SEX RATIOS AND EGG PRODUCTION OF *ZYGORIBATULA* SPP. (ACARI, CRYPTOSTIGMATA) IN THE NEGEV DESERT OF SOUTHERN ISRAEL

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ZYGORIBATULA SPP.
PASSALOZETES
c. f. AFRICANUS
POPULATION
BREADING ACTIVITY
NEGEV DESERT

SUMMARY : Experimental plots were established on a watershed at Advat farm in the central Negev Highlands. Litter bags were deployed at two time intervals ; five replicates were collected from each site before a water amendment and after. Certain features are common to the deserts of southwestern U.S.A. and the Negev desert, despites differences in rainfall regimes.

ZYGORIBATULA SPP
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POPULATION
REPRODUCTION
DÉSERT DU NEGEV

RÉSUMÉ : Un arrosage de parcelles expérimentales a été mis en place à la ferme Advat dans les hautes terres centrales du Negev. Des sacs de litière ont été déployés à deux intervalles ; à cinq reprises des récoltes ont été faites à chacun des sites avant et après l'amendement par l'eau. Certains faits sont communs aux déserts du sud-ouest des U.S.A. et au désert du Negev, en dépit des différences dans les régimes des pluies.

INTRODUCTION

Previous studies on the reproductive behaviour of desert litter and soil-inhabiting cryptostigmatid mites have been carried out in the southern parts of the U.S.A. (WALLWORK, 1980 ; WALLWORK *et al.*, 1984 ; WALLWORK *et al.*, 1985). These studies were designed to test the validity of NOY-MEIR's (1973) ' trigger-pulse-reserve ' paradigm in relation to free-living soil mites. We showed that reproductive activity of the species studied was related to long-term seasonal rainfall patterns and could not be altered, to any appreciable extent, by simulated rainfall amendments applied on the study site at other times of the year. We concluded, therefore, that the response of these mites to rainfall events in these deserts was a result of the natural selection process that had been operating over a long period of time. In other words, it was not a strictly opportunistic response in most cases. The present report examines the possibility that the findings from North American deserts may have a generality that extends to species of Cryptostigmata occurring in the Negev Desert of southern Israel.

STUDY SITE AND METHODS

Experimental plots were established on a watershed at Avdat farm in the central Negev highlands.

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The main features of this area are described by STEINBERGER and WHITFORD (1988). Briefly, the soil is loessial and fine textured, and the dominant perennial shrub is *Hammada scorparia* (Pomel) Iljin. Winters (the rainfall season) are cool and the summers hot. Annual rainfall varies between 25 mm and 152 mm with an average of 68.8 mm. The months of September, October and November are characterised by heavy dew formation, although much of this moisture evaporates when the sun rises.

During the summer period of 1983, aboveground production of the annual plant *Stipa capensis* Thumb. was collected from the Avdat site. The plant material was air dried and 10 ± 0.01 g aliquots were placed in 20 × 20 cm litter bags (1.5 mm fiber glass window screen). Three pairs of plots, each 10 m × 10 m were set up, each pair on a different topographical location on the watershed, namely the loess plain, mid-slope and hill top. The litter bags were deployed at two time intervals, namely 1 November 1983 (95 bags per plot) and 2 September 1984 (50 bags per plot). The bags were secured with iron pins to prevent movement. During transportation to and from the field, each litter bag was placed in a plastic sac to minimize loss of plant material. Five replicates were collected from each site before a water amendment and after. The schedule for these operations is given in Fig. 1. Collections were made before sunrise and transported to the laboratory for the extraction of microarthropods. The study extended from November 1983 to January 1985.

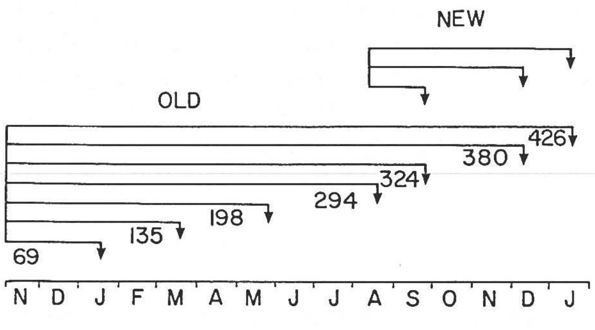

FIG. 1 : Schedule of sampling period.

