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EFFECTS OF IONIZING RADIATIONS ON MITE POPULATIONS AT THE NEVADA TEST SITE

A Thesis
Presented to the
Department of Zoology
Brigham Young University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Richard R. Walker
August 1971

This thesis, by Richard R. Walker, is accepted in its present form by the Department of Zoology of Brigham Young University as satisfying the thesis requirement for the degree of Master of Science

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

The stresses imposed on all levels of life by ionizing radiations have recently received considerable attention. Concern has developed from a general response to the biological implications that may attend increased levels of radioactive materials in the environment (Boffey, 1969; Edwards, 1969; and Morgan, 1969), or a nuclear catastrophe (Eberhardt, 1967). Studies of cellular and organismal responses have contributed substantially to what is known about these stresses, but less has been learned about responses at the community and population levels (Sacher, 1966 and Casarett, 1968).

While levels of radioactive materials have increased sharply during the past two decades, ionizing radiations are not recent phenomena (Woodwell, 1963). Since they have always been among the natural components of the environment, Woodwell (1962, 1967), and Platt (1962) suggested that they should be studied as natural environmental variables. Experimental designs to study radiation stress should, therefore, include studies of their interactions with other environmental and biological components of the ecosystem.

With few exceptions (Auerbach, 1958; Coleman and Macfadyen, 1966; Teresi and Newcombe, 1966; Marshall, 1966; and Reeves, 1971) methods of quantitatively measuring population responses to radiation stresses have been developed while studying either plant communities, small mammals, or reptiles. Arthropods, particularly mites and associated arachnids, have been neglected or only incidentally reported. Further, the form of radiation reported in earlier studies has almost always been gamma, while beta radiation has received relatively little attention.

Teresi and Newcombe (1966), stressed this omission and emphasized that the biological responses to beta radiation need to be better understood. They suggested that the total contact beta does from fallout is much greater than the associated gamma dose, and is possibly a more relevant problem for study. This view was corroborated by Rhoads et al. (1968) who suggested that there is sufficient evidence of beta damage to desert plants to merit further investigation.

The objectives of this study were to examine two population responses (i.e., species diversity and trophic organization) of desert mites, under field conditions, to ionizing radiations--particularly the effects of beta radiation. The results may be used to estimate responses of similar populations during nuclear war, in contaminated environments, or perhaps in pest control programs.

LOCATION AND DESCRIPTION OF SAMPLING SITES

The study area (Fig. 1) at the United States Atomic Energy Commission Nevada Test Site was located on Pahute Mesa, 112 km northwest of Mercury, Nye County, Nevada. It was situated in a southern extension of the Great Basin Desert at an elevation of 1859 m, and was characterized by low hills. The United States Weather Bureau, Las Vegas, Nevada, recorded 18.7 cm annual rainfall at the study area during 1968, and 25.4 cm in 1969. See Allred, Beck, and Jorgensen (1963) for a detailed description of the area.

Artemesia spp (Sagebrush) and _Juniperus_ _osteosperma_ (Torr.) Little (Juniper) formed the dominant vegetation (Rhoads, et al., 1968), while _Cowania mexicana_ D. Don var. _stansburiana_ (Torr.) Jeps. (Desert rose), _Ephedra nevadensis_ Wats (Brigham tea), and _Grayia_ _spinosa_ (Hook.) Moq. (Hopsage) made up the major portion of the remaining flora. Frequent hybridization between _Artemesia_ _tridentata_ Nutt. and _Artemesia_ _arbuscula_ Nutt. subsp. _nova_ (A. Nels.) Ward made it impossible to distinguish these species in many locations.

Five sampling sites northwest and northeast of the Project Cabriolet Ground Zero (G.Z.) were designated as Sites I, II, IIIa, IIIb and IV (Fig. 2).[1]

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[1] Project Cabriolet was an underground, partially contained nuclear test in the Plowshare series. It was detonated Jan. 26, 1968 and had a yield of 2.3 ± 0.5 kt.

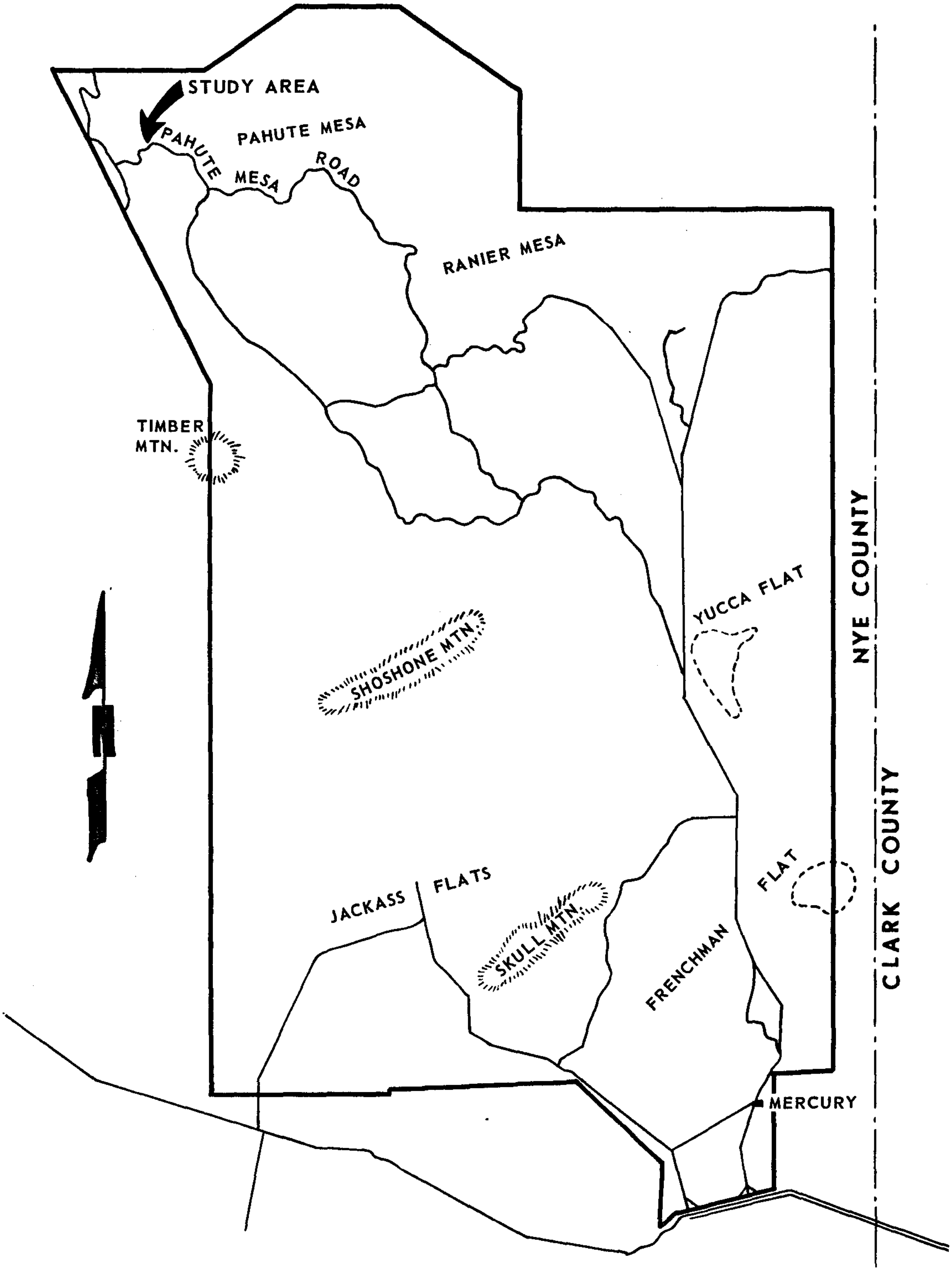

Fig. 1. Nevada Test Site, Mercury, Nevada. Location of the study area is indicated with an arrow.

