Technical Report No. 183

SOIL MICROARTHROPOD FAUNA OF THE PAWNEE NATIONAL GRASSLAND, 1970

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GRASSLAND BIOME

U.S. International Biological Program

November 1972

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ABSTRACT

The biomass of soil microarthropods at Pawnee National Grassland was estimated from Tullgren extractions of core samples taken during summer 1970. A grand mean of 413 mg/m^2 (dry weight) was obtained, in a range of values from 0.03 to 1.40 g/m^2. Biomass estimates included some herbivorous species as well as true soil-litter arthropods, but nevertheless were lower than biomass values reported for other grassland areas or for forest floors. Separate estimates are given for the various faunal groups, and weekly variation throughout the summer is considered.

INTRODUCTION

This report gives results of a 4-month study of soil microarthropods in experimental and natural shortgrass prairie areas in the Pawnee National Grassland. The long range objective of this project was to generate data for a functional model of the energetics of the soil microarthropod community. Unfortunately, that goal had to be abandoned. The work has been restricted to the initial phase, which was to obtain biomass estimates for the various groups of soil microarthropods. Sampling for this work was completed in the summer of 1970. This technical report features the biomass estimates and includes a listing of species of soil mites. However, names are not yet available for the majority of the mite species.

Microarthropods belong to that group of soil animals sometimes designated as "meiofauna" (Murphy, 1953). For convenience the soil fauna may be divided into "microfauna" (protozoa and other minute animals), "meiofauna" (microarthropods and nematodes), and "macrofauna" (larger arthropods, annelid worms, and others). Although such a classification is useful conceptually, the categories intergrade with one another. A more productive approach has been to subdivide the fauna into groups based on function rather than size. The importance of microarthropods in soils and their relations to detritus, other fauna, and microflora, have been reviewed recently by Christiansen (1970), Crossley (1970), and Witkamp (1971).

In this study the faunal group is defined by the following sampling method: 5-cm diameter and 5-cm deep soil cores extracted with a Tullgren-type apparatus. The faunal segment thus sampled consists of mites, collembolans, and other small arthropods. Some overlap occurs between our samples and those of other workers studying macroarthropods, but the amount of overlap is minor. A major part of the biomass of soil arthropods consists of mites and collembolans, which are not being sampled by others.

It should be emphasized that the fauna sampled in this manner contains many herbivores as well as detritus-feeders. Tetranychid mites and homopterans were well represented in our samples. The shortgrass prairie differs from tallgrass or forest floor habitats in that a sampling core can encompass the entire aboveground plant as well as the soil surface and subsurface.

METHODS

The experimental design was to sample the first eight watersheds one week and the 10 stress treatment plots the next week, alternating over the study period. Each watershed was sampled by extracting five cores for a total of 40 soil cores per sample date. The experimental treatment on these watersheds was grazing by cattle at various levels of intensity. Each of the 10 stress plots was sampled by extracting five soil cores for a total of 50 soil cores per sample date. The stress area was to have included fertilization and irrigation treatments, but these were not implemented during our sampling period because of equipment failure. Watersheds 1 through 8 were gridded and sampling locations determined by random number tables. The stress area was not gridded, except into plots. Inside each plot, sampling locations were determined by throwing a 1-m^2 hoop randomly into the plot.

Most of the time, the soil of Pawnee prairie was too dry and loose to form a cohesive core for Berlese extraction. When removed from the sampling tool, cores crumbled and dropped from the retainer. To give the soil more cohesiveness, a procedure was adopted of pouring one-half gallon of water over each core sampling site before samples were removed. This procedure should not have affected the number of microarthropods in the sample, because the water was spread over enough area to avoid effects at the margins. When removed from the sampling tool, cores were wrapped in aluminum foil for transport to the laboratory. Extraction in a Tullgren apparatus was performed after the procedure of Merchant and Crossley (1970). Microarthropods were sorted to species group and enumerated. Representatives of each group were dried at 65°C for 24 hr and weighed. From these representative weights, the enumerations of species groups were converted to biomass estimates.