One plot in each location received a supplemental water treatment during the winter season of 1983/84, from day 69 (8 Jan. 1984) to day 135 (25 March 1984) equivalent to a total of 100 mm of rain during a 10 week period. A second supplemental water equivalent to 120 mm of rain was added over a 4 week period in the late summer between day 294 (2 Sept. 1984) and day 324 (1 October 1984). The water was delivered by four sprinkler heads on each plot at an intensity of 7 mm per hr. There was no surface run-off at this intensity of irrigation.

Microarthropods were extracted from the litter for 72 hr in a modified Tullgren Funnel apparatus. Animals were collected in water, counted, and the Cryptostigmata accumulated in 70 % alcohol. These mites were mounted in Hoyers for sex determination, and the eggs present in gravid females were counted.

RESULTS

Rainfall Data

The rainfall events at Avdat from November 1983 to May 1985 are shown in Fig. 2. These records extend beyond the date of completion of the study reported here (10 january 1985), but the additional data are included to complete the picture for two winter seasons. Clearly, these data confirm that this is a winter rainfall desert and also that the rainfall events during this period of the year have a stochastic element in their timing and magnitude. During the winter of 1983/84, rainfall peaks occurred in January and March whereas in the following winter peaks were recorded in October, November, February, March and April. Futhermore, the March 1985 peak was about twice the magnitude of any of the other peaks. No rainfall was meaured during the summer months of 1984.

Population Data

Only three species of cryptostigmatid mites were collected from the study sites, namely *Passalozetes* c. f. *africanus* and two different but, as yet, unidentified species of the genus *Zygoribatula* which are designated *A* and *B* for present purposes. Of these three species, only *Zygoribatula* sp. *A* was

