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POPULATION DENSITIES AND BIOMASS OF ABOVEGROUND ARTHROPODS UNDER VARIOUS GRAZING AND ENVIRONMENTAL STRESS TREATMENTS ON THE PAWNEE SITE, 1971

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ABSTRACT

The arthropod component on the Pawnee grasslands was sampled during the 1971 season primarily through the use of a D-vac suction apparatus. Samples taken included bimonthly samples on ungrazed plots and grazed (1970)-ungrazed (1971) plots, samples on four dates on differentially grazed pastures (ungrazed, light, moderate and heavily grazed), samples on five dates on environmentally stressed areas (no treatment, nitrogen added, water added and water plus nitrogen added), pit trap sampling, and individual plant sampling.

Bimonthly sampling revealed greater numbers of arthropods in the permanently ungrazed plots throughout the season. Biomass figures followed the same general pattern. The data from the differentially grazed pastures provided similar density curves for the lightly grazed and permanently ungrazed plots with a somewhat lower curve for the moderately grazed plots with the lowest numbers of arthropods occurring in the heavily grazed plots. Population density curves derived for the environmentally stressed areas show that arthropods, as a group, responded most to the water plus nitrogen treatment followed by water alone, both in mean numbers and biomass. Some increase was shown in the nitrogen treated plots over the untreated plots on one sampling date only (May 21) but this response was undoubtedly correlated with abundant rainfall during the previous 20 days.

Plotting these arthropods according to feeding habit revealed that plant sucking insects showed the greatest response to water plus nitrogen followed by water, no treatment, and nitrogen, the latter two curves being very close. Omnivores (primarily ants)

showed the greatest response to water plus nitrogen on May 21, and thereafter all curves were close together. Plant tissue feeding arthropods responded to the water plus nitrogen on July 8, but otherwise all curves were close. Predators responded to water plus nitrogen on August 24, but otherwise all curves were close. Scavenger arthropods responded slightly to the water plus nitrogen treatments on all dates.

Arthropods were not collected in sufficient numbers in the pit traps to compare the effect of differential grazing. Sampling of insects on three forb species (*Gutierrezia sarothrae*, *Artemisia frigida*, and *Chrysothamnus nauseosus*) revealed an increasing amount of arthropod biomass present on the plants in the light use pasture as the season progressed despite the fact that arthropod numbers showed a decrease on the last sampling date.

INTRODUCTION

While a general description of the Pawnee Grassland Biome Intensive Site was given by Jameson (1969), more specific information concerning the climate, vegetation, and soils of the areas sampled for aboveground insects can be found in reports by Bertolin and Rasmussen (1969); Franklin (1969); Sims et al. (1971); Van Haveren and Galbraith (1971); and Rasmussen, Bertolin, and Almeyda (1971). Data relating to soils and herbage dynamics of the environmental stress areas are not yet available (Lauenroth and Sims 1973). Previous reports relating to the insect component of this grassland are by Van Horn (1969); Lavigne and Rogers (1970); Thatcher, Inyamah, and Mitchell (1970); Cwik (1970); Bell (1970, 1971); Lloyd and Grow (1971); Lavigne, Rogers, and Chu (1971); Dickinson and Leetham (1971); Yount and Thatcher (1972); Van Horn (1972); Reed (1972); Kumar et al. (1972); and Pfadt (1972).

METHODS, MATERIALS, AND SAMPLING DESIGN FOR ABOVEGROUND INSECT SAMPLING

The sampling for aboveground insects in 1971 at the Pawnee Site, with some modification and expansion, was a continuation of the work done during 1970 (Dickinson and Leetham, 1971). The areas (treatments) sampled were essentially the same as in 1970, but the frequency of sampling was modified. Also the techniques of separation in the laboratory were modified to more closely compare with those being used at other network sites of the Grassland Biome.

The basic objective of the sampling schedule for the season was to perform frequent but less intense sampling throughout the year to monitor the population trends and provide data for comparing the Pawnee Site with other network sites. The sampling intensity was reduced because of the frequency of sampling dates. At six specified dates during the year, very intensive sampling was done to get a more in depth view of the insect population under various environmental stresses. These major sample dates were spaced approximately 6 weeks apart and were coordinated with other studies at the site to help provide in depth information on all aspects of the community. These studies included abiotic factors as well as primary producers and all levels of consumers and decomposers.

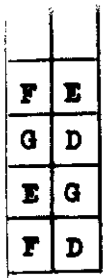
The treatments sampled, nine in all (Fig. 1), included:

Treatment 1 - Permanently Ungrazed

Treatment 2 - Light Grazed

Treatment 3 - Moderate Grazed

Treatment 4 - Heavy Grazed



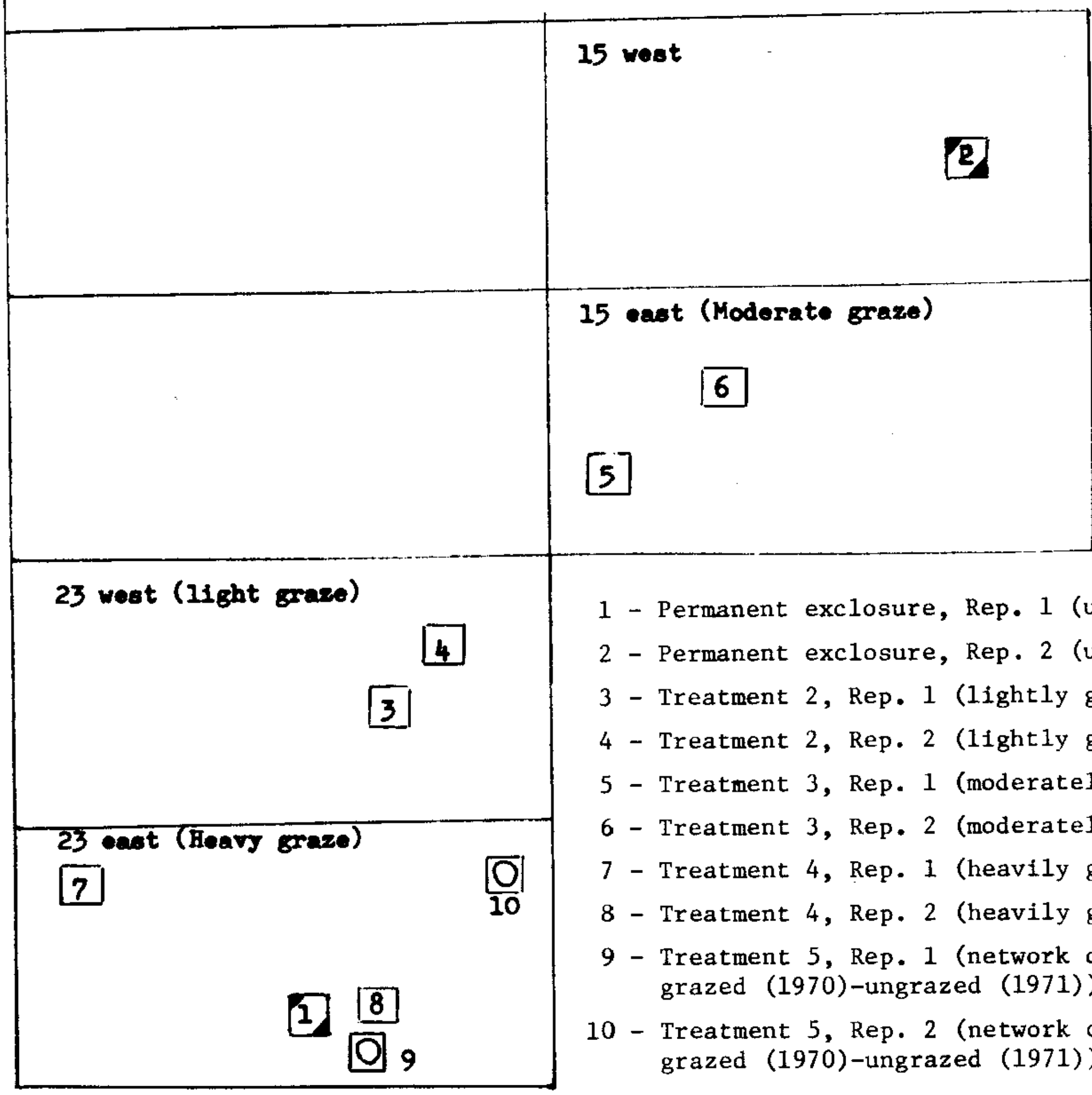
Environmental Stress Area

D - Control

E - Irrigated

F - Fertilized (nitrogen)

G - Irrigated plus fertilized (nitrogen)



1 - Permanent exclosure, Rep. 1 (ungrazed)

2 - Permanent exclosure, Rep. 2 (ungrazed)

3 - Treatment 2, Rep. 1 (lightly grazed)

4 - Treatment 2, Rep. 2 (lightly grazed)

5 - Treatment 3, Rep. 1 (moderately grazed)

6 - Treatment 3, Rep. 2 (moderately grazed)

7 - Treatment 4, Rep. 1 (heavily grazed)

8 - Treatment 4, Rep. 2 (heavily grazed)

9 - Treatment 5, Rep. 1 (network comparison, grazed (1970)-ungrazed (1971))

10 - Treatment 5, Rep. 2 (network comparison, grazed (1970)-ungrazed (1971))

Fig. 1. Approximate location of aboveground insect sampling areas, 1971.

Treatment 6 - Grazed (1979)-Ungrazed (1971)

Treatment D - Control, no grazing and no stress

Treatment E - Irrigated

Treatment F - Fertilized (Nitrogen)

Treatment G - Irrigated and Fertilized

A more detailed discussion of the above treatments is given by Sims et al. (1971). Treatments 1 and 6 (permanently ungrazed and grazed (1970)-ungrazed (1971) were the only treatments used for the more frequent network comparison sampling because all other network sites were using only these two treatments. Sampling on treatments 1 and 6 was conducted at 2-week intervals (biweekly) from mid-April to the first week in October. Each treatment was replicated twice, with five samples taken per replicate per sample date (10 samples per treatment). The intensive sampling was conducted on all treatments on the following dates: March 25, May 1, June 25, August 20, October 15, and December 15.

On all treatments macroplots of 0.5 to 1.0 ha were layed out and a grid system set up within them. The sample points within the grid were selected by means of a random numbers' table. Once a particular point had been sampled, it was eliminated from further sampling. If all points within a grid were eventually sampled, then repeat sampling would begin. Actually, only the grid point was repeated with the actual sample taken adjacent to the original one. Repeat sampling was done only on the two replicates of Treatment 1. The sampling locations on all treatments is illustrated in Fig. 1.

The basic method of field collection of the samples was essentially the same as in 1970, i.e., a 0.5-m^2 circular trap with a 16-mesh screen was dropped by means of a two-cheeled cart fitted with an 18-ft boom, and the insects were collected from within the trap. The collection methods were constant across all treatments.

Two major steps were added to the 1970 collecting methods for the 1971 season. The first addition was to accurately record the vegetation within the trap after it was dropped. The plants were recorded by species, estimated field weight, and phenology. This information was recorded in hopes that insect-plant host associations could later be determined.

Following the herbage estimation, the trap contents were vacuumed in two stages. The first-stage vacuum was a "once-over-lightly" design to capture the more active insects and retain as little refuse as possible. The second-stage vacuum was designed to take all plant material and litter down to ground level. All tall vegetation was clipped prior to vacuuming.

Once in the laboratory, the first-stage vacuum samples were frozen to kill all insects. The samples were then transferred to plastic vials for shipment to the University of Wyoming Entomology Department for hand sorting. The second stage vacuum samples were put in Berlese funnels to extract the insects by driving them out of the plant refuse with heat and light. The funnels were 14 inches in diameter and fitted with 25 watt light bulbs for heat. All samples were left in the funnels for a minimum of 48 hr or until the contents were thoroughly dry. The extracted insects were then sent to the University of Wyoming for sorting and identification.

At Wyoming, the Berlese samples were hand-sorted. All the organisms thus collected were preserved in vials. The identification was mainly carried up to family level in the University of Wyoming Entomology Department. For further identification, representative samples of the organisms were sent to specialists throughout the United States. Occasionally, identifications were not possible to the species level, or even higher taxa. All such identifications are included in a technical report by Kumar et al. (1972).

Biomass was determined according to the method described by French (1970) in which, all prior to weighing, samples were dried in an oven at 70°C for 24 hr. Each sample was weighed on a balance with a precision of 10^{-5}g.

Status of Samples

At the time this report was written, all samples received from the Pawnee Site had been processed, the information transmitted to the National Resource Ecology Laboratory to be keypunched for insertion in the computor, and analysis completed and corrected as of July 1972.

Trophic analysis was based on the following food habit classification which was modified after Evans and Murdoch (1968) and McDaniel (1971):

1. Plant sap feeder - feeding on various parts of plants through the use of sucking mouthparts, excluding nectar feeders.
2. Plant tissue feeder - feeding only on various parts of the plants, including blossoms, using chewing mouthparts; including rasping sucking (thrips).

3. Omnivore - feeding on both plant and animal tissue.

4. Scavenger - feeding on dead and decomposing matter, both plant and animal.

5. Entomophagous predator - feeding largely or exclusively on other insects.

6. Entomophagous parasite - as larvae feeding and destroying only one insect usually from within.

7. Pollen feeder - confined to feeding on pollen in some stage of growth.

8. Seed predator - feeding largely on seeds at some stage in the life history.

It is expected that as more information is made available, this classification will be further modified. When the term herbivore is used in the text, it ordinarily refers to categories (1) and (2) above.

PERMANENTLY UNGRAZED AND GRAZED (1970)-UNGRAZED (1971) PLOT SAMPLING

Bimonthly Sampling

Vacuum samples were taken on two plots, (i) permanently ungrazed and (ii) grazed (1970)-ungrazed (1971), on a bimonthly basis from April 29 to September 29, 1971. An additional series of samples was taken on October 26. These data are presented in Tables 1 to 13 with the information broken down to a major group level. The total number of insects collected on a given date, the mean number per square meter, and the mean biomass in grams per square meter are given.

Taking the groups individually throughout the season, the following trends were observed:

Araneida: Except for May 13 and June 16, spiders were much more abundant in the permanently ungrazed pasture. This is to be expected since these nonselective predators had more than twice as much potential prey available in these plots on most sampling dates.

Acarina: The mites were consistently more abundant in the permanently ungrazed pasture except on August 22 when none were taken in these plots. On July 14 and September 10 no mites were collected in either plot which was unexpected.

Chelonethida: Pseudoscorpions, which feed chiefly on small insects, were collected only on April 29 and August 22 and only in the permanently ungrazed pastures. Since they were present on these two dates, we can assume that the sampling technique is inadequate for providing a representative sample of these litter-inhabiting organisms. It is possible that in responding to moisture they burrow into the soil and thus are not picked up by the vacuum.

Table 1. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date April 29, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean Biomass g/m^2	Total No.	Mean No./m^2	Mean Biomass g/m^2
Araneida	12	2.4	.00262	2	0.4	.00048
Acarina	72	14.4	.00110	5	1.0	.00020
Chelonethida	7	1.4	.00296	--	--	--
Collembola	--	--	--	1	0.2	.00003
Neuroptera	1	0.2	.00016	1	0.2	.00016
Hemiptera	41	8.2	.00926	14	2.8	.00262
Homoptera	9	1.8	.00057	32	6.4	.00112
Orthoptera	--	--	--	1	0.2	.02688
Diptera	16	3.2	.00260	7	1.4	.00067
Coleoptera	200	40.4	.08713	128	25.6	.10440
Lepidoptera	7	1.4	.00593	2	0.4	.00009
Hymenoptera	58	11.6	.00989	93	18.6	.02320
TOTAL	423	84.6	.12222	286	57.2	.16985
Adults	267	53.4	.09949	226	45.2	.11095
Nymph/larvae	156	31.2	.04947	60	12.0	.04894

Table 2. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date May 13, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Araneida	9	1.8	.00250	12	2.4	.00281
Acarina	68	13.6	.00150	9	1.8	.00025
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	1	0.2	.00016	1	0.2	.00016
Hemiptera	42	8.4	.00139	16	3.2	.00054
Homoptera	8	1.6	.00064	10	2.0	.00086
Orthoptera	--	--	--	1	0.2	.00414
Diptera	3	0.6	.00033	2	0.4	.00063
Coleoptera	181	36.2	.07577	125	25.0	.12864
Lepidoptera	3	0.6	.00118	5	1.0	.00189
Hymenoptera	92	18.4	.01086	53	10.6	.00816
TOTAL	407	81.4	.09432	234	46.8	.14809
Adults	285	57.0	.05511	179	35.8	.05753
Nymph/larvae	122	24.4	.03922	55	11.0	.09056

Table 3. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date May 25, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean $No./m^2$	Mean Biomass g/m^2	Total No.	Mean $No./m^2$	Mean Biomass g/m^2
Araneida	13	2.6	.00332	2	.4	.00059
Acarina	16	3.2	.00056	5	1.0	.00021
Chelonethida	--	--	--	--	--	--
Collembola	1	0.2	.00000	1	0.2	.00000
Neuroptera	--	--	--	4	0.8	.00065
Hemiptera	101	20.2	.00484	2	0.4	.00038
Homoptera	15	3.0	.00129	25	5.0	.00166
Orthoptera	1	0.2	.00296	--	--	--
Diptera	14	2.8	.00329	5	1.0	.00070
Coleoptera	166	33.2	.07756	131	26.2	.05662
Lepidoptera	2	0.4	.00099	--	--	--
Hymenoptera	206	41.2	.02327	118	23.6	.01253
Thysanoptera	3	0.6	.00003	1	0.2	.00001
Trichoptera	2	0.4	.00427	1	0.2	.00213
TOTAL	540	108.0	.12238	295	59.0	.07548
Adults	419	83.8	.08358	269	53.8	.04247
Nymph/larvae	121	24.2	.03883	26	5.2	.03305

Table 4. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date of June 7, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Group	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Araneida	1	0.2	.00087	--	--	--
Acarina	63	12.6	.00104	6	1.2	.00009
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	2	0.4	.00033	1	0.2	.00016
Hemiptera	15	3.0	.00066	4	0.8	.00026
Homoptera	6	1.2	.00078	6	1.2	.00058
Orthoptera	--	--	--	1	0.2	.00421
Diptera	10	2.0	.00089	1	0.2	.00002
Coleoptera	35	7.0	.05728	37	7.4	.06699
Lepidoptera	1	0.2	.00014	4	0.8	.01199
Hymenoptera	113	22.6	.01199	44	8.8	.00575
TOTAL	246	49.2	.07398	104	20.8	.09005
Adults	222	44.4	.02534	95	19.0	.03903
Nymph/larvae	23	4.6	.04823	9	1.8	.05101

Table 5. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date June 16, 1971

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean Biomass g/m^2	Total No.	Mean No./m^2	Mean Biomass g/m^2
Araneida	--	--	--	3	0.6	.00083
Acarina	34	6.8	.00050	8	1.6	.00012
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	--	--	--	3	0.6	.00049
Hemiptera	13	2.6	.00118	14	2.8	.00129
Homoptera	43	8.6	.00415	32	6.4	.00284
Orthoptera	1	0.2	.00358	1	0.2	.00358
Diptera	17	3.4	.00171	45	9.0	.00425
Coleoptera	46	9.2	.05654	46	9.2	.02692
Lepidoptera	7	1.4	.00072	26	5.2	.03995
Hymenoptera	37	7.4	.00470	79	15.8	.00843
Thysanoptera	--	--	--	1	0.2	.00001
TOTAL	198	39.6	.07308	258	51.6	.08871
Adults	173	34.6	.03663	241	48.2	.07710
Nymph/larvae	25	5.0	.03647	17	3.4	.01165

Table 6. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date July 2, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Araneida	--	--	--	--	--	--
Acarina	38	7.6	.00058	7	1.4	.00011
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	--	--	--	2	0.4	.00032
Hemiptera	9	1.8	.00118	--	--	--
Homoptera	31	6.2	.00400	18	3.6	.00165
Orthoptera	--	--	--	--	--	--
Diptera	20	4.0	.00316	18	3.6	.00363
Coleoptera	33	6.6	.11434	32	6.2	.01237
Lepidoptera	5	1.0	.00199	2	0.6	.00023
Hymenoptera	18	3.6	.00366	10	2.0	.00175
Thysanura	--	--	--	1	0.2	.00001
TOTAL	154	30.8	.12891	90	18.0	.02007
Adults	129	25.8	.01846	81	16.2	.01934
Nymph/larvae	25	5.0	.11046	9	1.8	.00074

Table 7. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date July 14, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Araneida	3	0.6	.00164	--	--	--
Acarina	--	--	--	--	--	--
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	--	--	--	1	0.2	.00016
Hemiptera	50	10.0	.02641	22	4.4	.00859
Homoptera	48	9.6	.00691	32	6.4	.00291
Orthoptera	2	0.4	.00381	1	0.2	.00079
Diptera	1	0.2	.00002	1	0.2	.00000
Coleoptera	89	17.8	.16613	30	6.0	.01001
Lepidoptera	10	2.0	.00129	--	--	--
Hymenoptera	24	4.8	.00616	2	0.4	.00067
Thysanoptera	1	0.2	.00001	4	0.8	.00004
TOTAL	228	45.6	.21239	93	18.6	.02320
Adults	193	38.6	.19810	82	16.4	.02197
Nymph/larvae	35	7.0	.01428	11	2.2	.00124

Table 8. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date July 28, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Araneida	3	0.6	.00038	--	--	--
Acarina	37	7.4	.00042	16	3.2	.00017
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	--	--	--	--	--	--
Hemiptera	3	0.6	.00045	--	--	--
Homoptera	12	2.4	.00217	17	3.4	.00158
Orthoptera	--	--	--	--	--	--
Diptera	--	--	--	--	--	--
Coleoptera	23	4.6	.01846	14	2.8	.00334
Lepidoptera	9	1.8	.00094	--	--	--
Hymenoptera	24	4.8	.00400	19	3.8	.00458
Thysanura	2	0.4	.00002	--	--	--
TOTAL	113	22.6	.02684	66	13.2	.00967
Adults	98	19.6	.02435	58	11.6	.00900
Nymph/larvae	15	3.0	.00250	8	1.6	.00067

Table 9. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date August 10, 1971

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean Biomass g/m^2	Total No.	Mean No./m^2	Mean Biomass g/m^2
Araneida	2	0.4	.00077	1	0.2	.00075
Acarina	1	0.2	.00001	--	--	--
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	--	--	--	1	0.2	.00016
Hemiptera	2	0.4	.00006	2	0.4	.00010
Homoptera	9	1.8	.00078	15	3.0	.00151
Orthoptera	--	--	--	1	0.2	.00079
Diptera	--	--	--	--	--	--
Coleoptera	8	1.6	.00524	12	2.4	.03104
Lepidoptera	--	--	--	--	--	--
Hymenoptera	10	2.0	.00247	2	0.4	.00098
TOTAL	32	6.4	.00933	34	6.8	.03533
Adults	28	5.6	.00909	24	4.8	.03367
Nymph/larvae	4	0.8	.00024	10	2.0	.00166

Table 10. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date August 22, 1971

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean Biomass g/m^2	Total No.	Mean No./m^2	Mean Biomass g/m^2
Araneida	23	4.6	.00138	2	0.4	.00034
Acarina	--	--	--	7	1.4	.00013
Chelonethida	6	1.2	.00254	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	1	0.2	.00024	2	0.4	.00040
Hemiptera	13	2.6	.00135	4	0.8	.00650
Homoptera	35	7.0	.00516	6	1.2	.00110
Orthoptera	--	--	--	--	--	--
Diptera	--	--	--	--	--	--
Coleoptera	81	16.2	.05154	28	5.6	.02987
Lepidoptera	5	1.0	.00052	--	--	--
Hymenoptera	10	2.0	.00052	8	1.6	.00099
Thysanoptera	1	0.2	.00001	--	--	--
TOTAL	175	35	.06326	57	11.4	.03933
Adults	128	25.6	.05636	44	8.8	.03173
Nymph/larvae	47	9.4	.00690	13	2.6	.00759

Table 11. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date September 10, 1971

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m²	Mean Biomass g/m²	Total No.	Mean No./m²	Mean Biomass g/m²
Araneida	1	0.2	.00002	1	0.2	.00075
Acarina	--	--	--	--	--	--
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	--	--	--	3	0.6	.00071
Hemiptera	3	0.6	.00048	1	0.2	.00078
Homoptera	2	0.4	.00020	2	0.4	.00020
Orthoptera	--	--	--	--	--	--
Diptera	1	0.2	.00965	--	--	--
Coleoptera	32	6.4	.02752	50	10.0	.06641
Lepidoptera	--	--	--	--	--	--
Hymenoptera	54	10.8	.00454	33	6.6	.00296
TOTAL	93	18.6	.04241	90	18.0	.07181
Adults	91	18.2	.04054	84	16.8	.05549
Nymph/larvae	2	.4	.00187	6	1.2	.01632

Table 12. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date September 29, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Araneida	--	--	--	--	--	--
Acarina	--	--	--	--	--	--
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	--	--	--	--	--	--
Hemiptera	1	0.2	.00030	--	--	--
Homoptera	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--
Diptera	1	0.2	.00348	2	0.4	.00244
Coleoptera	27	5.4	.24738	18	3.6	.38732
Lepidoptera	5	1.0	.00520	--	--	--
Hymenoptera	2	0.4	.00456	1	0.2	.00076
TOTAL	36	7.2	.29092	21	4.2	.39052
Adults	29	5.8	.25302	20	4.0	.38908
Nymph/larvae	7	1.4	.00790	1	0.2	.00144

Table 19. Numbers and biomass of different groups of aboveground arthropods taken in two grassland treatments with a D-vac suction apparatus for the date, October 26, 1971.

Group	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Araneida	--	--	--	--	--	--
Acarina	--	--	--	--	--	--
Chelonethida	--	--	--	--	--	--
Collembola	--	--	--	--	--	--
Neuroptera	1	0.2	.00164	3	0.6	.00492
Hemiptera	1	0.2	.00030	3	0.6	.00090
Homoptera	--	--	--	--	--	--
Orthoptera	--	--	--	--	--	--
Diptera	--	--	--	--	--	--
Coleoptera	23	4.6	.17384	18	3.6	.42924
Lepidoptera	2	0.4	.00208	--	--	--
Hymenoptera	--	--	--	--	--	--
TOTAL	27	5.4	.17786	24	4.8	.43506
Adults	16	3.2	.11994	18	3.6	.27546
Nymph/larvae	11	2.2	.05792	6	1.2	.15960

Collembola: These primitive insects appear to be rare on the Pawnee Site having been collected only on two dates, April 29 and May 25. This is not surprising since these tiny insects "prefer" areas of high humidity and are probably most abundant around temporary pools on the Pawnee Site. Very few Collembola were collected from the belowground samples.

Neuroptera: They are predaceous and occur in small numbers on the grassland and appear to be more or less evenly distributed between plots. Since they generally feed on soft bodied insects such as aphids which are in short supply on the Pawnee Site, it is not surprising to find them present in very low numbers. Additionally, they must compete with ladybird beetles for the available supply of aphids.

Hemiptera: These sucking insects, mostly represented on site by plant feeding bugs (Lygaeidae), occurred in far greater numbers in the permanently ungrazed plots, except on June 16 where they were present in about equal numbers. This is rather surprising as it would be expected that more succulent foliage would be available in the grazed (1970)-ungrazed (1971) plots. Therefore, the assumption must be made that there is some host preference being exhibited and that there is a greater availability of preferred hosts in the permanently ungrazed situation.

Homoptera: Closely related to Hemiptera, and represented primarily by leafhoppers, occurred in variable numbers in the different plots, although early in the season the grazed (1970)-ungrazed (1971) plots were favored. As explained in more detail later, the large mesh of the collecting bags probably allowed many leafhoppers to escape since nymphal forms were largely absent in the samples.

Orthoptera: Grasshoppers were collected in such small numbers by this sampling technique that no trend can be discerned.

Diptera: Early in the season, the two winged flies were collected abundantly, apparently favoring the permanently ungrazed plots except on June 16. Since their feeding habits are highly variable ranging from pollen and nectar feeding to parasitism, it must be assumed that the concentration in the permanently ungrazed plots reflected either more abundant shaded resting sites or the presence of more hosts of one kind or another.

Coleoptera: Like the Diptera, the beetles exhibit a wide range of feeding habits from scavenging to predation. Even at the family level, it is not safe to assign feeding habits. For example, the Carabidae which are generally considered to be predators contain a large group of species which are herbivorous (Bell, 1971). Early in the season, beetles were more abundant in the permanently ungrazed pastures; but as the season progressed, the populations tended to even out.

Lepidoptera: This order is represented by moths and butterflies, neither of which occur in large numbers on the grassland. Berlese extraction does not leave adult specimens in recognizable condition for identification, and the taxonomy of the larval stages needs a great deal of work. Two additional factors are important: (i) the lights used to run the Berlese samples attract night flying moths which occasionally infiltrate samples and (ii) the occurrence of intermittently spaced wheat fields in the area make it impossible to adequately determine, except through larval collections, what Lepidoptera occur normally on the grassland. The most common species is an arctiid (*Apanthesis blakei* Grote), the larvae of which are present both in the fall and spring when they are commonly observed feeding on newly emerged shoots of grasses, sedges, and various forbs.

Hymenoptera: This insect order contains the wasps, bees, and ants. Many of the wasps, because of their minute size, are not adequately sampled by the present technique. The solitary bees, because of their habit of constructing underground burrows and feeding only at flowering forbs, have been largely missed. The majority of Hymenoptera collected are ants. The numbers among plots are highly variable and generally reflect the presence of an ant colony in the vicinity of the sample. Neither plot appeared to be more favorable as a nesting or foraging site. This is to be expected since most ants are omnivores.

Thysanoptera: With the exception of the August 22 collection, thrips were only recorded intermittently throughout the season and in very small numbers. Most thrips of which we have knowledge from the Pawnee Site are associated with the blossoms of flowering forbs. Kneebone (1957) recorded thrips infesting blue grama seed heads in fields where blue grama was grown for seed; however, we have not investigated this possibility at the Pawnee Site. In a survey of pasture grass infesting insects in East Africa, Nye (1960) found that "if grass-seed production is attempted the seed-feeding thrips are liable to become economic pests."

Thysanura: These primitive insects were only collected twice during the season on the Pawnee Site although on the grasslands south of Shoshoni, Wyoming, they are commonly observed. Nothing is known of their feeding habits.

Trichoptera: The aquatic larvae of this order occur in the permanent ponds on the Pawnee Site, but thus far this stage has not been sampled. The adults, which are somewhat similar to moths in general appearance, have hairy wings or wings covered with scales held roof-like over the body. Only on May 25 were adults picked up in the vacuum sampling which is easily explained since the adult members of this order emerged simultaneously from the pupal cases at specific times of the year.

In total numbers, the insects and related organisms consistently appeared in higher numbers in the permanently ungrazed plots with the exception of the June 16 samples where there was an apparent infiltration of adult insects into the grazed (1970)-ungrazed (1971) plots. Additionally, late in the season there were two dates on which there appeared to be equal numbers under both treatments. The higher numbers of insects found in the permanently ungrazed plots is consistent with the data collected by Morris (1967, 1968) where most taxonomic groups he sampled were commonest in areas left ungrazed for 2 to 3 years.

When the bimonthly data are broken down to compare adult insects with immatures, there are consistently more adults than immatures throughout the season. The ratio drops from roughly 2 to 1 early in the season to 50 to 1 at the season's end on September 10 in the permanently ungrazed pasture. In the grazed (1970)-ungrazed (1971) plots the ratio changes from about 4 to 1 to 12 to 1 at the season's end. These figures would seem to indicate population explosion in the latter plots. Interestingly, about the end of May the number of immatures collected drops radically which would seem to indicate that the sampling technique is missing some types of immatures (such as cicadellids), or immatures present on the grasslands are utilizing plants as rearing quarters, and thus remain uncollected.

Bimonthly data are presented in Tables 14 to 45 on the total numbers, mean number per square meter, and the mean biomass in grams per square meter for specific families of the more commonly occurring insect orders. The four orders covered are Coleoptera, Diptera, Hemiptera, and Homoptera.

The families of Coleoptera covered are as follows:

Scarabaeidae: With one exception, the only scarab bettle collected in the aboveground samples was *Rhyssemus*, new species. Most specimens were collected before the beginning of June, probably indicating some kind of mating flight. More specimens were collected in the permanently ungrazed plots. Nothing is known of this species, but because of the high incidence of specimens in belowground samples it probably feeds on the roots of grasses. It is not surprising that the sampling technique does not pick up the dung bettle adults, (*Aphodius* sp.) which, while very active throughout the season, only emerge to fly from cow pat to cow pat.

Tenebrionidae: The bettles in this family are represented both by scavengers and by plant feeding species. Prior to June 7, these beetles were more abundant in the grazed (1970)-ungrazed (1971) plots. After this date, with the exception of August 10 and September 10, these beetles were more often collected in the permanently ungrazed pastures.

Curculionidae: These snout-nosed beetles occurred in variable numbers throughout the season on the two plots, although their mean biomass tended to be greater in the grazed (1970)-ungrazed (1971) plots. As adults, these beetles are primarily plant feeders, many species

Table 14. Numbers and biomass of Coleoptera by family for date of April 29, 1971.

Family	Permanently Grazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Scarabaeidae	86	17.2	.01227	68	13.6	.00979
Tenebrionidae	14	2.8	.05196	23	4.6	.06084
Curculionidae	28	5.6	.00603	12	2.4	.02042
Coccinellidae	4	0.8	.00024	--	--	--
Staphylinidae	1	0.2	.00010	13	2.6	.00140
Carabidae	2	0.4	.00292	4	0.8	.00893
Chrysomelidae	41	8.2	.00984	--	--	--
Elateridae	2	0.4	.00034	1	0.2	.00219
Anthicidae	1	0.2	.00009	--	--	--

Table 15. Numbers and biomass of Diptera by family for the date April 29, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Cecidomyiidae	1	0.2	.00002	3	0.6	.00006
Chironomidae	2	0.4	.00032	--	--	--
Culicidae	1	0.2	.00016	1	0.2	.00014

Table 16. Numbers and biomass of Hemiptera and Homoptera by family for the date of April 29, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
HEMIPTERA						
Lygaeidae	31	6.2	.00130	11	2.2	.00033
Cydnidae	8	1.6	.00625	--	--	--
Phymatidae	1	0.2	.00017	--	--	--
Coreidae	1	0.2	.00153	1	0.2	.00178
Tingidae	--	--	--	1	0.2	.00016
Miridae	--	--	--	1	0.2	.00035
HOMOPTERA						
Cicadellidae	8	1.6	.00049	2	0.4	.00038
Pseudococcidae	1	0.2	.00008	30	6.0	.00073

Table 17. Numbers and biomass of Hemiptera and Homoptera by family for date of May 13, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m 2	Mean biomass g/m2	Total No.	Mean No/m2	Mean biomass g/m2
HEMIPTERA						
Lygaeidae	41	8.2	.00123	15	3.0	.00045
Phymatidae		--	--	1	.2	.00009
Tingidae	1	.2	.00016		--	--
HOMOPTERA						
Cicadellidae		--	--	3	.6	.00031
Pseudococcidae	8	1.6	.00064	7	1.4	.00056

Table 18. Numbers and biomass of Coleoptera by family for date of May 25, 1971.