RESULTS

Total Fauna

Biomass estimates of total soil arthropods by date are given in Table 1. Biomass (g dry wt/m^2) ranged from 0.03 to 1.40 during the summer. Grand means for the values reported in Table 1 are: Watersheds 1 through 8 (lumped), 0.412 ± 0.0376 (N = 64); stress treatment area 0.265 ± 0.0540 (N = 7). Differences between the grand means for the stress area vs. watersheds 1 through 8 are not statistically different, based on comparisons of untransformed biomass values. The stress area is not considered further in this report.

An analysis of variance for the biomass estimates of watersheds 1 through 8 (Table 2) detected significant effects of both watershed and date ($P < 0.05$). A two-way analysis was performed on untransformed values. Table 3 shows mean biomass of total soil arthropods by watershed number and by date. The first and last collection dates appear to have yielded

Table 1. Biomass estimates (g/m^2) of total soil microarthropods at Pawnee National Grassland, summer 1970.

Watershed	May 13	May 28	June 12	June 27	July 10	July 23	Aug. 6	Aug. 20
1	1.043	0.114	0.118	0.145	0.738	0.142	0.206	0.321
2	0.890	0.467	0.559	0.300	0.245	0.418	0.410	0.087
3	0.498	0.254	0.401	0.155	0.174	0.391	0.125	0.038
4	0.674	1.436	0.503	0.605	0.614	1.391	0.682	0.164
5	0.593	0.274	0.248	0.916	0.190	0.585	0.240	0.078
6	0.384	0.604	0.589	0.103	0.774	0.441	0.272	0.095
7	0.369	1.019	0.315	0.074	0.368	0.162	0.471	0.096
8	0.278	0.435	0.502	0.131	0.284	0.242	0.591	0.230

Watershed	May 20	June 5	June 19	July 5	July 17	July 29	Aug. 12
9	0.288	0.188	0.174	0.340	0.460	0.411	0.060

Table 2. Two-way analysis of variance on biomass data for dates (time) and watersheds (data from Table 1) for watersheds 1 through 8 only.

Source	Sum of Squares	df	Mean Square	F
Watersheds	1.226889	7	0.175269	2.60[a/]
Dates	1.188849	7	0.169835	2.52[a/]
Discrepance	3.298987	49	0.067326	
Total	5.714725	63		

a/ Significant at $P < 0.05$

Table 3. Mean biomass estimates (g/m^2) for total soil microarthropods in watersheds 1 through 8 and for collection dates (SE = standard error, N = no. samples).

Watershed	Mean	SE	N	Date	Mean	SE	N
1	0.352	.1230	8	5/13	0.591	.0944	8
2	0.422	.0843	8	5/28	0.575	.1568	8
3	0.254	.0565	8	6/12	0.404	.0584	8
4	0.753	.1514	8	6/27	0.304	.1065	8
5	0.413	.0967	8	7/10	0.422	.0875	8
6	0.408	.0862	8	7/23	0.466	.1369	8
7	0.359	.1068	8	8/6	0.397	.0669	8
8	0.336	.0551	8	8/12	0.139	.0334	8

different biomass estimates. Watersheds 3 and 4 appear to support extremes of soil arthropod biomass. These conclusions are tentative, however, since the distribution of biomass estimates is skewed. Table 4 shows the distribution of biomass estimates and the distribution of a set of transformed values. Application of a log transformation to the biomass data, of the form:

$$X^1 = \log_e (X \cdot 100)$$

tended to remove the skewness. Differences between watershed biomass estimates disappeared when an analysis of variance was performed on the transformed data. For collection dates, however, differences between biomass estimates remained significant ($P < 0.01$). The transformation may not be appropriate, however.

Mean biomass data estimates of total soil arthropods in watersheds receiving different grazing pressures are compared in Table 5. Differences between means (when tested with an analysis of variance on either transformed or untransformed values) are borderline ($0.10 < P < 0.05$). The highest biomass occurred on the lightly grazed watersheds (numbers 4 and 5), and the lowest biomass on the most heavily grazed (numbers 1 and 3). The biomass on ungrazed and moderately grazed watersheds was intermediate.