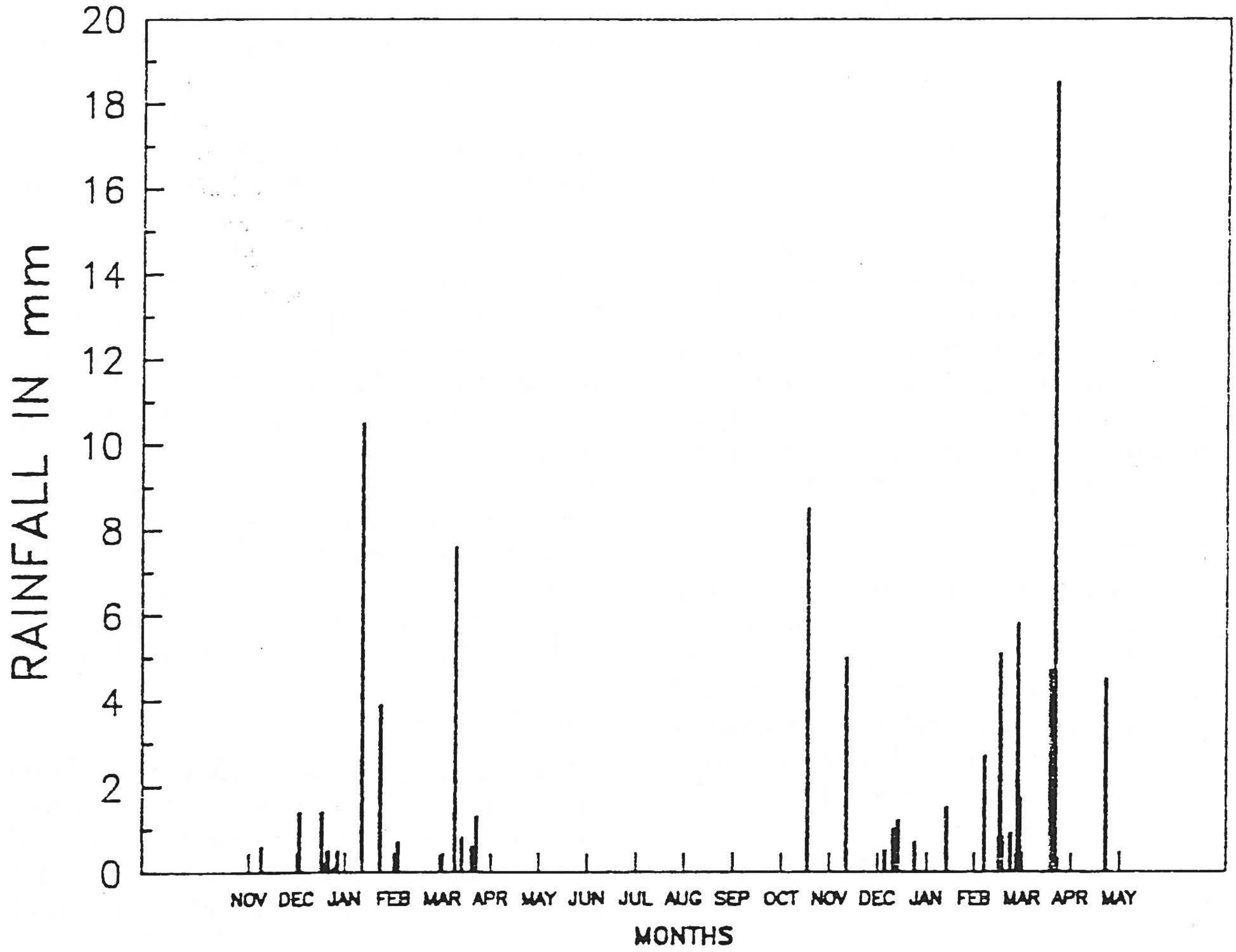

FIG. 2 : Rainfall data Advat 1983-1985.

recovered in sufficient numbers to permit data on egg counts to be obtained.

Total numbers of males and females of *Zygoribatula* sp. *A* recovered from five replicates of litter bags at each locality on three sampling dates in winter 1984/85 are given in Table 1. During this period, litter bags that had been placed on the plots in November 1983 through 10 January 1985, but very few mites were collected until 30 September 1984. The data for this second winter of the study, which commenced with application of the second supplemental water treatment, are considered here.

Several points worthy of note emerge from an analysis of the data given in Table 1. First, there is some variation in the sex ratio over the time span of the sampling and from site to site in the sampling area, i.e. this variation has temporal and spatial components. Despite this variability which appears to be stochastic, numbers of females and

TABLE 1 : Numbers of females and males of *Zygoribatula* sp. *A* present in five litter bags at each sampling site (C = control, W = watered) in winter 1984/85.

Date	Litter Status	Loess Plain C		W		Mid slope C		W		Hill top C		W		Totals	
30-ix-84	Old				1	5	2			18	38	107	112	130	152
	New					19				4	4	28	10	51	14
25-ix-84	Old	3	1	1				2	3	296	198	155	147	457	344
	New		1									49	31	49	32
10-i-85	Old		1		1			33	42	11	4	46	44	90	92
	New				1	3	3	4	3			12	16	19	23
Totals		3	3	1	3	27	5	39	48	329	244	397	360	796	663
		$\underbrace{\quad}_{6}$		$\underbrace{\quad}_{4}$		$\underbrace{\quad}_{32}$		$\underbrace{\quad}_{87}$		$\underbrace{\quad}_{573}$		$\underbrace{\quad}_{757}$		$\underbrace{\quad}_{1\,459}$	

males often approximate to a 1:1 ratio. Second, as may be expected, populations of *Zygoribatula* are lower in the ' new ' litter than in the litter that was deployed in 1 November 1983. This suggests that colonization of fresh litter by *Zygoribatula* is a relatively slow process. Third, colonization is most in evidence on the hill top plots and least on the loess plain. This suggests that the hill top provides a more stable soil environment than the mid slope and loess plain. Finally, colonization by *Zygoribatula* is greater on watered plots than on controls on mid slope and hill top sites. WALLWORK *et al.* (1984) also found larger numbers of cryptostigmatid mites on watered compared with unwatered plots in their Chihuahuan desert study.

