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The Role of Microarthropods and Nematodes in Decomposition in a Semi-arid Ecosystem

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Summary. We sampled the soil microarthropod community monthly in the oak-mesquite sand hill ecosystem. Small fungiphagous prostigmated mites (pyemotids, lordalychids and tarsonemids) that dominated the soil fauna in winter were replaced by large predaceous mites (rhodacarids and laelapids) in summer and autumn.

We compared organic matter loss and microarthropod and nematode populations in shinnery oak (*Quercus harvardii*) using insecticide and untreated litter in fiberglass litterbags.

Microarthropods extracted from litterbags showed a seasonal pattern similar to the soil cores except that collembolans and psocopterans were abundant in the litter and not in the soil cores. Numbers of free living nematodes were consistently greater than from untreated litter. The ratio of non-stylet to stylet bearing nematodes extracted from litter decreased from 4:1 in one month bags to 0.8:1.0 in the one year bags. Laboratory experiments showed that rhodacarid mites fed voraciously on nematodes.

Untreated litter exhibited higher rates of organic matter loss than the insecticide treated litter; 20% and 35% respectively.

We suggest that the abundant mesostigmatid mites prey on free living nematodes and that eliminating the predators allows the nematodes to overgraze the fungi and bacteria. The soil modifies the microclimate in buried litter allowing for higher biological activity, hence higher rates of decomposition.

Introduction

Decomposition of plant litter in terrestrial ecosystems involves complex interactions between microflora, microfauna, and physical environment (Crossley 1970; Douce and Webb 1978; Vossbrinck et al. 1979). Microarthropods have been implicated as regulators of microbial decomposition of various plant litters (Edwards and Heath 1963; Wallwork 1970; McBrayer 1977). Proposed mechanisms for such involvement by microarthropods include the comminution of litter which significantly increases surface/volume ratios thereby increasing potential microbial activity, grazing on senescent microbial colonies to stimulate activity and dispersal of fungi and bacteria throughout litter deposits via ambulation (Douce and Webb 1978).

Most of our understanding of decomposition processes has come from studies conducted in mesic, wooded ecosystems. There have been relatively few studies dealing with the ecology of desert microarthropods (Krivolutsky 1968; Wood 1971; Wallwork 1972a; Edney et al. 1976; Santos et al. 1978; Franco et al. 1979; Santos and Whitford 1981). The desert soil fauna is generally impoverished and strongly localized in its distribution (Wallwork 1972b). The soil faunas of most mesic systems are dominated by earthworms, various apterygotic insects (especially collembola) and mites of the suborder Cryptostigmata. Various xeric systems have been found to be mainly populated by mites of the suborder Prostigmata with cryptostigmatids making up a smaller percentage of the community assemblage (Wood 1971; Price 1973; Douce and Crossley 1977; Santos et al. 1978). The microarthropod fauna in desert systems, being different from more mesic systems, may affect litter decay processes in ways other than those indicated from studies of temperate ecosystems.

Studies which have dealt with the rate of decomposition of litter in mesic systems have almost exclusively followed the fate of litter on the soil surface. Studies in such systems have indicated maximum activites of most decomposer organisms in the upper litter layers. In most desert systems, the sparse vegetation cover and loose, sandy nature soil of the produce surface conditions typically too extreme to support much biological activity during most of the day and throughout much of the year. Further, substantial amounts of litter are translocated and buried by the action of sheet water flow during high intensity rains and by aeolean sand during frequent winds. The result is a poorly defined, if present, litter layer structure on the soil surface and the presence of accumulations of buried litter along arroyos, wind-screened depressions, and in aeolean dunes. Santos and Whitford (1981) suggested that these processes led to higher decomposition rates in buried litter as opposed to surface litter on a Chihuahuan desert bajada.

This study examines the composition and seasonal variation of the soil microarthropod community in an oak-mesquite sand dune community in the desert-grassland transition zone of southeastern New Mexico. We also examined the role of soil microarthropods in the decomposition of buried litter and compared rates of mass loss of buried and surface litter.

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Material and Methods

Study Area

These studies were conducted on the site of the Department of Energy's proposed Los Medanos Nuclear Waste Isolation Pilot Plant. The site is approximately 40 km east of Carlsbad, in Eddy County, New Mexico at the northern edge of the Chihuahuan Desert (Schmidt 1979). The area is subject to hot summers and mild winters. Precipitation is light and unevenly distributed throughout the year with late summer and late spring receiving most of the yearly total. The average annual precipitation for the 10-year period preceding this study (1968–78) was 422 mm. Air temperatures ranged from −17 C in January to 40 C in July during the study period.