Major Animal Groups

Biomass estimates for the major animal groups are given in Table 6. Insecta accounted for almost 50% of the biomass of arthropods. Cryptostigmata (Oribatid mites) comprised about 25% of the biomass and Prostigmata (primarily tetranychid mites) about 17%.

Table 4. Distribution of biomass estimates (data from Table 1).

Untransformed		Log$_e$ Transform	
Class Mode	f	Class Mode	f
.13	19	1.6	1
.33	20	1.8	2
.53	15	2.0	7
.73	4	2.2	7
.93	3	2.4	13
1.13	1	2.6	14
1.33	1	2.8	14
1.53	1	3.0	4
		3.1	2

Table 5. Biomass estimates (g dry wt/m^2) of total soil microarthropods in areas receiving different intensities of grazing for watersheds 1 through 8.

Measures	Grazing Pressure: Ungrazed (watersheds 2-8)	Lightly Grazed (watersheds 4-5)	Moderately Grazed (watersheds 6-7)	Heavily Grazed (watersheds 1-3)
Mean biomass	0.379	0.583	0.383	0.304
Standard Error	0.0499	0.0973	0.0666	0.0666
No. samples	16	16	16	16

Table 6. Biomass estimates (mg/m^2) for species groups for watersheds 1 through 8 (spiders not included).

Groups	Watershed								Mean		SE
	1	2	3	4	5	6	7	8			
Collembola	6.0	15.8	9.0	21.5	13.1	20.0	11.0	9.8	13.7	±	0.711
Prostigmata	33.8	62.0	60.8	120.5	70.7	67.1	62.0	89.0	70.7	±	3.15
Mesostigmata	3.4	3.6	3.2	10.5	5.7	6.3	7.6	7.8	6.0	±	0.012
Cryptostigmata	88.5	103.4	78.1	164.2	62.7	186.3	117.3	75.3	109.5	±	5.54
Astigmata	4.7	1.2	0.5	4.2	2.4	4.5	11.3	7.4	4.5	±	0.438
Other Insecta	216.4	217.5	102.9	431.7	250.2	123.5	149.5	148.2	205.0	±	13.12
Total	336.9	423.3	254.5	752.6	415.8	407.7	358.7	337.5	412.9	±	18.60

Grazing treatments produced little effect on the distribution of biomass among these categories. The heavily grazed treatments (watersheds 1 and 3) tended to be lower in all categories. Insecta were more abundant in the lightly grazed watersheds (numbers 4 and 5) than the average for all watersheds. Cryptostigmata tended to support lower biomass on the ungrazed (numbers 2 and 8) and lightly grazed (numbers 4 and 5) watersheds and higher biomass on the moderately grazed watersheds (numbers 6 and 7). These trends are masked by the large variation between the two replicate watersheds in each case.

Variation in Time

Fig. 1 illustrates changes in biomass throughout the summer for the major arthropod groups. Insecta and Prostigmata trended downward throughout the sampling period. Possibly, the samples were not taken early enough to obtain the maximum biomass attained by these two groups. Cryptostigmata and Collembola showed slight upward trends during the season. The Insecta and Prostigmata biomass had secondary peaks during July, possibly as a response to brief rainy periods or possibly due to phenology. These trends are not discernable in the total biomass estimates (Table 3) since the trends offset one another to some extent.