Breading Activity

Table 2 gives data on the frequency of gravid females of *Zygoritabula* sp. *A* at the sampling sites during the winter 1984/85. Breeding activity at this time is most widespread on the hill top site and lowest on the loess plain. This is not unexpected since these sites support the highest and lowest numbers, respectively, of females. There is also slightly greater breeding activity on watered plots compared with controls on the hill top and mid slope sites, but this is probably not a significant difference.

TABLE 2 : Frequency (%) of gravid females of *Zygoribatula* sp. *A* at the sampling sites during the winter 1984/85 (C = control, W = Watered).

Date	Litter Status	Loess Plain C	Loess Plain W	Mid slope C	Mid slope W	Hill top C	Hill top W
30-ix-84	Old	—	—	100	—	100	98
	New	—	—	100	—	75	78
25-xi-84	Old	66	—	—	100	96	92
	New	—	—	—	—	—	98
10-i-85	Old	—	—	—	82	100	74
	New	—	—	66	100	—	25

Egg output per gravid female is quite variable, from 1 to 8. As the frequency distributions indicate, however, a clutch size of 4 or 5 is common (Figs. 3-6) and an overall mean for 615 gravid females is 4.0. The average clutch size for 502 females collected from ' old ' litter (4.0) was slightly higher but not significantly so than that for 113 females collected from ' new ' litter (3.76).

Numbers of female *Zygoribatula* sp. *A* recovered from the loess plain (Table 1) were too low for detailed analysis, and they are not considered further. Figs. 4 and 5 provide a breakdown of frequency distributions of egg counts on gravid females in the mid slope control and watered plots for the winter period 1984/85. Figs. 5 and 6 present the corresponding data for the hill top site.

Clutch sizes on mid slope control plots were 4 or 5 (exceptionally 6) (Figs. 3). In contrast, a rather wider spread occurred on the watered plots at this location (Fig. 4). This general pattern is also a feature of the hill top population, although it must be noted that breeding activity of *Zygoribatula* colonizing ' new ' litter on the control (unwatered) plots is virtually non-existent (Fig. 5, and see Table 1). Some enhancement of breeding activity is apparent on these plots after watering (Fig. 6) and the frequency distribution of egg counts is very similar to that obtained from the ' old ' litter.

Other Cryptostigamta

Zygoribatula sp. *B* and *Passalozetes africanus* were collected infrequently and in low numbers. Eight males and eight females of *Zygoribatula* sp. *B* were recovered from ' old ' litter mainly from the mid slope and hill top sites. The clutch size varied from 3 to 7 with a mean of 4.4. Three females only of this species were collected (one from each topographical locality) from ' new ' litter, with clutches of 4, 6 and 7, respectively, These counts are within the range of variation shown by *Zygoribatula* sp. *A*. *Passalozetes africanus* females were collected only from ' new ' litter on control plots on the mid slope on 10-1-85; eight specimens containing either 2 or 3 eggs each. This is identical to the data obtained for *Passalozetes californicus* from the Chihuahuan desert (WALLWORK *et al.*, 1984). Although numbers of *Zygoribatula* sp. *B* and *Passalozetes africanus* are low, the data on reproductive biology are consistent with those for other related species.