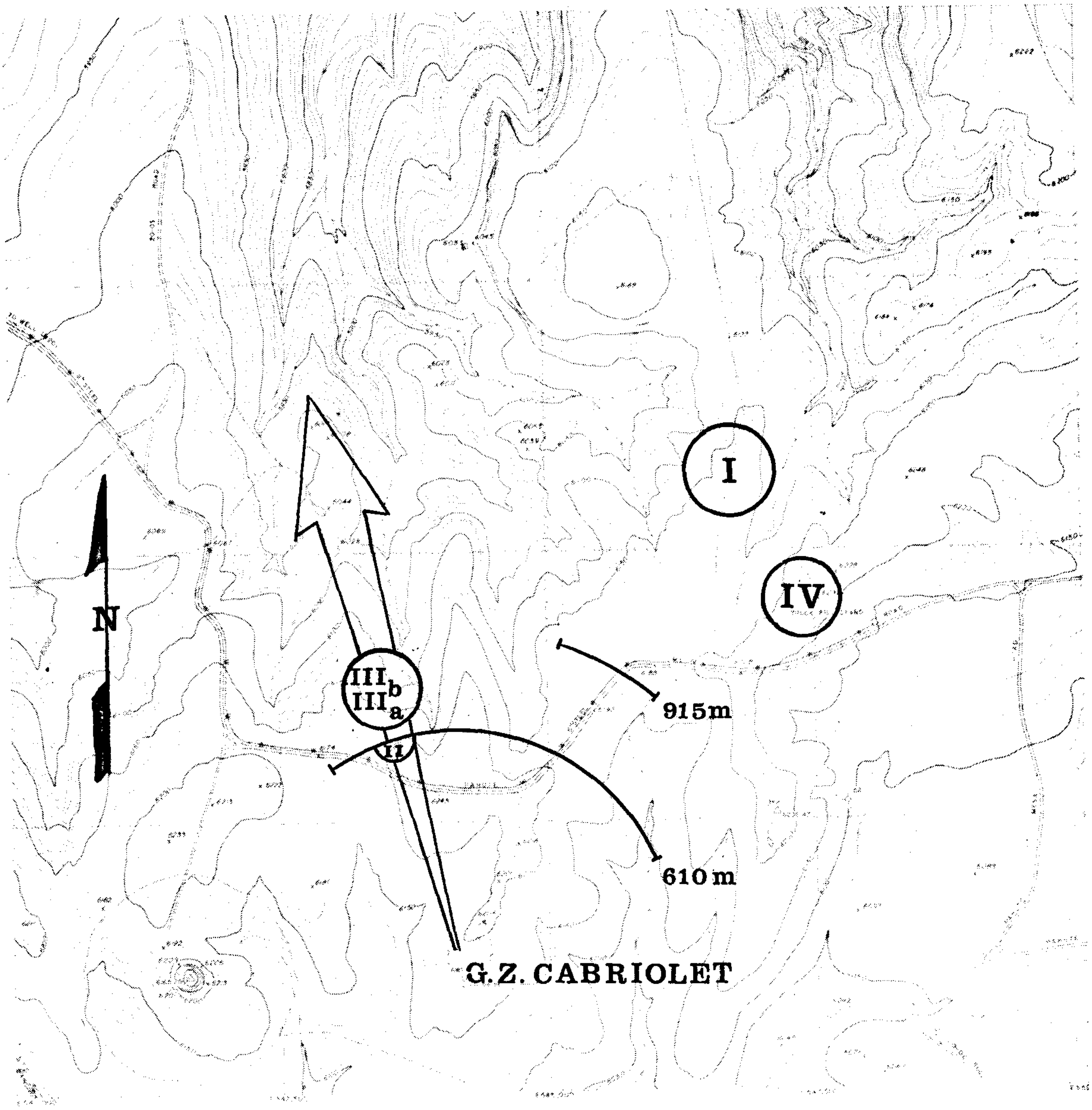

Fig. 2. Study area showing Ground Zero (G.Z.) of Cabriolet, direction of fallout cloud (indicated by arrow), location and distance from G.Z. of dosimeter arcs, and individual study sites. G.Z. coordinates were: longitude W 116° 30' 52.0082", latitude N 37° 16' 51.0715".

The fallout cloud from Cabriolet provided the source of radiation for this study. The five collection sites were selected on the basis of their positions relative to the fallout pattern, and the varying amounts of radiation damage to sagebrush. Sites II, IIIa, and IIIb (experimental sites) were located within the fallout pattern, whereas Sites I and IV (control sites) were not (Fig. 2). The five sites were not enlosed nor otherwise delimited with physical boundaries, but served as collection areas.

Two dosimeter arcs, 610 m and 915 m from G.Z., were established within the projected northwestern pattern to monitor the fallout (Fig. 2) (Rhoads, et al., 1968). The actual pattern, however, moved northeast from G.Z. and completely missed, by several hundred meters, the dosimeters in the 915 m arc. When the study sites were established within the actual fallout pattern, the radiation levels of Sites IIIa and IIIb had to be estimated (Table 1). This was done by determining the rate of isotope decay of the known levels at the 610 m arc, and comparing these with the radiation levels recorded seven months following detonation, in August, 1968.

Site I was designated as a control in 1968 for the three sites within the fallout pattern. It was situated well outside of the pattern with its nearest exposure approximately 1500 m northeast of G.Z. (Fig. 2). The site was located in a shallow depression somewhat sheltered from the wind. Sagebrush appeared much more vigorous than similar plants in Site II, although they were much the same as those in Sites IIIa and IIIb.

Site II was nearest to the radiation source at 580 m from G.Z. (Fig. 2). This site was located on the southern, windward exposure of a low hill directly

Table 1. Average beta and gamma radiation levels at various locations within Sites II, IIIa, and IIIb.

Sampling Site	Distance from Ground Zero	Average Beta and Gamma Levels (Rads) on the Windward (W) and Leeward (L) Sides of Sagebrush[a]	
		Beta	Gamma
Site II	610m	W- 5783 L- 5783	W- 794 L- 661
Site IIIa Site IIIb	640m	W- 5139 L- 3212	W- 344 L- 397
Site IIIa Site IIIb	670m	W- 3694 L- 2409	W- 291 L- 317
Site IIIa Site IIIb	700m	W- 2088 L- 1605	W- 264 L- 264
Site IIIa Site IIIb	730m	W- 2088 L- 1766	W- 264 L- 238
Site IIIa Site IIIb	760m	W- 2088 L- 2088	W- 211 L- 185

[a] Site IIIa, the windward plant parts; and Site IIIb, the leeward plant parts, shared the same location. Original radiation levels were obtained only for Site II, while those of Sites IIIa and IIIb were estimated.

within the fallout path. Sagebrush was short and dwarfed, although the species composition was similar to that of the control site. Its stunted condition was possibly due to the physical exposure of the area, and locally heavy dust from a nearby road (Beatley, 1965).