	Permently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m2	Mean biomass g/m2	Total No.	Mean No/m2	Mean biomass g/m2
Scarabaeidae	118	23.6	.01699	87	17.4	.01036
Tenebrionidae	12	2.4	.03851	21	4.2	.03891
Curculionidae	6	1.2	.00877	8	1.6	.00543
Staphylinidae	1	.2	.00009	1	.2	.00009
Carabidae	9	1.8	.01086	--	--	--
Chrysomelidae	4	.8	.00096	--	--	--

Table 19. Numbers and biomass of Coleoptera by family for date of May 13, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Scarabaeidae	138	27.6	.01862	74	14.8	.01066
Tenebrionidae	16	3.2	.04160	23	4.6	.09348
Curculionidae	14	2.8	.00928	8	1.6	.01656
Coccinellidae	1	.2	.00118	--	--	--
Carabidae	6	1.2	.00228	9	1.8	.00684
Chrysomelidae	--	--	--	1	.2	.00014
Elateridae	1	.2	.00219	--	--	--

Table 20. Numbers and biomass of Diptera by family for the date of May 13, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Cecidomyiidae	1	.2	.00002	--	--	--

Table 21. Numbers and biomass of Diptera by family for date of May 25, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m²	Mean biomass g/m²	Total No.	Mean No/m²	Mean biomass g/m²
Cecidomyiidae	--	--	--	1	.2	.00002
Culicidae	--	--	--	1	.2	.00014
Asilidae	1	.2	.00095	--	--	--

Table 22. Numbers and biomass of Hemiptera and Homoptera by family for the date of May 25, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m²	Mean biomass g/m²	Total No.	Mean No/m²	Mean biomass g/m²
HEMIPTERA						
Lygaeidae	95	19.0	.00284	1	.2	.00003
Cydnidae	3	.6	.00151	--	--	--
Phymatidae	1	.2	.00017	--	--	--
Tingidae	2	.4	.00032	--	--	--
Miridae	--	--	--	1	.2	.00035
HOMOPTERA						
Cicadellidae	6	1.2	.00090	8	1.6	.00086
Pseudococcidae	5	1.0	.00032	9	1.8	.00070
Psyllidae	1	.2	.00000	--	--	--
Aphididae	3	.6	.00005	8	1.6	.00010

Table 23. Numbers and biomass of Coleoptera by family for date of June 7, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Tenebrionidae	12	2.4	.05315	11	2.2	.05411
Curculionidae	5	1.0	.00088	8	1.6	.01008
Coccinellidae	4	0.8	.00020	3	0.6	.00014
Staphylinidae	3	0.6	.00027	1	0.2	.00009
Carabidae	2	0.4	.00130	5	1.0	.00092
Chrysomelidae	3	0.6	.00078	--	--	--
Elateridae	1	0.2	.00008	--	--	--
Anthicidae	1	0.2	.00049	5	1.0	.00092

Table 24. Numbers and biomass of Diptera by family for date of June 7, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Cecidomyiidae	5	1.0	.00011	1	0.2	.00002
Therevidae	1	0.2	.00022	--	--	--

Table 25. Numbers and biomass of Hemiptera and Homoptera by family for the date of June 7, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
HEMIPTERA						
Lygaeidae	14	2.8	.00050	4	0.8	.00026
Tingidae	1	0.2	.00016	--	--	--
HOMOPTERA						
Cicadellidae	2	0.4	.00061	4	0.8	.00041
Pseudococcidae	2	0.4	.00015	1	0.2	.00008
Aphididae	1	0.2	.00001	--	--	--
Psyllidae	1	0.2	.00000	--	--	--
Issidae	--	--	--	1	0.2	.00009

Table 26. Numbers and biomass of Hemiptera and Homoptera by family for date of June 16, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
HEMIPTERA						
Lygaeidae	11	2.2	.00048	13	2.6	.00110
Miridae	2	.4	.00070	1	.2	.00018
HOMOPTERA						
Cicadellidae	40	8.0	.00392	31	6.2	.00275
Pseudococcidae	3	.6	.00022	--	--	--
Issidae	--	--	--	1	.2	.00009

Table 27. Numbers and biomass of Coleoptera by family for date of June 16, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No/m2	Mean biomass g/m2	Total No.	Mean No/m2	Mean biomass g/m2
Scarabaeidae	10	2.0	.00144	16	3.2	.00230
Tenebrionidae	11	2.2	.05240	6	1.2	.01061
Curculionidae	7	1.4	.00119	10	2.0	.00837
Coccinellidae	8	1.6	.00037	3	.6	.00021
Staphylinidae	2	.4	.00018	--	--	--
Carabidae	--	--	--	3	.6	.00364
Mordellidae	2	.4	.00014	--	--	--
Histeridae	--	--	--	1	.2	.00071

Table 28. Numbers and biomass of Diptera by family for date of June 16, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No/m2	Mean biomass g/m2	Total No.	Mean No/m2	Mean biomass g/m2
Sciaridae	2	.4	.00006	--	--	--

Table 29. Numbers and biomass of Coleoptera by family for date of July 2, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Tenebrionidae	7	1.4	.10786	4	0.8	.00308
Curculionidae	10	2.0	.00408	5	1.0	.00590
Coccinellidae	5	1.0	.00027	5	1.0	.00026
Staphylinidae	--	--	--	1	0.2	.00009
Carabidae	1	0.2	.00129	3	0.6	.00209
Chrysomelidae	6	1.2	.00047	2	0.4	.00017
Mordellidae	1	0.2	.00007	--	--	--

Table 30. Numbers and biomass of Hemiptera and Homoptera by family for the date of July 2, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
HEMIPTERA						
Lygaeidae	2	0.4	.00006	--	--	--
Tingidae	7	1.4	.00112	--	--	--
HOMOPTERA						
Cicadellidae	31	6.2	.00400	16	3.2	.00146
Issidae	--	--	--	2	0.4	.00018

Table 31. Numbers and biomass of Coleoptera by family for date of July 14, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Scarabaeidae	1	0.2	.00061	--	--	--
Tenebrionidae	33	6.6	.14126	3.0	.6	.00309
Curculionidae	10	2.0	.00166	1.0	.2	.00028
Coccinellidae	5	1.0	.00007	--	--	--
Staphylinidae	8	1.6	.00240	9.0	1.8	.00306
Carabidae	12	2.4	.00835	6.0	1.2	.00238
Chrysomelidae	15	3.0	.00568	--	--	--
Anthicidae	1	0.2	.00001	3.0	.6	.00029
Cicindelidae	1	0.2	.00544	--	--	--

Table 32. Numbers and biomass of Hemiptera and Homoptera by family for date of July 14, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m²	Mean biomass g/m²	Total No.	Mean No/m²	Mean biomass g/m²
HEMIPTERA						
Lygaeidae	33	6.6	.01254	21.0	4.2	.00855
Cydnidae	14	2.8	.01095	--	--	--
Coreidae	1	0.2	.00179	--	--	--
Nabidae	2	0.4	.00113	--	--	--
HOMOPTERA						
Cicadellidae	46	9.2	.00677	31.0	6.2	.00266
Issidae	1	0.2	.00009	--	--	--
Cercopidae	1	0.2	.00004	--	--	--
Margarodidae	--	--	--	1.0	.2	.00025

Table 33. Numbers and biomass of Coleoptera by family for date of July 28, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Scarabaeidae	--	--	--	1	0.2	.00014
Tenebrionidae	9	1.8	.00613	3	0.6	.00231
Curculionidae	7	1.4	.00916	2	0.4	.00057
Coccinellidae	1	0.2	.00005	--	--	--
Staphylinidae	--	--	--	--	--	--
Carabidae	1	0.2	.00285	--	--	--
Chrysomelidae	3	0.6	.00021	6	1.2	.00019
Anthicidae	1	0.2	.00002	2	0.4	.00012

Table 34. Numbers and biomass of Hemiptera and Homoptera by family for date of July 28, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
HEMIPTERA						
Tingidae	3	0.6	.00045	--	--	--
HOMOPTERA						
Cicadellidae	12	2.4	.00217	17	3.4	.00158

Table 35. Numbers and biomass of Coleoptera by family for date of August 10, 1971.

Family	Permanently Ungrazed Total No.	Permanently Ungrazed Mean No./m^2	Permanently Ungrazed Mean biomass g/m^2	Grazed (1970)-Ungrazed (1971) Total No.	Grazed (1970)-Ungrazed (1971) Mean No./m^2	Grazed (1970)-Ungrazed (1971) Mean biomass g/m^2
Tenebrionidae	4	.8	.00481	6	1.2	.01926
Curculionidae	2	.4	.00025	3	.6	.00264
Coccinellidae	1	.2	.00006	--	--	--
Carabidae	--	--	--	1	.2	.00885
Chrysomelidae	--	--	--	1	.2	.00014
Bruchidae	1	.2	.00012	--	--	--

Table 36. Numbers and biomass of Hemiptera and Homoptera by family for date of August 10, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m²	Mean biomass g/m²	Total No.	Mean No./m²	Mean biomass g/m²
HEMIPTERA						
Lygaeidae	2	.4	.00006	2	.4	.00010
HOMOPTERA						
Cicadellidae	9	1.8	.00078	15	3.0	.00151

Table 37. Numbers and biomass of Coleoptera by family for date of August 22, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m²	Mean biomass g/m²	Total No.	Mean No./m²	Mean biomass g/m²
Tenebrionidae	31	6.2	.02905	18	3.6	.01818
Curculionidae	28	5.6	.01834	5	1.0	.00843
Coccinellidae	3	0.6	.00128	3	0.6	.00018
Carabidae	5	1.0	.00067	1	0.2	.00285
Chrysomelidae	12	2.4	.00170	--	--	--

Table 38. Numbers and biomass of Hemiptera and Homoptera by family for date of August 22, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
HEMIPTERA						
Lygaeidae	11	2.2	.00103	--	--	--
Coreidae	--	--	--	4	.8	.00650
Tingidae	2	0.4	.00032	--	--	--
HOMOPTERA						
Cicadellidae	35	7.0	.00516	6	1.2	.00110

Table 39. Numbers and biomass of Coleoptera by family for date of September 10, 1971.

Family	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
	Total No.	Mean No/m2	Mean biomass g/m2	Total No.	Mean No/m2	Mean biomass g/m^2
Scarabaeidae	11	2.2	.00321	9	1.8	.00130
Tenebrionidae	15	3.0	.01870	25	5.0	.03562
Curculionidae	2	0.4	.00527	12	2.4	.02928
Coccinellidae	1	0.2	.00007	--	--	--
Carabidae	--	--	--	1	0.2	.00007
Chrysomelidae	3	0.6	.00026	2	0.4	.00006

Table 40. Numbers and biomass of Diptera by family for date of September 10, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Asilidae	1	0.2	.00965	--	--	--

Table 41. Numbers and biomass of Hemiptera and Homoptera by family for date of September 10, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
HEMIPTERA						
Cydnidae	--	--	--	1	.2	.00078
Tingidae	3	0.6	.00048	--	--	--
HOMOPTERA						
Cicadellidae	2	0.4	.00020	2	.4	.00020

Table 42. Numbers and biomass of Coleoptera by family for the date of September 29, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Scarabaeidae	3	0.6	.00432	--	--	--
Tenebrionidae	15	3.0	.13278	9	1.8	.26916
Curculionidae	6	1.2	.08318	9	1.8	.11816
Coccinellidae	1	0.2	.01178	--	--	--
Carabidae	1	0.2	.01292	--	--	--
Chrysomelidae	1	0.2	.00240	--	--	--

Table 43. Numbers and biomass of Hemiptera by family for the date of September 29, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Lygaeidae	1	0.2	.00030	--	--	--

Table 44. Numbers and biomass of Coleoptera by family for the date of October 26, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Tenebrionidae	16	3.2	.14048	15	3.0	.27916
Curculionidae	5	1.0	.03106	2	0.4	.14920
Chrysomelidae	1	0.2	.00230	1	0.2	.00088

Table 45. Numbers and biomass of Hemiptera by family for the date of October 26, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Family	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Lygaeidae	1	0.2	.00030	3	0.6	.00090

being found associated with flowering forbs on the Pawnee Site. However, almost every part of a plant may be attacked, from the roots upward.

Coccinellidae: The predacious "lady bird" beetles were infrequently collected, tending to favor the permanently ungrazed plots until the latter part of the season when numbers evened out in the two plots. Their food, both in the larval and adult stage, is usually aphids. Since aphids were rarely observed or collected on the Pawnee grassland, the small numbers of lady bird beetles followed the expected trend.

Staphylinidae: The rove beetles, although collected only on scattered occasions, were found to favor the permanently ungrazed plots.

Carabidae: The numbers and biomass of carabid beetles collected on the two grazing treatments varied widely from data to date, leaving no discernible trends. As pointed out by Bell (1971), the majority of species on the Pawnee Site are plant feeders instead of carnivores. Only three of the six species collected in the vacuum trap samples were in sufficient numbers to be considered important, i.e., *Amara farcta* LeConte, *Harpalus desertus* LeConte, and *Selenophorus planipennis* LeConte. Bell considers all three species to be primarily phytophagous although they may take some animal food.

Chrysomelidae: With few exceptions the leaf feeding beetles were found in the permanently ungrazed plots. Since they are associated primarily with forbs, one is led to speculate that greater numbers of forbs occurred in these plots as well. Three undetermined species representing the genera (*Chaetocnema*, *Phyllotreta*, and *Altica*) were collected by the vacuum sampler.

Elateridae: The click beetles were rarely picked up by the vacuum sampler and then only early in the season. As larvae these insects feed on the roots of grasses and have been recorded as being very destructive to certain crops.

Anthicidae: These flower-loving beetles were rarely collected on the Pawnee Site. As adults they are probably pollen feeders.

Mordellidae: These tumbling flower beetles were only collected on two dates, both times appearing in samples from the permanently ungrazed pastures. The larvae live in decaying wood and in plant pith, and some are predacious.

Histeridae: A single histerid beetle was picked up in a grazed (1970)-ungrazed (1971) plot.

Cicindelidae: These predacious beetles are infrequently observed on the differentially treated grazing pastures; instead they tend to congregate in the vicinity of Owl Creek. Only one specimen was collected by the vacuum sampler in a permanently ungrazed plot, *Cicindela punctulata* Oliver.

These beetles tend to favor ants as prey in the rangeland habitat.

Bruchidae: The bruchids also were only represented by one specimen, *Acanthoscelides fraterculus* (Horn). These beetles as adults feed on the pollen of the flowering forbs which serve as host for the larval stages which destroy the seeds. Large numbers have been reared from *Oxytropis sericae* and various species of *Astragalus* on the Pawnee Site, so it is surprising that more specimens have not been collected. However, because of their small size (about one half the size of leafhoppers) many have undoubtedly been able to escape through the large mesh screen of the vacuum sampler.

The families of Diptera covered are Cecidomyiidae, Chironomidae, Culicidae, Asilidae, Therevidae, Sciaridae, all but one asilid being collected early in the season.

Cecidomyiidae: These minute two-winged flies were picked up in the vacuum sampler in small numbers from the end of April to the beginning of June. These are the so-called "gall midges" because most species cause galls to form on plants, although a few live in decaying organic matter.

Chironomidae: These are minute flies for the most part and in as much as their larval stages are spent in the aquatic environment, it is not surprising that specimens were only picked up once. As larvae many species feed as scavengers in the mud at the bottom of ponds and are often known as "blood worms." The adults are often seen swarming near the edges of ponds.

Culicidae: Three specimens of mosquitoes were collected between April 29 and May 25 in these two grazing treatments. All were females; and since the female of the species is blood sucking, it is probable they were attracted to the personnel operating the vacuum sampler. Like chironomids, their larval stage is spent in an aquatic environment and some species are known to be able to complete their development in a hoofprint filled with water.

Asilidae: Only two specimens of this predatory insect group were picked up during the entire season. These represent only two species of the 21 species known to occur on the Pawnee Site (Rogers and Lavigne, 1972), 14 of which occur in these pastures. These authors have suggested a more accurate method of sampling these voracious flies which may take 30 or more prey in a single 10-hr day.

Sciaridae: Dark-winged fungus gnats were picked up in the bimonthly sampling only once. The larvae of most species live in fungi and decaying plant materials, but a few attack the roots of living plants.

Therevidae: The stiletto flies are predacious in the larval stage, but little is known of the feeding habits of the adults. Since adults are not common, it is not surprising that only one adult was collected during the season.

The families of Hemiptera which were collected in the vacuum sampling on the two different pasture types were Lygaeidae, Cydnidae, Phymatidae, Coreidae Tingidae, Miridae, and Nabidae.

Lygaeidae: Most species of these sucking insects feed on seed although some, including the chinch bug (*Blissus leucopterus* (Say)), feed on the sap of the host plant. The majority of these plant bugs collected on the two pasture treatments were this species. With the exception of June 16 and August 10 when numbers collected were nearly equal, much greater populations of the chinch bug were found in the permanently ungrazed pasture. According to Webster (1915), few insects have been as destructive to grain fields and caused greater pecuniary losses than the chinch bug. As early as 1785 wheat fields of North Carolina farmers were so overrun with chinch bugs as to threaten a total destruction of grain. Many other grasses also serve as hosts. In these two pastures this species averaged $3.25/m^2$.

Cydinidae: These so-called burrower bugs are reported by Borror and DeLong (1971) as being found beneath stones, in sand, and in the mold about the roots of grass tufts and also are fairly common on grasses, weeds, berries, and flowers. With the exception of one specimen, those collected were recovered from the permanently ungrazed pasture. Two species were represented in these samples, *Pangaeus congruus* (Uhler) and *Amnestus pallidus* Zimmer, the former being much more abundant.

Phymatidae: The ambush bugs are predacious and feed on other insects much in the same manner as robber flies, i.e., sucking out the internal contents of the prey. These insects were picked up in the vacuum sample only in late April and May and are represented by two species in the genus *Phymata*. Their absence in later collections may be due to their tendency to favor flowering forbs as prey foraging sites.

Coreidae: These bugs, represented by what is probably the boxelder bug (*Leptocoris trivittatus* (Say)), were only collected by the traps on three occasions, April 29, July 14, and August 22. These insects are also plant sap feeders and are supposed to be more common in late summer and fall when they enter buildings in search of hibernating quarters.

Tingidae: The so-called lace bugs, named for the sculpturing of the wings of the adults, were found in the permanently ungrazed pastures with the exception of a single specimen. They appeared in this pasture in small numbers throughout the season. These small bugs, usually whitish as adults and black in the nymphal stage, feed chiefly on the leaves of shrubs and were represented by *Corythaica acuta* (Drake) until mid-July when other species replaced it.

Miridae: Despite the fact that "plant bugs" are common inhabitants of pastures (Osborn, 1939), very few were collected by the vacuum trap in these pastures and all in the first half of the season, primarily in the grazed (1970)-ungrazed (1971) pasture.

Nabidae: Nabids, like phymatids, are predacious bugs with sucking mouthparts. Only two specimens of *Pasgasa fusca* Stern were collected by the vacuum trap all season, these on July 14 in the permanently ungrazed pasture.

The families of Homoptera represented in the vacuum sampling in the two pasture treatments were Cicadellidae, Pseudococcidae, Psyllidae, Aphididae, Issidae, Margarodidae and Cercopidae.

Cicadellidae: As was expected, the leafhoppers, all of which are known plant feeders, were the most commonly collected Homoptera being represented throughout the season in the samples. As explained later, it is felt that larger numbers were present, but were missed due to their small size and ability to escape through the mesh of the vacuum trap. Several species appeared in the samples as would be expected since 67 species have been recorded from the Pawnee Site, but *Flexamia flexulosa* (Ball) was the most common, averaging 2.05/m^2. There was no distinct "preference" shown for pasture type. Peak numbers of leafhoppers were collected in July. Many species of leafhoppers were collected in July. Many species of leafhoppers have been indicted as transmitters of plant diseases, and their effect on rangeland in such a capacity is yet to be investigated.

Pseudococcidae: Populations of mealybugs were highest early in the season, disappearing in late June. Numbers were too small to detect a trend towards either pasture type. These insects, whose name is derived from the mealy or waxy secretions covering their bodies, may feed on almost any part of the host plant.

Psyllidae: This family was represented in the collection by only two specimens of *Craspedolepta artemisiae* Forester, one collected on May 25 and the other on June 7, and both in the permanently ungrazed pasture. These jumping plant lice feed on plant sap and, where known, food relationships are quite specific.

Aphididae: Specimens of these plant sucking insects were collected only on May 25 and June 7. Most species of aphids are associated with flowering forbs such as *Senecio* Sp. Many of the species which are found on the plants are tended by ants which feed on the exuded fluids of the aphids and in turn provide them with protection from predacious insects. Other methods of sampling have also indicated that aphids are not locally abundant on the Pawnee Site.

Issidae: Only five specimens of the issid, *Bruchomorpha suturalis* Melichar, were collected by the vacuum traps, four of these being found in the grazed (1970)-ungrazed (1971) pasture between June 7 and July 2. These plant sucking insects have short wings and a beetle like snout.

Margarodidae: A single adult male margarodid, *Stomacoccus* sp., was collected in the aboveground samples on July 14 in the grazed (1970)-ungrazed (1971) pasture. Margarodids are normally found around the roots of plants beneath the soil surface except when males search for females.

Cercopidae: The spittlebug family, nymphs of which live in a mass of spittle on the stem of the plant while feeding, was represented by a single specimen of *Philaronia bilineata* (Say) collected in the permanently ungrazed pasture on July 14.

As stated previously for Hymenoptera, the family Formicidae (ants) accounted for most of this order collected in bimonthly samples. Seven species of ants were represented with *Monomorium minimum* being the most commonly collected species, averaging $4/m^2$. The other species present and their relative abundance during the time period April 29 to September 10 were as follows: *Myrmica sabuleti americana*, $1.75/m^2$; *Formica neogagates*, $0.3/m^2$; *Formica obtusopilosa*, $0.2/m^2$; *Leptothorax tricarinatus*, $1.3/m^2$; *Tapinoma sessile*, $0.18/m^2$; *Solenopsis molesta validiscula*, $1.7/m^2$.

Bimonthly Sampling Expressed in Terms of Feeding Habit

The feeding habits of between 40 and 50 percent of the insects collected by the vacuum sampler are unknown. The remaining 50 to 60 percent are known or have been surmised by the fact that all members of a particular family exhibit the same feeding characteristics. Tables 46 to 56 present data collected, according to food habit, for the bimonthly sampling periods. These same data are presented graphically in Fig. 2 to 5. As can be seen in both the graphs and tables, omnivores and plant sap feeding insects were much greater numerically in the permanently

Table 46. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date April 29, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Plant sap	99	19.8	.00432	49	9.8	.00200
Plant tissue	42	8.4	.00993	1	0.2	.02688
Omnivore	58	11.6	.00989	93	18.6	.02320
Scavenger	1	0.2	.00010	13	2.6	.00140
Predator	29	5.8	.00590	7	1.4	.00958
Unknown	194	38.8	.09210	123	24.6	.09681

Table 47. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date May 13, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Plant sap	117	23.4	.00336	34	6.8	.00156
Plant tissue	--	--	--	2	0.4	.00429
Omnivore	92	18.4	.01086	53	10.6	.00816
Scavenger	--	--	--	--	--	--
Predator	16	3.2	.00494	22	4.4	.00981
Unknown	182	36.4	.07516	123	24.6	.12426

Table 48. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date May 25, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No/m ^{2}	Mean biomass g/m ^{2}	Total No.	Mean No/m ^{2}	Mean biomass g/m ^{2}
Plant sap	127	25.4	.00472	33	6.6	.00227
Plant tissue	9	1.8	.00422	--	--	--
Omnivore	201	40.2	.02283	118	23.6	.01253
Scavenger	1	0.2	.00009	1	0.2	.00009
Predator	23	4.6	.01513	6	1.2	.00124
Unknown	179	35.8	.07541	137	27.4	.05938

Table 49. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date June 7, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No/m ^{2}	Mean biomass g/m ^{2}	Total No.	Mean No/m ^{2}	Mean biomass g/m ^{2}
Plant sap	83	16.6	.00232	16	3.2	.00092
Plant tissue	3	0.6	.00072	1	0.2	.00421
Omnivore	111	22.2	.01173	41	8.2	.00548
Scavenger	3	0.6	.00027	1	0.2	.00009
Predator	6	1.2	.00297	11	2.2	.00201
Unknown	39	7.8	.05582	33	6.6	.07719
Parasite	1	0.2	.00014	1	0.2	.00014

Table 50. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date June 16, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Plant sap	90	18.0	.00584	61	12.2	.00467
Plant tissue	1	0.2	.00358	1	0.2	.00358
Omnivore	37	7.4	.00470	72	14.4	.00803
Scavenger	2	0.4	.00018	--	--	--
Predator	--	--	--	9	1.8	.00497
Unknown	68	13.6	.05880	115	23.0	.06749

Table 51. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date July 2, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No./m^2	Mean biomass g/m^2	Total No.	Mean No./m^2	Mean biomass g/m^2
Plant sap	71	14.2	.00464	28	5.6	.00186
Plant tissue	6	1.2	.00047	2	0.4	.00017
Omnivore	14	2.8	.00167	4	0.8	.00059
Scavenger	--	--	--	1	0.2	.00009
Predator	1	0.2	.00129	5	1.0	.00241
Unknown	61	12.2	.12084	50	10.0	.01495
Parasite	1	0.2	.00000	--	--	--

Table 52. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date August 10, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No./m2	Mean biomass g/m2	Total No.	Mean No./m2	Mean biomass g/m2
Plant sap	12	2.4	.00085	17	3.4	.00161
Plant tissue	--	--	--	2	0.4	.00094
Omnivore	7	1.4	.00106	1	0.2	.00032
Scavenger	--	--	--	--	--	--
Predator	2	0.4	.00077	3	0.6	.00978
Unknown	10	2.0	.00653	11	2.2	.02270
Plant pollen	1	0.2	.00012	--	--	--

Table 53. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date August 22, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No./m2	Mean biomass g/m2	Total No.	Mean No./m2	Mean biomass g/m2
Plant sap	49	9.8	.00652	16	3.2	.00610
Plant tissue	12	2.4	.00170	--	--	--
Omnivore	5	1.0	.00032	5	1.0	.00086
Scavenger	--	--	--	--	--	--
Predator	36	7.2	.00610	5	1.0	.00358
Unknown	73	14.6	.04870	31	6.2	.002877

Table 54. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date September 10, 1971.

	Permanently Ungrazed			Grazed (1970)-Ungrazed (1971)		
Feeding habit	Total No.	Mean No/m^2	Mean biomass g/m^2	Total No.	Mean No/m^2	Mean biomass g/m^2
Plant sap	5	1.0	.00068	3	0.6	.00099
Plant tissue	3	0.6	.00026	2	0.4	.00006
Omnivore	54	10.8	.00454	32	6.4	.00291
Scavenger	--	--	--	--	--	--
Predator	2	0.4	.00967	5	1.0	.00153
Unknown	29	5.8	.02725	48	9.6	.06631

Table 55. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date September 29, 1971.

Feeding habit	Permanently Ungrazed Total No.	Permanently Ungrazed Mean No./m^2	Permanently Ungrazed Mean biomass g/m^2	Grazed (1970)-Ungrazed (1971) Total No.	Grazed (1970)-Ungrazed (1971) Mean No./m^2	Grazed (1970)-Ungrazed (1971) Mean biomass g/m^2
Plant sap	1	0.2	.00030	--	--	--
Predator	1	0.2	.01178	--	--	--
Unknown	34	6.8	.24884	21	4.2	.39052

Table 56. Comparison of mean numbers and biomass per square meter of aboveground arthropods representing different trophic levels on the sampling date October 26, 1971.

Feeding habit	Permanently Ungrazed Total No.	Permanently Ungrazed Mean No./m^2	Permanently Ungrazed Mean biomass g/m^2	Grazed (1970)-Ungrazed (1971) Total No.	Grazed (1970)-Ungrazed (1971) Mean No./m^2	Grazed (1970)-Ungrazed (1971) Mean biomass g/m^2
Plant sap	1	0.2	.00030	3	0.6	.00090
Plant tissue	2	0.4	.00230	--	--	--
Predator	1	0.2	.00164	2	0.4	.00328
Unknown	23	4.6	.17362	19	3.8	.43088

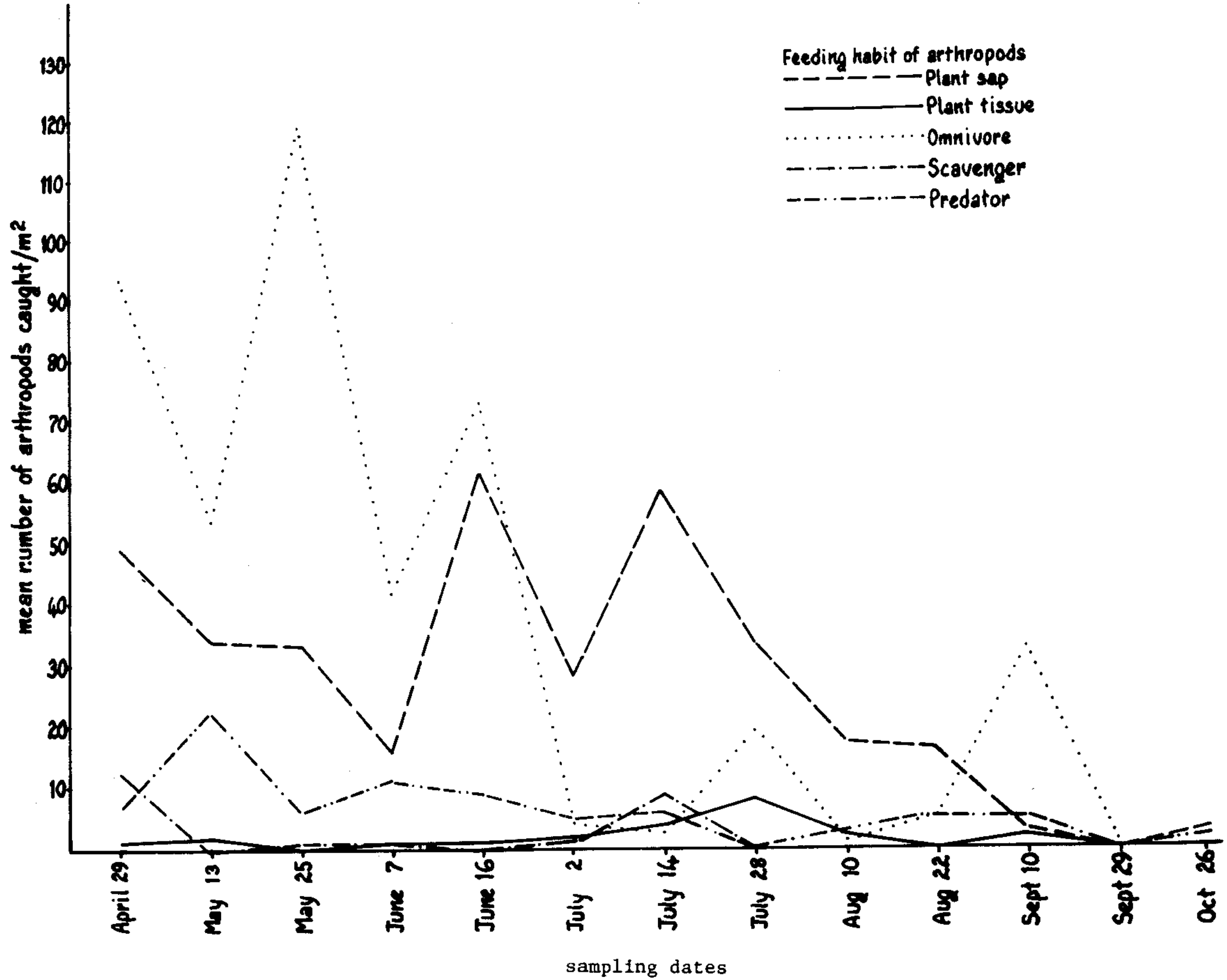


Fig. 2. Comparison of mean numbers per meter squared of aboveground arthropods representing different trophic levels collected bimonthly during 1971 with a D-vac suction apparatus on the grazed (1970)-ungrazed(1971) treatment.

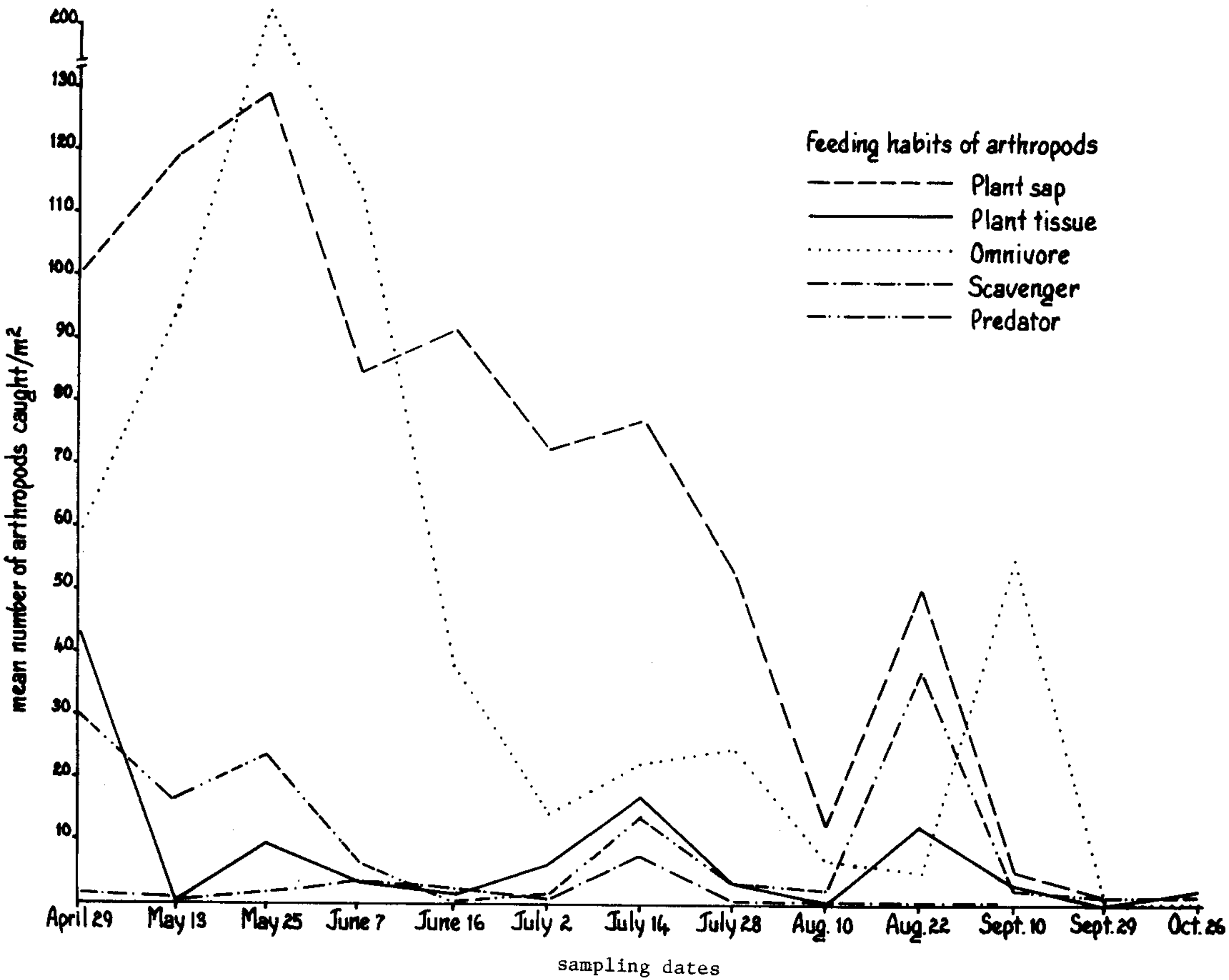


Fig. 3. Comparison of mean numbers per meter squared of aboveground arthropods representing different trophic levels collected bimonthly during 1971 at Pawnee with a D-vac suction apparatus on the permanently ungrazed treatment.