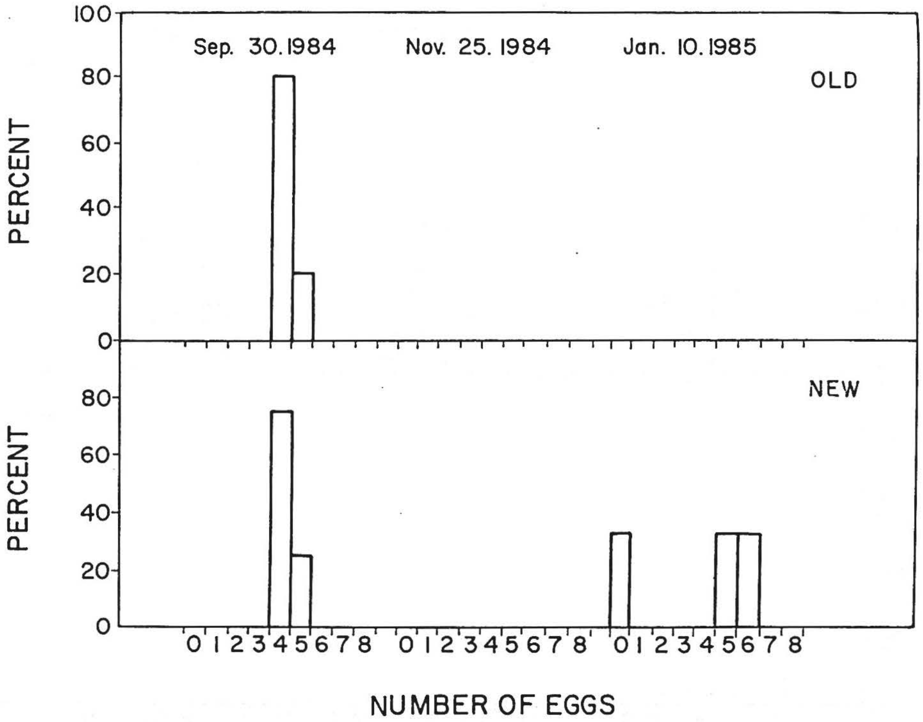

FIG. 3 : Frequency % of egg production in *Zygoribatula* sp. A on the mid slope control plots in winter 1984/85.

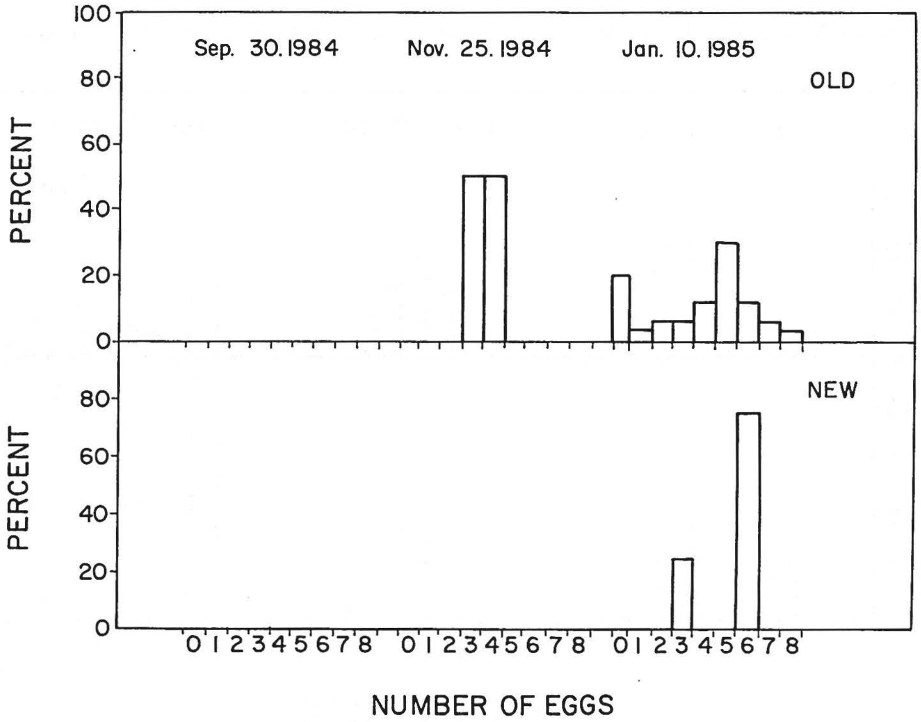

FIG. 4 : Frequency % of egg production in *Zygoribatula* sp. A on the mid slope watered plots in winter 1984/85.