Radiation damage to the sagebrush was not apparent for three months after detonation, but by late May occasional yellowing was seen. Color changes and death progressed through the summer until most of the leaves, on both the leeward and windward sides of the plants, had either fallen or had turned a dark brown-grey. There was no apparent recovery during the remaining period of the study and new foliage did not appear except for numerous sagebrush seedlings.

Site IIIa was located 150 m north of Site II, on the leeward side of the same hill (Fig. 2). Foliage on the windward side of the sagebrush in this area, which had obviously been damaged by radioactive fallout, provided the collection material for this site.

Site IIIb was situated at the same location as Site IIIa (Fig. 2). This site, however, included those plants or plant parts which had been less exposed to the radiation (Table 1) because of shielding by Junipers, large rocks, other sagebrush, etc. Leaf color change at this site during 1968 was similar to that in Site II, thus making it easy to distinguish between the heavily irradiated plants of Site IIIa and the shielded plants of Site IIIb. With a major portion of the windward side of the plants dead (Site IIIa) the viable root system continued to provide the remaining few leeward branches of Site IIIb with an abundant nutrient supply during the latter part of 1968 and through the summer of 1969.

The result was unusually lush foliage and infloresence ("flag effect") which provided abundant foliage for sampling during the summer of 1969.

Site IV was used as a backup control during 1961. It was located well outside of the fallout pattern, approximately 1400 m from G.Z. (Fig. 2). This site was established after the 1968 season to serve basically as a control for Site II. As with Site II, this control was situated on a southern, windward, exposure and the sagebrush appeared short and stunted.

METHODS

Methods of Collecting

Mites were collected from Artemesia spp by gathering foliage 6 - 10 cm in length from arbitrarily selected plants. To minimize sampling bias, only one or two spurs were taken from any given plant at each monthly collection. Enough were taken to fill a 30 X 90 cm plastic bag to a depth of approximately 15 cm. Five such samples were collected from each site once a month from June through September, 1968 and 1969.[2] Sites II and IIIa were sampled only during 1968 since the radiation damage or death of the host plants in these areas prevented collecting during the 1969 summer.

Samples were each placed in modified Berlese funnels for 48 hr. The mites were then removed, and representatives of eighteen species groups were mounted in Hoyer's media for identification. The number of mites within each sample varied widely and rather than relying on estimates of the total numbers, all mites were counted.

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[2] Duff from beneath the host plants was collected in a similar manner. Smaller bags, 30 X 60 cm, were filled approximately 10 cm deep and, as before, each bag constituted one sample. Each site was sampled five times during 1968 but the following year the collections were discontinued and the data were not used for analysis.

Methods of Analysis

Quantitative measurements in population and community studies frequently employ sex ratios, age class distributions, coefficients of community (Woodwell and Oosting, 1965), equitability indices (Lloyd and Ghelardi, 1964), and similarity indices (Daniel, 1963; and Daniel and Platt, 1968). Use of such methods assumed that the various parameters involved were predictable. In the present study predictability of these parameters, and others of the population's composition, was uncertain; thus, the above measurements could not be used. Woodwell (1967) and Garrett (1969) suggested that an index of species diversity, by itself, was a meaningful criterion of a population's response to stress. Garrett (1969) further suggested that the highly random fluctuations inherent in these other methods were not characteristic of species diversity indices.

Pielou (1966) presented a series of diversity indices fitted to particular sampling methods and distributions. A version of Shannon's index (Pielou, 1966), which was well fitted for the present study, was used:

$$\hat{H}_j = -\sum_{i=1}^{s} \hat{\pi} \log \hat{\pi}$$

where: $\hat{\pi} = n_{ij}/N_j$, and n_{ij} is the total number of individuals in the i^{th} species of the j^{th} collection, and N_j is the total number of individuals in the j^{th} collection,

s = the total number of species in the population (= 18).

Basharin (1959) demonstrated $\hat{H}_j$ to be a biased estimator of H_j and if used, s must be known since the size of the bias depends on s. He further proved that the expectation of $\hat{H}_j$ is:

$$E(\hat{H}_j) = H_j - \frac{s-1}{2N_j}$$

Applying this correction factor, the index used in the present study becomes:

$$\hat{H}_j = \frac{s-1}{2N_j} - \sum_{i=1}^{s} \hat{\pi} \log \hat{\pi}$$

A second test of the population's response was determined by measuring the variation in sensitivity of the different trophic levels present. Rohde (1959) showed that under laboratory conditions the predatory mite of a two species interaction was predictably more sensitive to radiation stress than was the prey mite. In the present study, an analysis of the fluctuations in time and space, of the numbers of individuals within each level was made by comparing the ratios of predaceous mites with phytophagus and scavenger forms. Percentages were used rather than total numbers so that this test, like the species diversity indices, would be less dependent on the wide variations caused by sampling methods. Ratios were computed with:

$$\Delta = \frac{P_i}{T_i - V_i}$$

where: P_i = the percentage of total number of mites in the i^{th} collection that were predaceous,

$\underline{T}_{\underline{i}}$ = the percentage of total number of mites in the $\underline{i}^{th}$ collection that were phytophagus,

$\underline{V}_{\underline{i}}$ = the percentage of total number of mites in the $\underline{i}^{th}$ collection that were scavengers.

RESULTS

Seventeen phenotypically distinct groups of mites were identified (Tables 2 and 3). Of these, one was parastic, ten predaceous, four scavengers, and two phytophagus (Table 4). Several specimens could not be identified and properly grouped so they were collectively placed in a miscellaneous grouping, bringing to 18 the number used for analyses. All groups were not represented in each collection or sample, and in several instances only one or two individuals of a given group were collected during the entire two year study (Tables 2 and 3). Others, such as the many species of Tennuipalpidae, were present in large numbers and in all samples. All species groups exhibited patchy distributions, resulting in wide variations among the sample means used to compute the species diversity indices and, further, caused some fluctuation among the ratios of the trophic level tests.

Species Diversity ($\hat{H}$)

Site I (Fig. 3). Diversity indices declined through both summers in this control. There was, however, more fluctuation between the monthly values of 1969 than during 1968. Initially, the values were 1.4 in June, 1968 and 1.6 in June, 1969. These then dropped to 1.2 in September, 1968 and 1.0 in September, 1969.

Site II (Fig. 4). This area was the most heavily irradiated of the

Table 2. Numbers of mites in each species group for all samples taken, 1968.