DISCUSSION

The faunal biomass estimates for soils of Pawnee National Grassland differ qualitatively and quantitatively from those reported for other grasslands or for forest soils. Evidently we sampled a significant number of herbivores, such as aphids and tetranychid mites, which are normally excluded from soil-litter samples. At Pawnee grassland the

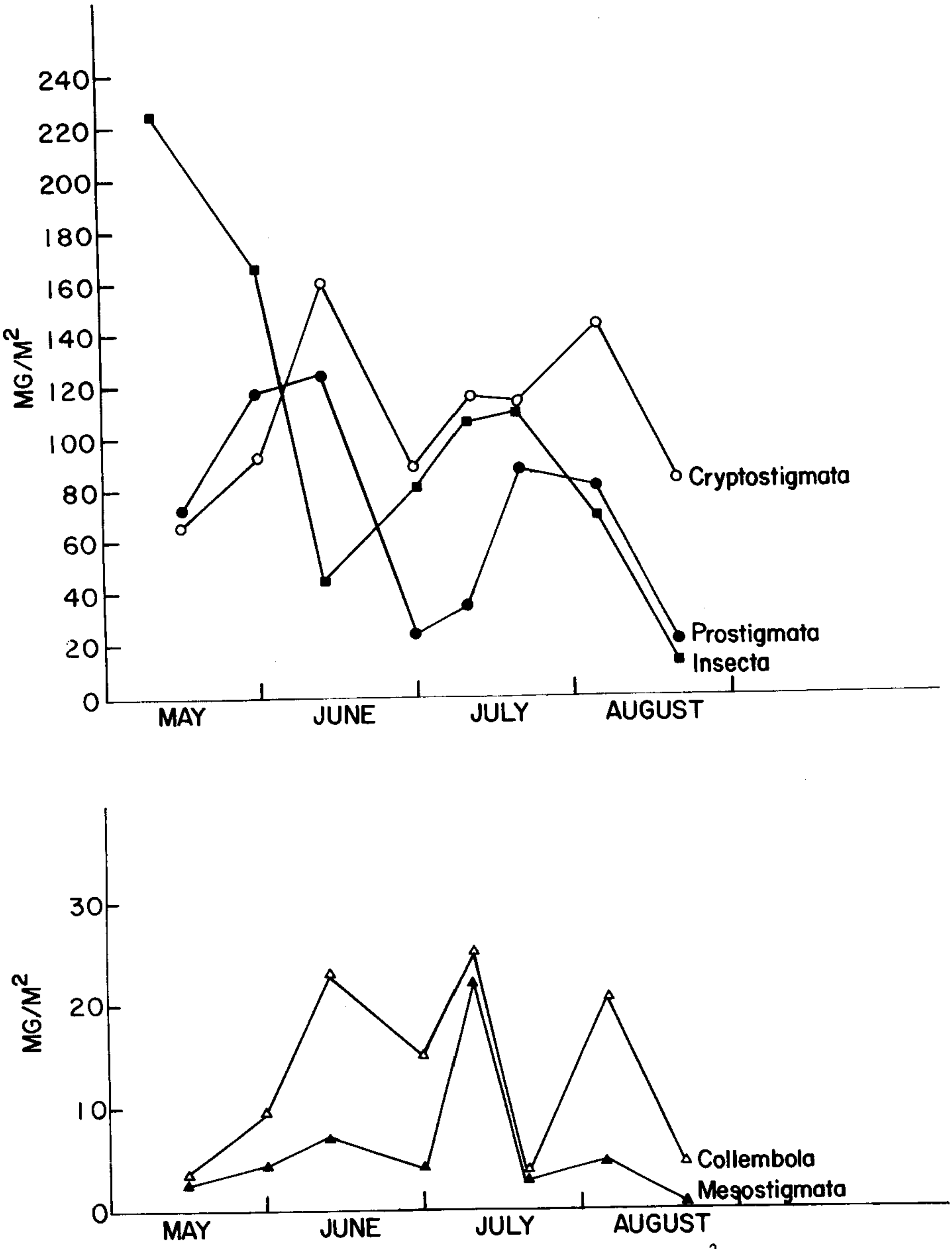

Fig. 1. Weekly changes in soil arthropod biomass (mg/m^2), summer 1970.

short grass was included in the core samples. In taller grasslands the green herb stratum usually is excluded from core samples, either by avoiding grasses or by clipping them. We believe that our procedure was the correct one for the shortgrass prairie. Where the height of the producer organisms is only a few centimeters, the small consumers feeding on them necessarily remain close to the soil. They are available to predators on the soil surface and may enter the soil during unfavorable conditions. Thus, these herbivores can justifiably be considered as a part of the soil microarthropod community. They are included in the categories "Prostigmata" and "Other Insecta" of Table 6.