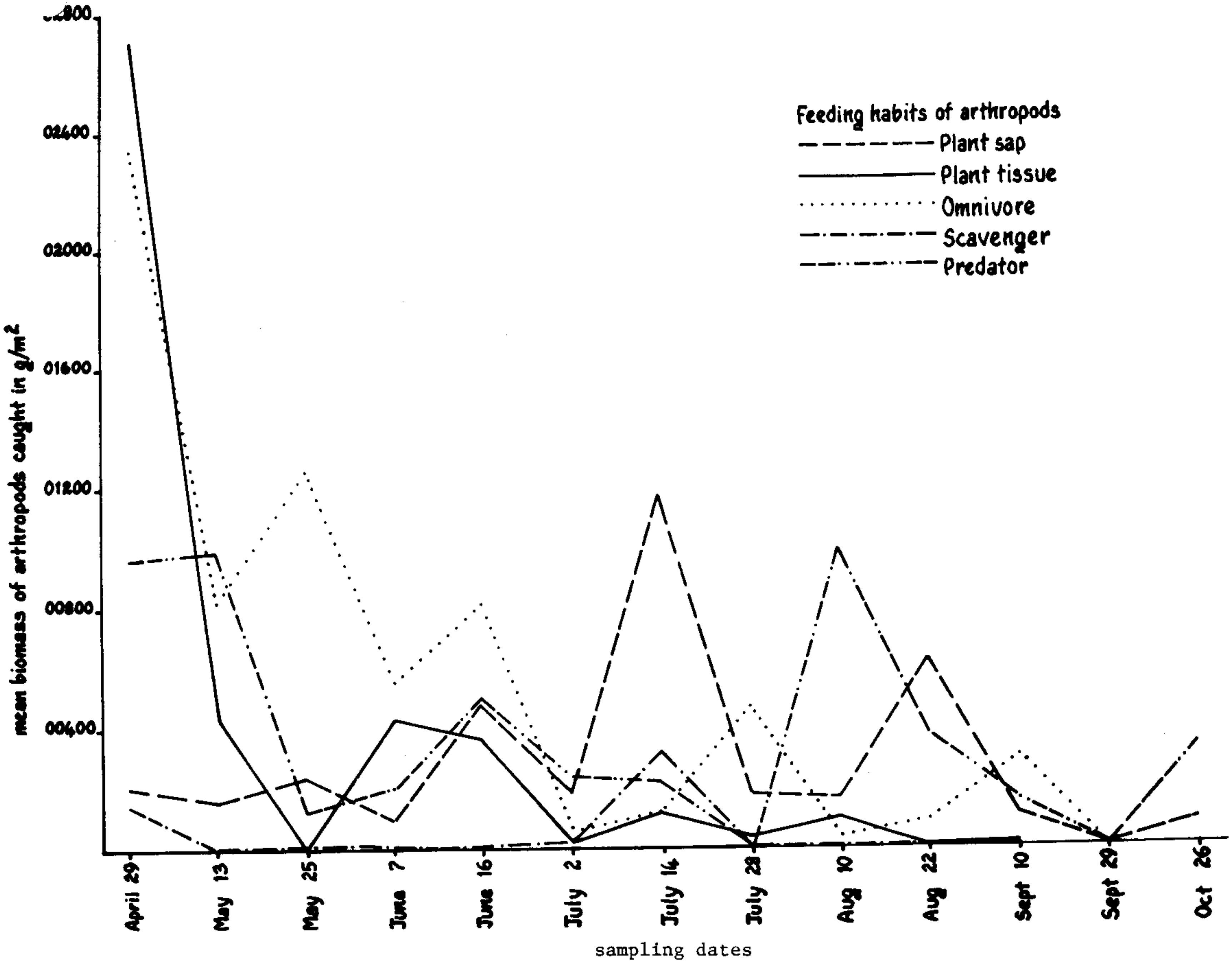


Fig 4. Comparison of mean biomass in grams per meter squared of aboveground arthropods representing different trophic levels collected bimonthly during 1971 at Pawnee with a D-vac suction apparatus on the grazed (1970)-ungrazed (1971) treatment.

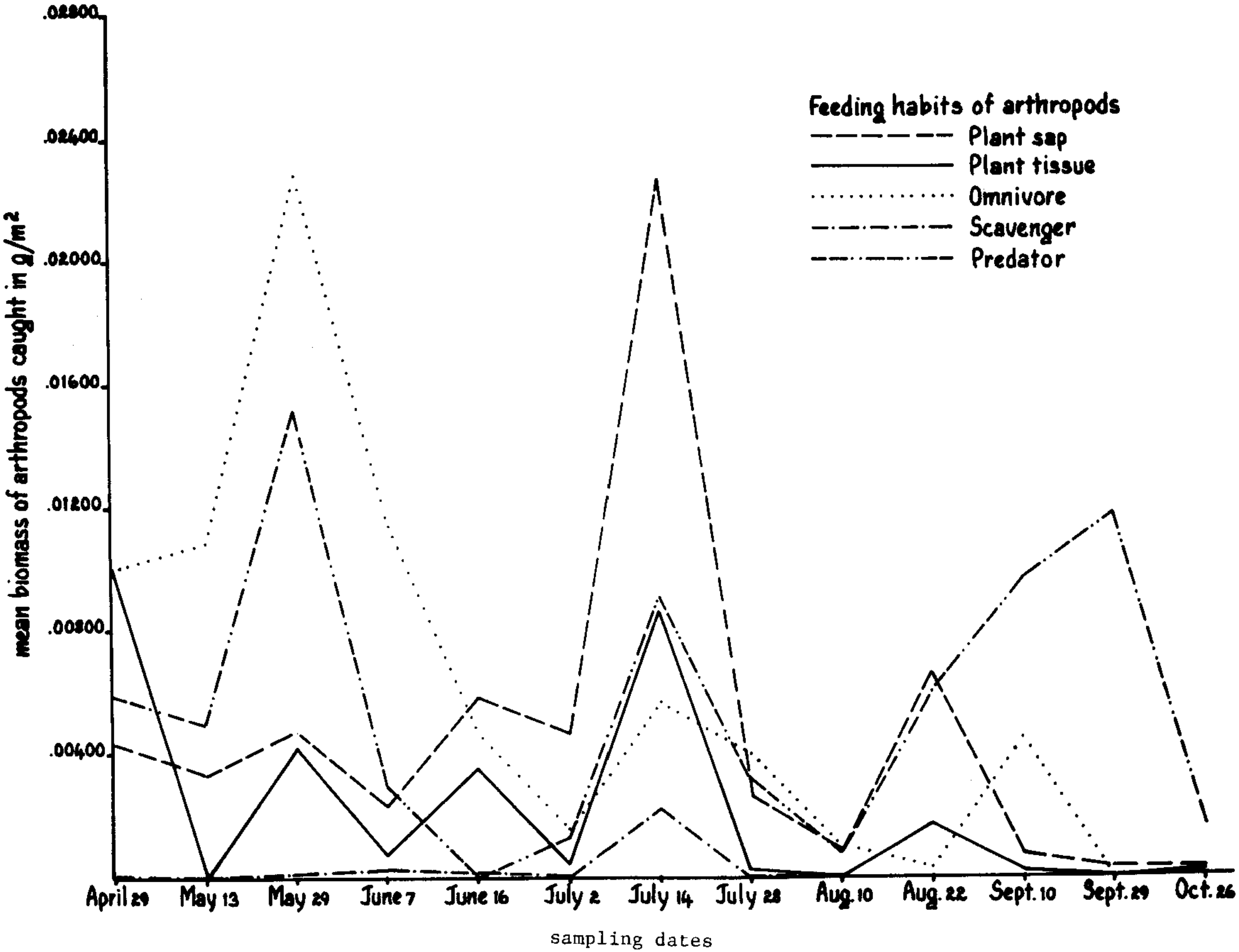


Fig. 5. Comparison of mean biomass in grams per meter squared of aboveground arthropods representing different trophic levels collected bimonthly during 1971 at Pawnee with a D-vac suction apparatus on the permanently ungrazed treatment.

ungrazed pasture. Scavengers, predators and plant tissue feeders did not show much variance, numerically, between pasture types. When the data is presented in terms of biomass as in fig. 2 to 5, the picture becomes somewhat confused, but here again omnivores and plant sucking insects predominate weight wise in the permanently ungrazed pastures. This is partly, of course, a reflection of greater numerical superiority. Interestingly enough in this same pasture scavengers, plant tissue feeders and predators are also represented by greater biomass on most dates during the season, perhaps indicating that they are feeding better under the permanently ungrazed conditions.

DIFFERENTIALLY GRAZED PASTURE SAMPLING

Comparison of Arthropods

Data are presented in Tables 57 through 60 on the mean numbers meter squared of aboveground arthropods, by order, taken in four grassland treatments on major sampling dates. The four treatments were ungrazed, lightly grazed, moderately grazed, and heavily grazed. Unfortunately, weather conditions were such that samples were not taken on the first major sampling date, i.e., March 25. As can be seen by examining the tables, the ungrazed and lightly grazed pastures supported the largest populations in many groups on the 2nd major sampling date. There was some shift in numbers between light and moderate grazing treatments, but populations in both continually exceeded those of the heavily grazed pasture. Lightly grazing the pastures favored a buildup of Homoptera (plant sucking insects) which was maintained throughout the season. The occurrence of large numbers of these plant bugs in the heavily grazed pasture early in the season probably reflects the almost constant appearance of new growth which was unavailable later in the season due to grazing pressure. The least number of Hymenoptera (represented primarily by ants) was found in the heavily grazed pasture.

Table 57. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	2.4	2.2	1.8	2.2
Acarina	14.4	3.6	1.8	3.4
Collembola	--	--	--	--
Orthoptera	--	0.6	0.2	0.2
Hemiptera	8.2	39.4	4.6	5.8
Homoptera	1.8	4.0	1.2	12.0
Thysanoptera	--	--	--	0.8
Lepidoptera	1.4	1.2	1.0	0.6
Hymenoptera	11.6	14.4	10.4	8.4
Coleoptera	40.0	21.0	20.2	18.2
Diptera	3.2	0.6	0.4	4.0
Neuroptera	0.2	0.2	--	--
Isoptera	--	--	0.4	0.2
Psocoptera	--	--	0.4	--
Lithobiomorpha	--	--	0.4	--
Chelonethida	1.4	--	--	--
TOTAL (Computer)	84.6	87.2	42.8	55.8
Adults	53.4	44.6	35.6	35.2
Nymph/larvae	31.2	42.6	7.2	20.6

[a/] Actually collected on or about April 29.

Table 58. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	--	0.6	--	--
Acarina	8.6	6.2	2.6	0.8
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	1.8	2.2	0.4	0.8
Homoptera	6.2	17.8	7.2	13.2
Thysanoptera	--	--	--	--
Lepidoptera	1.0	8.8	1.0	1.4
Hymenoptera	3.6	19.2	19.4	1.6
Coleoptera	6.6	6.6	4.6	5.4
Diptera	4.0	0.4	1.2	0.8
Neuroptera	--	0.2	--	0.2
Psocoptera	--	--	--	--
TOTAL (Computer)	31.8	62.0	36.6	24.2
Adults	26.8	50.8	34.8	18.6
Nymph/larvae	5.0	11.2	1.8	5.6

a/ Actually collected on or about July 2.

Table 59. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	4.6	1.6	1.6	0.2
Acarina	--	--	0.4	--
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	2.6	0.2	0.2	0.6
Homoptera	7.0	11.0	5.8	3.0
Thysanoptera	0.2	--	--	--
Lepidoptera	1.0	0.4	4.0	0.2
Hymenoptera	2.0	1.0	0.8	5.0
Coleoptera	16.2	5.4	11.0	5.0
Diptera	--	0.2	--	--
Neuroptera	0.2	0.4	--	0.2
Chelonethida	1.2	--	--	--
TOTAL (Computer)	35.0	20.2	23.8	14.2
Adults	25.6	11.6	19.2	11.4
Nymph/larvae	9.4	8.6	4.6	2.8

a/ Actually collected on or about August 22.

Table 60. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	--	0.2	0.4	--
Acarina	--	--	--	--
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	0.2	--	--	0.4
Homoptera	--	0.4	2.4	--
Thysanoptera	--	--	--	--
Lepidoptera	0.4	0.6	--	0.2
Hymenoptera	--	--	--	--
Coleoptera	4.6	1.0	1.4	2.6
Diptera	--	--	0.2	--
Neuroptera	0.2	--	--	--
Isoptera	--	--	--	--
Psocoptera	--	--	--	--
Chelonethida	--	--	--	--
Total (computer)	5.4	2.2	4.4	3.2
Adults	3.2	1.2	4.4	3.0
Nymph/larvae	2.2	1.0	--	0.2

a/ Actually collected on or about October 26.

This was to be expected since these omnivores utilize large amounts of pollen and nectar and flowering plants were largely absent in this pasture. Similarly Coleoptera were much scarcer in heavily grazed plots reflecting in large measure the absence of the flowers and seeds upon which many species feed and develop. There was no apparent trend in the rest of the groups although the Psocoptera (psocids) were only picked up in the moderately grazed pasture. The presence of Thysanoptera (thrips) only in the heavily grazed pasture is misleading. Various species of Thrips occur both in flower heads and grass blossoms, but their small size precludes their being picked up by this method of sampling. The large number of Acarina (mites) present early in the season in the ungrazed pasture may indicate that many are scavengers and the presence of undisturbed litter is necessary for population buildups. The other groups occur too infrequently or no trend is evident, so nothing else can be added.

When total arthropod numbers by grazing treatments are looked at numerically (Tables 57-60) as well as graphically (Fig. 6), the only definite trends that can be ascertained are that the heavily grazed pastures generally supported smaller populations of arthropods and that the numbers of arthropods in the treatments showed a steady decline as the season progressed, at about the same rate for all treatments.

Similar information is presented in Tables 61 to 64 and Fig. 7 wherein the data are presented as insect biomass. Because of the great number of species involved, it is difficult to attribute any significance to these figures. As in other cases where biomass is presented by taxonomic category, the most that can be said is that observed changes represent changes in species composition. When taken on a family basis in the major orders, those insects having the greatest numbers of biomass fell in the families of

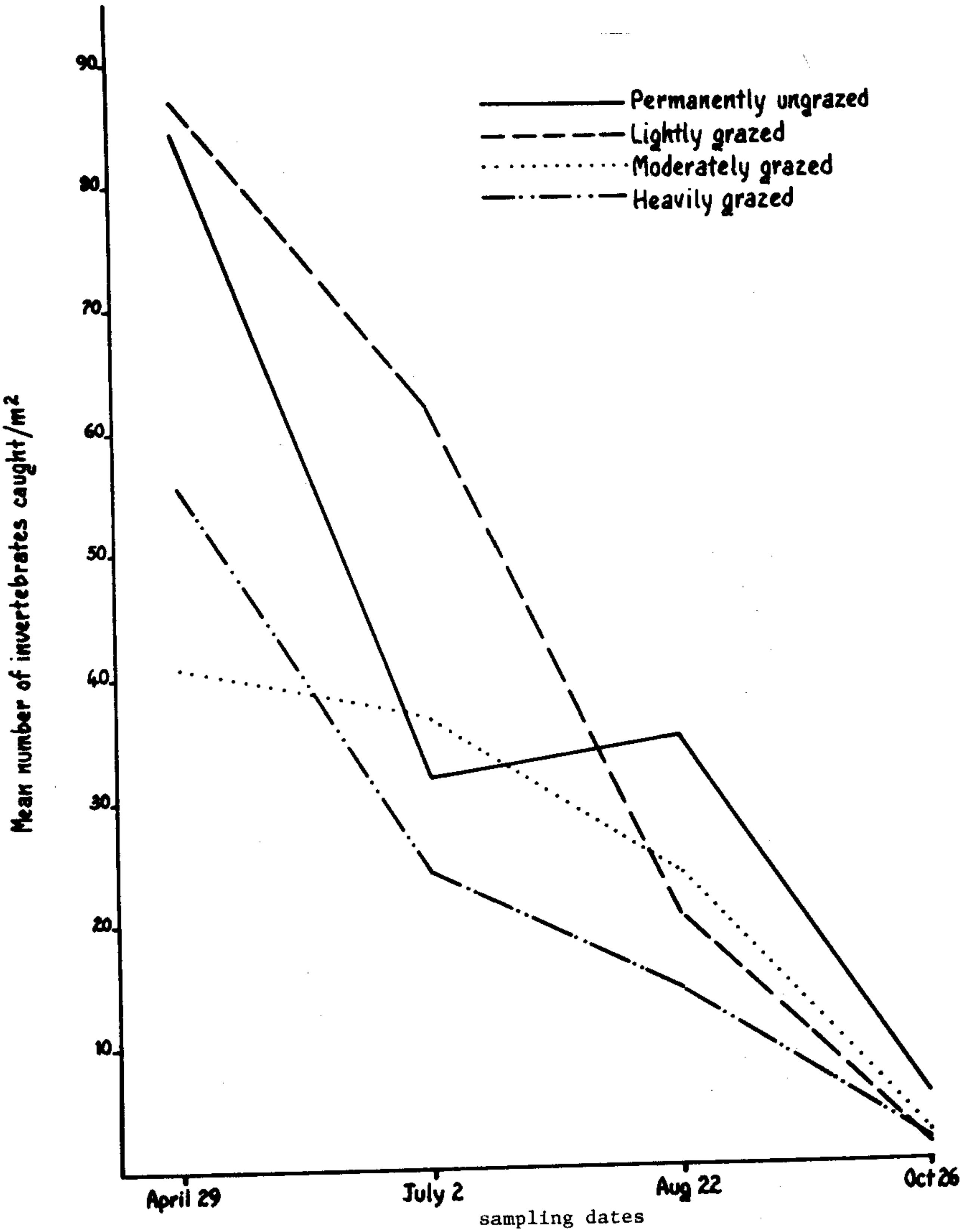


Fig. 6. Comparison of effects of four grazing treatments on arthropod populations on the Pawnee Site (1971), as expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on the second, third, fourth and fifth major sampling dates.

Table 61. Comparison of mean biomass in g/m^2 of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	.00263	.00310	.00362	.00306
Acarina	.00111	.00021	.00025	.00022
Collembola	--	--	--	--
Orthoptera	--	.04268	.00159	.00952
Hemiptera	.00926	.01488	.00354	.00120
Homoptera	.00057	.00170	.00055	.00382
Thysanoptera	--	--	--	.00004
Lepidoptera	.00593	.00324	.00314	.00320
Hymenoptera	.00990	.01533	.00540	.00551
Coleoptera	.08804	.10638	.03832	.10215
Diptera	.00260	.00020	.00027	.00307
Neuroptera	.00016	.00016	--	--
Isoptera	--	--	.00018	.00009
Psocoptera	--	--	.00000	--
Lithobiomorpha	--	--	.00197	--
Chelonethida	.00297	--	.00197	--
TOTAL (Computer)	.12317	.18787	.05882	.13188
Adults	.07359	.11016	.03648	.08889
Nymph/larvae	.04948	.07751	.02234	.04299

a/Actually collected on or about April 29.

Table 62. Comparison of mean biomass in g/m^2 of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	--	.00141	--	--
Acarina	.00066	.00047	.00017	.00006
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	.00118	.00351	.00012	.00118
Homoptera	.00400	.00913	.00282	.00593
Thysanoptera	--	--	--	--
Lepidoptera	.00199	.07108	.00472	.01159
Hymenoptera	.00366	.01366	.00617	.00482
Coleoptera	.11434	.03483	.00575	.02040
Diptera	.00316	.00000	.00167	.00065
Neuroptera	--	.00032	--	.00016
Psocoptera	--	--	.00000	--
TOTAL (Computer)	.12900	.13397	.02143	.04479
Adults	.01854	.11225	.02067	.01747
Nymph/larvae	.11046	.02172	.00076	.02732

a/Actually collected on or about July 2.

Table 63. Comparison of mean biomass in g/m^2 of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	.00138	.00070	.00081	.00033
Acarina	--	--	.00010	--
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	.00135	.00019	.00162	.00009
Homoptera	.00516	.01451	.00246	.00283
Thysanoptera	.00001	--	--	--
Lepidoptera	.00052	.00021	.00208	.00010
Hymenoptera	.00072	.00320	.00123	.00449
Coleoptera	.05226	.05734	.05207	.01843
Diptera	--	.00012	--	--
Neuroptera	.00024	.00033	--	.00024
Chelonethida	.00254	--	--	--
TOTAL (Computer)	.06418	.07660	.06037	.02652
Adults	.05728	.05135	.05652	.02515
Nymph/larvae	.00690	.02525	.00385	.00137

a/Actually collected on or about August 22.

Table 64. Comparison of mean biomass in g/m ^{2} of aboveground arthropods of different groups taken in four grassland treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.[a/]

Group	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Araneida	--	.00008	.00016	--
Acarina	--	--	--	--
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	.00770	--	--	.00942
Homoptera	--	.00612	.01030	--
Thysanoptera	--	--	--	--
Lepidoptera	.00208	.00312	--	.00104
Hymenoptera	--	--	--	--
Coleoptera	.17384	.03170	.05766	.09674
Diptera	--	--	.0000	--
Neuroptera	.00164	--	--	--
Isoptera	--	--	--	--
Psocoptera	--	--	--	--
Chelonethida	--	--	--	--
Total (computer)	.18526	.04102	.06812	.10720
Adults	.11994	.03178	.06812	.10616
Nymph/larvae	.06532	.00924	--	.00104

a/Actually collected on or about October 26.

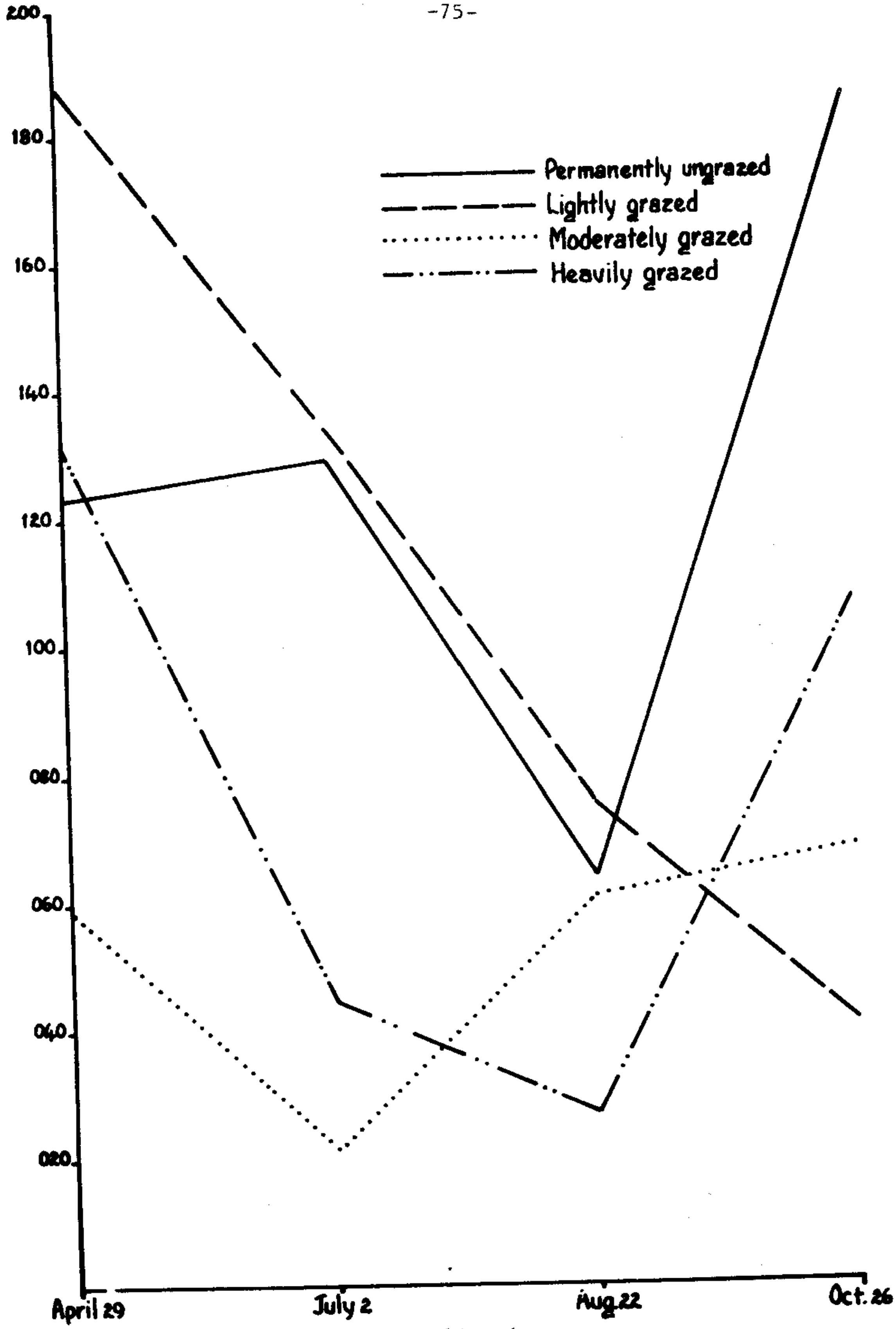


Fig. 7. Comparison of effects of four grazing treatments on biomass of arthropod populations on the Pawnee Site (1971), as expressed in grams per meter squared, collected with a D-vac suction apparatus on the second, third, fourth and fifth major sampling dates.

Scarabaeidae, Tenebrionidae, and Lygaeidae (Tables 65 to 68). The extreme upsurge in biomass on the fifth sampling date (October 26) reflects the presence of large numbers of arctiid larvae (Lepidoptera) feeding on various living plants, and large numbers of curculionids and tenebrionids (Coleoptera). The former are probably all plant tissue feeders, whereas the latter appear to gravitate from scavenging to plant tissue feeding.

Abundance of Arthropods Expressed in Terms of Feeding Habit

Utilizing the same information used in establishing the types of feeding habits for insects collected in the bimonthly samples, comparisons were made of the effect of grazing pressure on the abundance of insects according to food habit. These data are presented graphically in Fig. 8 to 12 and in Tables 69, 70, 71, and 72.

As can be seen from the data, plant sap feeding arthropods (Fig. 8) were more abundant per square meter in the lightly grazed pasture. Ungrazed and heavy grazing pressure were about even in their effect on abundance of these insects, whereas very few sap feeding arthropods were found in the moderate grazed pasture.

Omnivores (primarily ants) (Fig. 9) were more abundant in the lightly and moderately grazed pastures. Although the numbers fall off drastically later in the season, this is probably an artifact of the weather, i.e., hot weather in August would keep them underground during the hotter part of the days, and by late October many species have retreated to chambers in which overwintering takes place. The samll numbers present in the ungrazed pasture was somewhat surprising. It should be noted, though, that the ungrazed pastures used were small plots (4 acres) within other pastures, and the conditions therein do not necessarily reflect the actual effect of non-grazing although these fenced plots were ungrazed for several years.

Table 65. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in major orders taken in four grassland treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Scarabaeidae	.01228	.00662	.00936	.00374
Tenebrionidae	.05196	.06838	.02003	.06932
Curculionidae	.00603	.02286	.00193	.02699
Coccinellidae	.00024	--	--	--
Staphylinidae	.00011	.00022	.00022	.00064
Carabidae	.00292	.00576	.00507	.00046
Chrysomelidae	.00984	.00048	.00028	.00024
Elateridae	.00034	.00110	--	.00008
Anthicidae	.00010	--	--	--
HEMIPTERA				
Lygaeidae	.00130	.00723	.00054	.00079
Cydnidae	.00626	.00547	.00078	--
Tingidae	--	.00064	.00016	.00032
Phymatidae	.00017	--	.00017	--
Corixidae	.00153	.00153	.00153	--
Miridae	--	--	.00035	--
Piesmidae	--	--	--	.00008
HOMOPTERA				
Cicadellidae	.00049	.00162	.00045	.00080
Pseudococcidae	.00008	.00008	.00008	.00279
Aphididae	--	--	.00002	.00022
DIPTERA				
Cecidomyiidae	.00002	.00004	.00002	.00007
Chironomidae	.00032	--	--	--
Culicidae	.00016	--	--	--

Table 66. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in major orders taken in four grassland treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Tenebrionidae	.10786	.02407	.00355	.01695
Curculionidae	.00408	.00056	.00056	.00028
Coccinellidae	.00027	.00015	.00027	.00063
Staphylinidae	--	--	.00049	--
Carabidae	.00129	.00567	.00040	.00129
Chrysomelidae	.00047	.00195	.00009	.00003
Anthicidae	--	.00001	--	--
Nitidulidae	--	--	--	.00062
Mordellidae	.00007	--	--	--
HEMIPTERA				
Lygaeidae	.00006	.00163	.00012	.00118
Cydnidae	--	.00156	--	--
Tingidae	.00112	.00032	--	--
HOMOPTERA				
Cicadellidae	.00400	.00885	.00269	.00586
Pseudococcidae	--	.00023	--	.00008
Aphididae	--	.00005	.00004	--
Psyllidae	--	--	.00010	--

Table 67. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in major orders taken in four grassland treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Tenebrionidae	.02641	.03973	.00957	.01711
Curculionidae	.01733	.00930	.01021	.00056
Coccinellidae	.00117	.00006	.00018	.00060
Carabidae	.00061	.00777	.03047	.00007
Chrysomelidae	.00155	.00038	.00145	.00009
HEMIPTERA				
Lygaeidae	.00093	--	--	.00009
Tingidae	.00029	.00019	--	--
Coreidae	--	--	.00162	--
HOMOPTERA				
Cicadellidae	.00469	.01388	.00246	.00283
Membracidae	--	.00026	--	--
Dictyopharidae	--	.00037	--	--

Table 68. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in major orders taken in four grassland treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Tenebrionidae	.14048	.00770	.05484	.09392
Curculionidae	.03106	.02400	.00282	.00282
Chrysomelidae	.00230	--	--	--
HEMIPTERA				
Lygaeidae	.00770	--	--	--
Tingidae	--	--	--	.00160
Cydnidae	--	--	--	.00782
HOMOPTERA				
Cicadellidae	--	.00612	.01030	--

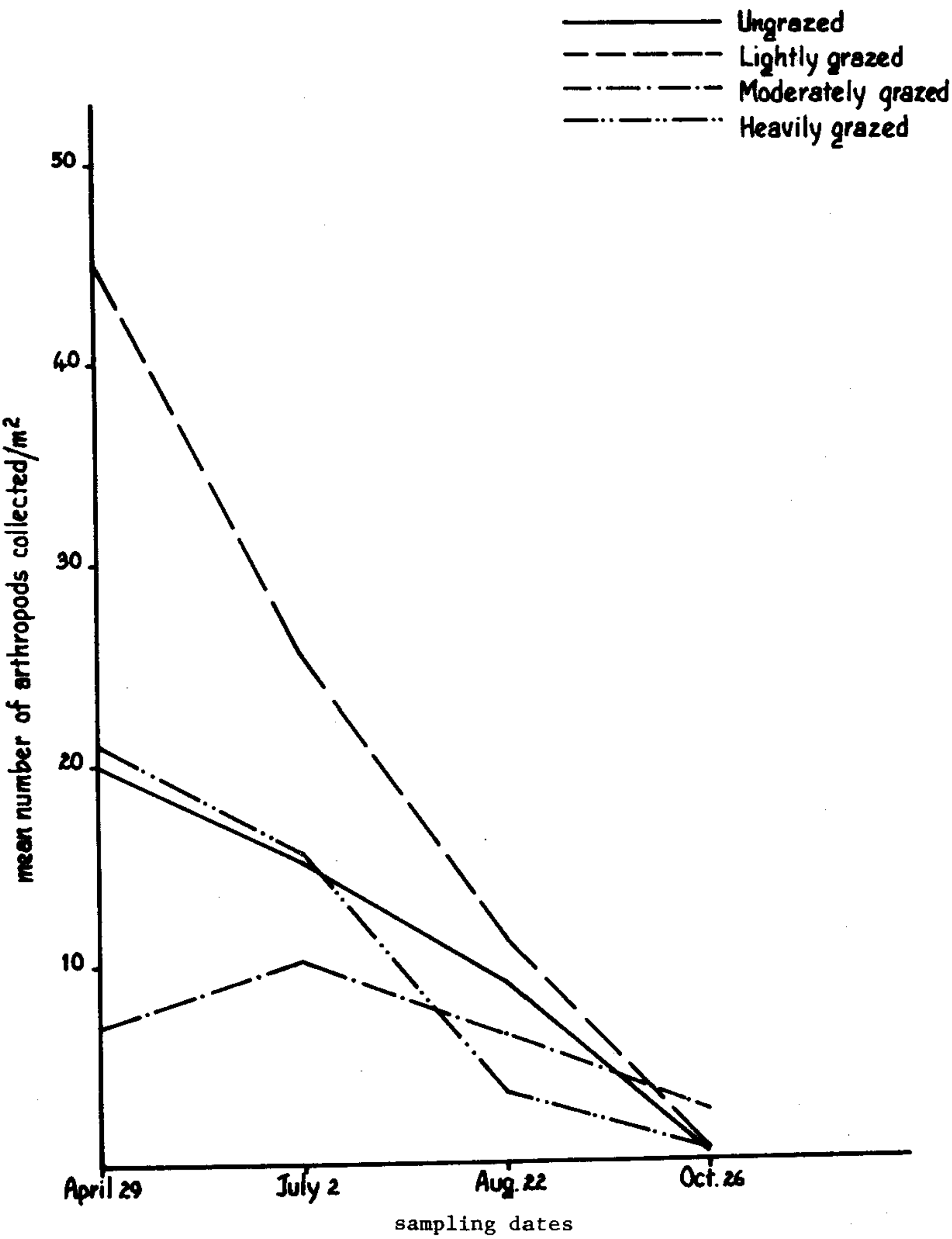


Fig. 8. Comparison of the abundance of plant sap feeding arthropods under four differential grazing treatments expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on four major sampling dates.

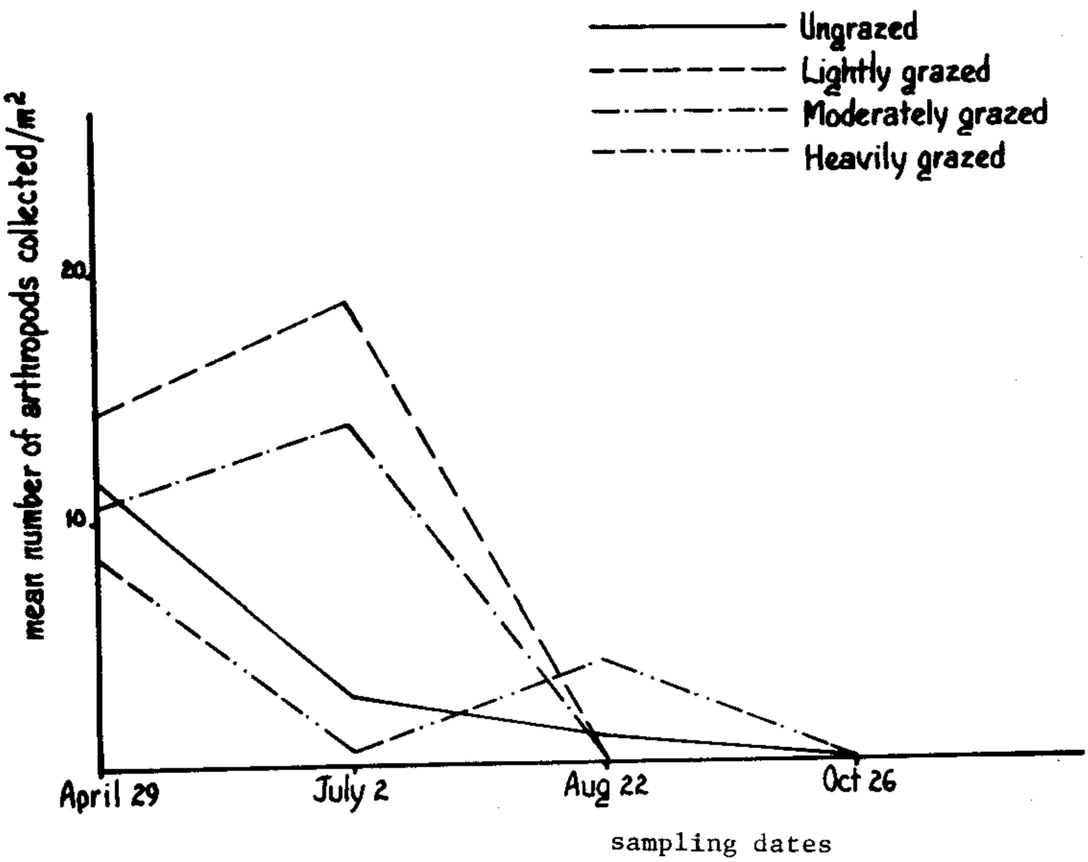


Fig. 9. Comparison of the abundance of arthropod omnivores under four differential grazing treatments expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on four major sampling dates.