Site Number and Month	Trombiculidae	Bdellidae	Nanorchestidae	Tennereffidae	Anystidae	Phytoseiidae	Stigmatidae	Smaridiidae	Neophylobius	Parasitengona	Trombidiidae	Oribatidae #1	Oribatidae #2	Oribatidae #3	Tydeidae	Tennuipalpidae	Tetranychidae	Miscellaneous	Total
Site I																			
June	2	1	0	0	2	98	2	0	2	0	14	6	2	0	204	92	0	4	429
July	0	0	2	0	0	61	4	0	1	0	0	0	0	0	32	155	0	7	266
Aug	0	0	1	0	1	40	10	0	2	0	0	0	1	0	67	71	0	7	201
Sept	0	1	3	0	13	56	0	0	0	0	0	0	0	0	162	62	0	4	301
Total	2	2	6	0	16	255	16	0	5	0	14	6	3	0	465	380	0	22	1197
Site II																			
June	0	0	64	0	1	0	2	0	0	0	4	0	0	0	0	94	0	11	176
July	0	0	22	0	1	1	5	0	0	0	0	0	2	0	0	93	4	10	138
Aug	1	1	18	0	21	1	0	0	0	0	0	0	4	2	0	174	0	12	234
Sept	0	0	1	0	17	0	2	0	0	0	0	0	1	0	0	105	3	14	142
Total	1	1	115	0	40	2	9	0	0	0	4	0	7	2	0	466	7	47	690
Site IIIa																			
June	0	0	61	0	2	0	9	0	0	0	8	4	3	0	15	71	1	9	186
July	0	0	7	0	0	0	6	0	0	0	5	0	0	0	1	107	7	10	145
Aug	1	0	14	0	3	0	3	0	0	0	0	2	0	0	3	60	1	8	95
Sept	0	0	0	0	18	0	3	0	0	0	0	3	0	0	4	24	0	9	61
Total	1	0	82	0	23	0	21	0	0	0	13	9	3	0	23	262	9	36	487

Table 2. (continued)

Site Number and Month	Trombiculidae	Bdellidae	Nanorchestidae	Tennereffidae	Anystidae	Phytoseiidae	Stigmatidae	Smaridiidae	Neophylobius	Parasitengona	Trombidiidae	Oribatidae #1	Oribatidae #2	Oribatidae #3	Tydeidae	Tennuipalpidae	Tetranychidae	Miscellaneous	Total
Site IIIb																			
June	4	0	57	0	28	2	12	0	0	1	21	15	1	0	54	69	1	21	287
July	0	0	2	4	4	12	6	0	0	0	3	1	0	0	0	58	4	1	95
Aug	0	0	8	0	19	1	1	0	0	0	0	1	0	0	0	152	2	8	192
Sept	0	0	1	0	99	6	6	0	0	0	0	0	0	0	0	82	1	11	200
Total	4	1	68	4	105	25	25	0	0	1	24	17	1	0	54	361	8	41	775

Table 3. Numbers of mites in each species group for all samples taken, 1969.

Site Number and Month	Trombiculidae	Bdellidae	Nanorchestidae	Tennereffidae	Anystidae	Phytoseiidae	Stigmatidae	Smaridiidae	Neophylobius	Parasitengona	Trombidiidae	Oribatidae #1	Oribatidae #2	Oribatidae #3	Tydeidae	Tennuipalpidae	Tetranychidae	Miscellaneous	Total
Site I																			
June	0	0	2	0	5	1	10	0	0	0	6	1	0	0	71	30	6	3	135
July	0	0	0	0	5	67	9	0	0	0	1	2	0	0	353	119	3	9	568
Aug	3	0	3	2	10	36	19	0	1	0	0	0	0	0	110	109	0	4	297
Sept	2	0	0	2	2	16	18	0	0	0	0	1	0	0	296	275	0	2	614
Total	5	0	5	4	22	120	56	0	1	0	7	4	0	0	830	533	9	18	1614
Site IIIb																			
June	3	0	2	0	7	0	2	0	0	0	8	0	0	1	2	34	5	2	65
July	1	0	3	0	2	0	0	1	0	0	4	0	0	0	0	94	0	4	106
Aug	0	0	3	0	8	1	3	0	0	0	0	1	0	0	0	149	4	0	169
Sept	0	0	2	0	10	1	3	0	0	0	0	3	0	0	1	278	0	0	298
Total	4	0	10	0	27	2	8	1	0	0	12	4	0	0	3	553	9	6	638
Site IV																			
June	1	0	1	0	3	0	18	0	0	0	9	2	5	0	5	234	1	2	281
July	0	0	7	0	3	0	4	0	0	0	7	1	2	0	1	423	0	6	454
Aug	2	2	11	0	10	0	30	0	0	0	0	1	2	0	0	889	3	0	950
Sept	0	0	2	0	4	0	14	0	0	0	1	0	3	0	3	996	0	0	1023
Total	3	2	21	0	20	0	66	0	0	0	17	4	12	0	9	2512	4	8	2708

Table 4. Trophic designation and relative abundance of mites collected, 1968 and 1969.

Species Observed	Trophic level	Percentage of Total Collection		
		Site I, II, IIIa and IIIb		Site IV[a]
		1968	1969	1969
1. Trombiculidae	parasitic	0.2	0.5	0.1
2. Bdellidae	predaceous	28.5	12.1	4.7
3. Nanorchestidae	"			
4. Tenneriffidae	"			
5. Anystidae	"			
6. Phytoseiidae	"			
7. Stigmatidae	"			
8. Smaridiidae	"			
9. Neophylobius	"			
10. Parasitengona	"			
11. Trombidiidae	"			
12. Oribatidae #1	scavenger	18.7	37.4	0.9
13. Oribatidae #2	"			
14. Oribatidae #3	"			
15. Tydeidae				
16. Tennuipalpidae	phytophagus	47.8	48.9	93.9
17. Tetranychidae	"			
18. Miscellaneous	undertermined	4.7	0.9	0.3

[a] Site IV is considered separately in this comparison since it did not qualify as a two year collection site.

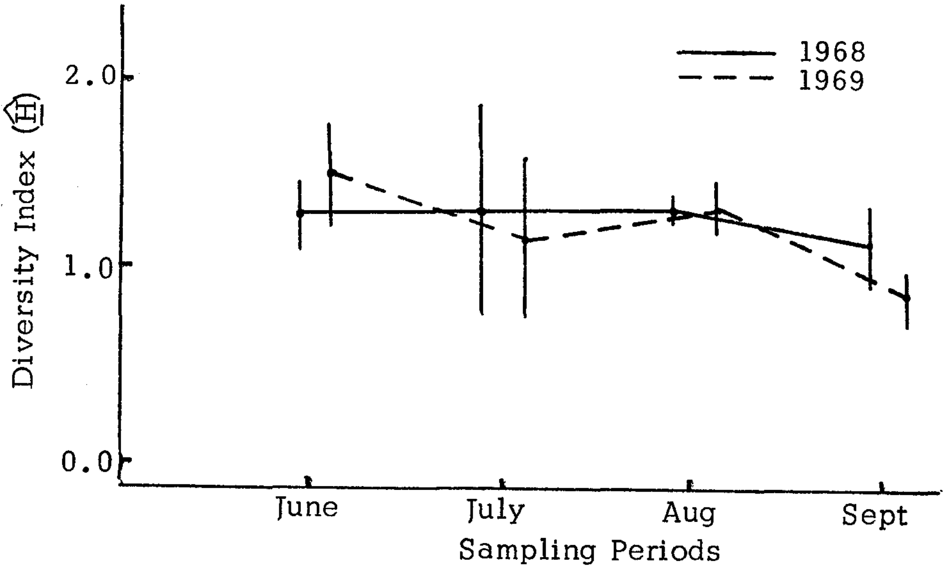

Fig. 3. Species diversity indices for mites in Site I, 1968 and 1969.

