Oecologia (Berl) (1981) 51:332–334

Oecologia

Influences of Porcupine (*Hystrix indica*) Activity on the Slopes of the Northern Negev Mountains – Germination and Vegetation Renewal in Different Geomorphological Types and Slope Directions

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Summary. Preliminary results show that the number and survival of seedlings within the diggings of the Indian crested porcupine (*Hystrix indica*) is usually higher than in the surrounding area. Species like *Erodium hirtum* (Willd.) (hemicryptophyte), *Helianthemum vesicarium* Boiss. (perennial), and *Diplotaxis harra* (Forssk.) Boiss. are conspicuous by their appearance in the diggings of the porcupine more than between the diggings. In contrast there are plants like *Helianthemum ledifolium* (L.) Mill. (annual), that appear in high numbers outside the diggings. In the case of *Erodium hirtum*, it appears that the porcupines help in rejuvenating the population. The porcupines feed on the older underground plant bulbs and the pockets formed by their diggings are convenient habitats for germination and growth of the young seedlings.

Introduction

During the winter of 1978–1979 observations on germination were carried out in the hilly areas west of Sede Boqer along the north-, south-, east- and west-facing slopes of one hill. In this area the annual average rainfall is approximately 90 mm, the vegetation is composed mainly of species of the Saharo Arabian phytogeographic distribution. On the northern and western slopes, we find mainly Irano Turanian plants, and in micro habitats like soil pockets between rocky slopes, which receive more water in comparison to other parts of this area, we find also Mediterranean plants (see Table 1) (Zohary 1962; Evenari et al. 1971). Three geological formations – Dorim, Shivta and Netser formations – are found in all of the study sites (Yair et al. 1978).

The aims of this study were: to investigate the relationship between porcupine digging activities, germination and survival of the seedlings; and to compare the germination and survival on different slope directions and geological formations.

The porcupine is a very common animal in the Negev mountains. It feeds on the underground storage organs of geophytes and hemicryptophytes. It was found by Shachak and Yair (in preparation) that the highest density of diggings on the slopes is within the Shivta formation – up to one digging every 2 square meters per year. Every digging indicates at least one geophyte or hemicryptophyte that was eaten. This means that, in a year, about fifty plants are eaten in every 100 square meters. One of the aims of this study is to find out if there is a correlation between the amount of plants eaten and their replacement by new seedlings.

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Table 1. The composition of shrubs that dominate the perennial plants, as a percentage of overall plant coverage in habitat -a- of the Drorim formation, and -d- of the Shivta formation, on the north (N), south (S), west (W), and east (E) slopes. (The full names of the plants are indicated at the bottom of the table)[a]

Habitat	a		d	
Coverage Orientation		%		%
N	*Artemisia*	87	*Artemisia*	27
			Gymnocarpos	20
S	*Artemisia*	50	*Gymnocarpos*	38
	Zygophyllum	35	*Artemisia*	25
W	*Zygophyllum*	50	*Artemisia*	29
	Artemisia	35	*Gymnocarpos*	25
			Stachys	20
E	*Hammada*	75	*Gymnocarpos*	38
	Artemisia	25	*Artemisia*	25

[a] *Artemisia herba-alba* Asso., *Gymnocarpos decander* Forssk., *Hammada scoparia* (Pomel) Iljin, *Stachys aegyptiaca* Pers., *Zygophyllum dumosum* Boiss. All the species mentioned in this table have Saharo Arabian phytogeographic distribution, except *Artemisia herba – alba*, which has an Irano Turanian distribution

As was shown in previous studies (Friedman 1971; Friedman and Orshan 1974, 1975; Evenari and Gutterman 1976), perennial plants such as *Artemisia herba-alba* Asso and *Zygophyllum dumosum* Boiss. found in all the areas studied inhibit germination in their immediate surroundings. It would be interesting to see if in the porcupine diggings, which are special habitats, the geophytes and hemicryptophytes would renew themselves better than outside the diggings. Another question was whether every year the geophytes renew themselves in small numbers or renew themselves in large numbers once in a number of years as is common with *Artemisia* and other perennials (Evenari and Gutterman 1976).

This research is a summary of the first season's study. The data collected is the beginning of comprehensive research to be carried out for a number of years.

Materials and Methods

Field observations were carried out in the rainy season of 1978–79 on the slopes of one hill west of Sede Boqer in the northern

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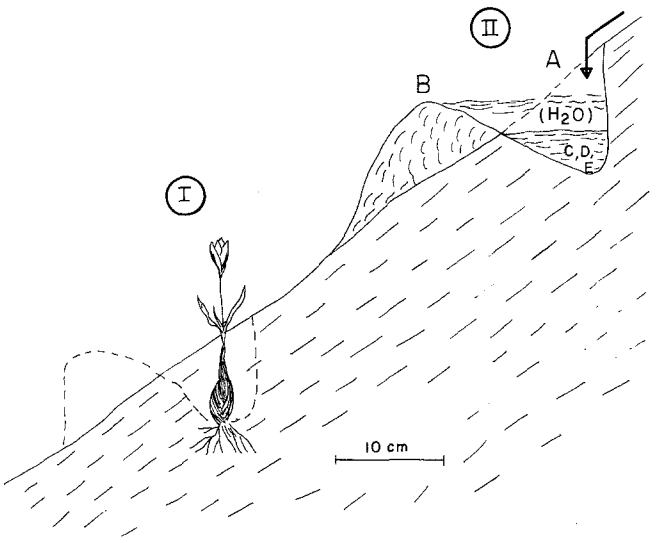