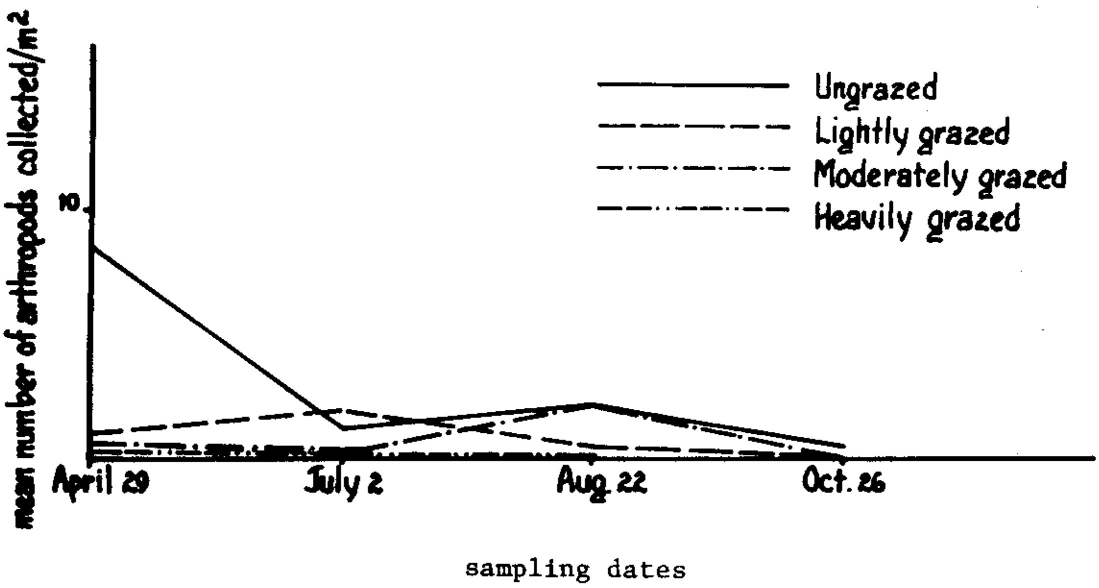


Fig. 10. Comparison of the abundance of plant tissue feeding arthropods under four differential grazing treatments expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on four major sampling dates.

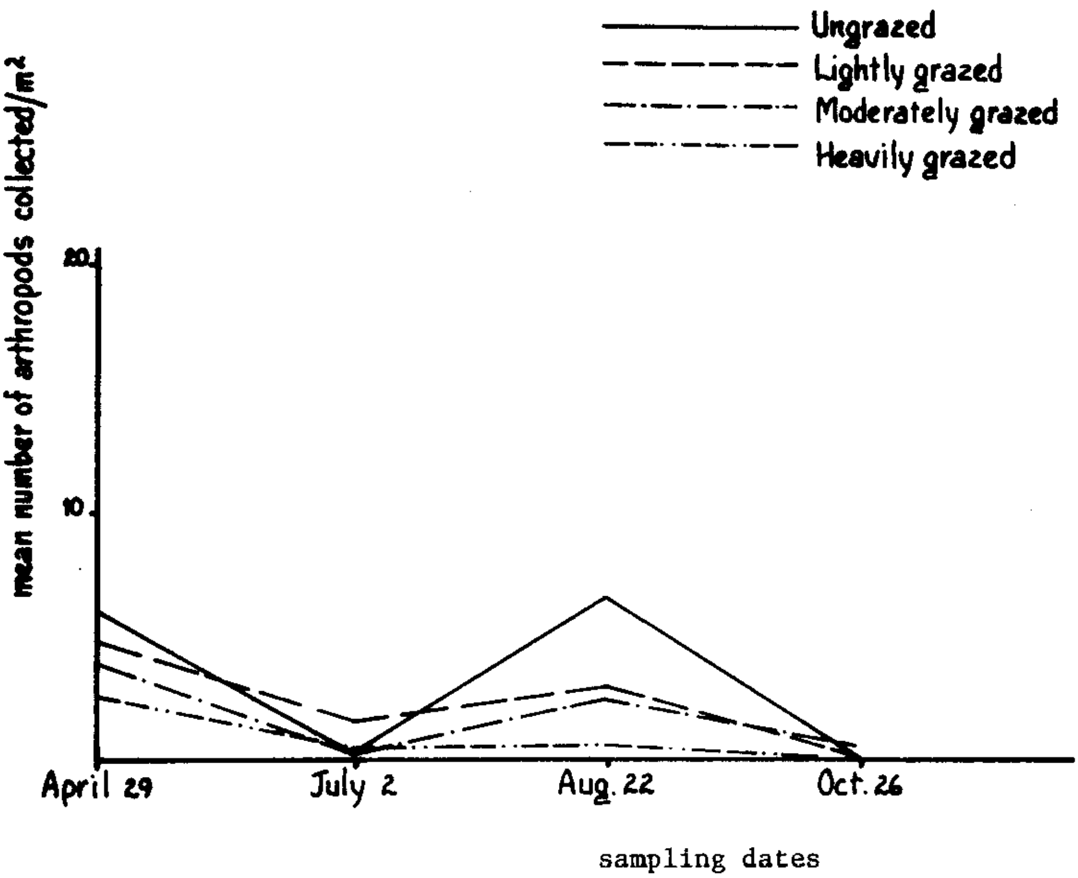


Fig. 11. Comparison of the abundance of predatory arthropods under four differential grazing treatments expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on four major sampling dates.

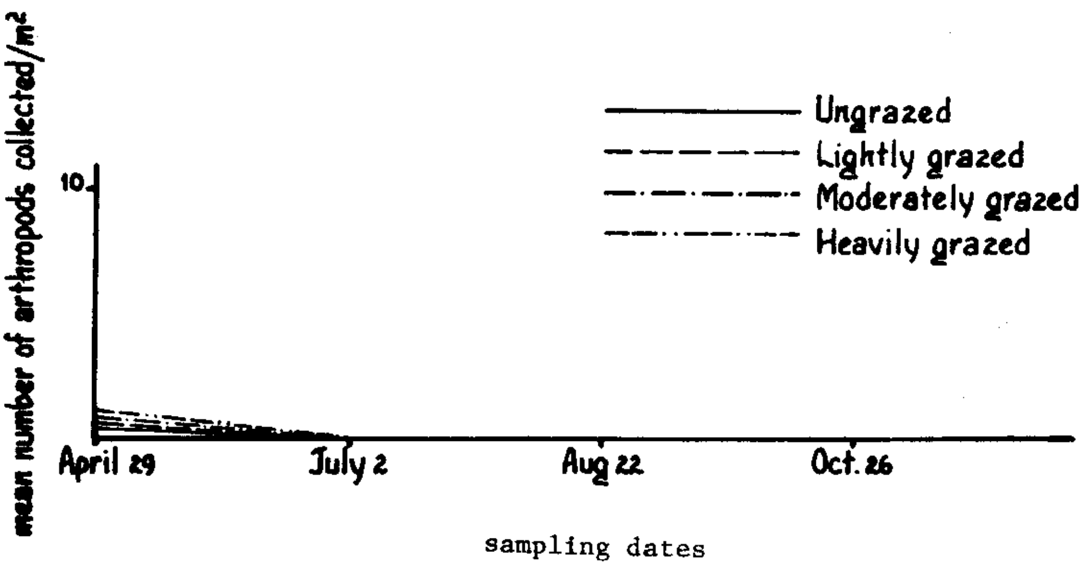


Fig. 12. Comparison of the abundance of scavenger arthropods under four differential grazing treatments expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on four major sampling dates.

Table 69. Comparison of mean numbers/m^2 of aboveground arthropods representing different trophic levels taken in four grassland treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.

Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant sap	19.8	44.8	6.8	21.2
Plant tissue	8.4	1.0	0.6	0.4
Omnivore	11.6	14.2	10.4	8.4
Scavenger	0.2	0.4	0.8	1.0
Predator	5.8	4.4	3.8	2.6
Unknown	38.8	22.4	20.4	22.2

Table 70. Comparison of mean numbers/m^2 of aboveground arthropods representing different trophic levels taken in four grassland treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.

Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant sap	15.2	25.6	10.2	15.6
Plant tissue	1.2	1.8	0.2	0.2
Omnivore	2.8	18.6	13.8	0.6
Scavenger	--	--	0.4	--
Predator	0.2	1.4	0.2	0.4
Unknown	12.1	14.6	11.8	7.4
Parasite	0.2	--	--	--

Table 71. Comparison of mean numbers/m^2 of aboveground arthropods representing different trophic levels taken in four grassland treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.

Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant sap	8.9	11.2	6.4	3.6
Plant tissue	2.2	0.4	2.2	0.2
Omnivore	0.9	0.2	0.2	4.2
Scavenger	--	--	--	--
Predator	6.5	3.0	2.4	0.6
Unknown	13.3	5.4	12.6	5.6

Table 72. Comparison of mean numbers/m^2 of abovegound arthropods representing different trophic levels taken in four grassland treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.

Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant sap	0.2	0.4	2.4	0.4
Plant tissue	0.4	--	--	--
Predator	0.2	0.2	0.4	--
Unknown	4.6	1.6	1.6	2.8

Plant tissue feeding arthropods (Fig. 10) appeared in small numbers in all plots, and the high numbers in April in the ungrazed plot probably reflect the availability of more cover in which insects could overwinter. Whelan (1927) pointed out that bunchgrasses provide winter cover for a great number of insects on the prairie in eastern Kansas.

The numbers of predatory arthropods (Fig. 11) were not significantly different in any of the pastures, the numbers being greatest on August 22 in the ungrazed pasture. The lightly grazed pasture consistently supported more arthropod predators than did the heavily grazed pasture. This undoubtedly reflects the difference in numbers of potential prey available to the predators (see fig. 6).

Scavenging arthropods (Fig. 12) apparently disappeared from all plots either by migration out of the area or movement beneath the soil surface between the end of April and the beginning of July. Numbers were so low on April 29 that it is possible that their apparent disappearance is an artifact of insufficient sampling. At the same time, scavengers were consistently present in the bimonthly samples even though on a given date no more samples were taken on one plot versus another.

As regards biomass of insects in terms of feeding habit, these data are presented in Tables 73, 74, 75, and 76 as well as graphically in Fig. 13 to 17. On the whole, the insects in the light use pasture had the greatest biomass, except for scavengers whose weights were so small as to exhibit little difference between pastures. No great differences in insect biomass are apparent in the other three pasture treatments.

Table 73. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland treatments with D-vac suction apparatus at the time of the second major sampling date May 1, 1971.

Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant sap	.00433	.00991	.00169	.00479
Plant tissue	.00994	.04316	.00187	.00976
Omnivore	.00990	.01518	.00540	.00551
Scavenger	.00011	.00022	.00040	.00073
Predator	.00590	.00902	.01066	.00352
Unknown	.09300	.11038	.03881	.10756

Table 74. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.

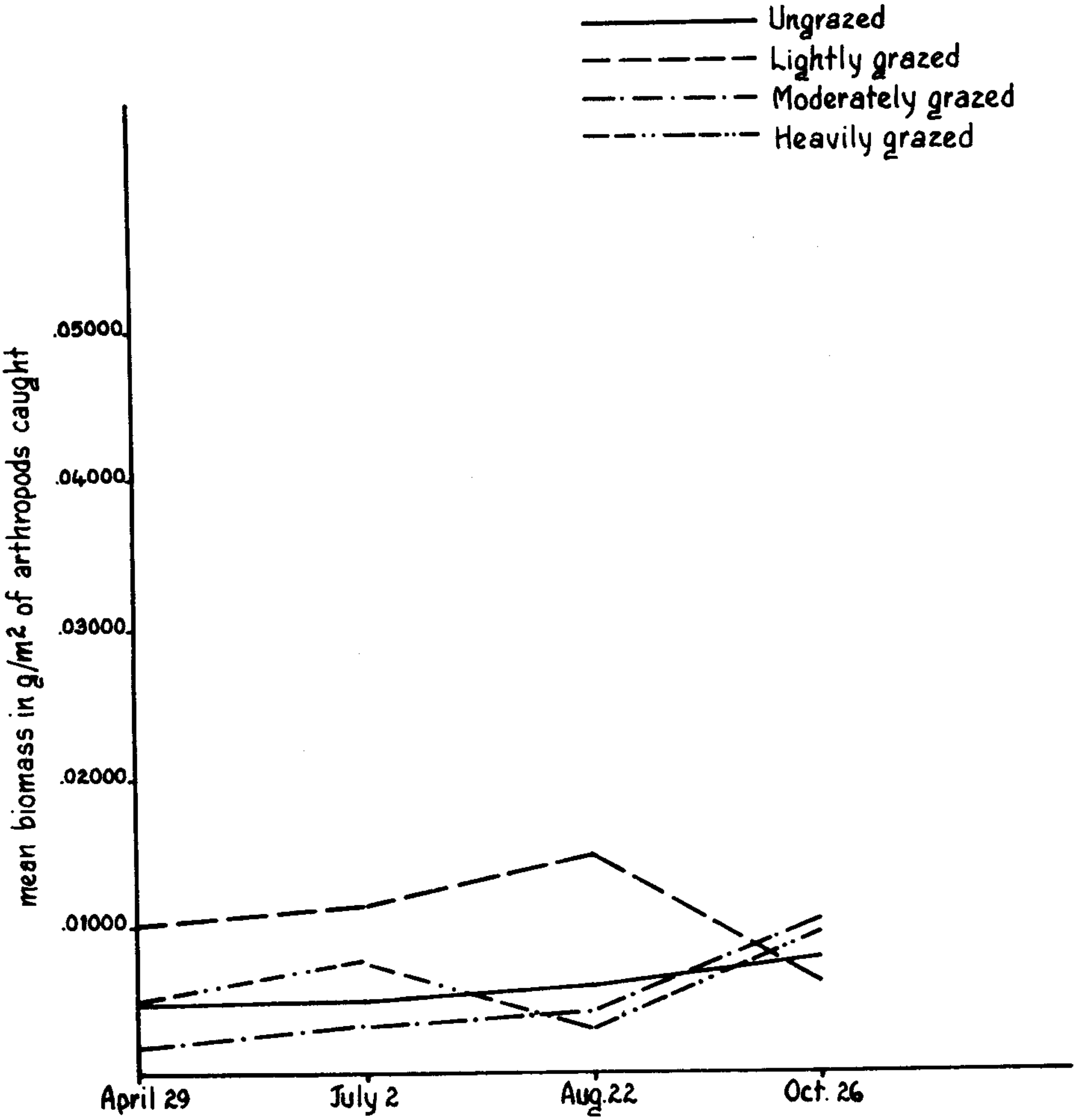
Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant sap	.00472	.01139	.00311	.00741
Plant tissue	.00047	.00195	.00009	.00003
Omnivore	.00167	.01148	.00589	.00108
Scavenger	--	--	.00049	--
Predator	.00129	.00739	.00040	.00146
Unknown	.12084	.10176	.01145	.03482
Parasite	.00000	--	--	--

Table 75. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.

Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant sap	.00593	.01469	.00418	.00292
Plant tissue	.00155	.00038	.00145	.00009
Omnivore	.00048	.00032	.00032	.00184
Scavenger	--	--	--	--
Predator	.00546	.00880	.02869	.00064
Unknown	.04493	.05240	.02573	.02104

Table 76. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.

Feeding habit	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
Plant Sap	.00770	.00612	.01030	.00942
Plant tissue	.00230	--	--	--
Predator	.00164	.00008	.00016	--
Unknown	.17362	.03482	.05766	.09778



sampling dates

Fig. 13. Comparison of plant sap feeding biomass expressed in grams per meter squared under conditions of four differential grazing treatments collected with a D-vac suction apparatus on four major sampling dates.

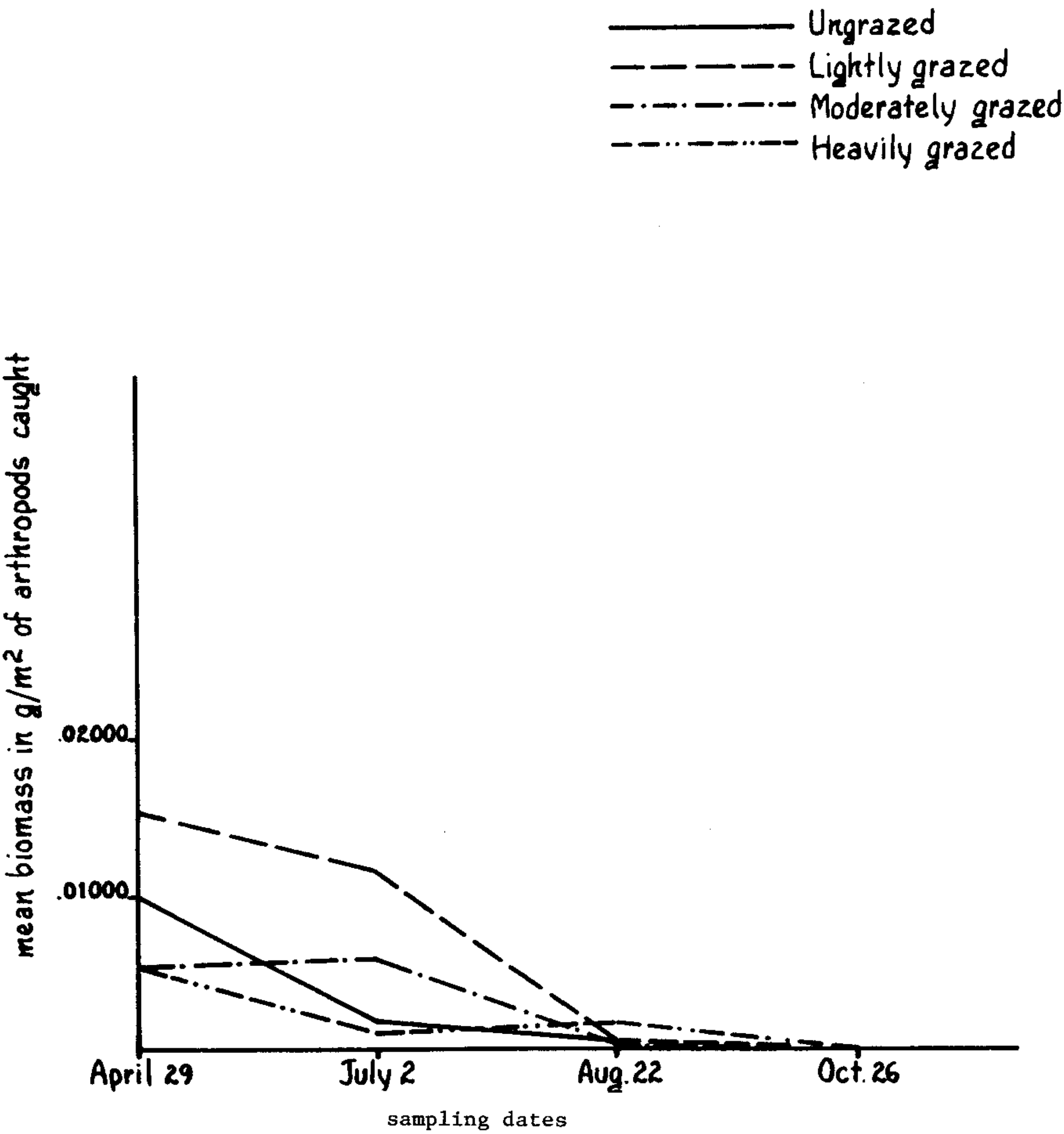


Fig. 14. Comparison of arthropod omnivore biomass expressed in grams per meter squared under conditions of four differential grazing treatments collected with a D-vac suction apparatus on four major sampling dates.

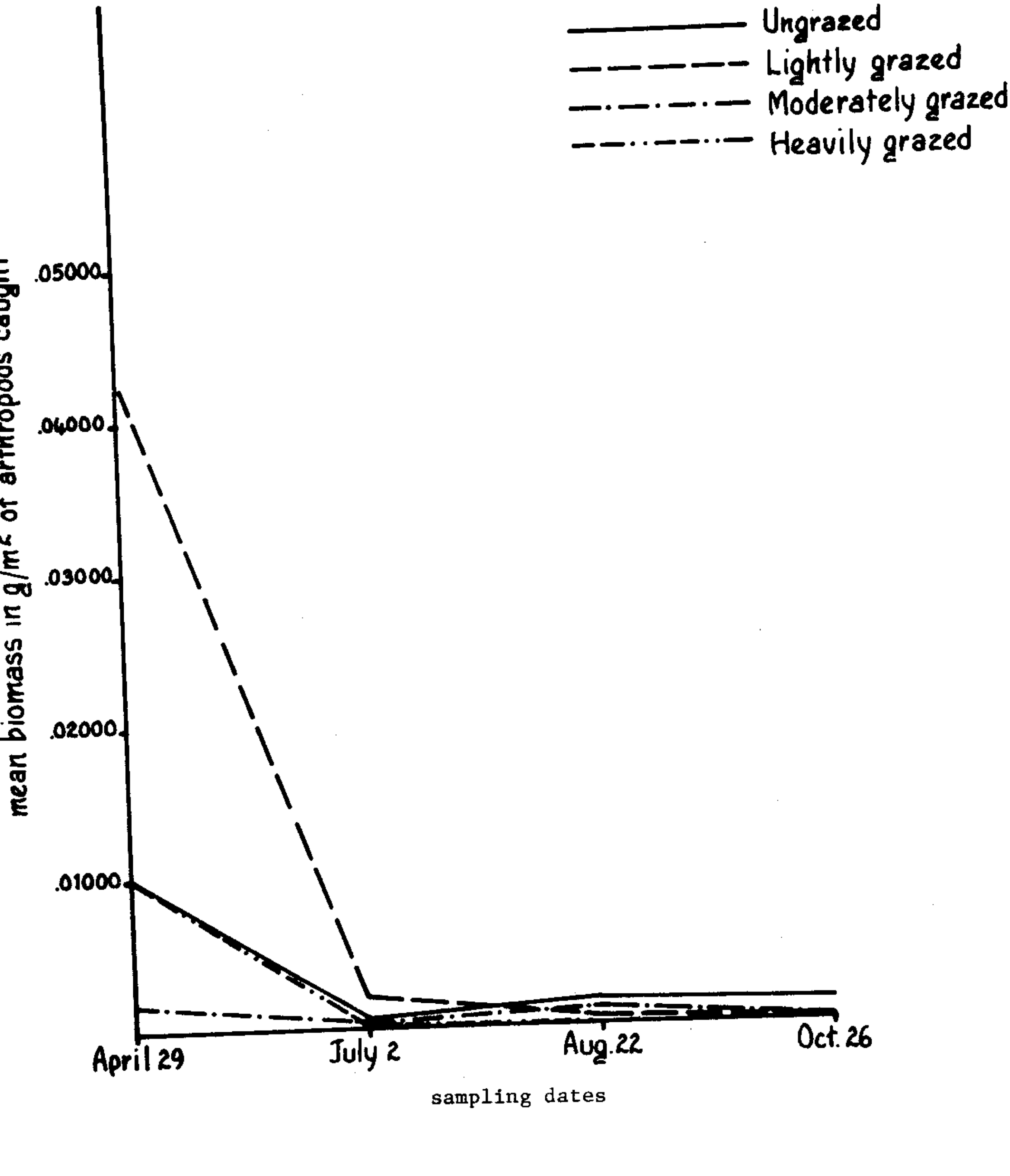


Fig. 15. Comparison of plant tissue feeding arthropod biomass expressed in grams per meter squared under conditions of four differential grazing treatments collected with a D-vac suction apparatus on four major sampling dates.

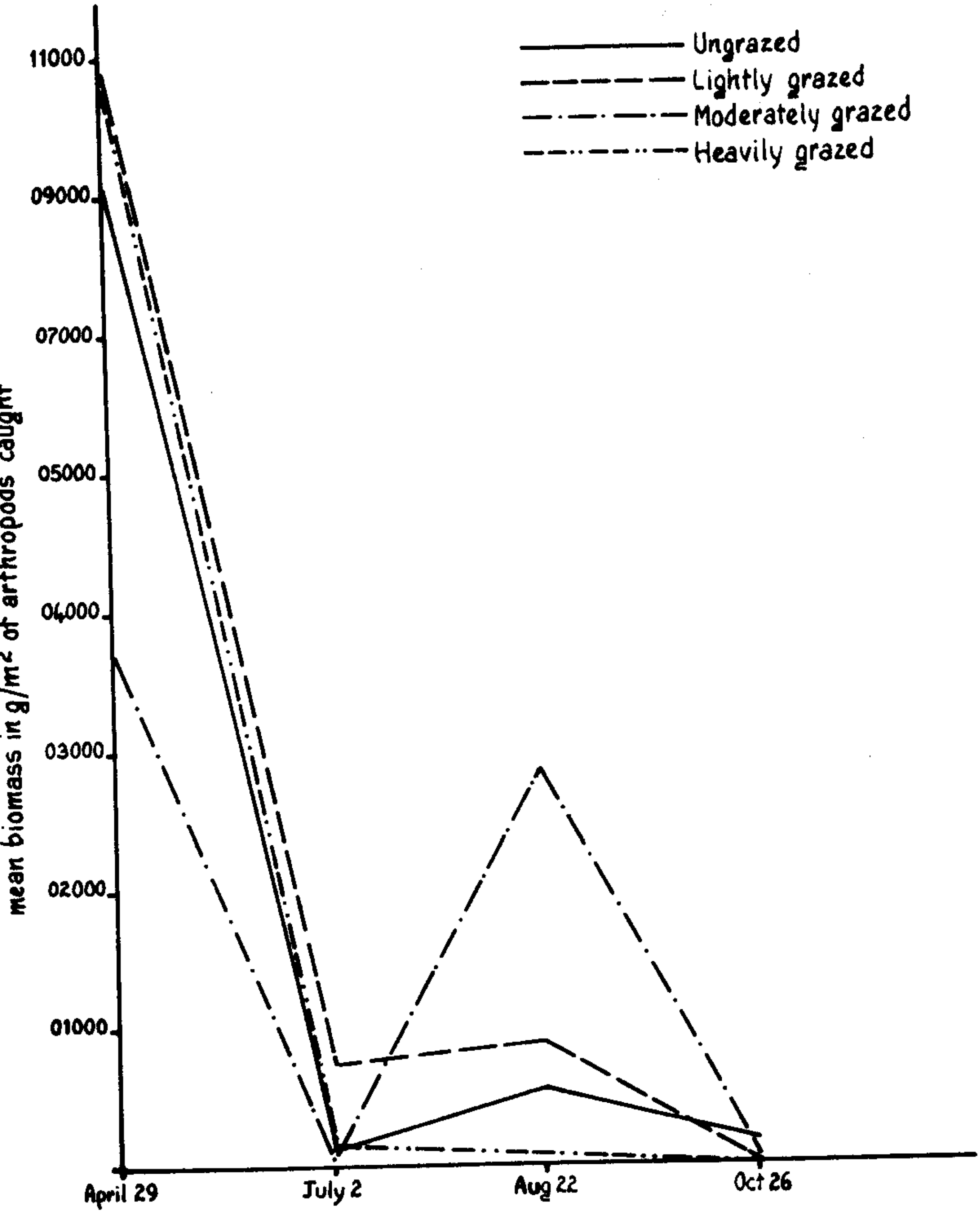


Fig. 16. Comparison of predatory arthropod biomass expressed in grams per meter squared under conditions of four differential grazing treatments collected with a D-vac suction apparatus on four major sampling dates.

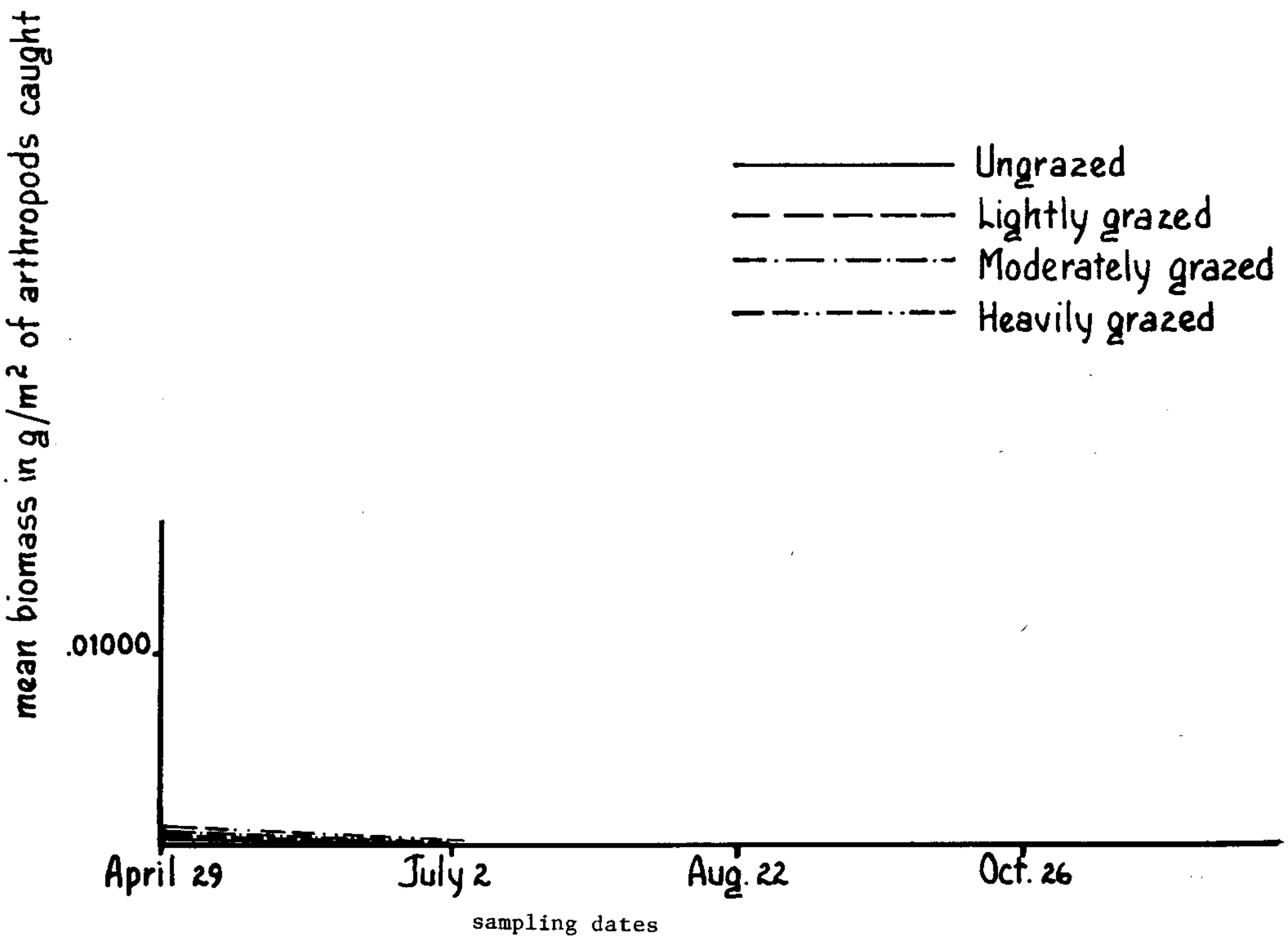


Fig. 17. Comparison of scavenger arthropod biomass expressed in grams per meter squared under conditions of four differential grazing treatments collected with a D-vac suction apparatus on four major sampling dates.

STRESS TREATMENT SAMPLING

Comparison of Arthropod Populations

The data on mean numbers per meter squared of aboveground arthropods are presented in Tables 77 through 81 by major group taken in four grassland stress treatments. The conditions of stress were control, water, nitrogen, and water plus nitrogen. Further details on the stress treatments may be found in Sims et al. (1971).

Samples of aboveground insects were collected in these plots on five major sampling dates (March 25, May 1, June 25, August 20, and October 15), using the previously described vacuum sampling technique. Numbers of the following major groups were insufficient to enable us to judge the effects of stress: Araneida, Collembola, Orthoptera, Thysanoptera, Neuroptera, Siphonaptera, Diptera, Chelonethida, Psocoptera, Ephemeroptera, and Trichoptera. Observed trends in the other groups are presented below. It should be noted that in all cases, numbers of samples taken were insufficient according to computer analysis. Consequently, no statistical differences can be detected.

Acarina: The mites responded to all three applications, but showed the greatest response numerically to the water plus nitrogen treatment. However, on the last two sample dates no mites were collected by the vacuum method.

Hemiptera: These sucking insects were represented primarily by *Blissus leucopterus* (Say) in the stress pastures (Table 82) although eight families had representatives in the plots. While there was no great differences between treatments on the first sample date (Tables 83 to 87), as the

Table 77. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the first major sampling date March 25, 1971.[a/]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	3.2	4.8	3.4	1.6
Acarina	1.6	1.0	0.6	8.0
Collembola	--	--	0.4	1.4
Orthoptera	1.0	0.4	0.8	0.4
Hemiptera	48.0	48.6	31.4	66.2
Homoptera	7.0	9.8	3.6	54.6
Thysanoptera	0.6	--	0.2	--
Lepidoptera	2.0	0.6	1.6	1.4
Hymencptera	31.8	16.8	13.0	16.6
Coleoptera	11.0	9.4	12.6	26.6
Diptera	--	1.2	0.4	1.8
Neuroptera	--	--	--	--
Siphonaptera	--	--	0.2	--
Chelonethida	--	--	0.4	--
TOTAL (Computer)	106.2	92.6	68.4	178.6
Adults	49.6	38.2	34.0	66.4
Nymph/larvae	56.6	54.4	34.4	112.2

a/Actually collected on or about April 16.

Table 78. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971. [a/]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	1.4	0.6	0.2	2.0
Acarina	6.8	35.2	48.6	179.2
Collembola	0.2	1.0	--	0.2
Orthoptera	0.2	0.2	--	0.2
Hemiptera	12.2	48.2	8.2	43.2
Homoptera	14.8	122.0	43.2	50.4
Thysanoptera	1.0	3.8	1.0	1.0
Lepidoptera	4.2	1.8	4.8	3.6
Hymenoptera	20.0	36.8	38.6	63.8
Coleoptera	7.4	15.8	11.2	32.2
Diptera	0.8	2.2	1.0	11.0
Neuroptera	--	--	--	--
Psocoptera	0.2	0.4	--	--
TOTAL (Computer)	69.2	268.0	156.8	386.8
Adults	42.0	109.4	101.0	304.2
Nymph/larvae	27.2	158.6	55.8	82.6

a/Actually collected on or about May 21.

Table 79. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.[a]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	3.0	1.8	1.2	1.8
Acarina	0.8	2.6	2.0	14.8
Collembola	--	--	--	0.4
Orthoptera	0.2	--	--	--
Hemiptera	5.8	11.8	3.2	21.4
Homoptera	33.0	48.6	23.4	111.4
Thysanoptera	--	--	--	5.2
Lepidoptera	5.4	8.6	5.4	7.8
Hymenoptera	18.4	20.8	19.4	18.2
Coleoptera	6.8	28.0	14.8	64.0
Diptera	0.4	7.2	0.8	4.0
Neuroptera	0.2	0.4	0.2	0.4
Ephemeroptera	--	0.2	--	--
Trichoptera	--	0.2	--	0.2
TOTAL (Computer)	74.0	130.2	70.4	249.6
Adults	51.2	93.8	56.2	168.8
Nymph/larvae	22.8	36.4	14.2	80.8

a/ Actually collected on or about July 8.

Table 80. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.[a/]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	2.2	2.0	0.6	5.2
Acarina	--	--	--	--
Collembola	--	--	--	--
Orthoptera	--	0.4	0.2	1.2
Hemiptera	0.6	10.0	0.8	38.6
Homoptera	5.0	17.0	2.6	17.6
Thysanoptera	--	--	--	6.0
Lepidoptera	3.4	7.4	2.4	8.0
Hymenoptera	0.2	11.0	2.4	15.2
Coleoptera	7.0	41.8	4.4	55.4
Diptera	0.4	0.2	--	--
Neuroptera	--	0.4	--	0.2
TOTAL (Computer)	18.8	90.2	13.4	147.4
Adults	12.8	76.0	9.8	127.4
Nymph/larvae	6.0	14.2	3.6	20.0

a/ Actually collected on or about August 24.