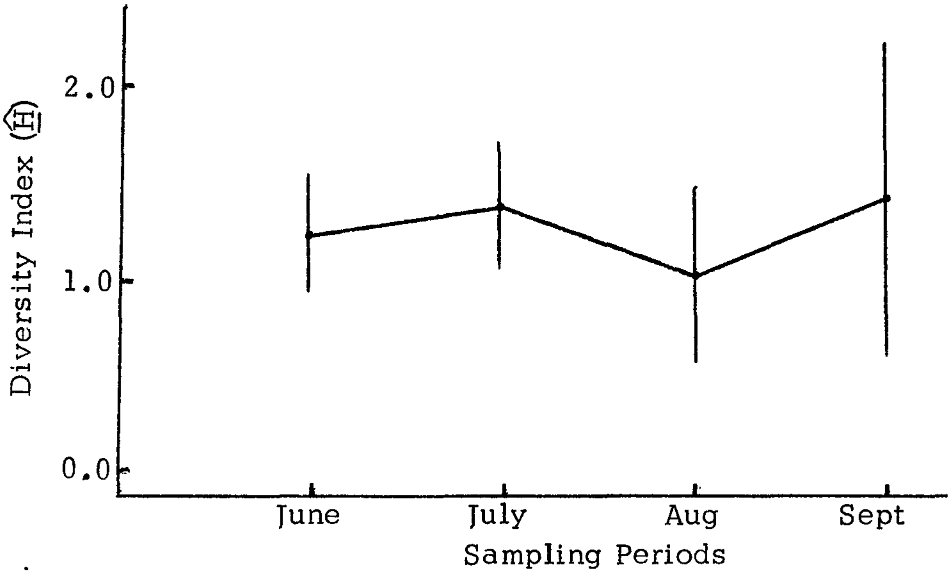

Fig. 4. Species diversity indices for mites in Site II, 1968.

study sites (Table 1). Diversity indices fluctuated through the summer of 1968, increasing slightly from 1.2 in June to 1.4 in September. Data were not obtained in 1969.

Site IIIa (Fig. 5). Heavy irradiation was also received in this area but not to the same extent as in Site II. Diversity indices dropped between June and July, 1968 from 1.5 to 1.2 and then increased to 2.0 in September. Again, data were not obtained during 1969.

Site IIIb (Fig. 6). The plants and plant parts included within this area received relatively moderate irradiation (Table 1), and $\underline{\hat{H}}$ showed a rapid decrease during both summers. In 1968 it dropped from 1.9 in June to 1.3 in September. During the following year it again dropped, this time from 1.9 in June to 0.7 in September.

Site IV (Fig. 7). Within this second control, a slight but persistent decline in $\underline{\hat{H}}$ was observed. The pattern was similar to that in Site I during 1969, but the decline was only from 0.8 in June, 1969 to 0.2 in September. These smaller figures were also reflected in the small variances about the means of each $\underline{\hat{H}}$. Also, the number of individual mites collected, but not the number of species, far exceeded those collected from any other site during either year (Tables 2 and 3).

Trophic Level Organization (Δ)

The respective percentages of mites comprising given trophic levels shifted markedly between 1968 and 1969 (Table 4). The overall average percentage of phytophagus forms remained approximately 48%, but the predaceous

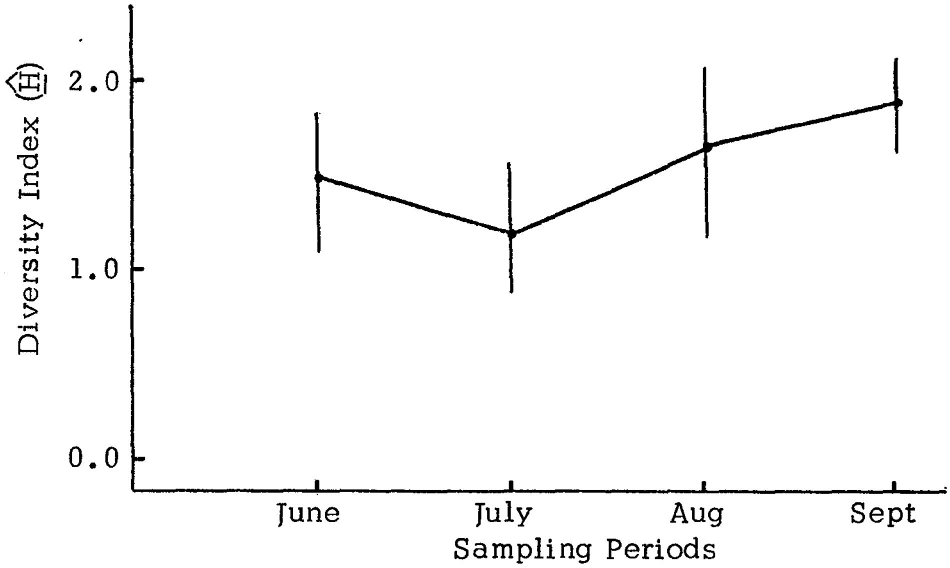

Fig. 5. Species diversity indices for mites in Site IIIa, 1968.

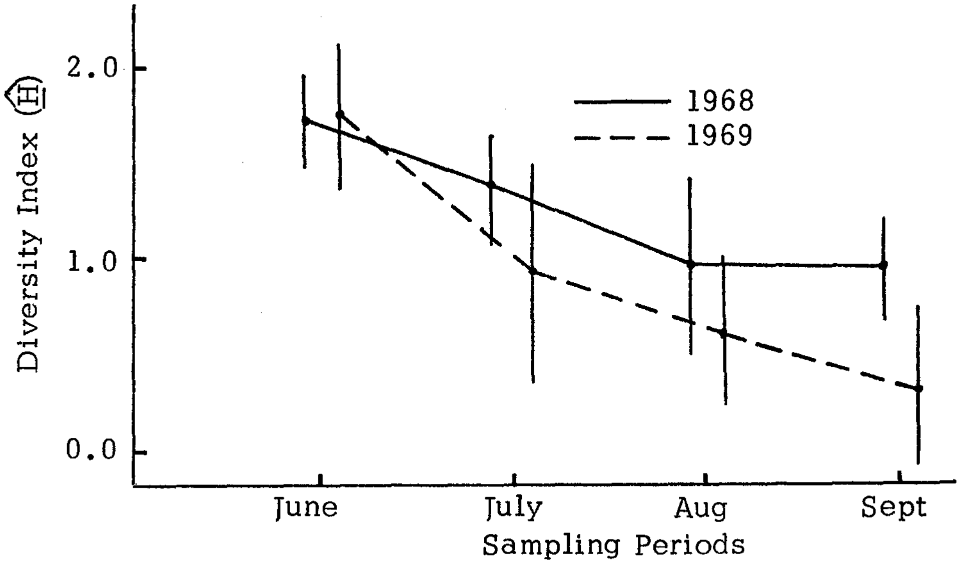

Fig. 6. Species diversity indices for mites in Site IIIb, 1968 and 1969.