Even with the inclusion of the herbivores, the microarthropod biomass measured is lower than that reported for other areas. This finding is not unexpected because of the dry condition of the soil at Pawnee Grassland. Soil microarthropods are notoriously moisture dependent as a group, so that low numbers might be anticipated. For the data present in Table 6, only the Prostigmata appear to be as numerous as in other areas because of the inclusion of tetranychid mites. The category "Astigmata" includes cheese-mites and relatives, which are seldom abundant in soils. Their abundance here seems high, but it may be artificial. Immatures of the Cryptostigmata may have been included in this category.

Table 7 compares biomasses obtained in this study with those reported by others for the categories Collembola, Mesostigmata, and Cryptostigmata. These categories are the ones least likely to have been affected by the inclusion of herbivorous species. The Collembola biomass estimates for Pawnee Grassland are lower than any reported for other grasslands or forest soils and are even lower than the generous ranges given by Paris

Table 7. Estimates of biomass (mg/m^2) for soil-litter microarthropods.

Source	Collembola	Mesostigmata	Cryptostigmata
Present study	13.3 h/	6.0 h/	109.5 h/
Hardwood a/ (Eastern Deciduous Forest)	170 h/	65 h/	646 h/
Liriodendron b/ (Eastern Deciduous Forest)	48.2 h/	29.9 h/	300.3 h/
Grassland average c/	100-1000 i/	-- k/	100-1400 ij/
Moor (Wales) d/	350 i/	--	--
Beech (Denmark) e/	60- 350 i/	--	90- 650 ij/
Fen (England) f/	--	--	220-1430 ij/
Grassland (England) g/	--	--	890 ij/

a/ Gist, unpublished.

b/ MacBreyer and Reichle, 1972.

c/ Paris, 1969.

d/ Healey, 1967.

e/ Bornebusch, 1930.

f/ Macfadyen, 1952.

g/ Block, 1966.

h/ Dry weight.

i/ Fresh weight.

j/ Total Acarina.

k/ No data.

(1969). (For making comparisons of dry weight biomasses with wet weights given by authors, a conversion of about 30% of wet weight may be appropriate.) The Cryptostigmata fall within the grasslands range given by Paris (1969), but tend to be lower than most reported.

The suggestion that light or moderate grazing pressure may promote an increase in the biomass of soil microarthropods is interesting and should be pursued in further experiments. A speculation might be that moderate grazing increases the rate of detritus production, or perhaps increases plant production itself at a rate sufficient to influence the soil microarthropods.

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APPENDIX I

SOIL ACARINA OF PAWNEE NATIONAL GRASSLAND

SUBCLASS ACARI

ORDER PARASITIFORMES

Family Ascidae

Arctoseius sp. (Creek bottom, heavy cattle usage area).

Gamasellus sp. Watersheds 1, 4, 5, 6, 8, stress area.

Platyseius sp. (On Tipulidae).

Family Laelapidae

Gen. sp. Watersheds 4, stress area.

Family Macrochelidae

Macrocheles sp. (On *Nicrophorus marginatus*).

Family Parasitidae

Eugamasus sp. (On *Nicrophorus marginatus*).

Family Phytoseiidae

(Several species currently being identified)

Watersheds 1, 2, 3, 4, 5, 6, 7, 8, stress area.

Family Rhodacaridae

Ololaelaps sp. Watersheds 1, 2, 4, 7, 8, stress area.

Family Uropodidae

Gen. sp. Watershed 7.

ORDER TROMBIDIFORMES

Family Anystidae

Gen. sp. Watersheds 2, 4, 6, stress area, headquarters.

Family Bdellidae

Cyta latirostris (Herm.). Watershed 7.

Spinibdella sp. Watersheds 2, 4, 7, 8, stress area.

Family Caligonellidae

Caligonella sp. Watershed 6.