Fig. 1. A schematic drawing of a longitudinal section of part of a slope. Part I, showing a geophyte and its subterannean storage bulb before the porcupine digs and consumes the plant. Part II, the porcupine digging (*A*) and the soil which was taken out (*B*) acts as a wind trap for organic matter (*C*), seeds (*D*) and soil particles (*E*) which accumulate in the bottom of the digging during the dry season. During the winter, runoff water also accumulates in this digging (H_2O)

Table 2. The number of seedlings in the porcupine diggings as a percent of overall germination. In the Drorim formation -a- or in the Shivta formation -d-, on the north (N), south (S), west (W) and east (E) slopes

Habitat	a			d		
Orientation	I[a]	II[b]	III[c]	I[a]	II[b]	III[c]
N	39	13	33	208	158	76
S	95	35	33	49	13	27
W	124	0	0	81	74	91
E	228	69	30	96	57	59
Total	486	117	24	434	302	70

[a] Sum of germination in 7 plots
[b] Number of seedlings in diggings
[c] % germination in diggings

Negev mountains. The investigation was carried out in 140 plots (25×50 cm) in which the number of seedlings of the different species, their survival and phenology, were recorded every month.

Along the northern, southern, western and eastern slopes the geological formations Drorim, Shivta and Netser are exposed. In these formations, five geomorphological types develop (which we called a–e), that allow for different habitats. In this study we discuss and compare only a. and d.

a- Bottom of slope with deep soil, usually on Drorim formation.

d- Belts or soil pockets between smooth or pitted faced hard massive limestone outcrops, in the Shivta formation (Yair et al. 1978). As we see in Table 1, along those parts of the slopes with one exception, there is a mixture of Saharo Arabian and Irano Turanian dominant plants. Only on the northern slopes in Drorim formation, we find a dominant plant – *Artemisia herba-alba* – which has Irano Turanian phytogeographic distribution. On these slopes, there are also Mediterranean plants in micro habitats which accumulate more runoff water in soil belts or pockets between the rocky slopes of the Shivta formation.

Results and Discussion

The porcupines dig on the slopes and plains in order to find and eat the underground storage organs of geophytes and hemicryptophytes. The density of the porcupine diggings in the Shivta formation can be as high as one digging every two square meters of soil. In the Drorim formation there are half as many diggings.

The average size of a digging is $5 \times 10 \times 12$ cm. From the field observations carried out in the Negev mountains, it appeared in many cases that the diggings of the porcupines provided a relatively good habitat for the germination and survival of the seedlings. As we can see from the schematic drawing of Fig. 1., the porcupine digging is a very important micro habitat under desert conditions. During summer, organic matter, seeds and soil particles which are moved by the wind on the soil surface, accumulate in the bottom of the diggings. During winter, runoff water also accumulates in these diggings, with an additional amount of soil particles and organic matter. In these diggings we can find much more organic matter than in other areas surrounding it, which raises the field capacity of the soil and the amount of nutrition. In the western slope of the Shivta formation 91% of the germination was in the diggings (Table 2), in the northern slope 76%, in the eastern 59% and in the southern only 27%. Similar results of germination in the diggings of porcupines were obtained on three slopes in the Drorim formation, in the north, south, and east slopes, between 30–37%.

It is interesting to note that in the formation that has many porcupine diggings there is much germination in the diggings (Table 2). In six of the eight habitats studied it was found that the density of seedlings was greater in comparison to the surrounding area. At times the ratio was up to 32:1. In spite of the higher density in the diggings in comparison to the area outside, the percentage of seedlings that survived was much greater in the diggings. This ratio can even reach 2:1.

Of 77 seedlings of *Diplotaxis* that germinated in -a- and -d-, 41 germinated in the diggings (53%). Of those, 22 remained alive (54%). Outside the diggings only 31% of the seedlings that germinated remained alive.

Helianthemum vesicarium – of 13 seedlings, 71% germinated in the diggings. Of these 62% survived compared to 24% of the seedlings that germinate outside the diggings.

Erodium hirtum – of 27 seedlings that germinated on the northern face, in -d-, where there are relatively many porcupine diggings compared to the other areas observed in the study, 48% germinated inside the diggings, of which 84% survived. Of those that germinated outside the diggings only 64% survived. It was noted that a plant eaten by the porcupine renews itself better in the diggings. From this we see that the porcupines help renew the population by eating the old plants and producing a better habitat for the germination, growth, and survival of young seedlings.

Even though 140 rectangles 25×50 cm were observed, which are the total number of experimental plots in this observation area, the number of seedlings was small. It was found in this work, as in other works (Friedman and Orshan 1974–1975; Evenari and Gutterman 1976), that the presence of adult *Artemisia herba-alba* and *Zygophyllum dumosum* inhibits the germination and development of annual seeds.

Table 3. Coverage of the plant *Artemisia herba-alba* as a percentage of all the perennial shrubs, and the number of seedlings on the different slope faces: north (N), south (S), west (W), and east (E)

Orientation	*Artemisia* % coverage	Total number of seedlings
N	87	39
S	50	95
W	35	125
E	25	228

For the dominant plant in the habitats in slopes with different orientations, see Table 1.

In the Drorim formation (a), we find an inverse relationship between the percent coverage of *Artemisia* on the different slope faces and the amount of seedlings (Table 3).

Another reason for the poor germination was the amount of rain (75 mm) that fell during the last winter. It was below the average annual rainfall (90 mm). Under these conditions it appears that there is an advantage for seedlings that germinated in the porcupine diggings.

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Received April, 1981