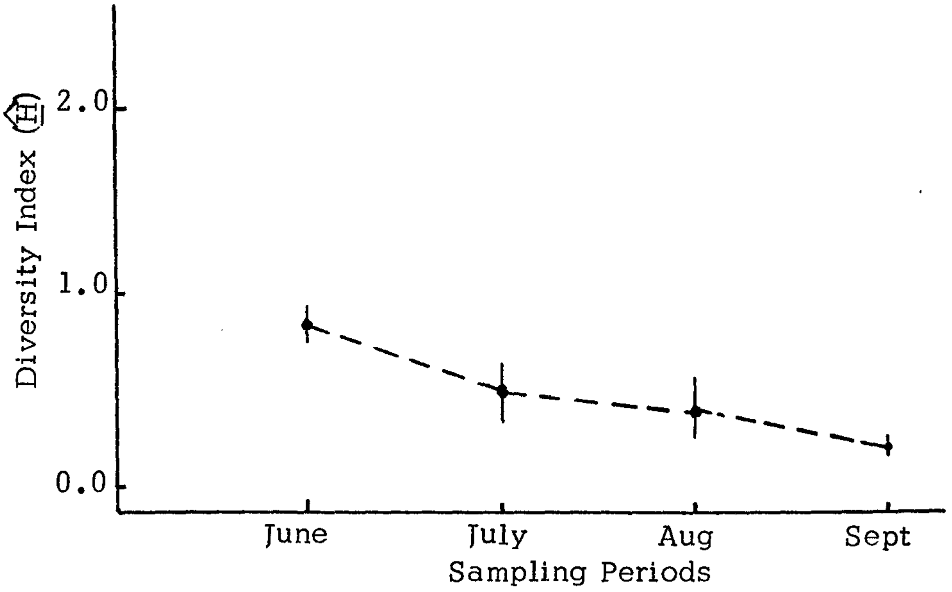

Fig. 7. Species diversity indices for mites in Site IV, 1969.

species declined within the same sites from 28.5% in 1968 to 12.1% in 1969, and scavenger forms increased from 18.7% to 37.4%. The percentage of the single parasitic species also doubled, but its numbers appeared too few to be considered important (Tables 3 and 4). Yearly differences in climatic conditions made analyses of the trophic associations among collections for the same year more meaningful than between years (Tables 5 and 6).

Site I (Fig. 8). Within the first control during 1968, the ratio of phytophagus and scavenger forms to predaceous mites remained between .32 and .39, a relatively stable pattern. During 1969, however, monthly fluctuations ranged from .31 in August to .06 in September.

Site II (Fig. 9). The trophic ratios exhibited a sharp drop during 1968, going from .78 in June to .29 in July, followed by a gradual decline to .18 in September.

Site IIIa (Fig. 10). The greatest single, between-month drop in Δ was observed in this site from June, 1968 to July. The initial figure of .85 dropped to .15 by July and then progressed upward through the remaining summer months to .67 in September.

Site IIIb (Fig. 11). Delta (Δ) dropped sharply, from .88 in June, 1968 to .18 in August and then rose even more abruptly to a high value of 1.2 in September. During 1969 a similar but smaller drop was plotted in this site in a series of percentage readings which, like those of Site I, were smaller during the second season. Delta then leveled at .09 in July and remained relatively constant through August and September.

Site IV (Fig. 12). Very little monthly fluctuation was observed in

Table 5. Percentage of monthly collections belonging to different trophic levels, 1968.

Site Number and Month	Parasitic	Predaceous	Scavenger	Phytophagus	Miscellaneous
Site I					
June	0.46	27.73	49.41	21.44	0.93
July	0.00	25.56	12.03	58.27	2.63
Aug	0.00	26.68	33.83	35.32	3.48
Sept	0.00	24.25	53.82	20.59	1.32
Site II					
June	0.00	40.34	0.00	53.40	6.25
July	0.00	21.01	1.44	70.28	7.24
Aug	0.42	17.52	2.56	74.35	5.12
Sept	0.00	14.08	0.70	76.05	9.85
Site IIIa					
June	0.00	43.01	11.82	38.70	4.83
July	0.00	12.41	0.68	78.62	6.89
Aug	1.05	21.05	5.26	65.26	8.42
Sept	0.00	34.42	11.47	39.34	14.75
Site IIIb					
June	1.39	43.20	24.39	24.39	7.31
July	0.00	32.63	1.05	65.26	1.05
Aug	0.00	15.10	0.52	80.20	4.16
Sept	0.00	53.00	0.00	41.50	5.50

Table 6. Percentage of monthly collections belonging to different trophic levels, 1969.

Site Number and Month	Parasitic	Predaceous	Scavenger	Phytophagus	Miscellaneous
Site I					
June	0.00	17.77	53.33	26.66	2.22
July	0.00	14.43	62.50	21.47	1.58
Aug	1.01	23.56	37.03	36.70	1.34
Sept	0.32	6.18	48.37	44.78	0.32
Site IIIb					
June	4.61	29.23	3.07	60.00	3.07
July	1.53	8.48	0.00	86.79	3.77
Aug	0.00	8.87	0.59	90.53	0.00
Sept	0.00	5.36	1.34	93.62	0.00
Site IV					
June	0.35	11.03	4.27	83.62	0.71
July	0.00	4.62	0.88	93.17	1.32
Aug	0.21	5.57	0.31	93.89	0.00
Sept	0.00	2.11	0.60	97.28	0.00

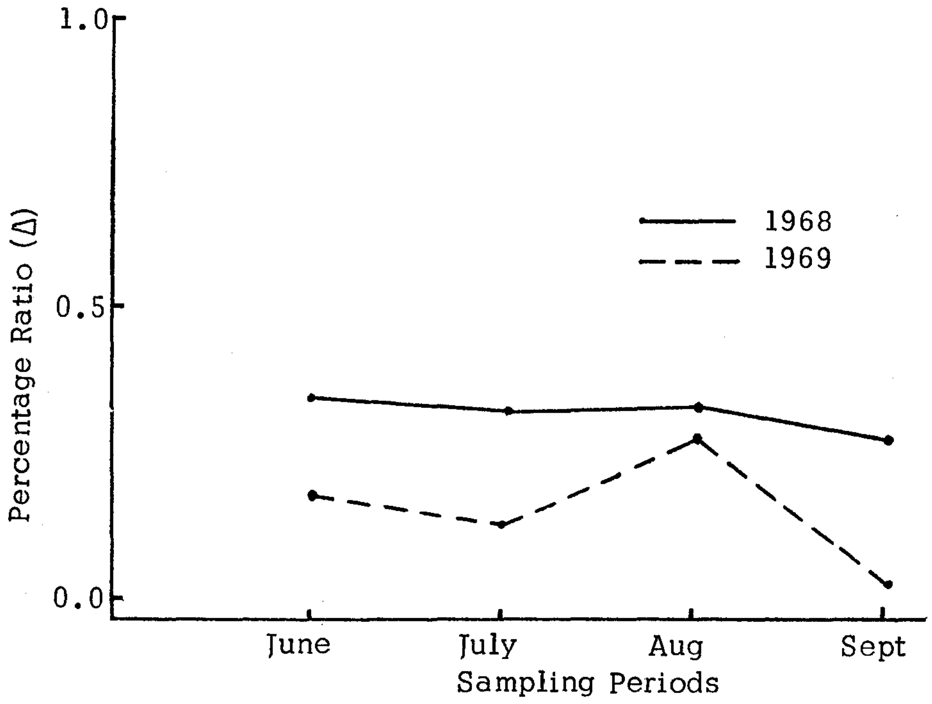

Fig. 8. Ratio of predaceous mites to phytophagus and scavenger forms in Site I, 1968 and 1969.