Table 81. Comparison of mean numbers/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.[a/]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	0.2	--	0.4	0.2
Acarina	--	--	--	--
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	3.4	31.4	4.8	17.8
Homoptera	1.8	13.0	--	38.2
Thysanoptera	--	--	--	--
Lepidoptera	0.4	0.2	--	--
Hymenoptera	--	--	--	--
Coleoptera	3.0	20.2	11.0	43.6
Diptera	--	--	--	0.2
Neuroptera	--	--	--	--
Chelonethida	--	--	--	--
TOTAL (Computer)	8.8	64.8	16.2	100.0
Adults	5.0	32.8	11.4	82.4
Nymph/larvae	3.8	32.0	4.8	17.6

a/ Actually collected on or about November 10.

Table 82. Comparison of mean numbers/m^2 of *Blissus leucopterus* taken in four grassland stress treatments with a D-vac suction apparatus.

Actual Sample Dates	Treatment			
	No Treatment	Water	Nitrogen	Water plus nitrogen
April 16	29.0	29.4	27.4	23.2
May 21	8.4	31.0	4.8	30.4
July 8	3.2	5.8	1.2	6.8
Aug. 24	0	9.2	0.6	12.0
Nov. 10	3.4	26.4	4.8	13.2

Table 83. Comparison of mean numbers/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the first major sampling date March 25, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	2.2	0.4	--	3.6
Tenebrionidae	2.0	1.0	2.0	2.6
Curculionidae	3.6	2.0	4.8	2.8
Coccinellidae	0.4	0.2	0.4	4.4
Staphylinidae	0.2	1.4	--	0.4
Carabidae	1.2	1.2	3.8	6.6
Chrysomelidae	0.4	1.4	0.8	1.8
Anthicidae	--	--	--	2.6
HEMIPTERA				
Lygaeidae	46.4	45.6	30.4	64.8
Cydnidae	--	--	--	0.2
Tingidae	1.4	2.8	0.4	0.8
Miridae	--	--	0.2	--
Nabidae	0.2	--	--	0.4
Coreidae	--	0.2	0.2	--
Corixidae	--	--	0.2	--
HOMOPTERA				
Cicadellidae	3.8	3.2	1.6	6.6
Pseudococcidae	0.2	0.6	1.4	1.6
Aphididae	3.0	6.0	0.6	42.0
Psyllidae	--	--	--	4.4
DIPTERA				
Cecidomyiidae	--	0.2	0.2	0.8
Culicidae	--	--	--	0.2
Calliphoridae	--	0.2	--	--

Table 84. Comparison of mean numbers/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	0.2	5.6	0.4	7.2
Tenebrionidae	1.4	0.6	0.8	1.6
Curculionidae	2.8	3.6	4.0	4.6
Coccinellidae	--	0.2	0.2	1.4
Staphylinidae	0.2	1.0	0.8	4.0
Carabidae	1.8	1.2	1.6	3.0
Chrysomelidae	--	0.2	0.2	2.4
Mordellidae	0.2	--	--	0.4
Ptilidae	--	0.2	--	--
HEMIPTERA				
Lygaeidae	12.2	46.8	7.6	42.2
Cydnidae	--	--	--	0.2
Tingidae	--	0.6	0.4	0.4
Miridae	--	0.8	--	1.4
Nabidae	--	--	0.2	0.2
HOMOPTERA				
Cicadellidae	2.2	6.0	0.6	9.0
Pseudococcidae	3.4	5.6	3.0	5.4
Aphididae	9.2	110.2	39.4	37.4
Cixiidae	--	0.2	--	--
Psyllidae	--	--	0.2	--
DIPTERA				
Cecidomyiidae	--	0.2	0.2	--
Culicidae	--	--	0.2	--

Table 85. Comparison of mean numbers/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	--	0.4	0.6	2.0
Tenebrionidae	0.6	1.0	0.8	3.6
Curculionidae	1.6	4.8	0.8	1.2
Coccinellidae	1.2	2.6	1.0	5.0
Staphylinidae	--	0.6	0.2	5.0
Carabidae	0.6	1.6	4.4	2.6
Chrysomelidae	2.2	7.0	5.8	20.8
Mordellidae	--	0.8	--	0.8
Anthicidae	0.2	2.6	0.4	14.6
Nitidulidae	0.2	0.2	--	0.2
Bruchidae	--	0.2	--	--
Cleridae	--	--	0.2	--
Silphidae	--	--	--	0.2
Cicinidelidae	--	--	--	0.2
HEMIPTERA				
Lygaeidae	4.6	10.6	1.4	19.2
Tingidae	1.0	0.2	1.6	0.4
Nabidae	--	0.8	--	1.8
Pentatomidae	0.2	--	--	--
Coreidae	--	0.2	--	--
HOMOPTERA				
Cicadellidae	31.8	45.8	23.4	105.8
Pseudococcidae	--	0.4	--	--
Aphididae	1.2	--	--	3.6
Issidae	--	2.0	--	2.0
Membracidae	--	0.4	--	--

Table 86. Comparison of mean numbers/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	0.8	--	--	0.2
Tenebrionidae	2.4	--	1.4	2.0
Curculionidae	1.6	8.0	1.6	5.1
Coccinellidae	0.4	2.8	--	0.7
Staphylinidae	--	0.6	--	5.4
Carabidae	0.8	2.8	0.8	18.1
Chrysomelidae	1.0	9.6	0.6	8.6
Anthicidae	--	17.2	--	8.1
Cantharidae	--	0.2	--	--
Meloidae	--	--	--	0.2
HEMIPTERA				
Lygaeidae	0.6	9.8	0.8	33.6
Nabidae	--	0.2	--	1.2
Pentatomidae	--	--	--	0.2
HOMOPTERA				
Cicadellidae	5.0	17.0	2.6	17.6
DIPTERA				
Therevidae	0.2	--	--	--
Syrphidae	--	0.2	--	--

Table 87. Comparison of mean numbers/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	--	--	0.2	--
Tenebrionidae	0.8	1.0	1.6	4.0
Curculionidae	0.6	2.4	0.2	11.8
Staphylinidae	--	--	--	0.8
Coccinellidae	--	2.0	0.4	0.4
Carabidae	--	1.4	0.4	1.4
Chrysomelidae	1.6	2.8	6.4	6.6
Anthicidae	--	10.6	1.8	18.6
HEMIPTERA				
Lygaeidae	3.4	27.4	4.8	16.2
Cydnidae	--	1.6	--	--
Tingidae	--	2.2	--	--
Nabidae	--	--	--	1.4
Coreidae	--	0.2	--	--
Pentatomidae	--	--	--	0.2
HOMOPTERA				
Cicadellidae	1.8	12.8	--	38.2
Issidae	--	0.2	--	--
DIPTERA				
Asilidae	--	--	--	0.2

season progressed populations were consistently larger in the plots treated with water and water plus nitrogen. Two factors are probably interacting to produce this result, more succulent plants and more cover. Two other lygaeids, *Crophius disconotus* (Say) and an unidentified species, were consistently collected in small numbers, but no trends were observable. Biomass figures (Tables 88 to 92) reflect the numerical data in the case of the Lygaeidae.

Homoptera: In the stress treatments this group was represented by seven families but species of Cicadellidae (leafhoppers) were by far the most numerous in numbers of specimens collected. While 17 species of leafhoppers were represented in the collections, only five species occurred in sufficient numbers to be examined for effects of stress. These were *Aceratogallia humilis* Oman, *Athysanella* sp., *Cuerna septrionalis* (Walker), *Flexamia flexulosa* (Ball), and *Gillettiella atropunctata* (Gillette). In all cases the application of nitrogen resulted in almost no increase (Tables 83 to 87). At peak populations, the application of water to the plots increased populations of these species by at least one-third, with the exception of *Aceratogallia humilis* where populations did not essentially change. The application of water plus nitrogen resulted in more than doubling the populations of all species except *A. humilis* which exhibited an approximate 58% increase. A greater number of leafhopper species were collected in the treatments where water was added, as opposed to those not receiving water.

Aphids, represented by *Iziphya* sp. and *Epameibaphis frigidae* (Osetlund), were present only in small numbers (less than $6/m^2$) in the control plots. The aphids were present intermittently in large numbers in the other plots, but since aphids occur in colonies,

Table 88. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the first major sampling date March 25, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	.00185	.00029	--	.00259
Tenebrionidae	.08421	.02429	.03870	.01683
Curculionidae	.00494	.00448	.01541	.00881
Coccinellidae	.00236	.00118	.00236	.00454
Staphylinidae	.00033	.00136	--	.00014
Carabidae	.00450	.00460	.01350	.02253
Chrysomelidae	.00028	.00168	.00060	.00192
Anthicidae	--	--	--	.00031
HEMIPTERA				
Lygaeidae	.00837	.00907	.00643	.00785
Cydnidae	--	--	--	.00036
Tingidae	.00112	.00224	.00032	.00064
Miridae	--	--	.00019	--
Nabidae	.00041		--	.00083
Coreidae	--	.00179	.00179	--
Corixidae	--	--	.00153	--
HOMOPTERA				
Cicadellidae	.00165	.00161	.00090	.00370
Pseudococcidae	.00008	.00024	.00056	.00064
Aphididae	.00019	.00054	.00004	.00347
Psyllidae	--	--	--	.00018
DIPTERA				
Cecidomyiidae	--	.00002	.00002	.00009
Culicidae	--	--	--	.00016
Calliphoridae	--	.00041	--	--

Table 89. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	.00014	.00403	.00029	.00533
Tenebrionidae	.01699	.03159	.00308	.03484
Curculionidae	.00827	.01408	.01131	.01365
Coccinellidae	--	.00118	.00118	.00167
Staphylinidae	.00005	.00045	.00046	.00172
Carabidae	.01232	.00639	.00550	.00538
Chrysomelidae	--	.00024	.00003	.00258
Mordellidae	.00007	--	--	.00014
Ptilidae	--	.00015	--	--
HEMIPTERA				
Lygaeidae	.00258	.00869	.00236	.01014
Cydnidae	--	--	--	.00078
Tingidae	--	.00048	.00032	.00032
Miridae	--	.00141	--	.00246
Nabidae	--	--	.00041	.00041
HOMOPTERA				
Cicadellidae	.00066	.00315	.00040	.00620
Pseudococcidae	.00129	.00216	.00125	.00159
Aphididae	.00065	.00721	.00238	.00285
Cixiidae	--	.00010	--	--
Psyllidae	--	--	.00001	--
DIPTERA				
Cecidomyiidae	--	.00002	.00002	--
Culicidae	--	--	.00016	--

Table 90. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	--	.00029	.00043	.00144
Tenebrionidae	.00473	.00385	.00308	.02930
Curculionidae	.00322	.00699	.00048	.00110
Coccinellidae	.00030	.00418	.00086	.00622
Staphylinidae	--	.00046	.00009	.00140
Carabidae	.00081	.00899	.02308	.01724
Chrysomelidae	.00101	.00233	.00184	.01192
Mordellidae	--	.00029	--	.00043
Anthicidae	.00010	.00127	.00002	.00313
Nitidulidae	.00012	.00016	--	.00012
Bruchidae	--	.00012	--	--
Cleridae	--	--	.00069	--
Silphidae	--	--	--	.00030
Cicindelidae	--	--	--	.00544
HEMIPTERA				
Lygaeidae	.00675	.00971	.00027	.02672
Tingidae	.00080	.00016	.00128	.00030
Nabidae	--	.00211	--	.00403
Pentatomidae	.00469	--	--	--
Coreidae	--	.00179	--	--
HOMOPTERA				
Cicadellidae	.01294	.01986	.01125	.05016
Pseudococcidae	--	.00008	--	--
Aphididae	.00010	--	--	.00032
Issidae	--	.00092	--	.00092
Membracidae	--	.00017	--	--

Table 91. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	.00058	--	--	.00016
Tenebrionidae	.02968	--	.00539	.02460
Curculionidae	.00660	.01611	.01017	.00946
Coccinellidae	.00121	.00269	--	.00250
Staphylinidae	--	.00067	--	.00827
Carabidae	.00402	.00376	.00469	.07106
Chrysomelidae	.00060	.00458	.00047	.01408
Anthicidae	--	.00679	--	.00195
Cantharidae	--	.00218	--	--
Meloidae	--	--	--	.00200
HEMIPTERA				
Lygaeidae	.00269	.00570	.00099	.01396
Nabidae	--	.00041	--	.00291
Pentatomidae	--	--	--	.00427
HOMOPTERA				
Cicadellidae	.00258	.01682	.00215	.02107
DIPTERA				
Therevidae	.00022	--	--	--
Syrphidae	--	.00026	--	--

Table 92. Comparison of mean biomass in g/m^2 of aboveground arthropods by family in the major orders taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.

Family	No treatment	Water	Nitrogen	Water plus nitrogen
COLEOPTERA				
Scarabaeidae	--	--	.00042	--
Tenebrionidae	.03944	.03850	.06160	.15400
Curculionidae	.00846	.00888	.02636	.15254
Staphylinidae	--	--	--	.01592
Coccinellidae	--	.04552	.00668	.01512
Carabidae	--	.02786	.02584	.03270
Chrysomelidae	.00870	.01860	.01694	.01834
Anthicidae	--	.04454	.00734	.08300
HEMIPTERA				
Lygaeidae	.00510	.06352	.00720	.06616
Cydnidae	--	.06256	--	--
Tingidae	--	.01760	--	--
Nabidae	--	--	--	.02898
Coreidae	--	.01786	--	--
Pentatomidae	--	--	--	.04692
HOMOPTERA				
Cicadellidae	.00642	.07786	--	.28038
Issidae	--	.00092	--	--
DIPTERA				
Asilidae	--	--	--	.01856

little significance can be attached to these numbers, other than that they were more common in plots receiving applications of nitrogen, water, and water plus nitrogen. No aphids were collected on any of the plots on the fourth and fifth sampling dates.

Lepidoptera: The great majority of lepidopterous specimens collected were in the larval stage. A large number of moths appeared in the samples on August 24, but we feel these can be largely discounted since most were attracted to the lights of the Berlese samples on a night when the building lights were inadvertently left off. Two kinds of larvae made up approximately two-thirds of those collected by the vacuum sampler.

An arctiid, *Apantesis blakei* Grote, was the most numerous species encountered. Larvae were first collected on July 8 and a few late instar larvae were still present on November 10. Overwintering takes place in the larval stage, and larvae continue to feed the following March and April, after which pupation occurs. In 1971 either pupation had already occurred prior to the beginning of sampling or the females which emerged in late May and June flew from other areas to the stress pastures to oviposit in response to the presence of moisture. The larvae are very migratory. One third more larvae were collected in the stress pastures in which moisture was applied. There was no apparent difference in populations between those plots treated with water alone ($7.6/m^2$) and those treated with water plus nitrogen ($7.0/m^2$).

Larvae of the other group were tentatively identified as Pyralidae (probably Crambinae) by the senior author. These larvae were present in the May 21 and July 8 samples. On the latter date populations were almost non-existent. The data did not show that a response to moisture was occurring, but the trend was for more larvae to be found in the plots not treated with water on May 21. Because there is usually sufficient soil water for plant growth at this time and many species of plants are just putting up new shoots, it would not be expected that differences would be seen. The larvae of the Crambinae are known to be grass feeders.

Hymenoptera: As in the case of the bimonthly sampling, the family Formicidae (ants) accounted for the majority of this major group collected on the stress pastures. The same species of ants were encountered plus a few specimens of *Lasius alienus americanus*. When the data are looked at for total Hymenoptera, no trends can be seen nor are there any when the data are broken down to the species level. As would be expected, there was an increase in foraging ants in late May as a result of the maturation of the first brood. The lack of foragers collected in August is a result of the high soil surface temperatures at that time of year. By November 10 all species would have retreated to winter quarters deep in the soil, and this is indicated by the data. As with other pastures, no western harvester ants (the most populous species on site) were collected during the entire season although colonies were present in all plots.

Coleoptera: Sixteen families of beetles are represented in the samples, only eight of which occur consistently throughout the plots over most of the season. The families of beetles only encountered occasionally were as follows: Mordellidae, Ptilidae, Nitidulidae, Bruchidae, Cleridae, Silphidae, Cantharidae, and Meloidae. It should be noted that both meloids and cantharids were common on the flower heads of snakeweed and rabbit brush in these plots in late summer and early fall, but their presence went undetected because of the timing of the sampling. A discussion of the other families is presented below.

Coccinellidae: On the first three sampling dates these predatory beetles were more than four times as common in the water plus nitrogen plots with the exception of July 8 when half as many occurred in the water treated plot (Tables 83 to 87). Thereafter, as populations declined no discernible trend was apparent. The most commonly collected lady bird beetle was *Hippodamia convergens* Guerin-Meneville which was present in the samples throughout the season. It was most prevalent on the first two sampling dates, at which time it was more than seven times as abundant in the water plus nitrogen treated plots as in any of the other treatments. On the July 8 sample date there were six species collected, and cocinelids as a group were almost five times more abundant on the plots treated with water plus nitrogen than on plots not treated with water, and almost twice as abundant as on the plots treated only with water. On the only sample date (July 8) on which *Hyperaspidius* sp. was collected, there were more than twice as many in the water plus nitrogen plot as in any of the other plots. With the exception of one beetle, all specimens of *Hippodamia parenthesis* (Say) were collected in plots treated with water. It should be noted that their primary prey, aphids, were not collected in the ESA (Environmental Stress Area) plots on the last two sample dates, indicating a probable population crash.

Tenebrionidae: This family was primarily represented in the ESA plots by *Blapstinus* sp., with occasional specimens of *Eleodes extricata* (Say) and *Edrotes routundus* (Say) being collected. No apparent trend could be observed, although more than twice as many tenebrionids were found in the water plus nitrogen plots on the last sample date perhaps because they were seeking shelter for the approaching winter (Tables 83 to 87).

Carabidae: Nineteen species of ground beetles were collected in the stress plots, but only *Amara farcta* LeConte, *Selenophorus planipennis*

LeConte, *Bembidion obscurellum* Motschoulsky, and *Microlestes linearis* LeConte were numerous. Two of these, *S. planipennis* and *A. farcta*, are largely herbivorous while the remaining two are carnivorous (Bell, 1971). As a group, carabids showed a strong "preference" for the water plus nitrogen plots by almost a two to one margin (Tables 83 to 87), except on July 8 when there was a heavy concentration of *B. obscurellum* ($2.8/m^2$) and *Harpalus desertus* ($1.2/m^2$) in the nitrogen only plot. This latter species (a herbivore) was present in small numbers in all plots on the first three sample dates, but only a single specimen was collected thereafter. While *M. linearis* showed a strong tendency to favor those plots treated with water, *B. obscurellum* did not. Neither *A. farcta* or *S. planipennis* showed marked tendencies, although on August 20 there were 14 times as many *A. farcta* collected in the water plus nitrogen plots.

Curculionidae: Among the ESA vacuum samples, 18 species of snout beetles appeared, but only five were collected with any regularity. These were *Aprion* sp., *Calandrinus insignis* Casey, *Calyptillus cryptops* Horn, *Gerstaeckeria basalis* (LeConte), and *Hyperodes grypidioides* Dietz. The larvae of *Apion* sp. "feed, for the most part, on seeds, principally those of legumes, though some form galls on the stems and leaves of plants, others, knots on the roots, while a few bore into the pitch and form a kind of coccoon [sic] of the gnawed particles" (Blatchley and Leng, 1916). No treatment preference was shown by *Apion* sp. early in the season, but the adults that emerged in late summer showed a preference for those plots treated with water by as much as 11 times that for the non-watered plots. On November 10 no *Apion* were collected in the latter plots.

Calandrinus insignis, a billbug, is not known to be an economic pest, but is in the same subfamily (Calandrinae) as some which are such as the bluegrass billbug, *Sphenophorus pasvulus* Gyllenhal. Larvae of the larger species in this subfamily bore into the stems of plants, especially grass and corn, while those of the smaller species infest seed and grains (Blatchley and Leng, 1916). These billbugs were rarely found in those plots treated with water. Adult populations peaked around May 21, at which time there were six times as many present in those plots not treated with water. No other differences were apparent.

All known species of *Gerstaeckeria* feed on cacti (Blatchley and Leng, 1916), so it is probably safe to assume that *G. basalis* is feeding on the common cactus on site, *Opuntia polyacantha*. This species was consistently present, as adults, in small numbers except for July 8 when only one specimen was collected. No apparent "preference" was shown for any treatment.

The authors are not aware of any literature concerning the remaining two species. In both cases, no apparent "preference" was shown for any treatment even though all curculionids are known to be plant feeders and presumably would respond to plant succulence. On November 10 *Hyperodes grypidioides* was collected ($2.6/m^2$) only in the water plus nitrogen plots, but here again it is probably a question of seeking winter shelter. When curculionids were treated as a group, there was a decided preference for those plots treated with water on the last two sample dates (Tables 83 to 87), suggesting that the presence of succulent host plants acts as an attractant.

Chrysomelidae: Nine species of leaf beetles plus the larvae of one species (unidentified) comprised the chrysomelid fauna of the ESA pastures.

The group as a whole showed a decided preference for those plots treated with water as opposed to those that were not. Since these beetles feed in both larval and adult stages on vegetative parts of plants, it is not surprising to find them favoring the more succulent growth. However, on May 21, July 8, and November 10, three times as many chrysomelids occurred in the water plus nitrogen plots as compared to water only (Tables 83 to 87). On all dates the leaf beetle biomass was greater in those plots treated with water, and with the exception of the first and last sample dates was more than three times greater on the water plus nitrogen plots than on those treated with water alone.

Since none of the beetles have been identified to species but only to genera, it is not possible to indicate the effect of stress on particular species. At least five genera are represented in the samples, *Altica*, *Chaetocnema*, *Phyllotreta*, *Dibolia*, and *Diabrotica*.

Scarabaeidae: As in the bimonthly samples, the dominant scarab beetle in the stress plots was *Rhyssemus*, new species. Adults were collected only on the first three sample dates and peak populations occurred in the May 21 sample. A definite preference was exhibited for the water plus nitrogen plots with about 10 times as many beetles occurring here as in those plots not treated with water on the 2nd and 3rd sample dates (Tables 83 to 87). Only in the May 21 sample were there high populations of the beetle in the water only plots. The beetles were probably attracted to these plots as oviposition sites and it will be interesting to see what sort of larval populations occur here in 1972.

Staphylinidae: The rove beetles were represented by 12 species in the stress plots. According to Borror and DeLong (1971), most species are predacious both in the adult and larval stages. As a group there was a decided preference for the plots treated with water as opposed to those not so treated (Tables 83 to 87). Presumably, as predators they were attracted to these plots by the abundance of potential prey. No one species was noticeably abundant and the composition of species changed as the season progressed. Adults of *Platystethus americanus* Erichson were abundant on the first two dates but only in those plots treated with water. Other species were collected only intermittently.

Anthicidae: Numerically this group was more abundant when present (last three sample dates) than any other group of beetles. The majority of flower beetles collected were vacuumed from those plots to which water had been added (Tables 83 to 87). Almost nothing is known of their feeding habits although Arnett (1960) reported the larvae of a species of *Notoxus* as being predacious. The adults are commonly found on flowers and foliage, and the larvae in vegetable detritus. Six species were collected in the ESA plots, of which *Ancthicus lutulentus* Casey, *Anthicus hastatus* Casey, and *Anthicus plectinus* Casey were most abundant. Only *A. lutulentus* and *A. hastatus* were collected from plots not treated with water. Because of their association with flowers, their abundance is probably a function of the availability of flowering plants in the sample. If nitrogen should prove to be a stimulant for flower growth, then one would expect a greater abundance of flower beetles in those plots treated with water plus nitrogen, a situation which is seen on July 8 and November 10.

Comparison of Group Totals in Number and Biomass

On all sample dates the water plus nitrogen plots contained the greatest number of individuals, and with the exception of the first sampling date these plots also contained the greatest biomass (Tables 77 to 81). After the first sampling date the water only plots also showed what appear to be significant differences in numbers from those obtained for plots which did not receive water (Fig. 18 and 19). Similar results are shown by the biomass figures (Tables 93 to 97). As the season progressed there was a greater difference apparent in numbers and biomass between plots treated with water and those not so treated. However, little difference can be seen between plots receiving no treatment and those receiving nitrogen alone. For the water plus nitrogen plots versus the control plots, the ratio changed from almost 2 to 1 on March 25 to 12 to 1 on November 10. Similarly, water alone versus no treatment showed a change from 1 to 1 ratio on March 25 to an 8 to 1 ratio on November 10.

On the first sample date immatures outnumbered adults in all plots except the nitrogen only plot. The may 1 data are confounded by a population explosion of mites and an apparent migration of leafhoppers into the water only plots. On the following sampling date, June 25, the leafhoppers had apparently moved into the water plus nitrogen plots. On the last three sample dates, adults exceeded immatures by at least a 2 to 1 ratio. Biomass data (Tables 93 to 97) reflect the fact that immatures weigh less than adults, and on all sampling dates biomass was less for immatures than adults. These data essentially agree with that collected from the four grassland treatments (Tables 61 to 64), but does not entirely agree with the bimonthly data (Tables 1 to 13) which sometimes shows more biomass for immatures in the spring months. As mentioned later, a modification of the collecting technique is necessary to catch those immatures which are undoubtedly escaping or more samples per plot need to be taken.

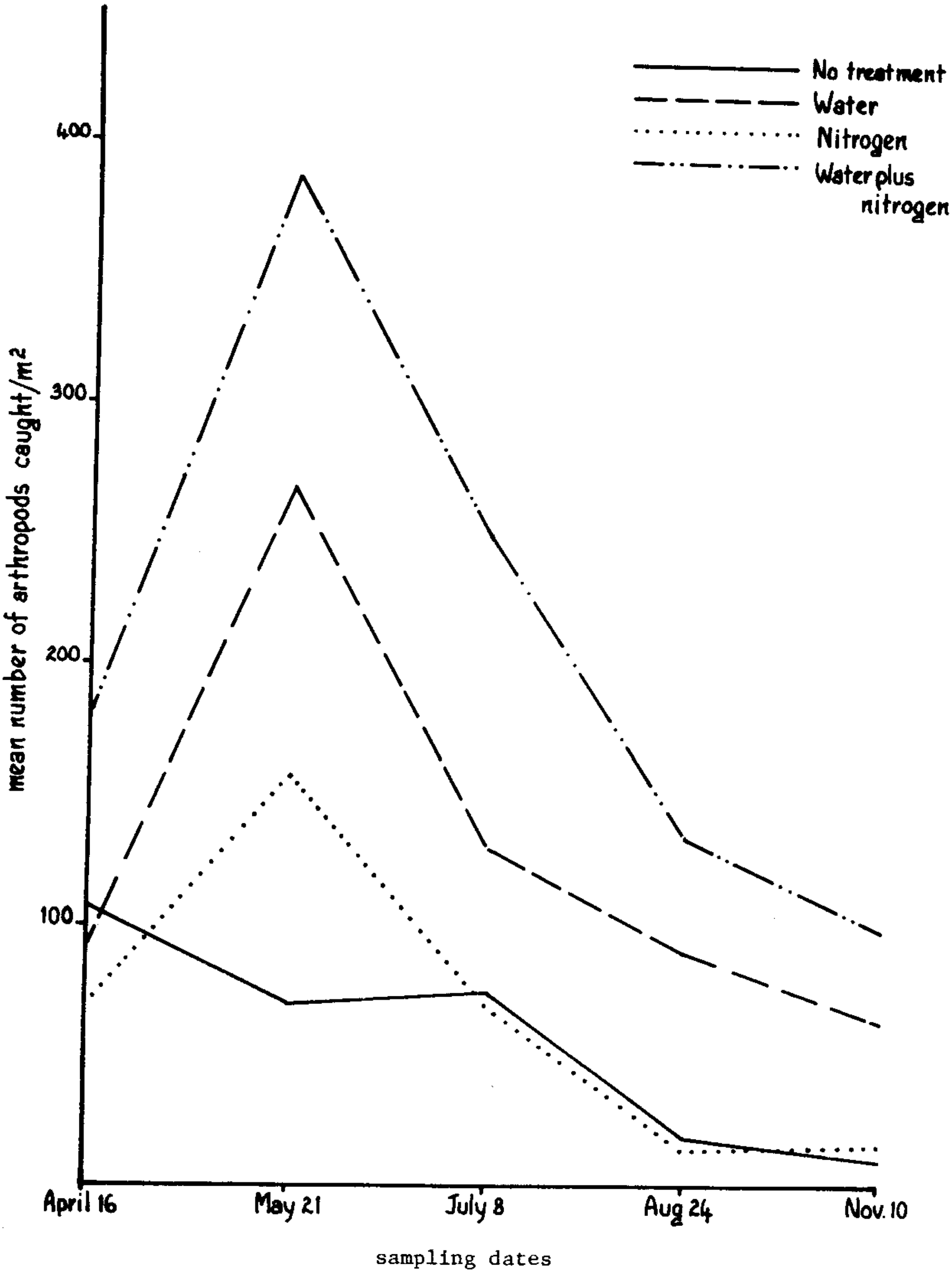


Fig. 18. Comparison of effects of four stress treatments on populations of arthropods on the Pawnee Site (1971), as expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on five major sampling dates.

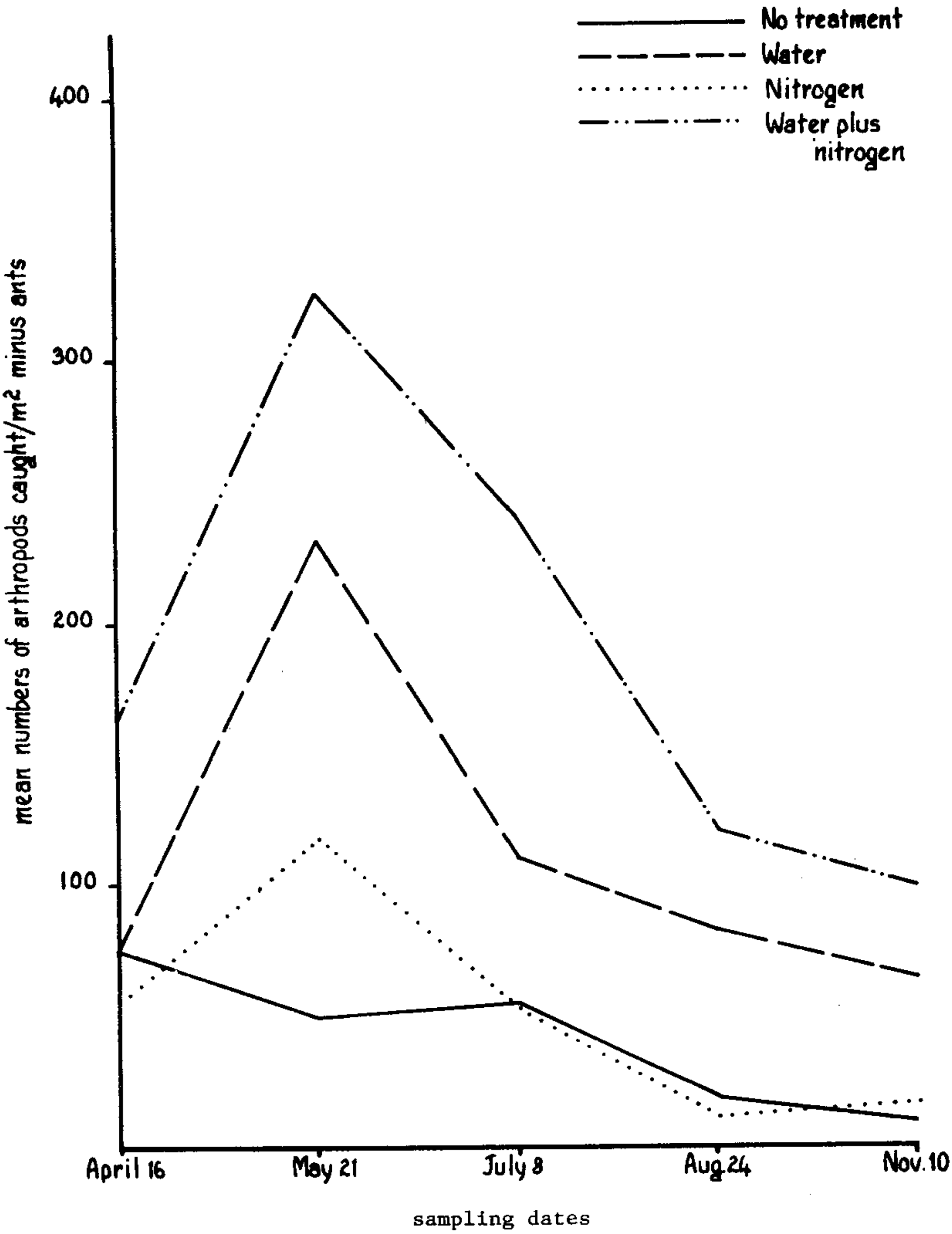


Fig. 19. Comparison of effects of four stress treatments on populations of arthropods on the Pawnee Site (1971), expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on five major sampling dates, but with ants (Formicidae) removed from the samples.

Table 93. Comparison of mean biomass in g/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the first major sampling date March 25, 1971.[a/]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	.00569	.01209	.00352	.00574
Acarina	.00010	.00000	.00001	.00057
Collembola	--	--	.00000	.00003
Orthoptera	.04074	.00667	.01274	.00772
Hemiptera	.00990	.01309	.01025	.00968
Homoptera	.00192	.00239	.00149	.00799
Thysanoptera	.00004	--	.00001	--
Lepidoptera	.00453	.00291	.00131	.01175
Hymenoptera	.03772	.00966	.00655	.00895
Coleoptera	.09927	.03953	.07118	.05906
Diptera	--	.00123	.00039	.00137
Neuroptera	--	--	--	--
Siphonoptera	--	--	.00008	--
Chelonethnida	--	--	.00085	--
TOTAL (Computer)	.19990	.08757	.10839	.11285
Adults	.17731	.04520	.06158	.08088
Nymph/larvae	.02259	.04237	.04681	.03197

[a/] Actually collected on or about April 16.

Table 94. Comparison of mean biomass in g/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.[a/]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	.00225	.00074	.00033	.00282
Acarina	.00009	.00046	.00038	.00203
Collembola	.00000	.00002	--	.00000
Orthoptera	.00952	.00952	--	.00296
Hemiptera	.00258	.01058	.00310	.01412
Homoptera	.00260	.01262	.00404	.01064
Thysanoptera	.00006	.00022	.00006	.00006
Lepidoptera	.03184	.00443	.00263	.00450
Hymenoptera	.01124	.02007	.02621	.02877
Coleoptera	.03841	.06068	.04548	.07174
Diptera	.00084	.00194	.00114	.00193
Neuroptera	--	--	--	--
Psocoptera	.00000	.00000	--	--
TOTAL (Computer)	.09942	.12128	.08336	.13957
Adult	.08304	.06619	.07572	.08791
Nymph/larvae	.01638	.05509	.00764	.05167

[a/]Actually collected on or about May 21.

Table 95. Comparison of mean biomass in g/m ^{2} of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac apparatus at the time of the third major sampling date June 25, 1971.[a/]

Group	No Treatment	Water	Nitrogen	Water plus nitrogen
Araneida	.00085	.00259	.00014	.00313
Acarina	.00004	.00019	.00014	.00025
Collembola	--	--	--	.00001
Orthoptera	.00358	--	--	--
Hemiptera	.01224	.01377	.00158	.03105
Homoptera	.01304	.02103	.01125	.05141
Thysanoptera	--	--	--	.00027
Lepidoptera	.00326	.00567	.00486	.01503
Hymenoptera	.01046	.02093	.01114	.00995
Coleoptera	.01051	.03316	.03193	.08110
Diptera	.00016	.00551	.00033	.00263
Neuroptera	.00016	.00032	.00016	.00032
Ephemeroptera	--	.00012	--	--
Trichoptera	--	.00145	--	--
TOTAL (Computer	.05431	.10475	.06154	.19727
Adults	.03656	.08327	.05150	.15459
Nymph/larvae	.01775	.02148	.01004	.04268

a/ Actually collected on or about July 8.

