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Decomposition along a rainfall gradient in the Judean desert, Israel*

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Summary. The effect of a rainfall gradient, from a semi-arid to extremely arid, on decomposition, were studied in the Judean desert, Israel. During the study period, the rainfall gradient obtained ranged from 308 mm to 24.4 mm. There was a annual mass loss of approximately 20% and 16% in the semi-arid and extremely arid regions, respectively. No significant correlation was found between the total rainfall and total mass losses. The data suggest that in an area where the conditions are not suitable for biological activity, the decomposition processes result from abiotic conditions, like temperature and radiation.

Key words: Decomposition – Rainfall – Desert – Gradient

Most studies of decomposition processes in arid regions have been done in North American deserts (Santos and Whitford 1981; Elkins and Whitford 1982; Santos et al. 1984; Schaefer et al. 1985; Whitford et al. 1986; Strojan et al. 1987). Decomposition of surface and buried litter was studied in a variety of those desert sites that varied from arid to semi-arid. Santos et al. (1984) reported that rates of surface litter decomposition had a higher correlation with long term average precipitation than with actual rainfall during the period of study. However, Strojan et al. (1987), found a significant relationship between mass loss and rainfall for leaves of three species of Mojave Desert shrubs. Using stepwise regression analysis, he re-analyzed the data of Santos et al. (1984) and concluded that actual rainfall and site specific differences were most important as determinants of decomposition. Whitford et al. (1986) found virtually no effect of supplemental water provided by sprinkler irrigation on decomposition rates in the Chihuahuan Desert, except during a prolonged rainless period. We currently view mass losses from surface litter in deserts as abiotic fragmentation with rainfall acting as a mechanical force rather than primarily stimulating biological activity.

The Judean desert of Israel provides a steep rainfall gradient from semi-arid to extremely arid over a very short distance. Rainfall over this gradient is entirely winter precipitation which eliminates the complication of seasonality that could have affected the study of Santos et al. (1984). We studied decomposition of wheat straw at a series of sites across the rainfall gradient in the Judean desert to obtain a comparison with the North American deserts.

Study sites

The Judean desert is a rain shadow desert which occupies the eastern slopes of the Judean mountains. The eastern border is the Dead Sea, which is about 400 meters below sea level. In the west, the Judean desert merges with the wetter areas of the Jerusalem mountains, which are 600–700 meters above sea level.

The climate varies from semi-arid in the west to extremely arid in the east. A strong relationship exists between the elevation and vegetation due to the rainshadow position of this desert. The mean annual rainfall decreases from about 500 mm in the western part to less than 100 mm in the east (Rosenan 1970b). This decrease in precipitation is accompanied by an average maximum temperature increase from 26° C to 32° C in August and a minimum temperature in January, which is the coldest month, of 15° C to 12° C, respectively (Rosenan 1970a).

Substrate in the area consists of Santonian chalk (Menuha formation), Campanian flint (Mashash formation), >Mastrichian phosphatic chalk, and Danian-Paleocen chalk, marls and limestones (Bentor et al. 1970;

* Dedicated in memory of Prof. M. Evenari

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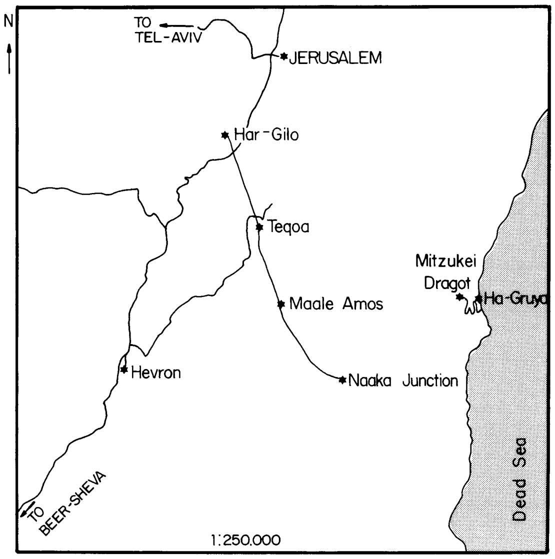

Fig. 1. The area map and sampling sites

Picard and Golani 1970). The mountain slopes are usually moderate in the desert fringe areas, while in the desert, steep slopes are more common.

The Har-Gilo site (Fig. 1) is 10 km south-east of Jerusalem in a mediterranean/semiarid desert fringe zone at an elevation of 914 m and an average rainfall of 500–600 mm. The Tekoa site (Fig. 1) is approximately 40 km east of Jerusalem at an elevation of 675 m with an average rainfall between 250–350 mm. Maale-Amos (Fig. 1) is 20 km southeast of Jerusalem at an elevation of 725 m in a region between the semi-arid and arid zone. The rainfall ranges between 200–400 mm. Naaka Junction (Fig. 1) is 23 km southeast of Jerusalem in the arid zone, at an elevation of 425 m. Mean annual rainfall is 152 mm. The Mitzukei Dragot (Fig. 1) site is 2 km west of the Dead sea at an elevation of 25 m. The average annual precipitation is between 100–150 mm. The Gruya site (Fig. 1) is located in the extreme arid zone near the Dead Sea at an elevation of −375 m. The mean annual rainfall is 61 mm.