The land surface in the area is a semi-arid, windblown plain sloping gently to the west and southwest. The surface is hummocky with sand ridges and stabilized dunes. A hard caliche layer is generally present beneath the sand (Griswold 1977). The elevation is approximately 1,000 m. The primary soil association is the Kermit-Berino, typified by sandy, deep soils from windworked mixed sand deposits (data from Draft Environmental Impact Statement, WIPP, 1979). The surface soil in a fine sand and fine sandy loam (particle size <2 mm) exhibiting generally poor water holding capacity. The vegetation of the area is polytypic, dominated by the shrubs: Shinnery oak (*Quercus harvardii* Rydb.), mesquite (*Prosopis glandulosa* Torr.), and sand sage (*Artemesia filifolia* Torr.). Shinnery oak, typically a low shrub not exceeding 1 m in height, is the most abundant shrub on the site, forming dense coppice stands and regularly reproducing by root sprouts (Martin 1978).

Study Design

Litter bags were used to estimate organic matter weight loss and litter-associated microarthropod dynamics. Shinnery oak leaves were harvested from shrubs near the site during December, 1978. Only senescent leaves which had not yet fallen to the ground were used in the litter decomposition study.

A modification of Santos and Whitford's (1981) chemical exclusion technique was employed to minimize microarthropod activity within litterbags. Equal amounts of oak leaves were soaked in distilled water (control) and 1% dilution by volume of chlordane solution for six h and dried at 60 C for 72 h. Approximately 10 grams of litter was placed in pre-weighed and labelled 170 cm^2 fiberglass mesh bags (mesh size = 1.5 mm) and staplet shut. Filled bags were weighed to an accuracy of .01 gm and the weights corrected for bag weights. During transportation to and from the field, each litter bag was isolated to minimize loss of material and microarthropods. Litterbags were placed in the field as "sets" of 10 bags of each litter treatment.

Four sets were distributed on the site in January 1979, two in April, and three in August. The litterbags were buried within stands of shinnery oak at depths of between 15 cm and 20 cm and flagged on the surface. No insecticide-treated bags were placed within 2 m of control bags. Litterbag sets were retrieved at intervals as indicated in Fig. 1. All bag sets were collected between 07.00 and 08.00 h. On the date the first litter bag sets were placed in the field, ten 10 cm × 15 cm deep soil cores were taken from the site for microarthropod extraction. This was repeated at one month intervals and the data were used for comparison with litterbag microarthropod communities. Soil samples were taken each month to gravimetrically determine soil moisture.

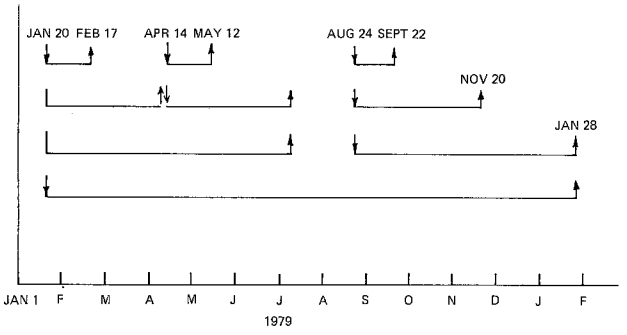

Fig. 1. The sequence of placement and retrieval of litterbag sets. Down pointing arrows indicate placement of a bag set in the field and up pointing arrows indicate retrieval from the field. Double sets of arrows indicate both surface and buried bags, single arrows indicate buried bags only

On the date of the first litterbag distribution (January), 40 control and 40 insecticide-treated litterbags were randomly staked to the soil surface of the study site. Ten surface bags of each treatment were then collected on the one-, three-, and six-month sampling dates and after one year. These bags served as sources of periodic comparison for weight loss rates and litter-associated microfauna between buried and surface litterbags.

Microarthropods were extracted from soil cores and litterbags returned from the field using modified Tullgren extractors. Seven buried control bags and 5 buried insecticide-treated bags were extracted from each bag set. From surface litterbag sets, 5 bags of each treatment were extracted. Bag contents and soil cores were extracted over water for 72 h with a 60 W light bulb 20 cm above each sample. Extracted organisms were counted and identified, and reference collections compiled.

After extraction, litterbag contents were dried for 72 h at 60 C then weighed and burned in a muffle furnace (700 C for 4 h) to determine organic matter content by weight. Percent organic weight loss was calculated for each litterbag using the following equation:

$$d=\frac{I+(A-Y)}{S_i}-F; \qquad \%d=\frac{d\times 100}{I-Y}$$

d = estimated organic matter loss from each sample.
I = initial dry weight of each sample (60 C for 72 h).
A = final inorganic weight (ash weight) of each collected sample (700 C for 4 h).
Y = weight of the initial inorganic content of each initial dry weight (estimated from each of ten standard samples of each treatment.
S_i = estimated inorganic content of the soil (mean of ten samples of soil burned in a muffle furnace).
F = final dry weight of each sample (60 C for 72 h) after collection.

Percentage weight loss data were normalized by angular transformation and single classification analyses of variance (Sokal and Rohlf 1969) were carried out with each data set to compare treatment means.

Free-living nematodes were extracted from three litterbags of each treatment by a combination of the Cobb