Table 96. Comparison of mean biomass in g/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac apparatus at the time of the fourth major sampling date August 20, 1971.[a/]

Group	No Treatment	Water	Nitrogen	Water plus nitrogen
Araneida	.00115	.00263	.00077	.00814
Acarina	--	--	--	--
Collembola	--	--	--	--
Orthoptera	--	.00379	.00362	.03495
Hemiptera	.00269	.00612	.00099	.02114
Homoptera	.00258	.01682	.00215	.02107
Thysanoptera	--	--	--	.00022
Lepidoptera	.00177	.04562	.00496	.03415
Hymenoptera	.00066	.00658	.00453	.02283
Coleoptera	.04268	.04061	.02071	.14386
Diptera	.00024	.00026	--	--
Neuroptera	--	.00032	--	.00036
TOTAL (Computer)	.05176	.12274	.03773	.28671
Adults	.03416	.11588	.03621	.25774
Nymph/larvae	.01760	.00686	.00152	.02897

a/ Actually collected on or about August 24.

Table 97. Comparison of mean biomass in g/m^2 of aboveground arthropods of different groups taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.[a/]

Group	No treatment	Water	Nitrogen	Water plus nitrogen
Araneida	.00034	--	.00016	.00008
Acarina	--	--	--	--
Collembola	--	--	--	--
Orthoptera	--	--	--	--
Hemiptera	.00510	.16154	.00720	.14206
Homoptera	.00642	.07878	--	.28038
Thysanoptera	--	--	--	--
Lepidoptera	.00208	.00104	--	--
Hymenoptera	--	--	--	--
Coleoptera	.05660	.18390	.14158	.47162
Diptera	--	--	--	.01856
Neuroptera	--	--	--	--
Chelonethida	--	--	--	--
TOTAL (Computer)	.07054	.42526	.15254	.91270
Adults	.06336	.33850	.14534	.84866
Nymph/larvae	.00718	.08676	.00720	.06404

[a/] Actually collected on or about November 10.

Abundance of Arthropods Expressed by Feeding Habit (ESA Plots)

Data are presented in Tables 98 to 107 on the abundance and biomass of arthropods collected from the ESA plots and analyzed according to food habit. These same data are presented graphically in Fig. 20 to 29. Both numerically and on a biomass basis plant sucking insects on the water plus nitrogen plots exceeded by about twice those on any other plots with the exception of May 21 when numerically there were more in the water only plot, but biomass was essentially the same (Fig. 20 to 25). Both in biomass and numbers, the plant sucking insects on the plots treated with water greatly exceed those on plots not receiving water. There appears to be no significant difference between the numbers of plant sucking insects collected on the no treatment plots and the nitrogen treated plots.

On the first three sample dates the plots treated with water plus nitrogen had the most plant tissue feeders on a numerical basis, but biomass did not follow this trend (Tables 98 to 103) except on July 8. On August 20 those plots treated with water contained essentially the same number of plant tissue feeders which was numerically 10 times as much as those not treated with water while the biomass was at least twice as much (Fig. 20 to 25). On the last sample date (Nov. 10) when most insects are seeking hibernation sites, there was essentially little difference between plots although all those treated had both greater numbers and more biomass than the untreated plot.

The omnivores, primarily ants, showed no apparent response to the stress treatments and this, as in the other pastures, undoubtedly

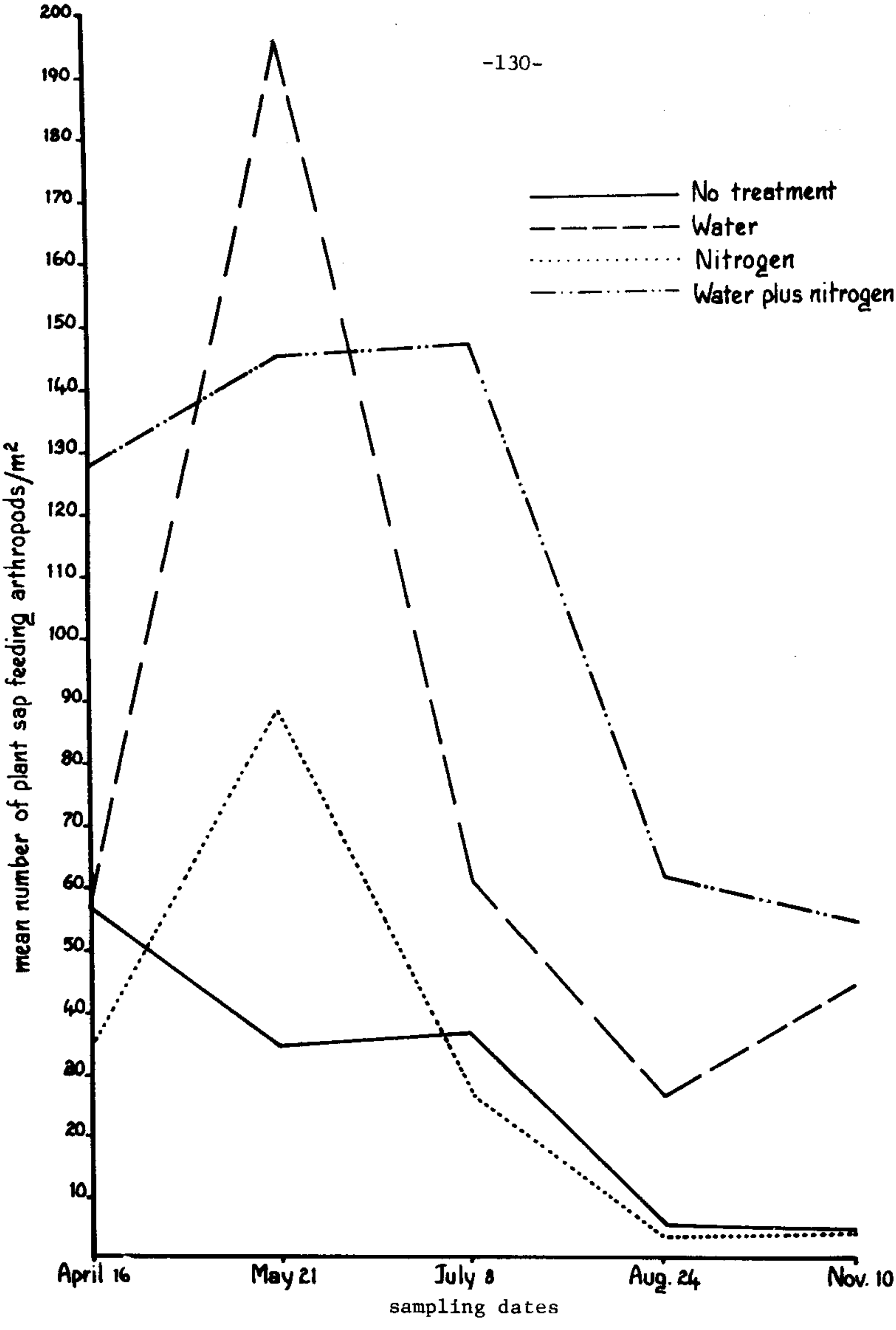


Fig. 20. Effect of four stress treatments on populations of plant sap sucking arthropods on the Pawnee Site (1971), expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on five major sampling dates.

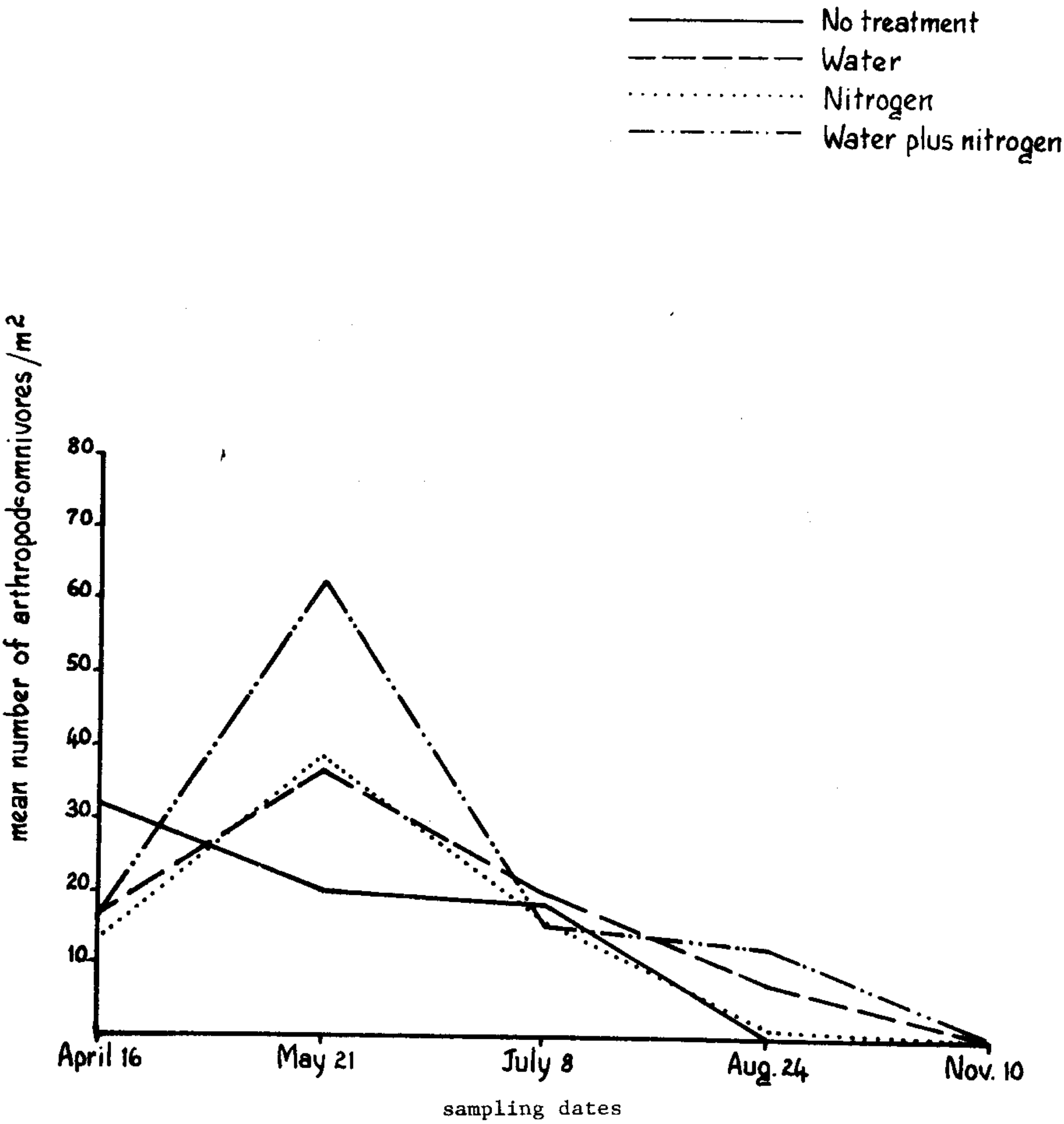


Fig. 21. Effect of four stress treatments on populations of arthropod omnivores on the Pawnee Site (1971), expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on five major sampling dates.

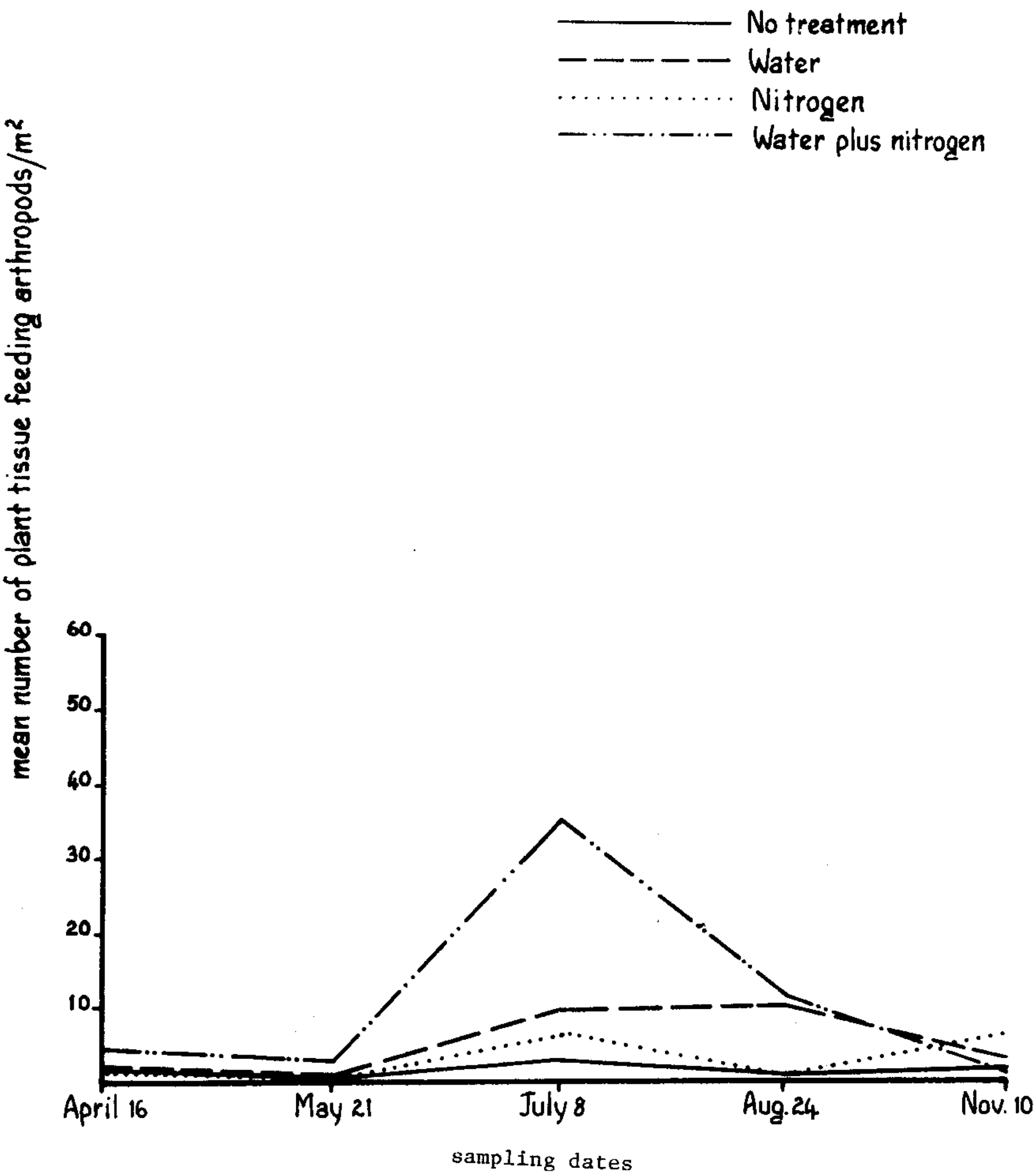


Fig. 22. Effect of four stress treatments on populations of plant tissue feeding arthropods on the Pawnee Site (1971), expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on five major sampling dates.

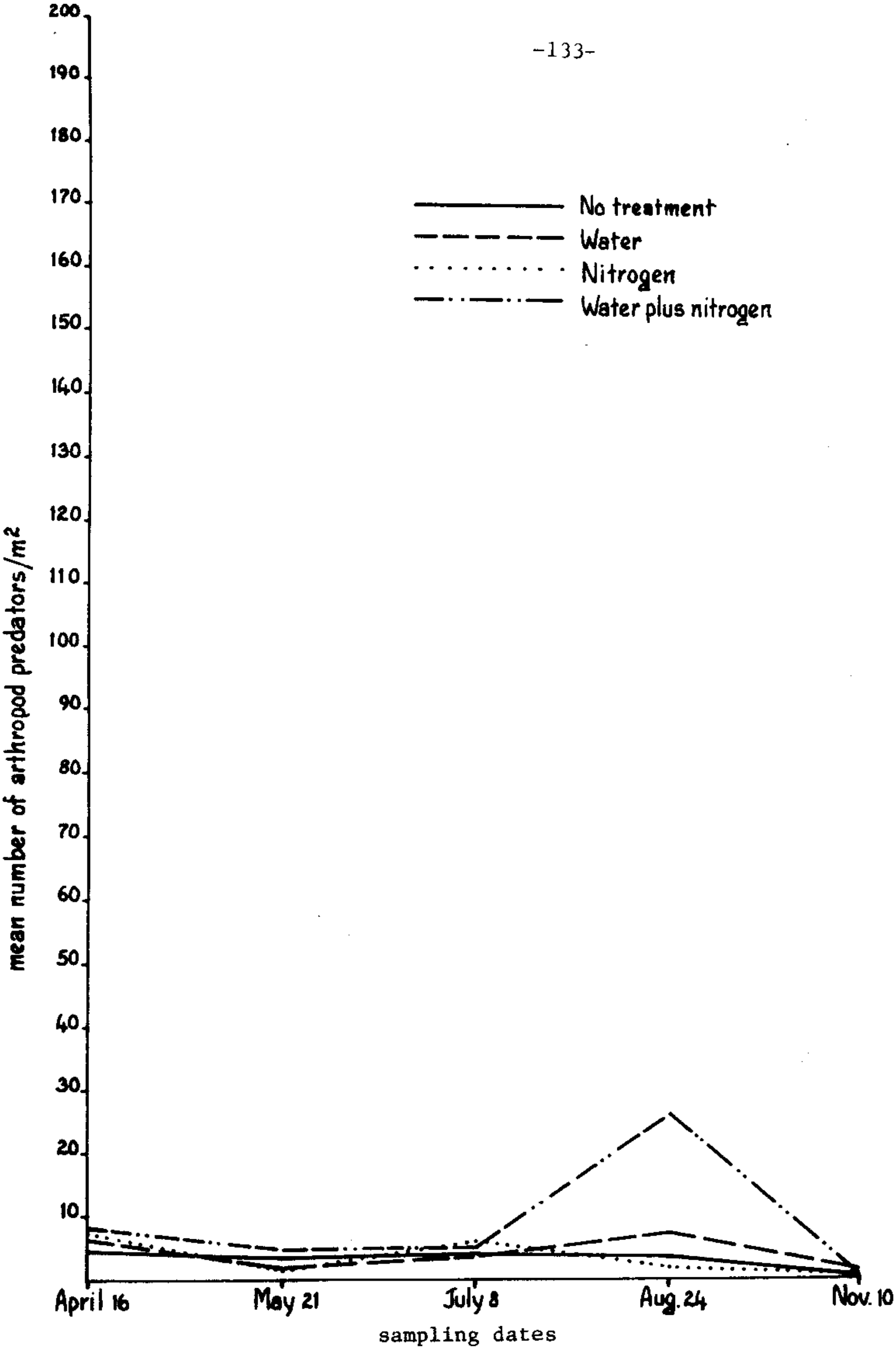


Fig. 23. Effect of four stress treatments on populations of arthropod predators on the Pawnee Site (1971), expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on five major sampling dates.

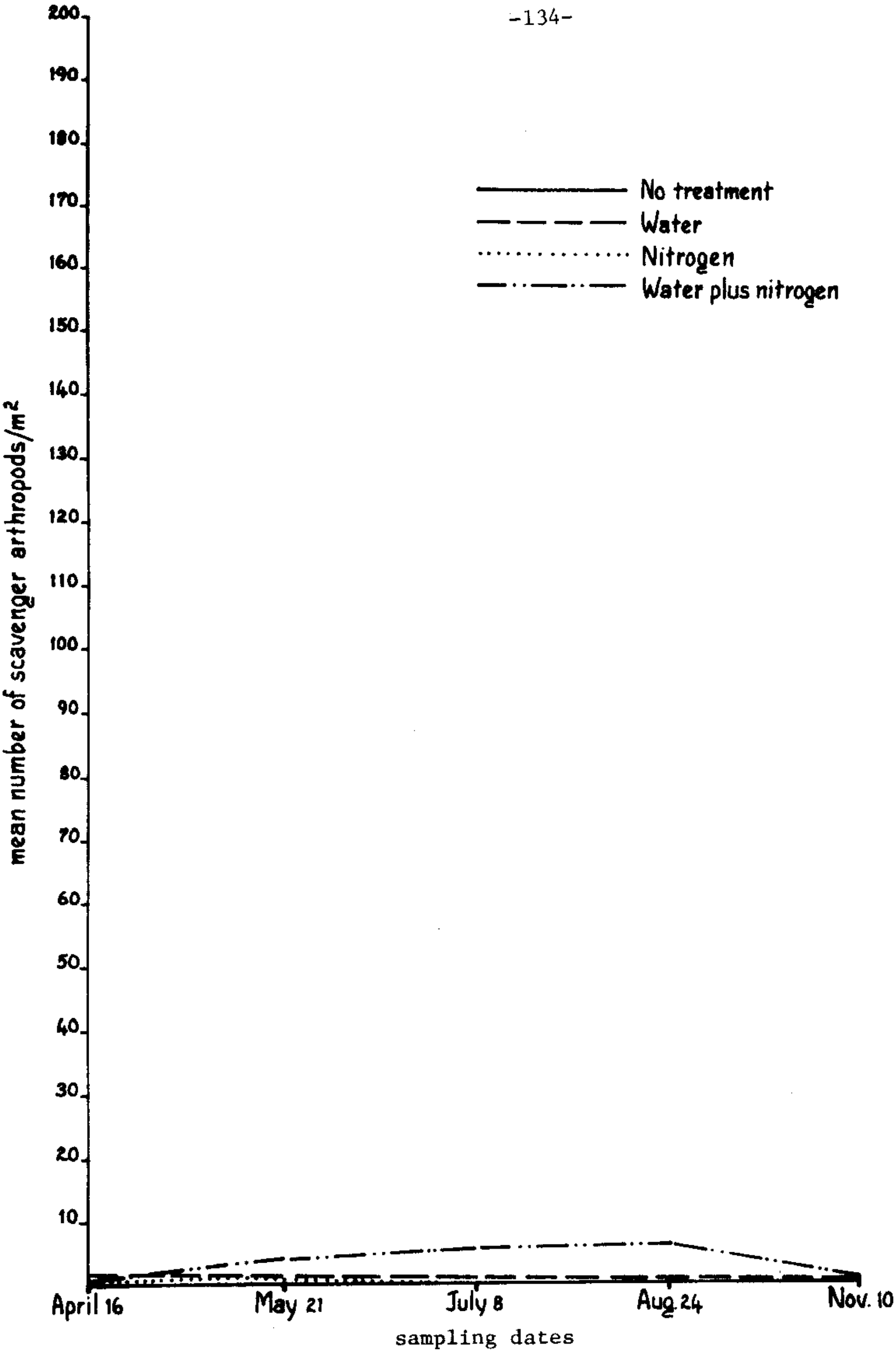


Fig. 24. Effect of four stress treatments on populations of scavenger arthropods on the Pawnee Site (1971), expressed in mean numbers per meter squared, collected with a D-vac suction apparatus on five major sampling dates.

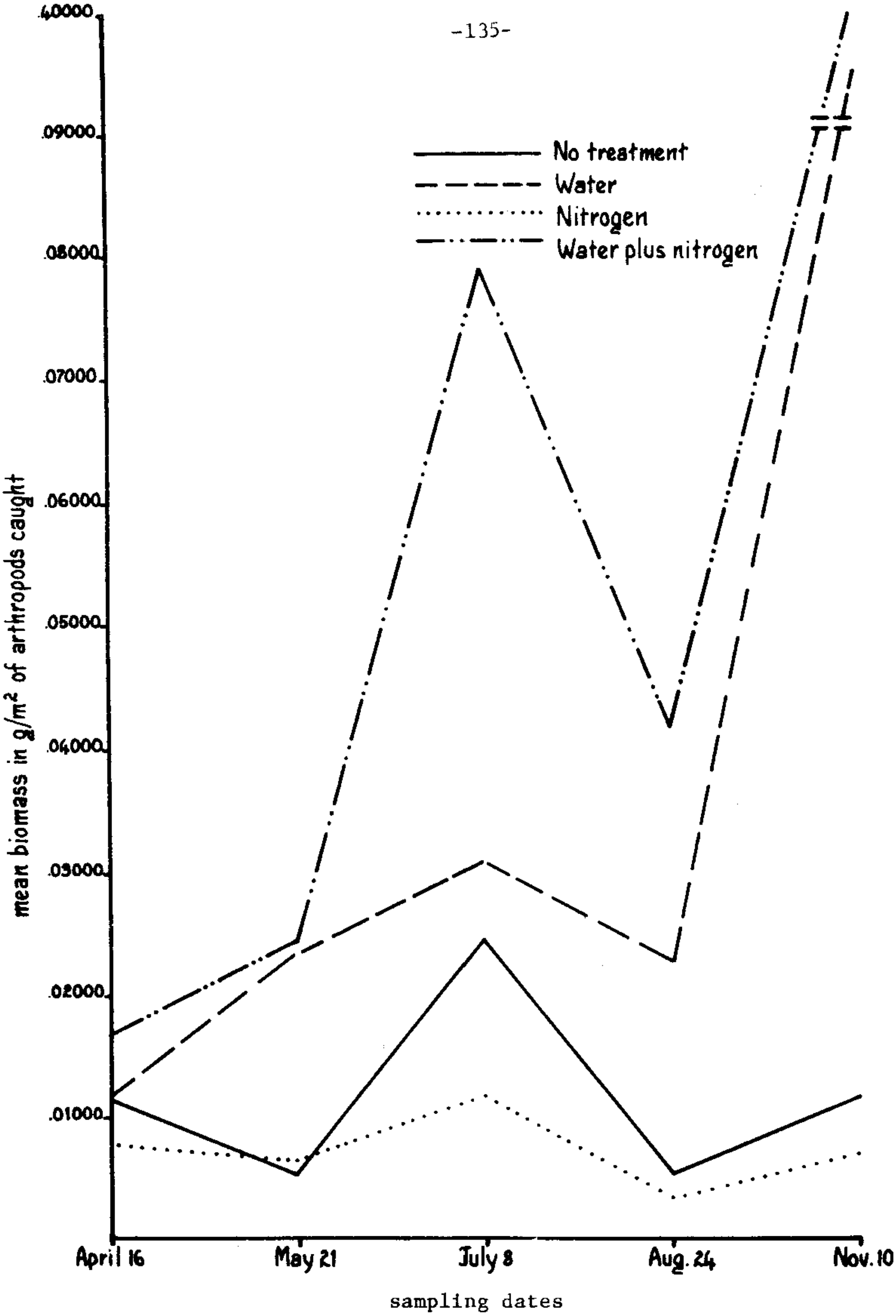


Fig. 25. Effect of four stress treatments on biomass in grams per meter squared of plant sucking arthropods on the Pawnee Site (1971), collected with a D-vac suction apparatus on five major sampling dates.

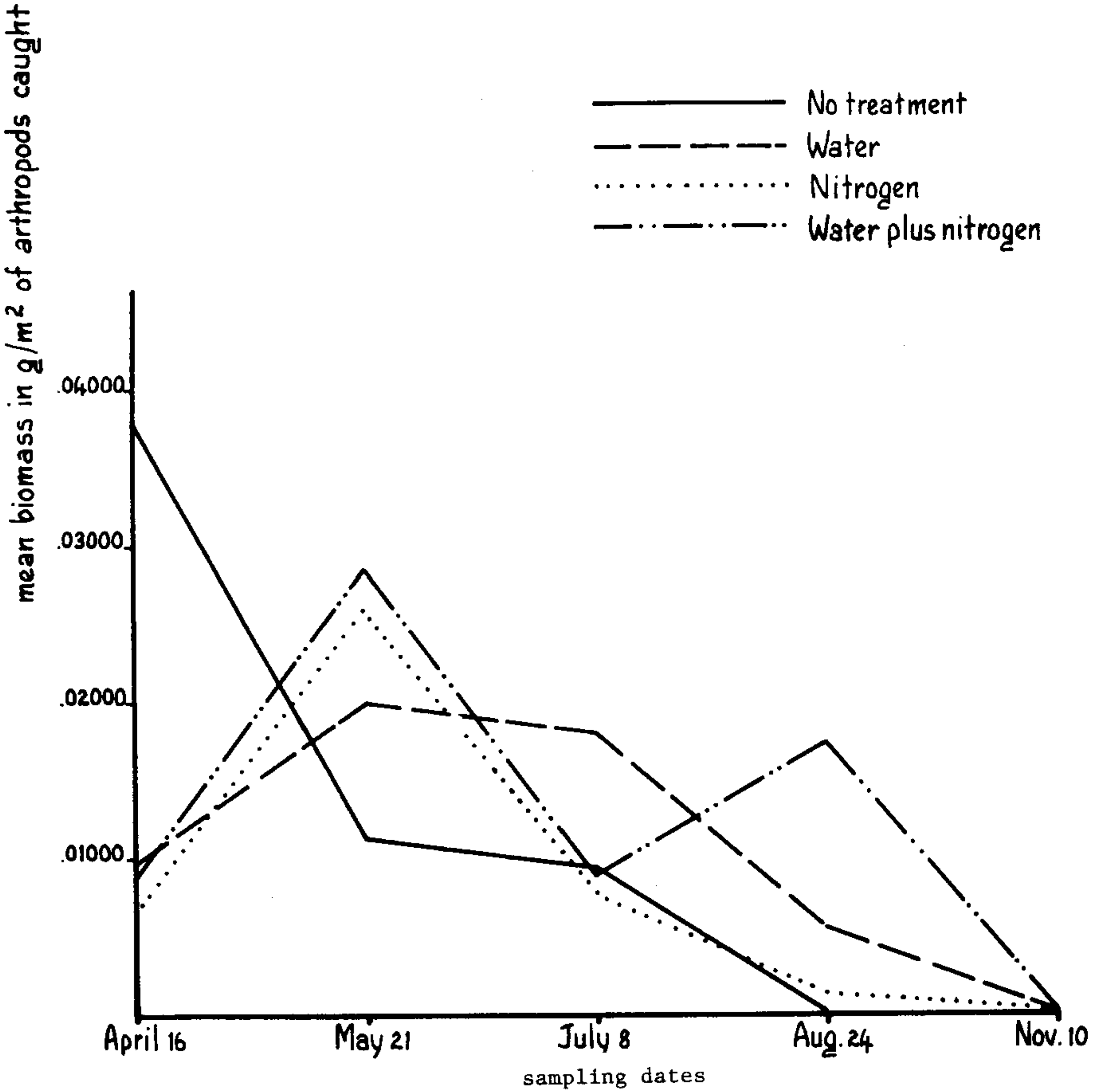


Fig. 26. Effect of four stress treatments on biomass in grams per meter squared of arthropod omnivores on the Pawnee Site (1971), collected with a D-vac suction apparatus on five major sampling dates.

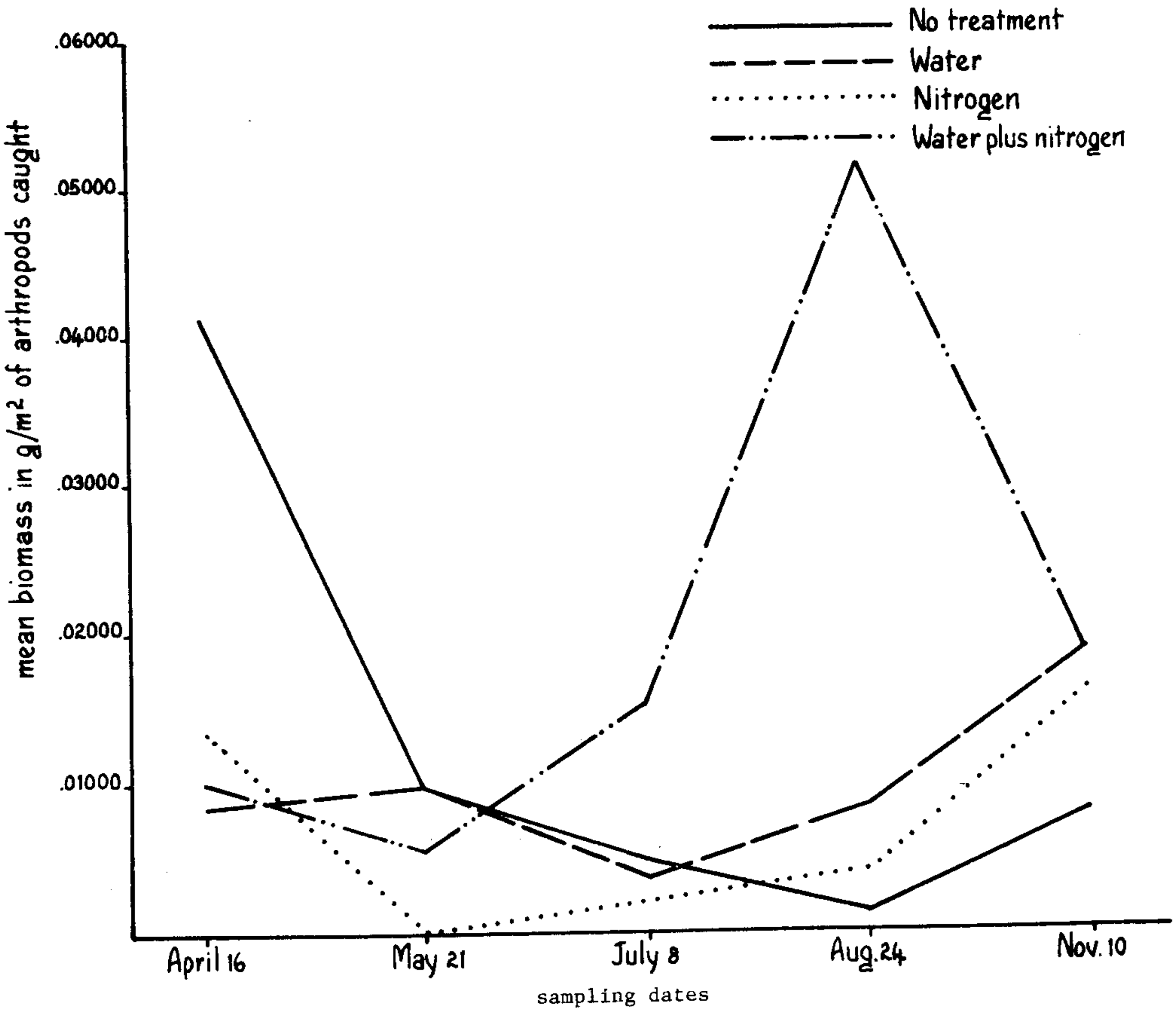


Fig. 27. Effect of four stress treatments on biomass in grams per meter squared of plant tissue feeding arthropods on the Pawnee Site (1971), collected with a D-vac suction apparatus on five major sampling dates.

