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The contribution of rodents to decomposition processes in a desert ecosystem

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Excavations made by desert rodents during the late non-growing season (April–August) accumulated litter amounts varying between 5·2 and 17·6 kg/ha and over a 1-year period 55·9 kg/ha of litter was buried in such excavations. There was a higher nitrogen content in litter in October, 17·6 ± 0·5 μg/g than the rest of the year, 13·5 ± 1·4 μg/g. Litter bag studies of decomposition of small quantities of buried litter similar to that accumulated in rodent excavations exhibited higher rates of decomposition than larger quantities of buried litter reported in the literature. Rodent excavating activity increases rates of decomposition and organic matter turnover and may effect the distribution of ephemeral plants in warm desert ecosystems.

Introduction

The contributions of small mammals to ecosystem processes can be viewed as either negative or positive. For example, the utilization of a high percentage of the total numbers of seedlings may be considered as a negative effect on the primary production component of the system. Rodents may kill as much as 100 per cent of the seedlings in forests and may disrupt regeneration capability. The destructive activities of small mammals have been compared to fungi and insects. For example, in forest regions the percentage of seedlings destroyed by rodents is high in comparison with the percentage killed by fungi and insects (Golley, Petrusewiez *et al.*, 1975). In a desert ecosystem, granivorous small mammals were estimated to use 86·5 per cent of the seed population (Chew & Chew, 1970). Brown, Reichman *et al.* (1979) showed that in plots where rodents were removed, seed densities were higher than in plots with rodents present. Thus, seed consumption by desert rodents is generally regarded as a process that reduces primary productivity hence is detrimental.

We observed that at certain times of the year rodents (*Dipodomys merriami* and/or *Perognathus penicillatus*) made numerous small excavations apparently in search of buried seeds or caches. These holes soon filled with plant litter and seeds, thereby providing not only a seed source, but a supply of organic matter and nutrients. This excavating behavior may therefore represent a beneficial effect of seed consumption by rodents and could also effect the spatial patterning of soil nutrients.

In this study we examined seasonal variation in density of rodent excavations, rates of hole filling, quantity and characteristics of materials trapped in the holes, and rates of decomposition of materials buried in such holes.

Study site

These studies were conducted on the Jornada site on the New Mexico State University

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Ranch, 40 km NNE of Las Cruces, Dona Ana County, New Mexico. The Jornada Site is a desert watershed varying in elevation from *c*. 2000 m to *c*. 1000 m. The 100 year annual rainfall average ± 1 standard deviation at the New Mexico State University Station, Las Cruces, New Mexico, is 211 ± 77 mm (Houghton, 1972), with most of that rainfall occurring during late summer from convectional storms. Summer maximum temperatures reached 40 °C and freezing temperatures are recorded from October through mid-April (data from the Jornada Site Weather Station). The soils are gravelly to sandy loams, and the area has an essentially monotypic cover of creosotebush, *Larrea tridentata*, (approximately 23 per cent cover). Creosotebushes average 1 m or more in height and the depth of the calche layer varies from approximately 0·2 to > 1 m.

Methods

Twenty, 1 m square, randomly placed, quadrat samples were taken monthly during 1980–1981. The number and size (diameter) of rodent excavations were recorded and the contents of the holes were collected. The hole contents were oven dried at 60 °C for 72 h; the organic components were separated from the soil particles and weighed (± 0·01 g).

Ten randomly placed 1 m^2 permanent plots were checked monthly; the litter accumulated in the month was collected, and if holes were filled with soil, this was recorded. Permanent plots provided data on rates of excavation, litter accumulation, and burial.

Nitrogen content of the organic material was determined by the Kjeldahl method (Tecator manual DS40).

Senescent creosotebush leaves and leaves and stems of the ephemeral *Baileya multiradiata* were oven dried at 60 °C for 72 h and mixed thoroughly. Litter bags (100 cm^2) made of 16/18 fiberglass mesh screen were filled with 5 g of this dried plant material. The bags were buried in 5 cm-deep trenches on the study site. A set of 10 bags was retrieved at each sampling date: 30, 60, 90, 180, 270, and 360 days after burial. Litter bags returned from the field were dried at 60 °C for 72 h then ashed in a muffle furnace at 700 °C for 4 h. The techniques described by Santos & Whitford (1981) were used to correct organic matter loss for soil infiltration.