Methods

We studied decomposition of wheat straw litter confined in fiberglass mesh bags. The straw was air dried, and subsamples oven dried at 60° C for 72 h to obtain oven dry mass. Each litter bag (20 × 20 cm fiberglass window screen, mesh size 1.5 mm) contained 10 ± 1 g of dried wheat straw. During transportation to and from the field, each litter bag was placed in a plastic bag to minimize the loss of plant material. Sets of 35 litter bags were placed on the soil surface in each of the locations on 10 November 1983. The litter bags were secured with wire pins to prevent movement. Collections were made as follows: 8 bags on 21 January, 8 bags on 16 March, 8 bags on 29 May and 5 bags on 18 September, 1984. Organic matter loss was calculated using the equation developed by Elkins and Whitford (1982).

A rain gauge was placed at each location to obtain actual rainfall during the study period. The data were analyzed by ANOVA and Duncan's Multipile Range Test.

Results and discussion

The climate varies from semi-arid in the west to extremely arid in the east. During this study period, the rainfall varied from 308 mm, which occurred during 32 events, and 24.4 mm, which occurred during 8 events, at Har-Gilo and Gruya station, respectively (Table 1). More than 50 percent of the total rainfall occurred before March and more than half of the rain events were larger than 6 mm.

There was a significant location and date effect on total mass loss (Table 2) with high rates measured at Har-Gilo and Teqoa, the wettest sites. However, the lowest rates were measured at the places where the total rainfall was 24.4 mm, 54.4 mm and 59.7 mm at Gruya, Metzukei Dragot and Naaka Junction, respectively (Table 3).

No significant correlation was found between the total rainfall and the total mass losses at the different locations ($P > 0.2$) nor between the mass losses and the number of rain events greater than 6 mm ($P > 0.5$).

The data support the conclusion of Whitford et al. (1986) that there is no direct relationship between mass losses from decomposing litter and rainfall in desert ecosystems. However, mass losses were higher at the sites that received more than 300 mm of precipitation over

Table 1. Rainfall distribution during the study period at the different locations

Location	Total rainfall (mm)	Total rain events	Rainfall to march (mm)	Total rain events to march
Har-Gilo	308.8	32(15)	201.6	19(8)
Teqoa	307.0	11(8)	196.6	8(5)
Maale-Amos	206.5	8(5)	100.1	5(3)
Naaka Junction	59.7	7(4)	53.4	6(3)
Metzukei Dragot	54.4	13(4)	37.0	8(3)
Gruya	24.4	8(2)	15.1	6(1)

Number in parenthesis indicates number of rain events greater than 6 mm

The rain occurred between:

Har-Gilo	14 October 1983–25 April 1984
Teqoa	08 November 1983–22 April 1984
Maale-Amos	24 November 1983–22 April 1984
Naaka Junction	02 January 1984–22 April 1984
Metzukei Dragot	12 November 1983–27 March 1984
Gruya	12 November 1983–29 March 1984

Table 2. Analysis of variance (ANOVA) carried out on total mass loss

Source of variation	Degrees of freedom	F value	Significance
Date	4	699.84	0.0001
Location	5	20.60	0.0001
Interaction	16	1.83	0.0353

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Table 3. Percent of mass remaining in the letter bags containing wheat straw litter located at the soil surface at the different location across the transect. Duncan Multiple range test for weight remaining at the end of the study period and at the end of the winter period

Location	Total weight remaining (%) 313 days		Weight remaining to march (%) 127 days
Har Gilo	77.29 A ±2.67	SD	80.28 A ±2.98
Teqoa	75.34 A ±2.05	SD	79.18 A ±1.51
Maale Amos	[a]	–	82.47 B ±1.61
Naaka Junction	83.10 B ±3.11	NS	83.49 B ±1.28
Metzukei Dragot	77.93 A ±4.41	SD	83.56 B ±1.37
Gruya	83.57 B ±2.27	NS	83.21 B ±4.26

[a] All the litter bags disappeared after the March sampling period
– Numbers followed by the same letter are not significantly different ($P<0.05$) for the same period of sampling period A, B
– SD significantly different at level $P<0.05$, between the different periods
– NS not significantly different between the different periods

the 6 month rain period than at two of the three arid sites. The relatively high rates of mass loss recorded at the Metzukei Dragot site may have been the result of 5 rain events recorded between the March sample date and the end of March (Table 1). There were only two rain events at Gruya and one rain at Naaka Junction after the March sampling date (Table 1). If mass loss from decomposing litter in a desert is primarily due to biological activity, then there should be a correlation between the number of rainfalls, and/or total rainfall. Number of rainfalls and total rainfall are indicators of the frequency and duration of conditions suitable for "pulses" of biological activity in the litter.

The absence of correlations between mass losses and these rainfall parameters suggests that mass losses are primarily the result of abiotic forces, like temperature and radiation.

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