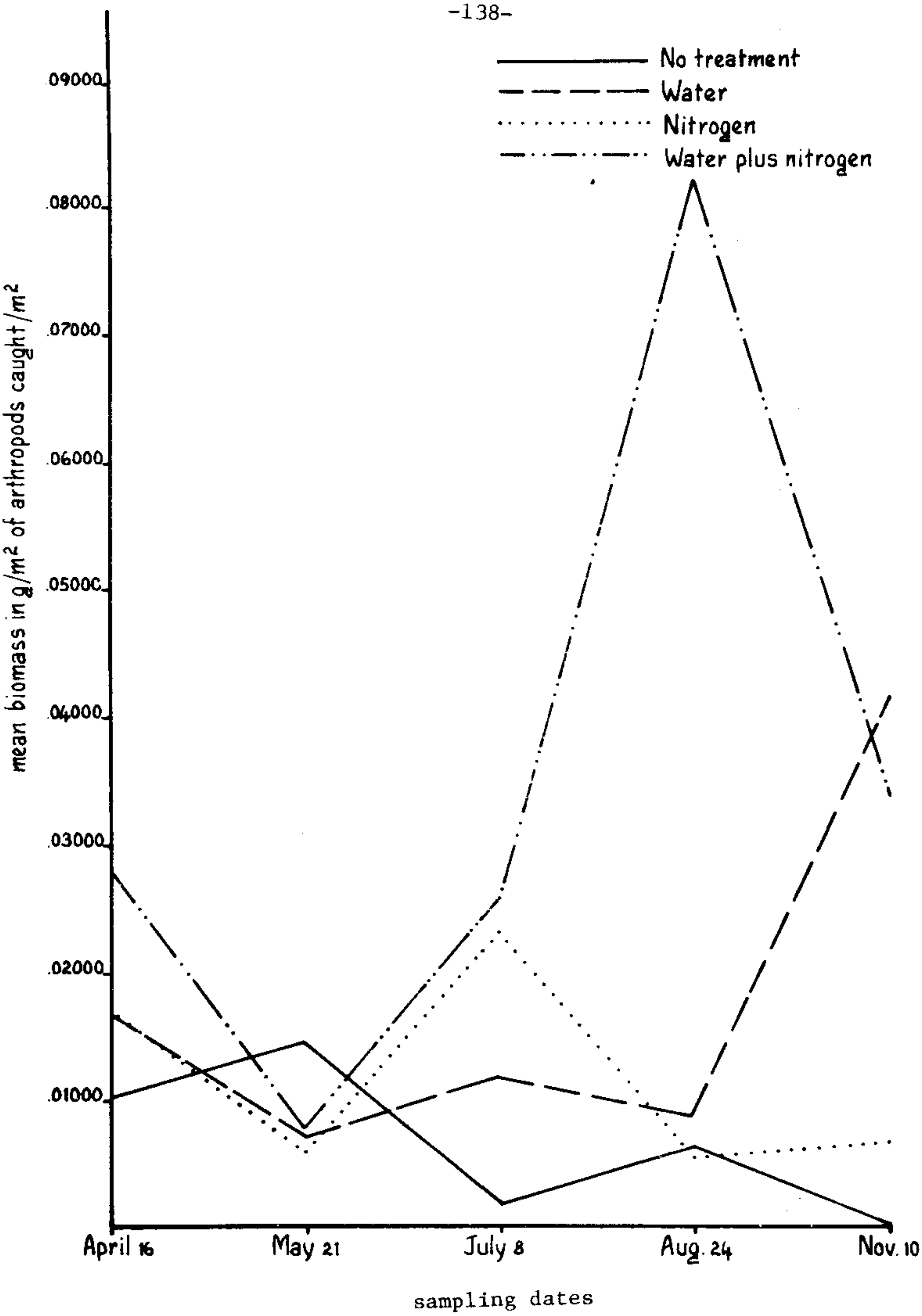


Fig. 28. Effect of four stress treatments on biomass in grams per meter squared of arthropod predators on the Pawnee Site (1971), collected with a D-vac suction apparatus on five major sampling dates.

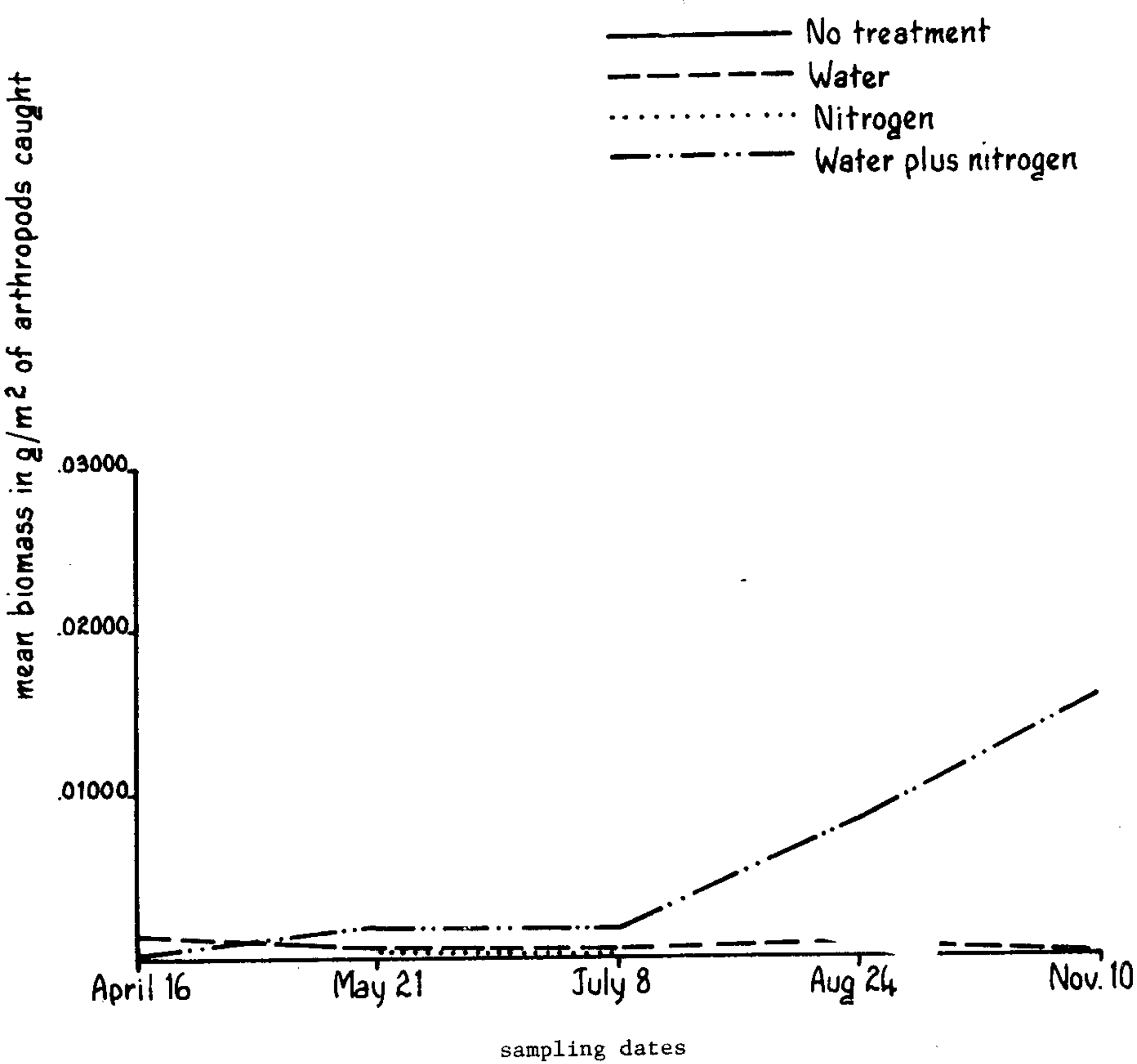


Fig. 29. Effect of four stress treatments on biomass in grams per meter squared of scavenger arthropods on the Pawnee Site (1971), collected with a D-vac suction apparatus on five major sampling dates.

Table 98. Comparison of mean numbers/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the first major sampling date March 25, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	57.0	56.6	34.6	127.4
Plant tissue	1.4	1.8	1.6	4.8
Omnivore	31.8	16.8	13.0	16.4
Scavenger	0.2	1.4	--	0.4
Predator	4.4	6.0	7.2	8.2
Unknown	11.4	10.0	12.0	21.4

a/Actually collected on or about April 16.

Table 99. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the first major sampling date March 25, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	.01154	.01162	.00812	.01677
Plant tissue	.04102	.00835	.01334	.00995
Omnivore	.03772	.00966	.00655	.00878
Scavenger	.00033	.00136	--	.00014
Predator	.01019	.01669	.01702	.02827
Unknown	.09910	.03990	0.6336	.04894

a/Actually collected on or about April 16.

Table 100. Comparison of mean numbers/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	34.6	194.8	88.6	144.4
Plant tissue	0.2	0.4	0.2	2.6
Omnivore	20.0	36.4	38.4	62.2
Scavenger	0.2	1.0	0.8	4.0
Predator	3.2	1.8	1.8	4.8
Unknown	11.0	33.6	27.0	168.8

a/Actually collected on or about May 21.

Table 101. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	.00532	.02351	.00659	.02437
Plant tissue	.00952	.00976	.00003	.00554
Omnivore	.01124	.02003	.02617	.02860
Scavenger	.00005	.00045	.00046	.00172
Predator	.01456	.00713	.00583	.00783
Unknown	.05874	.06040	.04428	.07151

a/ Actually collected on or about May 21.

Table 102. Comparison of mean numbers/m^2 of aboveground arthropds representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.[a/]

Feeding Habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	38.6	61.8	27.0	146.4
Plant tissue	2.6	9.6	6.4	35.4
Omnivore	18.2	20.0	16.0	15.6
Scavenger	--	0.6	0.2	5.2
Predator	3.8	3.8	5.6	5.0
Unknown	10.8	34.0	15.2	42.0
Non-feeding	--	0.2	--	--
Plant pollen	--	0.2	--	--

a/ Actually collected on or about July 8.

Table 103. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	.02453	.03093	.01169	.07860
Plant tissue	.00470	.00360	.00202	.01505
Omnivore	.00939	.01816	.00786	.00911
Scavenger	--	.00046	.00009	.00170
Predator	.00182	.01190	.02323	.02612
Unknown	.01387	.03945	.01665	.06669
Non-feeding	--	.00012	--	--
Plant pollen	--	.00012	--	--

a/ Actually collected on or about July 8.

reflects the proximity of colonies to the samples and not the abundance of ants (Tables 98 to 107) (Fig. 21 and 26). No omnivores were collected on the last sampling date, which was also expected since ants seek over-wintering chambers deep in the ground early in October.

Scavenger arthropods occurred in consistently larger numbers in those plots treated with water. From the second sampling date onward, both numbers and biomass of scavenger arthropods in the water plus nitrogen plots exceeded, by at least three times, those in the water only plots (Tables 98 to 107), and by at least 10 times those collected in plots receiving no water. Collected specimens were insufficient to show any difference between the control plots and the nitrogen treated plots (Fig. 24 to 29).

Almost no differences were apparent between plots in the case of predatory arthropods with the exception of August 24 when the water plus nitrogen plots appeared to contain the largest numbers of predators followed by the water only plots (Tables 98 to 107). However, when biomass is considered, with the exception of May 1, the water plus nitrogen plots contained heavier individuals throughout the season (Fig. 28). The high biomass figures for the water only plots on November 10 probably reflect dense vegetation in which insects are seeking winter hibernation quarters.

In conclusion, there appears to be a definite trend for plant sucking arthropods, plant tissue feeding arthropods, and scavenger arthropods to favor the water plus nitrogen plots over all others, even water alone. The results of these tests imply the existence of mechanisms that participate in the effective allocation of grazing by herbivorous insects. The existence of these mechanisms has been well documented by many authors and reviewed by Thorsteinson (1960) and Schoonhoven (1968). Several authors reviewed by Thorsteinson

Table 104. Comparison of mean numbers/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	5.6	26.6	4.0	56.2
Plant tissue	1.0	10.0	0.8	10.2
Omnivore	--	7.4	1.4	11.1
Scavenger	--	0.6	--	5.5
Predator	3.2	7.0	1.4	23.6
Unknown	9.0	22.4	5.8	19.3
Plant pollen	--	16.2	--	8.2

a/Actually collected on or about August 24.

Table 105. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 20, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	.00527	.02269	.00344	.04140
Plant tissue	.00134	.00837	.00409	.05114
Omnivore	--	.00559	.00141	.01752
Scavenger	--	.00067	--	.00827
Predator	.00635	.00928	.00545	.08200
Unknown	.03881	.06981	.02333	.08444
Plant pollen	--	.00633	--	.00195

a/Actually collected on or about August 24.

Table 106. Comparison of mean numbers/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	5.2	44.4	4.8	54.6
Plant tissue	1.4	2.8	6.2	6.0
Scavenger	--	--	--	0.8
Predator	0.2	1.6	0.8	0.8
Unknown	2.0	16.0	4.4	37.8

[a/] Actually collected on or about November 10.

Table 107. Comparison of mean biomass in g/m^2 of aboveground arthropods representing different trophic levels taken in four grassland stress treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.[a/]

Feeding habit	No treatment	Water	Nitrogen	Water plus nitrogen
Plant sap	.01152	.24032	.00720	.39346
Plant tissue	.00778	.01860	.01602	.01738
Scavenger	--	--	--	.01592
Predator	.00034	.04360	.00684	.03376
Unknown	.05090	.12274	.12248	.45218

[a/] Actually collected on or about November 10.

have shown that organic nitrogen compounds stimulate feeding in such insects as leafhoppers, caterpillars, wireworms and grasshoppers. Nutrients such as carbohydrates, amino acids and also some vitamins may act as phagostimulants (Schoonhoven, 1968) and certainly the addition of water plus nitrogen to a plant may well serve to stimulate the production of all of these.

It should be noted that in Ohio two other stresses, that of mowing and burning, were applied to planted fields of oats to determine their effect on the arthropod component (Bulan and Barrett, 1971). Only Coleoptera were taken to the species level, "Coleoptera species/ area diversity was significantly lower in the burned area."

GRASSLAND FIELD LAYER INSECT COMPOSITION

An identification list of the arthropods of the Pawnee Site has been composed (Kumar et al., 1972), and in it are listed those insects collected on site from 1968 through 1971 which have been identified. Evans and Murdoch (1968) while studying a grassland in Michigan inventoried the insect population. Their figures on numbers of species and percentages of total species/order are presented in Table 108 as a comparison of the insect fauna so far collected on the Pawnee Site. As the comparison stands, our grassland has more species of Orthoptera, Homoptera, and Coleoptera whereas the Michigan grassland contains greater numbers of species of Odonata, Trichoptera, Lepidoptera, Diptera and Hymenoptera. Nevertheless, a considerable amount of Pawnee material remains to be identified, and it is expected that eventually Odonata and Orthoptera may be the only major groups where great discrepancies occur. It should be noted here that a partial inventory of insects

Table 108. Taxonomic Comparison of the field layer insects of a grassland insect community in Michigan with both above- and belowground insects on the Pawnee grassland as of January 1972.

Order	Michigan [a/]		Pawnee	
	No. of species	% of total	No. of species	% of total
Ephemeroptera	3	0.2	3	0.3
Odonata	35	2.2	9	1.0
Orthoptera	33	2.1	55	5.9
Psocoptera	5	0.3	5	0.5
Thysanoptera	3	0.2	1	0.1
Hemiptera	69	4.4	55	5.9
Homoptera	54	3.4	102	10.9
Neuroptera	8	0.5	6	0.6
Coleoptera	169	10.7	374	39.8
Strepsiptera	1	0.0	--	--
Mecoptera	1	0.0	--	--
Trichoptera	13	0.8	2	0.2
Lepidoptera	218	13.8	26	2.8
Diptera	394	24.9	122	13.0
Hymenoptera	578	36.5	166	17.6
Anoplura	--	--	1	0.1
Collembola	--	--	9	0.9
Isoptera	--	--	2	0.2
Siphonaptera	--	--	1	0.1
Thysanura	--	--	1	0.1
TOTAL	1584	100.0	940	100.0

[a/] Figures taken from Evans and Murdoch (1968) and spiders of the foothill rangeland in Montana is being prepared by G. B. Hewitt et al., of the USDA and Agricultural Research Services.

OTHER SAMPLING

Pit Trap

In order to derive some measure of the relative abundance of night crawling insects on the three pastures (light, moderate, and heavy use), it was decided to utilize some sort of pit trap. Since there is an injunction against destructive sampling, and in order not to interfere with other experiments being conducted on the pastures, traps were placed in a single location in the approximate center of each pasture. The traps used were 2 m long, 10 mm wide, and 6 mm deep. Two traps were buried to the lip in a back to back position in each pasture so that insects coming from both directions would be captured. The traps were constructed in a manner such that one side and two ends rose above the level of the soil so that a metal cover could be affixed which helped prevent dilution of the formaldehyde solution by both windblown debris and rain.

The traps were set monthly in July, August, September, and October, and three times in June. Formaldehyde solution was placed in the traps just prior to 9 PM, and the arthropods caught were collected at 6 AM the following morning. The data is presented in Table 109. The top number in each square represents the number of individuals caught, and the number beneath in parentheses represents the total weights of the individuals collected in milligrams. The number following the family or genus name refers to individual species not yet identified. As can be seen from the data, no species was represented by a sufficient number of specimens so that grazing treatments could be compared. The most that can be said for the data is

Table 109. Summary in numbers and biomass by species of arthropods collected in pit traps in the light, moderate, and heavy use pastures between 9 pm and 6 am on selected nights during the 1971 growing season.

Date	Treatment	Chilopdia *Arabius* sp.	Chenonethida *Parachernes nubilis*	Solpugida	Araneida Lycosidae 03	Araneida Lycosidae 04	Araneida 48
6 June 1971	2		1 (2.12)		1 (1.64)	2 (11.84)	
	3						
	4			1 (13.26)	1 (1.64)		2 (0.08)
12 June 1971	2				1 (1.64)	2 (11.84)	
	3			1 (13.26)	3 (4.92)		
	4			2 (26.52)	1 (1.64)	2 (11.84)	
19 June 1971	2				2 (3.28)	3 (17.76)	
	3					1 (5.92)	
	4				3 (4.92)	1 (5.92)	
4 July 1971	2			3 (39.78)	1 (1.64)	2 (11.84)	
	3			3 (39.78)	2 (3.28)	1 (5.92)	
	4					1 (5.92)	
5 August 1971	2				3 (4.92)		
	3					1 (5.92)	
	4						
11 September 1971	2	1 (4.93)			1 (1.64)		
	3					1 (5.92)	
	4	2 (9.86)					
21 October 1971	2					1 (5.92)	
	3					1 (5.92)	
	4					2 (11.84)	

Table 109. (Continued).

Date	Treatment	Araneida 54	Araneida 63	Araneida 64	Araneida 65	Araneida 66	Araneida 67
6 June 1971	2						
	3						
	4						1 (2.42)
12 June 1971	2		2 (1.40)				
	3						
	4		1 (0.70)				
19 June 1971	2						
	3		3 (2.10)				
	4		1 (0.70)				
4 July 1971	2		1 (0.70)	1 (0.86)			
	3						
	4	1 (0.38)		2 (1.72)	1 (1.16)		
5 August 1971	2			1 (0.86)		2 (0.96)	
	3			1 (0.86)			
	4						
11 September 1971	2			1 (0.86)			
	3						
	4						
21 October 1971	2						
	3						
	4						

Table 109. (Continued).

Date	Treatment	Acarina 01	Acarina 07	Neuroptera Myrmeleontidae Genus ? 01	Entomobryidae *Entomobrya multifasciata*	Carabidae *Harpalus desertus*	*Microlestes linearis*
6 June 1971	2						
	3						
	4						
12 June 1971	2						
	3						
	4						
19 June 1971	2			1 (0.82)			
	3						
	4						
4 July 1971	2					1 (14.24)	
	3						
	4		6 (0.42)		1 (0.02)		2 (0.72)
5 August 1971	2					2 (28.48)	
	3						
	4						
11 September 1971	2					2 (28.48)	
	3						
	4	1 (0.23)					
21 October 1971	2					2 (28.48)	
	3						
	4						

Table 109. (Continued).

Date	Treatment	*Evanthrus constrictus*	*Amara farcta*	*Bembidion obscurellum*	*Pasimachus elongatus*	*Cymindis planipennis*	Chrysomelidae *Phyllotreta pusilla*
6 June 1971	2						
	3						
	4						
12 June 1971	2			1 (1.99)			
	3						1 (0.16)
	4						
19 June 1971	2						
	3						
	4						
4 July 1971	2						
	3						
	4						
5 August 1971	2	3 (12.36)					
	3	1 (4.12)					
	4				1 (221.32)		
11 September 1971	2		1 (6.46)				
	3						
	4						
21 October 1971	2						
	3					2 (22.68)	
	4						

Table 109. (Continued).

Date	Treatment	*Notodonta puncticollis*	Curculionidae *Calandrinus insignis*	*Gerstaeckeria basalis*	*Gerstaeckeria lecontei*	*Hyperodes grypidioides*	Elateridae *Aeolus* sp.
6 June 1971	2			3 (39.54)		1 (3.53)	
	3			4 (52.72)			
	4			1 (13.18)			
12 June 1971	2						
	3	2 (0.88)		2 (26.36)		1 (3.53)	
	4			1 (13.18)			
19 June 1971	2		3 (4.23)	1 (13.18)	1 (13.20)	1 (3.53)	
	3			1 (13.18)			
	4			1 (13.18)			1 (1.67)
4 July 1971	2			1 (13.18)			
	3		1 (1.41)				
	4						
5 August 1971	2			2 (26.36)			
	3	1 (0.44)		1 (13.18)			
	4						
11 September 1971	2				1 (13.20)		
	3			1 (13.18)	1 (13.20)		
	4						
21 October 1971	2						
	3						
	4						

Table 109. (Continued).

Date	Treatment	Meloidae 09	Scarabaeidae *Rhyssemus* sp.	Scarabaeidae 32	Staphylinidae *Bladius* sp.	Tenebrionidae *Blapstinus* sp.	*Eleodes extricata*
6 June 1971	2						
	3		3 (2.16)			6 (23.10)	
	4					1 (3.85)	
12 June 1971	2						
	3		3 (2.16)				
	4					1 (3.85)	
19 June 1971	2						
	3					4 (15.40)	
	4				1 (0.54)		
4 July 1971	2						2 (65.68)
	3						
	4						
5 August 1971	2			1 (3.98)			3 (98.52)
	3					1 (3.85)	1 (32.84)
	4	1 (20.14)					
11 September 1971	2						
	3					1 (3.85)	
	4						1 (32.84)
21 October 1971	2						
	3						
	4						1 (32.84)

Table 109. (Continued).

Date	Treatment	*Embaphion muricatum*	*Eleodes* sp.	Coleoptera 77	Cicadellidae *Athysanella* sp.	*Flexamia flexulosa*	Lygaeidae *Blissus leucopterus*
6 June 1971	2						
	3						
	4						
12 June 1971	2						
	3						
	4					5 (2.55)	
19 June 1971	2						
	3					1 (0.51)	
	4			6 (0.84)	1 (0.51)		
4 July 1971	2					2 (1.02)	
	3					4 (2.04)	
	4				1 (0.51)		1 (0.15)
5 August 1971	2	2 (59.68)					
	3	3 (89.52)					
	4						
11 September 1971	2						
	3		1 (187.18)				
	4						
21 October 1971	2						
	3						
	4						

Table 109. (Continued).

Date	Treatment	Lepidoptera 05	Formicidae *Myrmica sabuleti americana*	*Formica neogagates*	*Formica obtusopilosa*	*Leptothorax tricarinatus*	Mutillidae *Dasymutilla fulvohirta*
6 June 1971	2						
	3		1 (1.58)				
	4						
12 June 1971	2					1 (0.45)	
	3		12 (18.96)				
	4		3 (4.74)				
19 June 1971	2		1 (1.58)				
	3		1 (1.58)				
	4					8 (3.60)	
4 July 1971	2		3 (4.74)	7 (4.90)			1 (5.34)
	3		2 (3.16)			6 (2.70)	
	4						
5 August 1971	2		2 (3.16)			3 (1.35)	
	3						
	4		3 (4.74)				
11 September 1971	2	3 (24.84)				1 (0.45)	
	3		13 (20.54)				
	4		5 (7.90)		3 (5.40)	2 (0.90)	
21 October 1971	2						
	3						
	4						

Table 109. (Continued).

Date	Treatment	Mutillidae 02	Diptera 47	Diptera 59	Diptera 80	Gryllidae 01	
6 June 1971	2						
	3						
	4						
12 June 1971	2						
	3						
	4						
19 June 1971	2	1 (6.10)	2 (1.56e)				
	3						
	4			2 (3.24)			
4 July 1971	2						
	3	1 (6.10)					
	4						
5 August 1971	2	1 (6.10)				1 (45.14)	
	3	1 (6.10)					
	4				7 (1.26)		
11 September 1971	2						
	3						
	4						
21 October 1971	2						
	3						
	4						

that these provide information on what kinds of organisms are active at night. Among the most active are several species of spiders, the carabid, *Harpalus desertus;* the curculionid, *Gerstaeckeria basalis;* the tenebrionids, *Blapstinus* sp. and *Eleodes extricata;* the leafhopper, *Flexamia flexulosa;* and the ants, *Myrmica sabuleti americana* and *Leptothorax tricarinatus.* It is probable that in the case of the last two species, the vacuum trap method is not providing a fair estimate of the ant population.

As a result of our above- and belowground arthropod investigation thus far, it appears that the following insects have the greatest impact on the Pawnee grassland and are therefore the logical species around which process studies should be written.

Herbivorous Arthropods

Plant tissue feeders

Opeia obscura (grasshopper) - most abundant species on site although not picked up by D-vac in either bimonthly samples or grazing treatments.

Amara farcta and *Selenophorus plannipennis* (carabids)- common species known to feed on vegetation.

Plant sap feeders

Blissus leucopterus (chinch bug) - most abundant hemipteran ($3.25/m^2$).

Flexamia flexulosa - most abundant leafhopper: adults ($2.05/m^2$); nymphs ($0.5/m^2$), obviously nymphs are escaping through the screen or are too fragile to survive the vacuum.

Seed predators

Pogonomyrmex occidentalis - while never picked up by vacuum samples, it is probably the most abundant ant on site, bioenergetic study completed (Rogers, Lavigne, and Miller, 1972).

Root feeders

Scarabaeid larvae - probably *Rhyssemus* sp. most abundant belowground showing ($2.2/m^2$).

Margarodids - unidentified to species, most abundant sucking ($19.6/m^2$).

Pollen and nectar feeders (ants)

Myrmica sabuleti americana - ($1.75/m^2$).

Monomorium minimum - most abundant ($4.0/m^2$).

Carnivorous Arthropods

Efferia helenae - a predatory fly (Asilidae), not picked up in D-vac samples.

Lycosa minnesotensis - most abundant spider on site.

Detrivorous Arthropods (dung insects)

Aphodius haemorrhoidalis (Scarabaeidae) - most abundant species in cow dung.

In summary, I would strongly urge that more types of sampling techniques which can be used to compare important insect groups such as ants across all grasslands should be studied. I would further recommend that sampling precedures be geared to the most important components of the insect world on each site, depending on what species are important. I would suggest that more emphasis be placed upon food and feeding studies in hopes that such data can be plugged into the computer to supplement our present knowledge. The collected data to date would seem to suggest that the best method of data comparison across sites is by treating arthropods by feeding habit, i.e., trophic level.

However, in order to do this it is necessary to determine upon what individual species feed.

Individual Plant Sampling for Aboveground Insects

Because some insects are host specific, or at least semi-host specific and because 0.5 square meter plot sampling may not pick up more than one forb plant of a particular species per sampling date, it was felt that some indication as to insects associated with particular plants might be of value. Additionally, this data might prove useful when a computor program is written to correlate aboveground insect sampling data with particular plant species. Consequently, a method was sought to collect all the insects on a particular plant at a given time. The plant species chosen were *Gutierrezia sarothrae*, *Artemisia frigida*, *Chrysothamnus nauseosus*, and *Eriogonum effusum*. Many insects are able to remain visually undetected on the branches of these bushy plants, so merely counting insects visually was rejected.

The first method used was that of placing a large plastic bag over individual plants, cutting the plant off at its base, and subsequently washing the organisms from the plant with alcohol. Twenty-five plants of each of the four species were taken in both the light and heavy grazed pastures. At the same time 5-inch diameter soil cores were taken at the point where the stem entered the soil to a depth of 6 inches. The aboveground data collected in this manner are presented in Tables 110 to 111 while the belowground data will appear in a technical report by Kumar et al. (1972) (see also Lloyd and Grow (1971)).

Table 110. Summary in numbers and biomass by species of insects washed from 25 plants of *Gutierrezia sarothrae*, *Artemisia frigida*, *Chrysothamnus nauseosus*, and *Eriogonum effusum* on the heavy use pasture 23 E, June 30, 1971.

Family		GUSA		ARFR		CHNA		EREF	
		# of in- sects	Bio- mass (mg)	# of in- sects	Bio- mass (mg)	# of in- sects	Bio- mass (mg)	# of in- sects	Bio- mass (mg)
Acarina									
Trombidiidae	06	5	0.20	1	0.04	2	0.08	2	0.08
Lycosidae	03					1	1.64	1	1.64
Araneida	19			1	3.75				
COLEOPTERA									
Carabidae									
Selenophorus planipennis				1	1.93				
Chrysomelidae	01							2	2.40
Chrysomelidae	05			1	1.53			1	1.53
Coccinellidae									
Delphestus pusillus		2	0.60	1	0.30	1	0.30	1	0.30
Curculionidae									
Apion sp.				1	0.32				
Calandrinus insignis				1	1.41				
Calyptillus cryptops				1	0.63				
Misc. Curculionidae	22			1	0.55				
Misc. Curculionidae	23			1	0.33				
Tenebrionidae									
Blapstinus sp.				1	3.85				
Misc. COLEOPTERA	56							1	0.46e
Lygaeidae	05			1	0.46				
Tingidae									
Hespertingis sp.		1	0.80						
Aphididae	02	42	3.78	2	0.18			1	0.09
Aphididae	09	9	0.72			3	0.27		
Cicadellidae									
Flexamia flexulosa		1	0.51	2	1.02			1	0.51
Pseudococcidae	03							1	0.70
Psyllidae		1	0.02						
Craspedolepta *Artemisiae*									
Misc. LEPIDOPTERA	69	1	21.84						
Misc. LEPIDOPTERA	70			2	0.52				
Formicidae									
Formica obtusapilosa				4	7.20				
Formica neogagates				1	0.70				
Monomorium minimum				5	1.90			1	0.38
Pteromalidae									
Mesopolobus sp.		1	0.10						
DIPTERA									
Sciaridae	02	1	0.16						
THYSANOPTERA	02			1	0.04				
THYSANOPTERA	04					2	0.12		
COLLEMBOLLA									
Entomobryidae									
Entomobrya multifasciata								1	0.02
TOTAL		64	28.73	29	26.66	9	2.41	12	8.11

Table 111. Summary in numbers and biomass by species of insects washed from 25 plants of *Gutierrezia sarothrae*, *Artemisia frigida*, *Chrysothamnus nauseosus*, and *Eriogonum effusum* on the light use pasture 23 W, June 30, 1971.

Family		GUSA # of insects	GUSA Biomass (mg)	ARFR # of insects	ARFR Biomass (mg)	CHNA # of insects	CHNA Biomass (mg)	EREF # of insects	EREF Biomass (mg)
Acarina									
Erythraeidae						1	0.25		
Trombidiidae		10	0.40	6	0.24				
Lycosidae	03	1	1.64	1	1.64	1	1.64		
Araneida	47					1	0.22		
COLEOPTERA									
Chrysomelidae	01	1	1.20					1	1.20
Psylloides punctulata		1	0.71						
Chrysomelidae	05	1	1.53						
Cleridae	03	1	1.12						
Coccinellidae									
Hyperaspidius trimaculatus						1	1.67		
Curculionidae		1	1.41						
Calandrinus insignis									
Curculionidae	23	1	0.33						
Curculionidae	34					1	0.94		
Tenebrionidae				1	3.85				
Blapstinus sp.									
Misc. COLEOPTERA	56							1	0.46
HEMIPTERA									
Lygaeidae	05	1	0.46	2	0.92	1	0.46		
Lygaeidae	23	1	0.80						
Pentatomidae				1	16.10				
Euptychodera corrugata									
Misc. HEMIPTERA	03	9	6.48e						
Misc. HEMIPTERA	04			6	1.08				
HOMOPTERA									
Aphididae	02					2	0.18	2	0.18
Aphididae	03					2	0.18		
Cicadellidae									
Aceratagallia humulis				10	2.80				
Gillettiella atropunctata				1	0.23				
Cuerna sp.						1	2.09		
Flexamia flexulosa		2	1.02	7	3.57	3	1.53	6	3.06
Issididae									
Bruchomorpha saturalis						1	0.46		
Membricidae									
Publilia modesta		7	1.26						
Pseudococcidae	04					1	0.08	4	0.32
Arctiidae		7	3.64	4	2.08				
Apantesis sp.									
Geometridae	02	1	0.12						

Table 111. (Continued).

Family		GUSA		ARFR		CHNA		EREF	
		# of in-sects	Bio-mass (mg)	# of in-sects	Bio-mass (mg)	# of in-sects	Bio-mass (mg)	# of in-sects	Bio-mass (mg)
Misc. LEPIDOPTERA	05	1	8.28						
Misc. LEPIDOPTERA	13					1	4.85		
Formicidae									
Formica obtusapilosa				1	1.80				
Trichogrammatidae								1	0.18
Ufens sp.									
TOTAL		46	30.40	40	34.31	17	14.55	15	5.40

Data from this method show no major differences in weights for total insects on plant species between pastures, except in the case of *Chrysothamnus nauseosus* where those plants in the light use pasture supported six times as much biomass on June 30 as those in the heavy use pasture. Numerically there were twice as many insects on the former. The much higher insect numbers on *Gutierrezia sarothrae* came from a colony of aphids on one plant. The lack of difference between plots was unexpected since the plants in the light use were much larger than those in the heavy use pastures, and it was predicted that the former would support a greater insect biomass.

However, many insects exhibit thanotosis (play dead) when a plant is touched and immediately fall to the ground, and it was felt that perhaps part of the insect component was being missed in the attempt to place the plastic bag over the plant. Consequently, it was decided to sweep 25 individual plants of each species with a standard 15-inch diameter insect aerial net. Unfortunately, by the time we had the opportunity to use this method (August 17), there were insufficient numbers of plants of three species available in the heavy use pasture due to grazing pressure so only the light use pasture was sampled (Table 112). Flowering of these species was just beginning. All four plant species were sampled in the light and moderate use pasture on September 6 when all species were in bloom (Tables 113 to 114). Additionally, *Eriogonum effusum* was sampled in the heavy use pasture.

Comparing the data for the apparent insect carrying capacity of *Eriogonum effusum* on September 6, it was found that there was no difference in either numbers or biomass between the light and moderate pastures, but that both supported almost five times as many insects and four times as much biomass as those plants in the heavy use pasture (Table 111).

Table 112. Summary in numbers and biomass by species of insects collected sweeping 25 plants each of *Gutierrezia sarothrae, Artemisia frigida, Chrysothamnus nauseosus,* and *Eriogonum effusum* on light use pasture 23 W, August 17, 1971.

Family		GUSA		ARFR		CHNA		EREF	
		# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)
Chrysomelidae									
Phyllotreta pusilla						1	0.16		
Notodonta puncticollis		10	4.40	1	0.44	3	1.32	1	0.44
Chrysomelidae	14					1	1.62e		
Cleridae	01	1	3.46	1	3.46				
	03	1	1.12						
Coccinellidae									
Hippodamia convergens		1	1.67						
Delphestus pusillus		2	0.60	2	0.60				
Curculionidae									
Apion sp.		1	0.32					1	0.32
Curculionidae	46					1	0.34		
Curculionidae	47			4	1.60				
Curculionidae	49	1	0.28						
Curculionidae	50	2	0.44						
Meloidae									
Epicuata ferruginea		2	14.76						
Misc. COLEOPTERA	70							1	0.40
Misc. COLEOPTERA	71							2	1.08
Misc. COLEOPTERA	72	1	3.46						
Misc. COLEOPTERA	73	2	2.84						
Misc. COLEOPTERA	74	1	1.48						
HEMIPTERA									
Lygaeide	04							3	5.61
Lygaeide	21							1	0.28e
Miridae	04			3	2.28				
Tingidae									
Corythaica acuta								1	0.80
Aphididae	01					16	1.28		
Cicadellidae		11	3.08	17	4.76	2	0.56	10	2.80
Aceratagallia humulis									
Athysanella sp.		1	0.51	5	2.55	3	1.53	5	2.55
Gillettiella *Atropunctata*		2	0.46	2	0.46	1	0.23	1	0.23
Cuerna sp.		8	16.72	36	75.24	2	4.18	2	4.18
Flexamia flexulosa		1	0.51	7	3.57			7	3.57
Balclutha neglecta		32	7.04	11	2.62	56	12.32	4	.88
Cicadellidae	47			1	2.40				
Cicadellidae	48					2	3.76		
Cicadellidae	49	1	2.10	4	8.40				
Dictyopharidae								1	1.84
Scolops sulcipes									
Issidiae						2	0.92		
Bruchomorpha suturalis									

Table 112. (Continued).