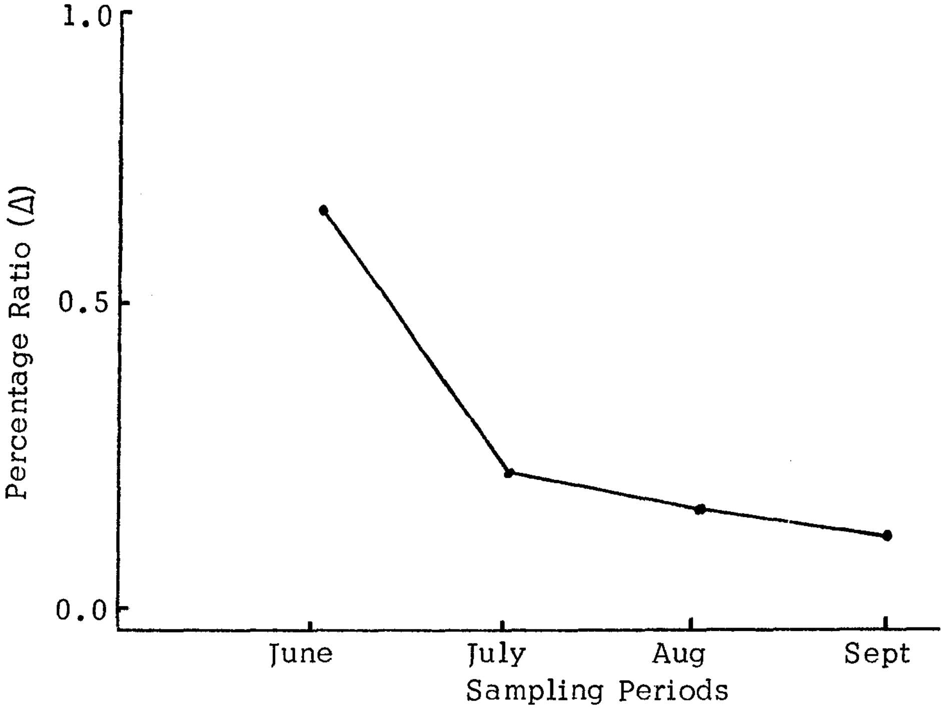

Fig. 9. Ratio of predaceous mites to phytophagus and scavenger forms in Site II, 1968.

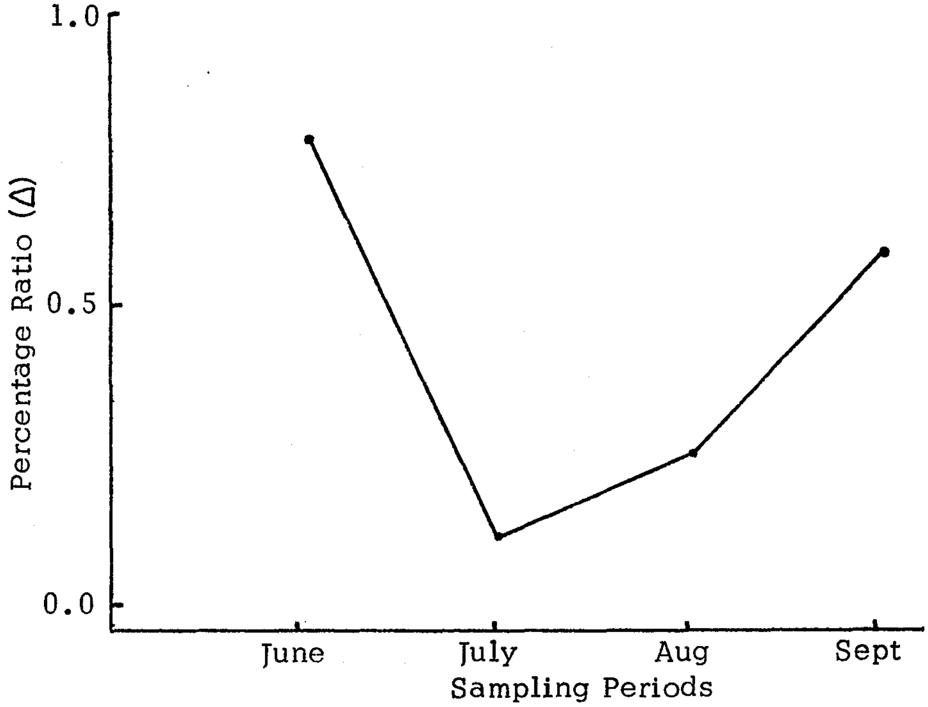

Fig. 10. Ratio of predaceous mites to phytophagus and scavenger forms in Site IIIa, 1968.

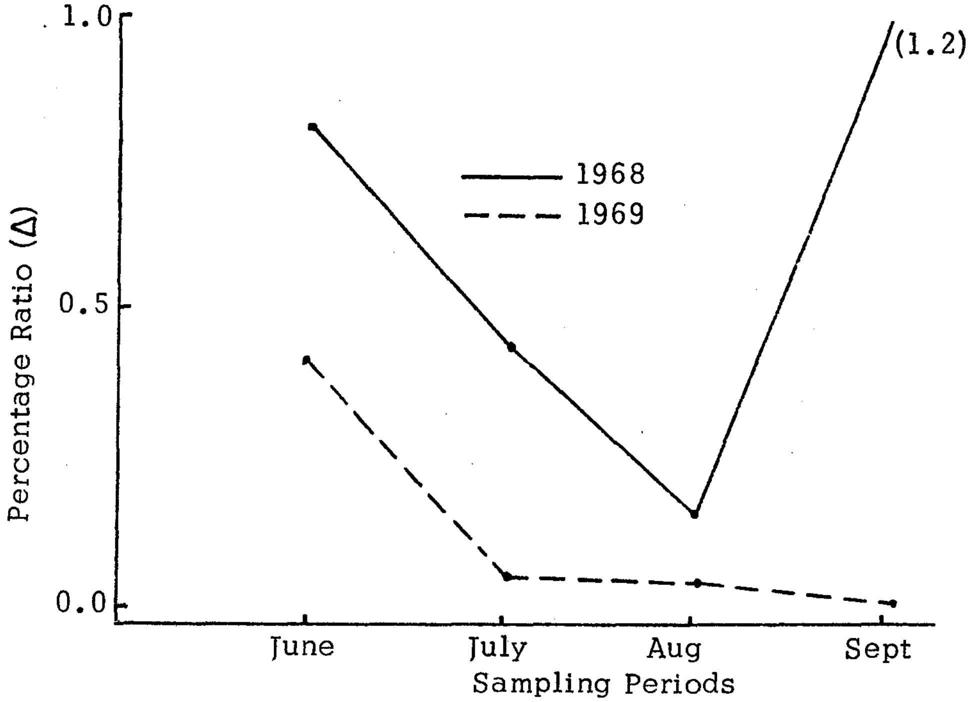

Fig. 11. Ratio of predaceous mites to phytophagus and scavenger forms in Site IIb, 1968 and 1969.

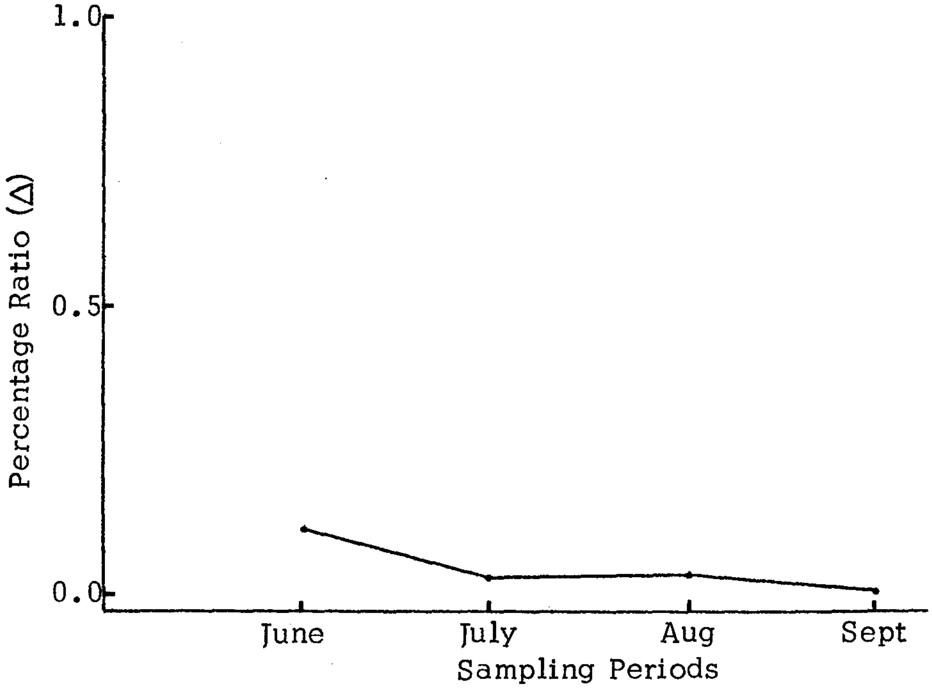

Fig. 12. Ratio of predaceous mites to phytophagus and scavenger forms in Site IV, 1969.