Results

Based on the permanent plots, the period of most intensive excavation was in the late spring through mid-summer (Fig. 1). This is also reflected in the quadrat estimates of evacuation densities (Fig. 2) which were highest during this same period. By late summer, there were virtually no excavations remaining (Figs 1, 2). Excavation activity was initiated again in September and remained relatively constant until April.

The average excavation was 4·4 ± 0·4 cm diameter and 1·5 cm deep and contained an average of 154 ± 90 mg litter. Quantities of litter in excavations varied from 21·99 kg/ha in July to zero in August and September (Fig. 2). The average quantity of litter trapped per unit area of excavations ranged from 0·3 mg/cm^2 to 2·5 mg/cm^2 depending upon the time of the year. There was an inverse relationship between the quantity of litter accumulated per unit area of excavation and the diameter of the hole (r^2 = 0·80). Virtually all excavations were under the canopy of creosotebushes or within 1 m of the edge of the canopy. There was significantly higher nitrogen content of the litter collected from the holes in October (17·58 ± 0·53 μg/g) than during the rest of the year (13·52 ± 1·4 μg/g) (F = 3·59, $P < 0·008$). The percentage of excavations buried per month ranged from 0 to 100 per cent (Fig. 1). Multiplying the per cent of excavations buried per month by the standing crop of litter trapped in excavations provides an estimate of quantities buried (Table 1) and of the nitrogen released by such decomposition. Estimated quantities buried ranged from a high of 17·6 kg/ha in August to 0 in October and over a 1-year period could add

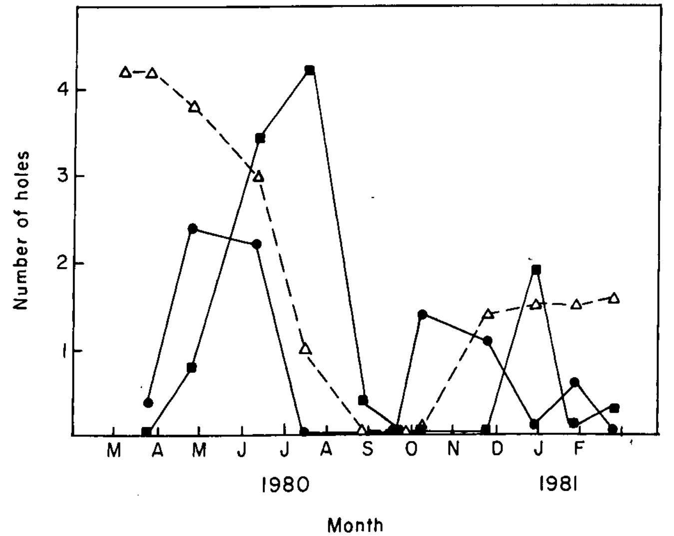

Figure 1. Numbers of new rodent excavations, excavations buried and excavations remaining on 10, 1 m^2 permanent plots. ●——●, New holes; ■——■, covered holes; △- - -△, remaining holes.

approximately 360 g nitrogen/ha assuming nitrogen release was proportional to decomposition (Table 1).

The decomposition rate of the small quantities of litter remained low during the cool part of the year varying from 0·12 per cent per day from December until February and dropping to 0·08 per cent per day from February until May and increasing to 0·13 per cent per day from May until August (Fig. 3).

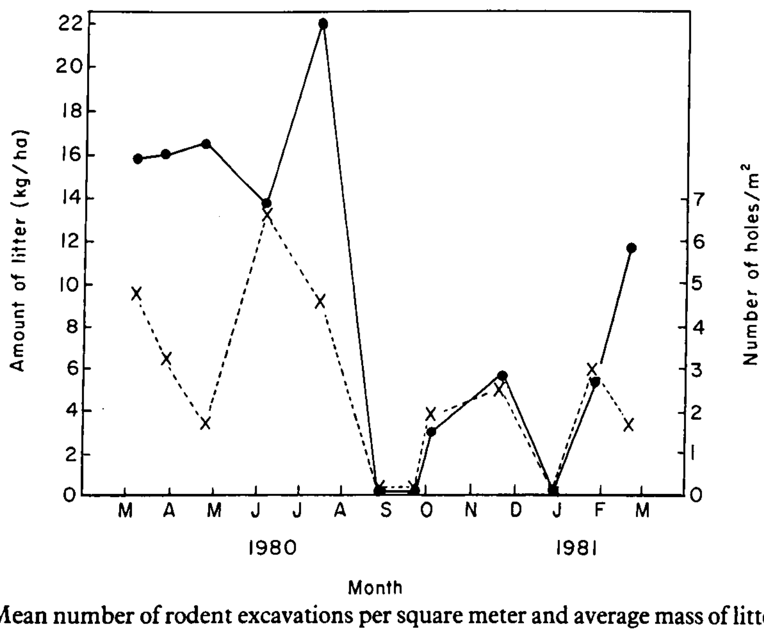

Figure 2. Mean number of rodent excavations per square meter and average mass of litter trapped in these excavations based on 20 random 1 m^2 quadrats during the months indicated. × - - - ×, Number of holes, ●——●, kg litter/ha.

