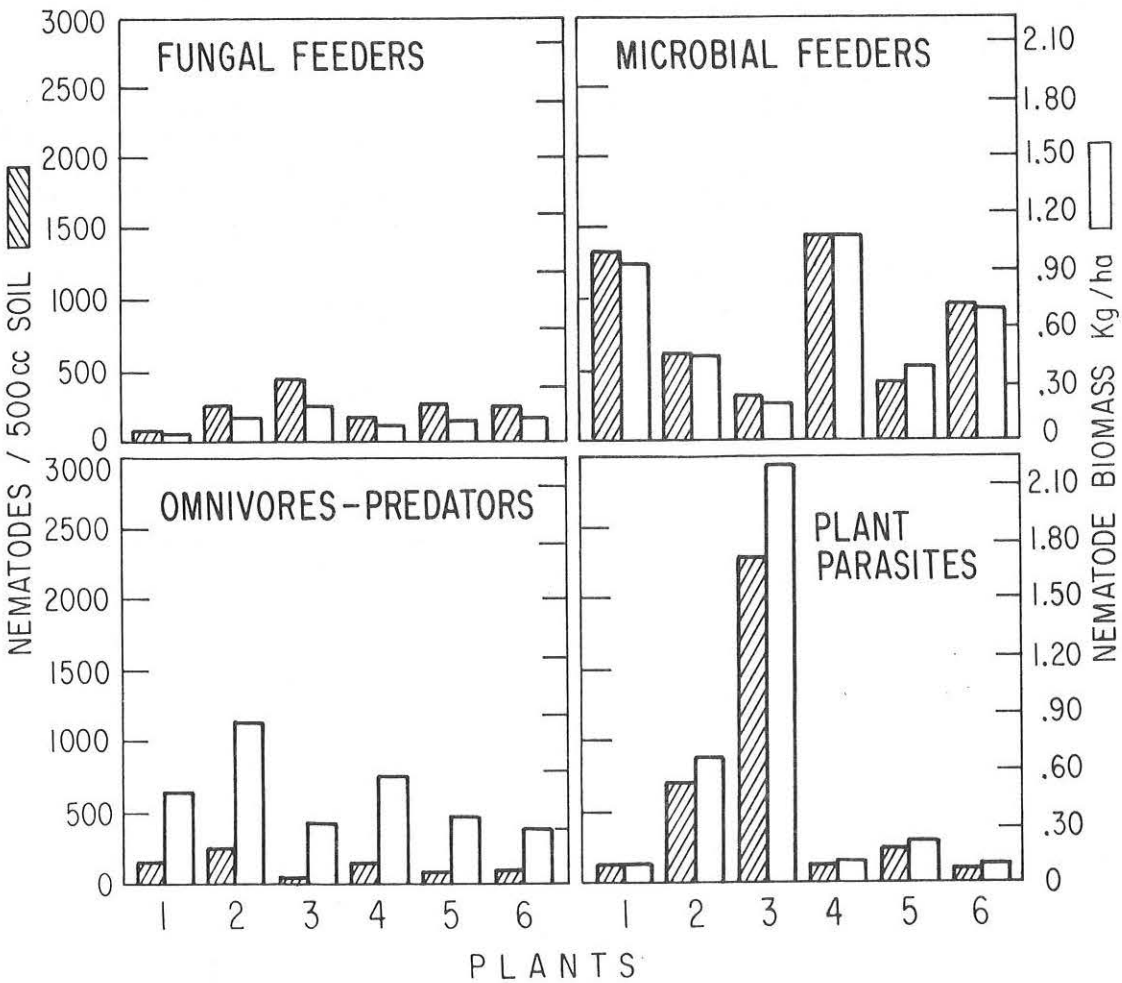


Figure 17. Numbers and biomass of nematode trophic groups, Curlew Valley, Utah. Plants: 1, *Argropyron;* 2, *Atriplex;* 3, *Artemisia;* 4, *Halogeton;* 5,*Chrysothamnus;* 6, *Bassia.*

The presence of the different trophic levels at various depths and positions will be related to the varying environmental conditions and hopefully to the biological food sources in 1974, in order to establish the influencing factors associated with the distribution of desert nematodes.

Biomass estimates from the 1972 desert areas (Mankau et al., 1973) and the validation sites are similar; as expected, however, they are considerably lower than the 8-17.5 g/m^2 reported for meadows by Nielsen (1949). The variations in biomass will be better understood as more information on abiotic and biotic factors in association with the nematodes is available. The lack of replication of samples at Rock Valley and other sites is, unfortunately, one variable that cannot be eliminated without additional funds.

EXPECTATIONS

Below-ground studies at Rock Valley, Nevada, will continue in 1974, using the same research design initiated in 1973. Investigations on cryptobiosis and its effects on the observed nematode population levels at the Rock Valley site will be initiated to discern the proportion which is metabolically active. In addition, we hope to measure the activity of bacteria, fungi and actinomycetes in the soil samples taken at Rock Valley, and relate their activity to the nematode biomass at each trophic level. The influence of abiotic factors on nematode populations will be assessed.

Seasonal sampling of nematodes at the other validation sites will be continued, emphasizing the nematode trophic levels and their energy consumption in relation to dominant vegetation. The additional sampling at all sites will provide data that will enable us to estimate the energy transfer at the nematode trophic levels with greater accuracy.

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