this site during 1969. Delta (Δ) dropped from .12 in June to .02 in September. This was shown to be the most stable pattern, as well as the smallest of the ratios found in any of the sites during the entire study period.

DISCUSSION AND CONCLUSIONS

Studies of population and community responses to ionizing radiation have largely neglected the mites. Because of their large numbers and diverse habits, however, mites comprise a significant part of the terrestrial community and should not be ignored. Furthermore, when references to the responses of mites to ionizing radiation have been made, the form of radiation has usually been gamma. This almost exclusive use of gamma radiation appears unjustified, since, as Teresi and Newcombe (1966) pointed out, the potential contact beta load from fallout is much greater than the potential associated gamma.

This study reports responses of naturally occurring desert mites to ionizing radiation. Responses were determined by analyses of species diversity indices and trophic level fluctuations. The major form of radiation was beta, but an attempt was not made to partition the effects of gamma and beta; thus, the major part of the population's response was assumed to be due to the greater magnitude of the beta radiation (Table 1) (Van Hook, 1970).

Species Diversity

Seasonal changes would be expected to cause a decreasing species diversity as the summer progressed within all of the sites, and further, the species diversity within the irradiated sites would likely decrease proportionately more (Woodwell, 1967; and Garrett, 1969). This predicted decrease in diversity was observed in the control sites, reflecting the normal seasonal changes, but within the experimental sites diversity increased. This increase under high environmental stress challenged the results reported by Woodwell (1967), Garrett (1969), and others who have reported decreasing diversity indices caused by increased stress.

Interpretation of these analyses necessitates first recognizing some factors about the species diversity index which, when altered, could change it. Increases or decreases in species diversity can result from increases or decreases in the equitability, or evenness, of the distribution of the individuals among the species. That is, the more equitable the distribution, the more diverse the population. Conversely, the more erratic or uneven the distribution, the less likely an individual will belong to a given species and the less diverse the population. This could occur if large numbers of individuals in one or two species were associated with many species containing very few individuals. By decreasing the number within the more abundant species, the difference between them and those with fewer numbers is decreased. The diversity index, therefore, is increased as the numbers approach equitability.

The stable and increasing diversity indices within the experimental sites were explained on the basis of decreasing numbers of the most abundant groups (Tables 2 and 3). In all study sites except Site I, Tennuipalpidae numerically dominated the collections. Even in Site I it comprised almost 32% of the individuals taken during both summers. However, Tydeids comprised another 38.8% of the collections in 1968 and 51.4% in 1969 (Tables 2 and 3). Increases in the numbers of these two groups caused the decreasing evenness, resulting in decreased diversity indices during 1969. Increasing numbers of Tennuipalpidae in Site II decreased the diversity and caused the index to fluctuate throughout the 1968 summer. Conversely, decreasing numbers of this group in Site IIIa contributed to the increase in diversity during 1968. Diversity indices for Site IIIb decreased during 1968 and 1969. This was likely because the relatively small radiation fallout on this site did not cause it to depart from the seasonal decrease. This was particularly apparent in 1969 when recovery was under way. The relative lack of change in the indices during 1968 was apparently due to the modifying effect of several species groups (Tennuipalpidae, Anystidae, Nanorchestidae, and Tydeidae).

The results suggest that species diversity tended to increase or remain stable when subjected to radiation stress. This was due to a more even distribution of individuals among the groups (particularly the decrease in Tennuipalpidae), rather than increasing numbers of the groups themselves.

Trophic Level Organization

MacArthur (1955), Auerbach (1958), and Edwards (1969) reported a decreasing predator-prey ratio when stress increased, and Rohde (1959) stated that a mite predator was more sensitive to the radiation stress than was the mite prey. Analyses of the trophic level organization generally agreed with these findings, and in the two control sites either a decreasing or fluctuating predator-prey ratio was observed. This was assumed to be the normal seasonal pattern. Results from irradiated Sites IIIa and IIIb, however, did not conform to the predicted results but rather, increased sharply after an initial drop.

As with the species diversity analyses, these ratios were greatly influenced by the phytophagus Tennuipalpidae and increased or decreased according to changes within that group. However, a relatively large proportion of the collections from Sites IIIa and IIIb was composed of several predaceous groups (Nanorchestidae, Anystidae, Stigmatidae, and Trombidiidae). Because of these groups the predator-prey ratio increased during the late summer, 1968, in spite of the increased radiation stress in these sites. This was also true for the increased ratio in Site I during August, 1969.

It is suggested that because of the apparently unpredictable and often extreme variations in the distribution patterns of these groups that more must be learned concerning their biology, and furthermore, that it is advisable to closely correlate controlled-laboratory investigations of radiation stress with those of naturally occurring populations.

SUMMARY

Studies of population and community stresses due to ionizing radiation have essentially neglected the mites. Also, when references have been made to the responses of mite populations to ionizing radiation the form of radiation used has almost always been gamma (Teresi and Newcombe, 1967). This study examined responses of the species diversity and trophic level organization of naturally occurring desert mites at the Nevada Test Site, to ionizing radiation.

Monthly collections were taken from control and experimental sites, after which the mites were removed with Berlese funnels. Eighteen species groups were identified and their responses to stress tested with species diversity indices and analyses of variations in predator-prey ratios.

Results showed that under normal environmental stress both species diversity and predator-prey ratios decreased. Increases and fluctuations in these two tests within the irradiated sites were found to be the result of modifications by disporportionately large numbers of individuals in a very few species groups.

Measurements using species diversity indices and analyses of trophic level organization are valuable tests of population responses to ionizing radiation. Along with the mite responses, this study showed that because different

factors within diversity indices lead to similar results, critical analysis of the reasons for the observed changes are essential.

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EFFECTS OF IONIZING RADIATIONS
ON MITE POPULATIONS AT THE
NEVADA TEST SITE

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ABSTRACT

Population and community studies dealing with radiation stress have essentially neglected the mites. When references have been made to the responses of mite populations to ionizing radiation, the form of radiation has almost always been gamma. This study reports results of naturally occurring populations of desert mites, at the Nevada Test Site, to ionizing radiation--largely beta. Eighteen species groups were identified from Berlese samples and tested for stress responses with species diversity indices and analyses of variations in predator-prey ratios. General agreement with previous studies showed a decreasing pattern in these two tests within the controls. This was interpreted as the normal seasonal pattern. The increase of these measurements, within the irradiated sites, was due to large fluctuations in the numbers of a few species groups.