Family Cheyletidae

Gen. sp. (Larva). Watershed 3.

Family Cunaxidae

Cunaxa capreolus (Berl.). Watersheds 3, 5, 8, stress area.

Cunaxoides biscutum (Berl.). Stress area.

Cunaxoides sp. Watersheds 2, 4, 5, 6, 8, stress area.

Family Erythraeidae

Balaustium sp. Watersheds 5, stress area.

Gen. sp. #1. Headquarters

Gen. sp. #2. Watersheds 8, stress area

Gen. sp. #3. Watershed 7.

Gen. sp. #4. Stress area.

Gen. sp. #5. Stress area.

(Larva). Watersheds 2, 3, 7, stress area.

Family Nanorchestidae

Nanorchestes sp. Watershed 7.

Family Neophyllobiidae

Neophyllobius sp. Watersheds 3, 4, 6, 8, stress area.

Family Paratydeidae

Neotydeus sp. Watersheds 2, 3, 4, 5, 6, 8, stress area.

Family Pyemotidae

Pyemotes sp. Watershed 4.

Family Raphignathidae

Raphignathus gracilis (Rack). Watersheds 2, 3, 4, 5, 6, 7, 8, stress area.

Family Stigmaeidae

Ledermulleria sp. Watershed 6.

Gen. sp. Watersheds 8, stress area.

Family Scutacaridae

Scutacarus sp. Watersheds 2, 4, 7, stress area.

Family Tarsonemidae

Gen. sp. (females). Watersheds 2, 3, 5, 7, 8, stress area.

Family Tetranychidae

Bryobia sp. Watersheds 2, 4, 6, 7, 8, stress area.

Monoceronychus sp. Watersheds 3, 4, 6, 8, stress area.

Gen. sp. #2. Watersheds 1, 3, 4, stress area.

Gen. sp. #3. Watersheds 3, 4, 5, 8, stress area.

Gen. sp. #4. Watersheds 1, 4, 5, 7, 8, stress area.

Gen. sp. #5. Watersheds 2, 4, 7, 8, stress area.

Gen. sp. #6. Watersheds 1, 4, 7, stress area.

Gen. sp. #7. Watersheds 1, 3, 5, stress area.

Gen. sp. #8. Stress area.

Gen. sp. #9. Watershed 8.

Gen. sp. #10. Watershed 4.

Family Tenuipalpidae

(Several species in identification). Watersheds 2, 3, 4, 5, 6, 7, 8, stress area.

Family Tuckerellidae

Tuckerella sp. Watersheds 7, stress area.

Family Tydeidae

Tydeus sp. #1. Watersheds 1, 2, 3, 4, 5, 6, 7, 8, stress area.

Tydeus sp. #2. Stress area.

Tydeus sp. #3. Stress area.

Tydeus sp. #4. Stress area.

Lorryia sp. Watershed 1.

ORDER CRYTOSTIGMATA

Family Carabodidae

Tectocepheus velatus (Mich.). Watershed 2, 4, 7, 8, stress area.

Family Ceratozetidae

Gen. sp. (Dry creek site).

Family Haplozetidae

Peloribates sp. Watersheds 4, 6, stress area.

Family Hermanniidae

Hermannia sp. Stress area.

Family Oribatulidae

Phauloppia sp. Stress area.

Scheloribates sp. Watersheds 4, 5, 7, stress area.

Zygoribatula sp. Stress area.

Gen. sp. Stress area.

Family Oppiidae

Oppia nova (Ouds.). Watersheds 2, 5, 7, 8, stress area.

Family Passalozetidae

Passalozetes sp. Watersheds 4, 7, 8.

ORDER ACARIDIAE

Family Acaridae

Gen. sp. Watersheds 4, 7, 8, stress area, headquarters.

Family Anoetidae

(Hypopus). Headquarters.

Family Saproglyphidae

(Hypopus). Headquarters.

APPENDIX II

FIELD DATA

Data collected on soil microarthropods at the Pawnee Site in 1970 is Grassland Biome data set A2U307B. A description and a listing of the data follow.