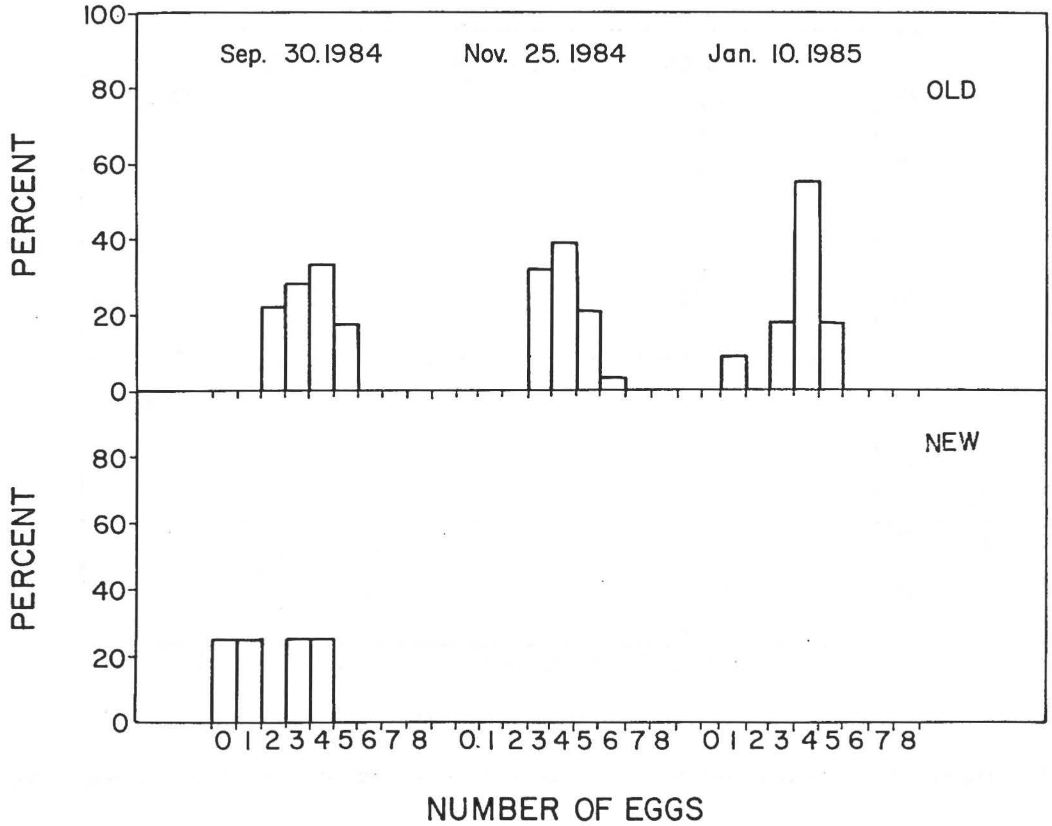

FIG. 5 : Frequency % of egg production in *Zygoribatula* sp. A on the hill top control plots in winter 1984/85.