Table 1. *Estimated quantity of leaf litter trapped in rodent excavations buried per month and quantity of nitrogen in the buried litter*

Month	Proportion of excavations buried	Quantity of litter buried (kg/ha)	Nitrogen content of litter (g/ha)
May	0·20	3·16	37·90
June	0·50	8·00	96·00
July	0·50	8·25	107·30
August	0·80	17·60	220·00
September	1·00	4·40	55·00
October	0	0	0
November	0·70	3·92	60·70
December	0·70	3·92	58·80
January	0·15	0	0
February	0·15	0·81	10·53
March	0·20	2·36	30·86
April	1·00	3·44	44·72
		Total 55·86	721·63

Discussion

The seasonal pattern of excavations by rodents reflects the relative availability of seeds on the surface. In the Chihuahuan desert, seed drop follows the onset of summer rains which trigger seed production by ephemeral and perennial plants. This seed drop generally occurs from late-August until mid-November. By late February, surface seeds are undoubtedly largely depleted and rodents intensify their use of buried accumulations or their own caches. Excavating caches and leaving the open excavations provides a trap for seeds and litter.

The intensive excavation and frequent intense wind storms during the period February until March combine to bury large quantities of litter. However, the larger input of buried litter occurs when the first summer rains erode soil that fills in the evacuations. Following rains when surface seeds are available, production of open excavations is reduced. Thus, the pattern of litter burial in rodent excavation is determined by the general climate and productivity patterns.

Although the nitrogen input from the decomposition of litter buried in rodent excavations is not very large on a whole area basis, the excavations serve also as seed traps. As the litter decomposes, nutrients are released into the soil around the buried seeds. These

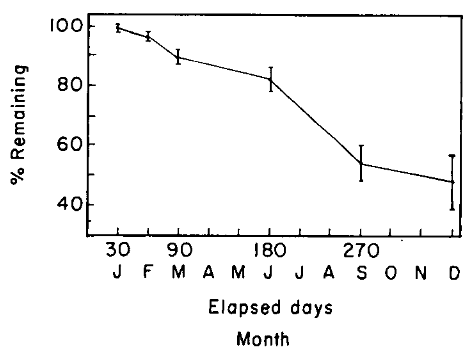

Figure 3. Organic matter loss from 5 g litter bags buried at 5 cm depth in a Chihuahuan desert ecosystem.

microsites thus have higher organic matter content and higher nitrogen than the surrounding soil. Seeds buried in such sites would therefore have a higher probability of germination and establishment than seeds in less favorable microsites. The pattern of rodent excavations concentrated under the canopies of creosotebushes could well contribute to the observation that ephemeral plants have higher density under canopies than in the open (Muller, 1953; Patten, 1978; Whitford, Fowler *et al.*, 1983*a*). The excavations contained an average of 154 mg litter, which represents 2·0 mg nitrogen added to an area of soil approximately 22 cm^2 when that litter has been completely decomposed. This enrichment could be significant for an establishment of seedlings of ephemeral plants.

This study provides support of Chew's (1974) idea that consumers effect ecosystems by affecting the rates of processes rather than by the energy they process. Whitford, Repass *et al.* (1983*b*) demonstrated that small quantities of litter on the soil surface decompose slowly whereas large accumulations disappear more rapidly. Santos & Whitford (1981) showed that buried litter disappeared more rapidly than surface litter, but they used relatively large quantities of litter. Litter buried in rodent excavations lost nearly half of the initial mass in 9 months and at mid-summer rates, litter buried in July would lose over half the initial mass by winter. Thus, rodents excavating activity increases the rate of decomposition and organic matter turnover and may contribute to establishment of ephemeral plant seedlings.

The idea for this study developed from discussions with our colleague Dr Robert Chew. This study was supported by Grants DEB 77–16633 and DEB 80–20083 from the Ecosystems Division of the U.S. National Science Foundation.

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