Data Description

Columns	*Format*	*Information*
1- 2	I2	Last two digits of year
3- 4	I2	Month
5- 6	I2	Day
7	I1	Sampling area[a/]
9-10	I2	Core number
11-72	31I2	Number of individuals found in each of 31 categories[b/]

---

a/ Sampling area numbers can be converted to treatment and replicate as follows:

Sampling Area	*Treatment*	*Replicate*
1	4	1
2	1	1
3	4	2
4	3	1
5	3	2
6	2	1
7	2	2
8	1	2
9 (environmental stress area (see below))		

If sampling area = 9, treatment and replicate are determined from the first digit of the "core number," i.e., the digit in column 9 as follows:

Value in Column 9	*Treatment*	*Replicate*
1	E	4
2	E	1
3	D	1
4	G	2
5	D	2
6	E	3
7	F	1
8	G	1
9	E	2
0	F	2

where:

Treatment D = control.

Treatment E = irrigated.

Treatment F = fertilized.

Treatment G = fertilized and irrigated.

In this case, only the second digit of the "core number," i.e., the digit in column 10 contains information on the core number.

b/ The 31 categories of mites, in the order in which their numbers are recorded, are as follows:

1 Poduridae
2 Sminthuridae
3 Entomobryidae
4 Araneae
5 Bdellidae
6 Neophyllobidae
7 Erethryidae
8 Cunaxidae
9 Prostig A
10 Prostig B
11 Not used
12 Other Prostigs
13 Laelaptidae
14 Rhodacaridae
15 Not used
16 Other Mesostigs
17 Ceratozeiidae
18 Liacaridae
19 Cymbaermaeidae
20 Epactozeiidae
21 Immature Oribatids
22 Other Oribatids
23 Astigs
24 Immature Insects
25 Ants
26 Diptera
27 Japygidae
28 Coleoptera
29 Psocotera
30 Thysanoptera
31 Homoptera

+++ FIELD DATA +++

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         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012

7005133229         1            25             1   1 1               7 2
7005133242           1          19       1         1 3
7005133213           2           8           1     1
7005133211         6            24         9   3   3 3     1           2
7005134193                       4                   1     2        11
7005136140             1        30       1 5 3     2 9   2   2 1 1
7005136177         2             6                               1
7005136176                       7       1 2       7
7005136186                       8                 1     2
7005138272           7          37       1     1   3     1           1
7005136191     1   1             8                   1
7005138274             1 1 1    12                       1 4     1
7005135263         1            16           1     1                   1
7005138222         1 2           8         1 1     1     1 1
7005137270                       8                      14
7005137230 3   1   1             7         1       1 1   1
7005137210                      13
7005137216                       6
7005138234                      12
7005138233         1            11                         1
7005137206                      14                   2           4
7005132123         1 1   1      19
7005131140                       5
7005131148                       5
7005131188                      22                 3
7005132141         1             1                           1
7005135241         1             6                   1 137             1
7005135 31 1                     3                                     1
7005132131                       2                   1       2
7005132104                       1                      50
7005131151                       2                 1
7005135202         1             3       3
7005133282                       7       2 1       2 1 1 1
7005134184         2 1          74         1       1    18 1         1 1
7005132124         2 1   1       1                 2           2    24
7005135243 1       3            11         2                   2
7005131255             1                                          46 1
7005134154                      11                 1     1     3     4 1
7005134157                      10                       1 1           1
7005134177         1            11         1         1     3
7005209174 1                                                 1
7005209184                       4                 1
7005209295                                 1     1
7005209264
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7005209185			1				1														
7005209204			3				3												3		1
7005209 75			2				2		2		2	1									
7005209172							10														
7005209181			1				21				1					1					
7005209183		1					3				2	1							1		
7005209245																1					
7005209203			5				4		6		6	2									
7005209205				1			2		2		2										
7005209215			4				16			1											
7005209254							7		11		3	5				1					
7005209212							3		1					1							
7005209261			1				1					1									
7005209292									3			1									
7005209173												2									
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