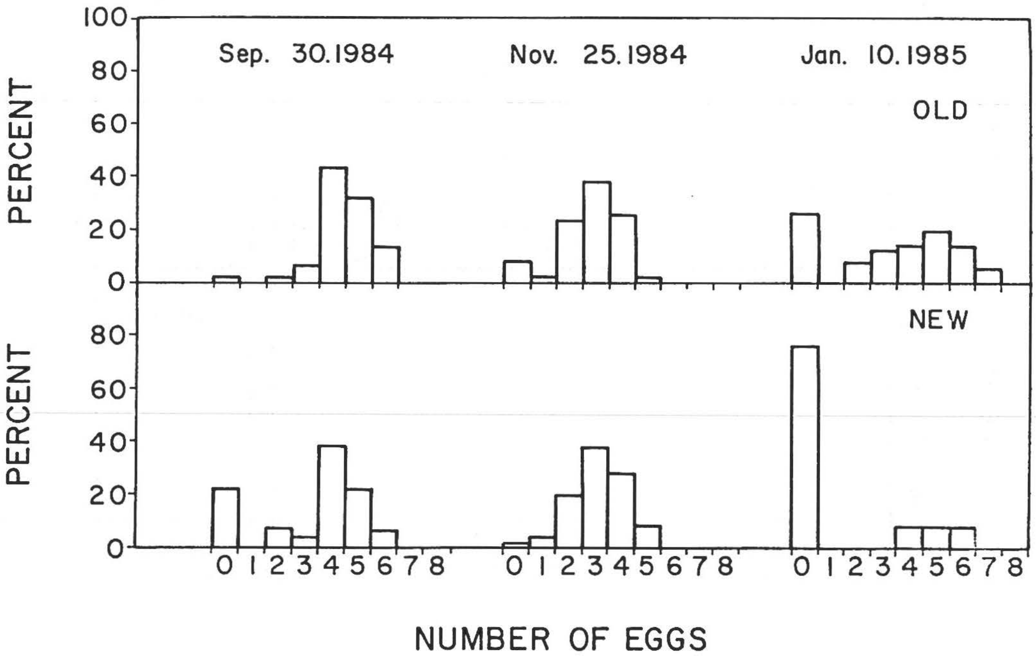

FIG. 6 : Frequency % of egg production in *Zygoribatula* sp. A on the hill top watered plots in winter 1984/85.

Discussion

Breeding activity for the two *Zygoribatula* spp. and *Passalozetes africanus* recorded from the Avdat site was monitored only from the early part of September 1984 until 10 January 1985. No mites were recovered from 'old' or 'new' litter on control and watered plots until 30 September 1984, and it can be assumed that reproduction was not occurring during the dry period. This activity commenced at the end of September 1984, particularly in the hill top sites, and this was slightly in advance of the first measurable rainfall event of the following winter season. This type of response is not inconsistent with the long-term response that we have described for Cryptostigmata in the Chihuahuan desert (Wallwork *et al.*, 1985). It may also reflect a stimulation of reproductive activity due to increased soil moisture occasioned by heavy dew formation during September. Further, there was enhanced activity of *Zygoribatula* sp. *A* on the hill top plots that received the water amendment during September/October 1984 and this again accords with our previous experience.

The largest breeding populations of *Zygoribatula* sp. *A* occur on the hill top site and we can ask why this should be so. Plant cover is greatest on the loess plain, but despite this fact, soil orgnic matter reaches its highest levels on the hill top (Steinberger, unpubl.). This organic matter may stabilize the moisture content of the soil during the winter rainfall season and also provide regular levels of food resources for detritivorous Cryptostigmata. Again, studies on microarthropods in Chihuahuan desert soils have shown that mite densities are directly related to the organic matter content of the soil (Santos *et al.*, 1978 ; Wallwork *et al.*, in press) and the findings from the Negev confirm this fact.

Concluding remarks

Although limited in scope, the various aspects of this study confirm findings previously obtained in the deserts of southwestern U.S.A. concerning the soil and litters-dwelling Crytostigmata. The breeding response (i.e. egg production) of *Zygoribatula* sp. *A* coincides with the period of natural winter rainfall in the Negev and is immediate. Also, the intensity of the breeding response (i.e. clutch size) is within the limits of variation shown by other desert-dwelling members of this genus. The same reproductive features are true for *Passalozetes africanus*. Simulated rainfall applied at the beginning of the 1984/85 winter season appears to stimulate activity of *Zygoribatula* sp. *A*, particularly on the hill top and mid slope sites, but clutch sizes are not markedly affected by this supplemental water. The picture that is emerging from the comparative studies on reproductive behaviour carried out in the deserts of southwestern U.S.A and the Negev indicates that certain features are common to both areas despite differences in rainfall regimes. These features appear to be the products of long-term selection processes.

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