Family		GUSA # of in-sects	GUSA Bio mass (mg)	ARFR # of in-sects	ARFR Bio-mass (mg)	CHNA # of in-sects	CHNA Bio-mass (mg)	EREF # of in-sects	EREF Bio-mass (mg)
Arctiidae				2	1.04				
Apantesis sp.									
LEPIDOPTERA	94			1	0.20				
Formicidae									
Myrmicea sabuleti americanus		1	1.58						
Monomorium minimum								1	0.38
Formica neogagates								8	0.70
Formica obtusopilosa						1	1.80	11	19.80
HYMENOPTERA	43					1	0.32		
HYMENOPTERA	44							1	1.20
HYMENOPTERA	45							1	0.30
HYMENOPTERA	46			1	0.08				
HYMENOPTERA	47			1	0.10				
HYMENOPTERA	48	2	6.24	1	3.12				
HYMENOPTERA	49			1	0.10				
HYMENOPTERA	50	2	1.72						
HYMENOPTERA	51	1	0.22						
HYMENOPTERA	52	1	0.10						
DIPTERA	88	2	0.48			1	0.24	2	0.48
DIPTERA	89					2	1.00		
DIPTERA	90	6	2.52	6	2.52	6	2.52		
DIPTERA	91							1	0.18
DIPTERA	92							1	0.20
DIPTERA	93							1	0.20
DIPTERA	94							2	0.44
DIPTERA	95							1	0.24
DIPTERA	96							1	1.42
DIPTERA	97	2	2.36						
DIPTERA	98	1	0.20						
DIPTERA	99	1	0.22						
DIPTERA	100	1	0.40						
DIPTERA	101	1	0.10						
ORTHOPTERA									
Acrididae		2	60.36						
Opeia obscura									
Amphitornus coloradus								1	18.10
Acrididae	24							1	14.98
TOTAL		104	141.75	107	115.54	101	34.10	73	83.60

Table 113. Summary in numbers and biomass by species of insects collected sweeping 25 plants each of *Gutierrezia sarothrae*, *Artemisia frigida*, *Chrysothamnus nauseosus*, and *Eriogonum effusum* on light use pasture 23 W, September 6, 1971

Family		GUSA		ARFR		CHNA		EREF	
		# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)
Bruchidae	02					2	1.84	1	0.92
Cantharidae									
Chauliognathus scutellaris		63	687.92			1	10.92		
Cleridae	03			1	1.12				
Coccinellidae									
Hippodamia convergens						1	1.67		
Delphestus pusillus						1	0.30		
Curculionidae	34	2	1.84	3	2.76	1	0.92		
Curculionidae	49					1	0.28		
Tenebrionidae									
Eleodes extricata						1	32.84		
Misc. COLEOPTERA	74					2	2.96		
Lygaeidae	04			4	7.48				
Lygaeidae	21			1	0.28e				
Pentatomidae	03							1	1.18
Cicadellidae									
Aceratagallia humulis						3	0.54		
Athysanella sp.						2	1.02		
Cuerna sp.				20	41.80	3	6.27	1	2.07
Empoasca sp.						11	3.08		
Cicadellidae	47	3	7.20	1	2.40	1	2.40		
Cicadellidae	49			3	6.30				
Dictyopharidae									
Scolops sulcipes								2	3.68
Bombylidae	01					1	2.94		
Formicidae									
Myrmica sabuleti americanus				3	4.74			1	1.58
Monomorium minimum						2	0.76		
Formica neogogates								5	3.50
Formica obtusopilosa		3	5.40					13	23.40
Misc. HYMENOPTERA	53							1	0.26
Misc. HYMENOPTERA	54							1	6.10
Misc. HYMENOPTERA	56	1	3.18						
Misc. HYMENOPTERA	61	2	8.20			1	4.10		
Misc. HYMENOPTERA	62					1	0.10		
Misc. HYMENOPTERA	63					1	0.10		
Misc. DIPTERA	102					7	6.02	12	10.32
Misc. DIPTERA	103							1	0.26
Misc. DIPTERA	105					8	9.76		
Arctiidae *Apantesis* sp.				3	1.56				
Misc. LEPIDOPTERA	94							6	1.20
Misc. LEPIDOPTERA	95							6	18.72

Table 113. (Continued).

Family		GUSA		ARFR		CHNA		EREF	
		# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)
Acrididae *Melanoplus gladstoni*						1	14.76		
Acrididae	24			4	59.92				
Araneida	57					1	2.62e		
Araneida	58			1	2.44				
TOTAL		74	713.74	44	130.80	53	106.20	51	73.19

Table 114. Summary in numbers and biomass by species of insects collected sweeping 25 plants each of *Gutierrezia sarothrae*, *Artemisia frigida*, *Chrysothamnus nauseosus*, and *Eriogonum effusum* on moderate use pasture 15 E, September 6, 1971.

Family		GUSA		ARFR		CHNA		EREF	
		# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Bio mass (mg)
COLEOPTERA									
Cantharidae									
Chauliognathus scutellaris		13	141.96						
Coccinellidae									
Delphestus pusillus						3	1.80		
Curculionidae	34			2	1.84	4	3.68	1	0.92
Meloidae									
Epicuata pennsylvanica		1	10.98						
E. ferruginea		7	51.66			1	7.38		
Meloidae	08	7	44.24			1	6.32		
COLEOPTERA	74							1	1.48
COLEOPTERA	75					1	1.12		
HEMIPTERA									
Lygaeidae	21			3	0.84e	2	0.56e	1	0.28e
Lygaeidae	29							1	0.48
Lygaeidae	30			1	1.34				
Nabidae	04	1	1.28						
Pentatomidae	04							1	2.02
Tingidae									
Corythaica acuta						1	0.80		
HOMOPTERA									
Cicadellidae		1	2.09	1	2.09				
Cuerna sp.									
Empoasca sp.						15	4.20		
Cicadellidae	47	1	2.40	2	4.80				
Dictyopharidae									
Scolops sulcipes		1	1.84					2	3.68
HYMENOPTERA									
Formicidae									
Myrmica sabuleti americanus								1	1.58
Misc. HYMENOPTERA	55							1	0.12
Misc. HYMENOPTERA	56					1	3.18	2	6.36
Misc. HYMENOPTERA	57					1	3.02	1	3.02
Misc. HYMENOPTERA	58							1	5.24
Misc. HYMENOPTERA	59							1	5.20
Misc. HYMENOPTERA	61					1	4.10		
Misc. LEPIDOPTERA	94							7	1.40
Misc. LEPIDOPTERA	95							6	18.60
Misc. LEPIDOPTERA	96			4	4.80				
Misc. DIPTERA	90	1	0.28			4	1.12		
Misc. DIPTERA	102							20	17.20
Misc. DIPTERA	104							1	0.18
Misc. DIPTERA	105							2	2.44
Misc. DIPTERA	106					7	3.36		
Misc. DIPTERA	107					1	1.18		

Table 114. (Continued).

Family		GUSA		ARFR		CHNA		EREF	
		# of in-sects	Bio-mass (mg)	# of in-sects	Bio-mass (mg)	# of in-sects	Bio-mass (mg)	# of in-sects	Bio-mass (mg)
ORTHOPTERA									
Acrididae									
Melanoplus infantalis				4	180.08				
Araneida	56							1	0.72
Araneida	58	1	2.44						
TOTAL		34	259.17	17	195.79	43	41.82	51	70.82

In the case of the other three plant species, those in the light use pasture supported more insects with greater biomass than the same plants in the moderate use pasture except for the heavier biomass of insects on *Artemisia frigida*, most of which was accounted for by four specimens of the grasshopper, *Melanoplus infantilis*. The majority of the biomass on *A. frigida* in the light use pasture was four specimens of *Melanoplus gladstoni*. Diet analysis has shown that both species feed on *A. frigida*. The insect component of *Gutierrezia sarothrae* and *Chrysothamnus nauseosus* was more than twice as much, both in numbers and biomass, in the light use pasture (Tables 113 to 115), suggesting some effect from grazing pressure.

When we look at the four species of plants on the three different dates (June 30, August 17 and September 6) for the light use pasture only,we see the same pattern of insect densities occurring on all plant species. The numbers are low on the first sample date, highest on the second, and approximately half of the second on the third sample date. However, we see a steady progression in insect biomass, except for *Eriogonum effusum* where there is not much difference between the second and third dates (Tables 111 to 113). The large insect biomass present on flowering *Gutierrezia sarothrae* on the third date resulted from the exceptionally high numbers of cantharids feeding on the pollen. This is the type of picture one would expect, i.e., as the plants become more mature and flower, greater numbers of insects would be expected to utilize them. The data collected by the vacuum samples (Fig. 5 and 6) present a diametrically opposed picture of insect population and biomass change on the light use pasture. One can only assume that the vacuum samples are being taken where only grass is present which

Table 115. Summary in numbers and biomass by species of insects collected sweeping 25 plants of *Eriogonum effusum* on heavy use pasture 23 E, September 6, 1971.

Family		GUSA		ARFR		CHNA		EREF	
		# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)	# of insects	Biomass (mg)
Bruchidae	02							3	2.76
Lygaeidae	07							1	4.48
Lygus sp.									
Miridae	03							1	0.62
Dictyopharidae								1	1.82
Scolops sulcipes									
DIPTERA	102							2	1.72
HYMENOPTERA	60							1	0.48
LEPIDOPTERA	94							1	0.20
Araneida	55							1	1.12
TOTAL								11	13.20

would explain the curve, i.e., as the grass dries out, either insect populations shift to more succulent forbs or many species have completed their aboveground development.

RELATION OF MEAN NUMBERS OF COLLECTED ARTHROPODS TO PRECIPITATION

Haufe (1966) has stated that "critical consideration of the response of animals in general and particularly of insects at different levels of biological integration reflects increasing significance of anomalies in the physical characteristics of water." Some observations indicate that winter rain increases the lethal effects of winter cold on insects (Messenger, 1959). "An interesting instance of the influence of summer precipitation on insect distribution and abundance is given by the pink bollworm, *Pectinophora gossypiella* (Saunders), in northern India (Punjab). Economically important infestations are limited to those areas where the normally excessively hot temperatures of summer are reduced by the cooling action of midsummer rainfall. Hence summer rainfall is an important climatic indicator for this species, even though the dominating climatic factor is temperature." (Messenger, 1959). Using the alfalfa weevil, Cook (1929, 1931) derived forecasting techniques for determining the potential spread of insect pests introduced into a new environment.

Dickinson and Leetham (1971) presented a graph showing a bimodal curve for the mean numbers of insects caught with the D-vac suction apparatus during the 1970 season on pastures under four grazing intensities. In the same graph (their Fig. 2) they showed precipitation peaks that appeared to be correlated with the insect population peaks. In this context they stated that "the bimodal population growth may be an inherent characteristic of the insects of the short grass prairie, possibly due to adaption to the distribution of precipitation, temperature, and their effect on primary productivity." It is unclear from the report whether arthropods other than insects were included in the curve. Additionally, the use of the term "inherent" implies that the curve would be bimodal, irrespective of the effect of precipitation, etc., on productivity.

Interestingly enough, however, when one examines the seasonal D-vac catch of arthropods for 1971 on the permanently ungrazed and the grazed (1970)-ungrazed (1971) plots, it is apparent that there is no bimodal population curve, but that the curve shows a steady decline from the peak in late May. When these curves are plotted against precipitation, there appears to be a direct relation since the single precipitation peak and the arthropod population peak (Fig. 30) coincide. In the event that the occurrence of large numbers of ants in the samples might have affected the curve, the curve was constructed with the ants deleted (Fig. 31). When comparing Fig. 30 and Fig. 31, it is apparent that the slope of the curve is not substantially changed, so we can assume that the curve has some validity.

One would expect, then, that if precipitation is an indirect driving variable affecting arthropod numbers the maintenance of a constant water level in the soil plus the addition of nitrogen would increase the succulence of plants, thereby resulting in the maintenance of large populations of arthropods. Even if this were not the case, it would be expected that by maintaining the plants in a succulent stage for a longer period of time, that the arthropod component would show a sustained numerical level beyond that found on

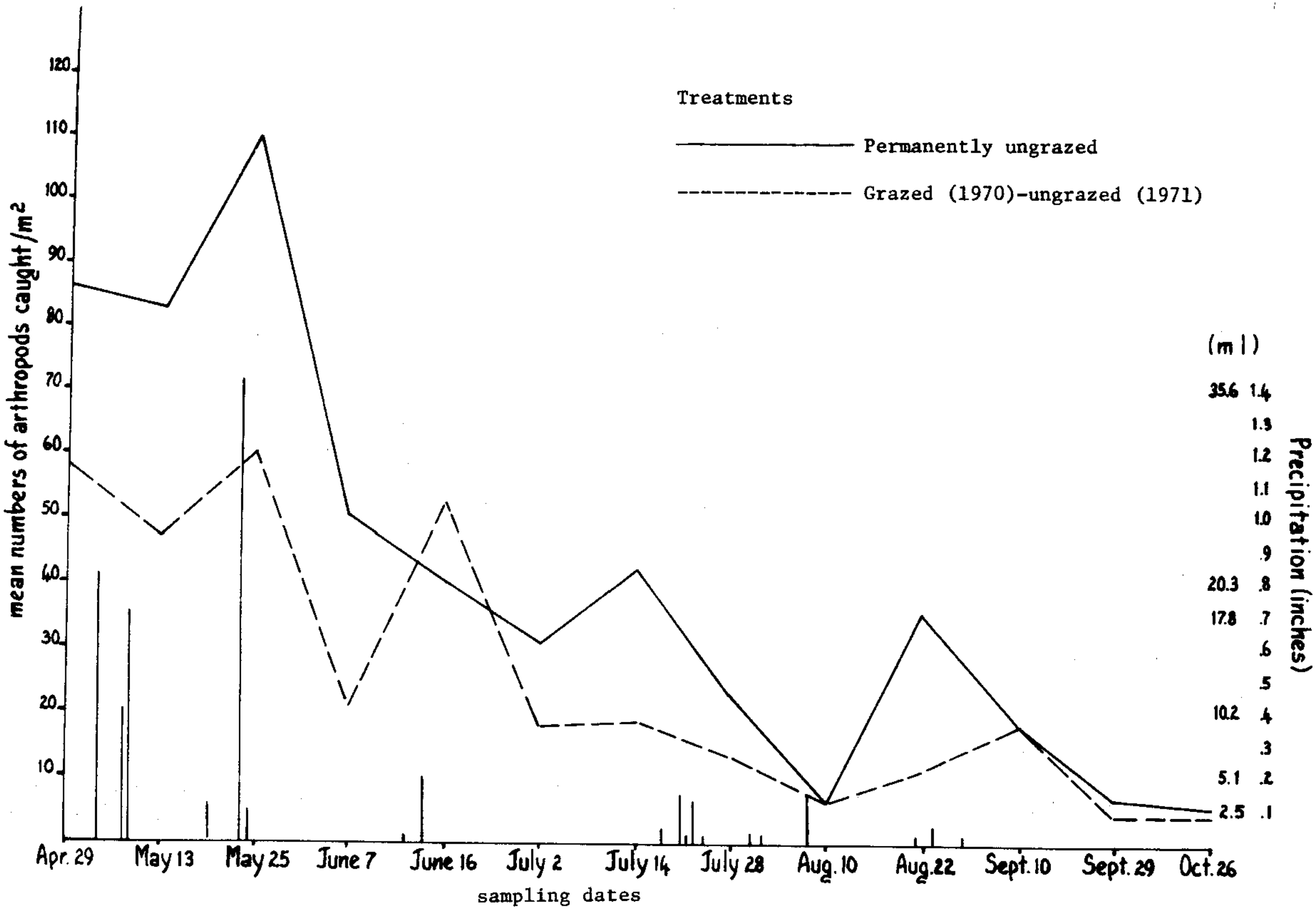


Fig. 30. Comparison of mean numbers per meter squared of aboveground arthropods with precipitation on the Pawnee Site during 1971.

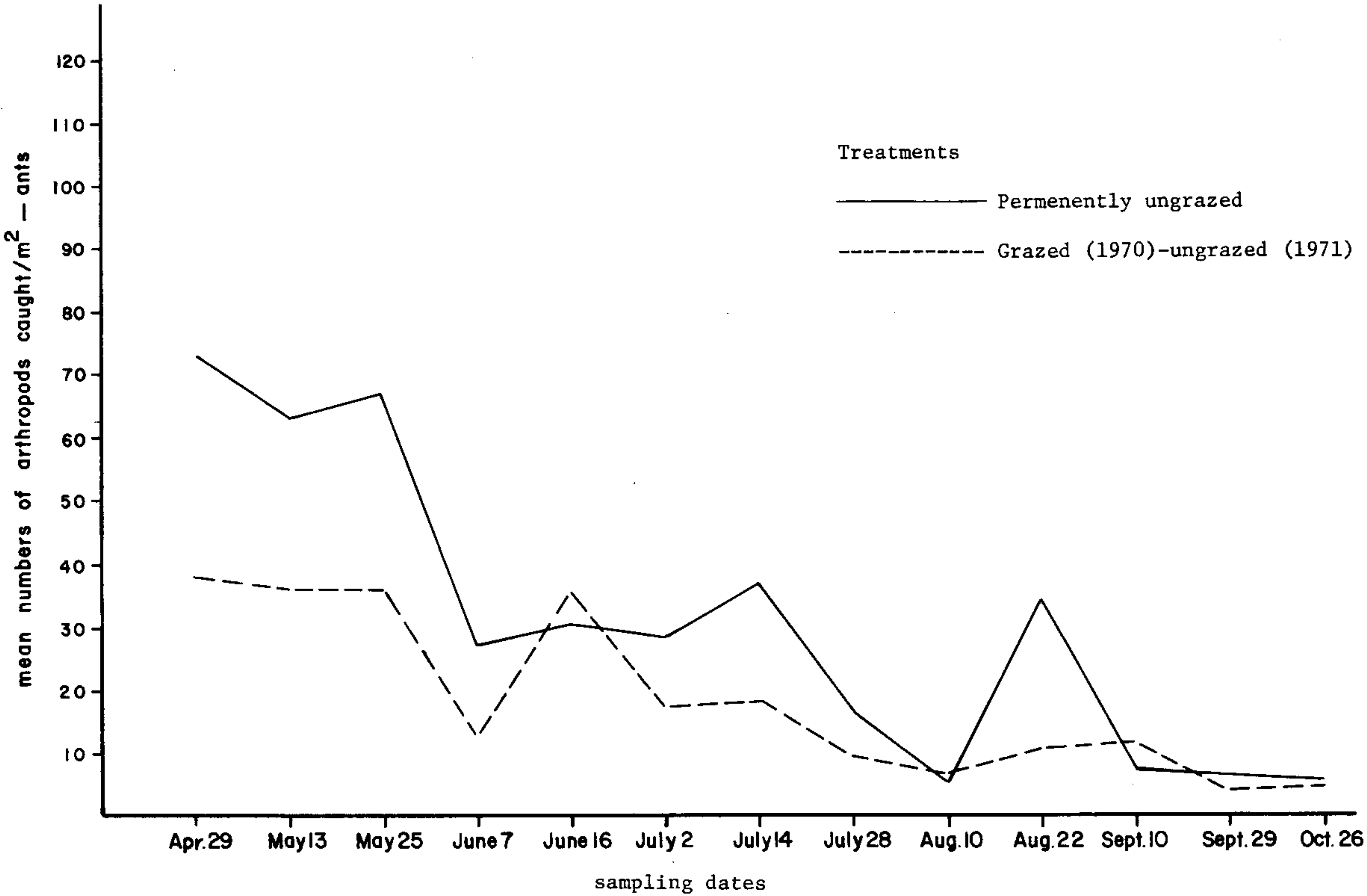


Fig. 31. Comparison of mean numbers per meter squared of aboveground arthropods collected in bimonthly samples on the Pawnee Site (1971) with the ant component deleted.

an untreated plot. When mean total arthropod numbers meter squared are plotted against the stress of water, nitrogen, and water plus nitrogen, it can be seen (Fig. 18) that the slope of the curves compare well with the slope of the curve for the bimonthly samples on the untreated plots. Additionally, the curves would seem to support the contention that there is a correlation between precipitation and insect abundance. Exactly what the correlation is needs to be investigated.

DISCREPANCIES IN THE PRESENT SAMPLING SYSTEM

While the current method of using a D-vac suction apparatus to sample the arthropods seems like a reasonable method for comparing the biota across various types of grasslands, glaring discrepancies are apparent as illustrated by the following examples.

The first illustration represents the major arthropod chewing component of the grasslands, the grasshopper. Some 42 species of grasshopper have been recorded from the Pawnee Site, 7 of which are confined to special habitats such as barrow pits and vegetation surrounding ponds. The other 35 species can be found on the open rangeland pastures, although 10 of these are rare. Out of the 25 common species which are regularly picked up by using a visual square-foot sampling method (Pfadt) (see also Pfadt, 1972), only 4 of these species have been picked up by the D-vac sampler on these same pastures. Three of these same species plus three more have been picked up by the D-vac on the environmentally stressed plots. Thus, we have only 7 species of grasshopper out of 25 being sampled (Table 116). More than this, of the four most abundant rangeland species, *Psoloessa delicatula, Cordillacris crenulata, Opeia obscura,* and *Melanoplus gladstoni,* only *P. delicatula* is being collected by the D-vac. Consequently, we must assume that the D-vac is inadequate for sampling grasshoppers.

Additionally, if we look at the results of the D-vac sampling as compared with the results attained by the 100-ft^2 visual estimate of Pfadt (Table 116), we immediately perceive that there is a major discrepancy in results. If the D-vac is correct in reporting no grasshoppers on the study pastures for June through August, then the grasshoppers I collected from these pastures during these months for diet analysis must be an artifact. It becomes apparent from the results presented in Table 117 that while the D-vac is successful in

Table 116. Comparison of species of grasshoppers present and picked up by D-vac suction appartus (* after name indicates that it is rare, x indicates those present, and - indicates those not present).

Grasshopper species present on sampled pastures	Species recorded by visual sq ft sampling (Pfadt) pastures 2,3, & 4	Picked up by D-vac Treatment
Psoloessa delicatula	x	1,2,6 & D [a/]
Arphia conspersa	x	2,6 & D
Erittetix simplex tricarinatus	x	3 & D
*Hesperotettix viridis**	-	1
Opeia obscura	x	F & G
Melanoplus infantilis	x	G
Trachyrhachys kiowa	x	G
Acrolophitus hirtipes	x	-
*Aeoloplides turnbulli**	-	-
Aeropedellus clavatus	x	-
Ageneotettix deorum	x	-
Amphitornus coloradus	x	-
Arphia pseudonietana	x	-
*Aulocara elliotti**	-	-
*Chortophaga viridifasciata**	-	-
Cordillacris crenulata	x	-
Cordillacris occipitalis	x	-
*Dissosteira carolina**	-	-
Encoptolophus sordidus costalis	x	-
*Hadrotettix trifasciatus**	-	-
*Heliaula rufa**	-	-
*Melanoplus confusus**	-	-
Melanoplus foedus	x	-
Melanoplus gladstoni	x	-
Melanoplus occidentalis	x	-
Melanoplus sanguinipes	x	-
*Mestobregma plattei**	-	-
Parapomala wyomingensis	x	-
Phlibostroma quadrimaculatum	x	-
Phoetaliotes nebrascensis	x	-
Spharagemon equale	x	-
Trachyrhachys aspera	x	-
Trimerotropis campestris	x	-
*Tropidolophus formosus**	-	-
Xanthippus corallipes	-	-

a/ See Fig. 1 for treatment designations.

collecting nymphs in the early part of the season while it is relatively cold, it becomes inefficient thereafter.

Table 117. Comparison of the efficiency of the D-vac suction appartus and the visual square-foot method (Pfadt) in estimating grasshoppers on the light, moderate, and heavy use pastures.

Major Sample Dates	Mean No. of Grasshoppers/m^2					
	Light Grazed		Moderate Grazed		Heavy Grazed	
	D-vac	Visual	D-vac	Visual	D-vac	Visual
May 1	0.6	--	0.2	--	0.2	--
June 25	0	2.6	0	1.4	0	1.2
August 20	0	1.6	0	1.4	0	1.0
October 15	0	0.2	0	0.3	0	0.1

One of the most important groups of sucking insects on the Pawnee Site are the leafhoppers (Cicadellidae) (Tables 118 to 121). The most easily observed species on site are two species of *Cuerna*, which according to Yount and Thatcher (1972) feed on almost every species of grass and forb on site. Yet in 11 bimonthly samples on the permanently ungrazed and the grazed (1970)-ungrazed (1971) plots, only a total mean number of 14 specimens of *Cuerna* sp. were collected by the D-vac suction apparatus. The previous year, according to Yount who made biweekly observations throughout the season on grasses and forbs, 1176 of her feeding and/or sighting records (1/7 of her total observations) were of *Cuerna* sp. These observations seem to be inconsistent with the data obtained by the D-vac.

On the other hand, 3.6 *Cuerna* sp./m^2 were collected with the D-vac suction apparatus on August 22 on the light use pasture. On August 17 the senior author collected 36 *Cuerna* sp. by sweeping 25 *Artemisia frigida* plants

Table 118. Comparison of mean numbers/m^2 of aboveground arthropods by family in major orders taken in four grassland treatments with a D-vac suction apparatus at the time of the second major sampling date May 1, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Scarabaeidae	17.2	9.2	13.0	5.2
Tenebrionidae	2.8	2.8	1.4	6.6
Curculionidae	5.6	4.8	1.6	0.4
Coccinellidae	0.8	--	--	--
Staphylinidae	0.2	0.4	0.4	0.8
Carabidae	0.4	2.0	1.6	0.4
Chrysomelidae	8.2	0.4	0.4	0.2
Elateridae	0.4	0.2	--	0.2
Anthicidae	0.2	--	--	--
HEMIPTERA				
Lygaeidae	6.2	37.0	3.6	5.2
Cydnidae	1.6	1.4	0.2	--
Tingidae	--	0.8	0.2	0.4
Phymatidae	0.2	--	0.2	--
Corixidae	0.2	0.2	0.2	--
Miridae	--	--	0.2	--
Piesmidae	--	--	--	0.2
HOMOPTERA				
Cicadellidae	1.6	3.8	0.8	2.2
Pseudococcidae	0.2	0.2	0.2	7.0
Aphididae	--	--	0.2	2.8
DIPTERA				
Cecidomyiidae	0.2	0.4	0.2	0.6
Chironomidae	0.4	--	--	--
Culicidae	0.2	--	--	--

Table 119. Comparison of mean numbers/m^2 of aboveground arthropods by family in major order taken in four grassland treatments with a D-vac suction apparatus at the time of the third major sampling date June 25, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Tenebrionidae	1.4	2.0	1.4	0.6
Curculionidae	2.0	0.4	0.4	0.2
Coccinellidae	1.0	0.6	1.0	2.2
Staphylinidae	--	--	0.4	--
Carabidae	0.2	0.6	0.2	0.2
Chrysomelidae	1.2	1.6	0.2	0.2
Anthicidae	--	0.2	--	--
Nitidulidae	--	--	--	0.8
Mordellidae	0.2	--	--	--
HEMIPTERA				
Lygaeidae	0.4	1.4	0.4	0.8
Cydnidae	--	0.4	--	--
Tingidae	1.4	0.4	--	--
HOMOPTERA				
Cicadellidae	6.2	16.6	5.6	13.0
Pseudococcidae	--	0.6	--	0.2
Aphididae	--	0.6	0.4	--
Psyllidae	--	--	1.2	--

Table 120. Comparison of mean numbers/m^2 of aboveground arthropods by family in major orders taken in four grassland treatments with a D-vac suction apparatus at the time of the fourth major sampling date August 22, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Tenebrionidae	5.6	2.0	2.8	2.2
Curculionidae	5.1	1.6	3.8	0.4
Coccinellidae	0.5	0.2	0.6	2.0
Carabidae	0.9	1.0	1.2	0.2
Chrysomelidae	2.2	0.4	2.2	0.2
HEMIPTERA				
Lygaeidae	2.0	--	--	0.6
Tingidae	0.4	0.2	--	--
Coreidae	--	--	0.2	--
HOMOPTERA				
Cicadellidae	6.3	10.6	5.8	3.0
Membracidae	--	0.2	--	--
Dictyopharidae	--	0.2	--	--

Table 121. Comparison of mean numbers/m^2 of aboveground arthropods by family in major orders taken in four grassland treatments with a D-vac suction apparatus at the time of the fifth major sampling date October 15, 1971.

Family	Ungrazed	Lightly grazed	Moderately grazed	Heavily grazed
COLEOPTERA				
Tenebrionidae	3.2	0.2	1.2	2.4
Curculionidae	1.0	0.8	0.2	0.2
Chrysomelidae	0.4	--	--	--
HEMIPTERA				
Lygaeidae	0.2	--	--	--
Tingidae	--	--	--	0.2
Cydnidae	--	--	--	0.2
HOMOPTERA				
Cicadellidae	--	0.4	2.4	--

on the same pasture. At the same time, he counted the number of *A. frigida* plants on two 100-m^2 transects in this pasture. The number of plants came to 504. Thus, the number of *Cuerna* per plant was 1.4 and the number of plants per m^2 was 2.52, providing a figure of 3.53 *Cuerna* sp./m^2, a figure remarkedly close to that provided by the D-vac. This would imply that *A. frigida* was the preferred host at this time of year when most grasses have gone to seed. Interestingly enough, three other densely distributed forb species were swept on the same date and at the same rate, *Gutierrezia sarothrae* with 8 *Cuerna* on 25 plants, *Eriogonum effusum* with 2, and *Chrysothamnus nauseosus* with 2. On this particular date, then, there was remarkable consistency, indicating that larger Homoptera are adequately sampled by the D-vac suction apparatus. Additionally, by circular reasoning then, one might suggest that two 100-m^2 transects were adequate for sampling individual forb species. The problem which arises is that since *Cuerna* sp. overwinter as adults, and the nymphs which appear in the spring are quite distinctive in color pattern, why did the D-vac apparatus not pick up any nymphs until the 6th bimonthly sample on July 2. The probably answer is that early instar nymphs are escaping throughthe screen immediately after the cages are dropped as suggested by Blocker, Reed, and Mason (1971).

It should be noted also that 50 species of leafhoppers have been collected on these pastures and identified by experts. However, specimens representing only 13 species have been collected from the D-vac samples. If we compare Fig. 2 and 5 we see that sucking insects are dominant both numerically and in biomass; thus it stands to reason that if only 1/4 of the leafhopper species are being picked up by the D-vac, a substantial portion of the energy flow is not being recorded. Additionally, *Flexamia flexulosa*, the most abundant leafhopper, has an overall seasonal adult density of 2.05/m^2 but only 0.5/m^2 in the nymphal stage. Since there cannot be more adults than nymphs, one can only conclude most nymphs are escaping or are being killed in the vacuum process.

A third example is that of ants. The majority of ants remain in the ground all summer long with only a small percentage of them doing the foraging for the colony. The D-vac picks up those ants which are above ground, or does it? The most abundant ant species on the pastures is the western harvester ant, *Pogonomyrmex occidentalis* (Cresson), with an average of 2676 ants/colony and an average of 28 colonies/ha under light grazing, and 23 under moderate grazing. Yet in 2 years, the D-vac has never picked up one specimen of the western harvester ant, even though we know that about 10% of the colony is foraging on a daily basis, from 9 AM to 5 PM.

The thrips (Thysanoptera) are ordinarily confined to the blossoms of flowers, and it is not unusual to collect as many as 100 thrips from a single blossom. Yet in all 11 bimonthly samples collected on these pastures, there was only a total mean number of 11 thrips/m^2 picked up by the D-vac. Here I suspect that the problem lies again with the mesh size of the screen. It is doubtful that any screen we could obtain would hold them. Obviously another system of sampling is desirable.

Taking this to a higher level, that of families missed by the D-vac, we can see by looking at Table 122 that the D-vac picks up representatives of all orders, but frequently misses whole families. Thus, it appears that the D-vac is relatively efficient in collecting Collembola, Hemiptera, Homoptera, and Neuroptera, but has collected only about half of the families in the Coleoptera, little more than a fourth of the families of Diptera, a third of the families of Hymenoptera, less than a fourth of the families of Lepidoptera, and only a third of the families of Orthoptera on the Pawnee Site. When this inefficiency is multiplied by the number of species missed, it must be readily apparent that a substantial amount of energy flow is being ignored.

Table 122. Comparison of the number of families of invertebrates taken using the D-vac suction technique as opposed to the number of families that have been collected by all techniques on the Pawnee Site.

Order	Total No. of families collected on Pawnee Site	No. of families represented in D-vac samples
Lithobiomorpha	1	1
Chelonethida	1	1
Arachneidae	6	2
Acarina	13	7
Anoplura	1	0
Coleoptera	39	20
Collembola	4	3
Diptera	32	9
Ephemeroptera	1	1
Hemiptera	14	10
Homoptera	12	10
Hymenoptera	30	11
Isoptera	1	1
Lepidoptera	9	2
Neuroptera	3	2
Odonata	3	0
Orthoptera	6	2
Psocoptera	2	1
Siphonoptera	1	1
Thysanoptera	1	1
Thysanura	1	1
Trichoptera	2	2

What are some of the factors that contribute to the inadequacy of the present sampling system?

1. As pointed out by Blocker et al. (1971), the mesh size of the screen is so large as to allow the escape of leafhoppers representing 8 genera as well as specimens representing 20 additional families of arthropods.
2. The number of samples taken is insufficient. On every date sampled the computor indicated that at least six times as many quadrats should have been sampled in order to obtain statistically significant figures.
3. The sampling technique is not designed to collect those insects that are most important on each grassland, but is only useful in showing that there are some differences between the arthropod fauna of various sites.
4. All samples taken are biased in the sense that while the grazing treatments are applied to the whole 100 acre pastures, the samples are mostly taken in small plots on hillsides adjacent to the watersheds. Since neither the behavior of cattle nor the distribution of forbs (which incidently are not even being sampled by the plant people) is random, it is impossible for the present sampling system to represent actual conditions on these pastures.
5. Many of the species of insects being missed respond to the movement of the dropped trap and fly off before the trap hits the ground.

LITERATURE CITED

Arnett, Ross H. 1960. The beetles of the United States (A manual for identification). Catholic Univ. Press, Washington, D. C. 1112 p.

Bell, R. T. 1970. Identifying Tenebrionidae (Darkling beetles). U.S. IBP Grassland Biome Tech. Rep. No. 58. Colorado State Univ., Fort Collins. 12 p.

Bell, R. T. 1971. Carabidae (Ground beetles). U.S. IBP Grassland Biome Tech. Rep. No. 66. Colorado State Univ., Fort Collins. 58 p.

Bertolin, G., and J. Rasmussen. 1969. Prelinimary report on the study of the precipitation on the Pawnee National Grassland. U.S. IBP Grassland Biome Tech. Rep. No. 17. Colorado State Univ., Fort Collins. 34 p.

Blatchley, W. S., and C. W. Leng. 1916. Rhynchophora or weevils of north eastern America. Nature Publ. Co., Indianapolis. 682 p.

Blocker, H. D., R. Reed, and C. E. Mason. 1971. Leafhopper studies at the Osage Site (Homoptera: Cicadellidae). U.S. IBP Grassland Biome Tech. Rep. No. 124. Colorado State Univ., Fort Collins. 25 p.

Borror, D. J., and D. M. DeLong. 1971. An introduction to the study of insects. Holt, Rinehart and Winston, Inc., New York. 812 p.

Bulan, Carol A., and G. W. Barrett. 1971. The effects of two acute stresses on the arthropod component of an experimental grassland ecosystem. Ecology 52(4):597-605.

Cook, W. C. 1929. A bioclimatic zonation for studying the economic distribution of injurious insects. Ecology 10:282-293.

Cook, W. C. 1931. Notes on predicting the probable future distribution of introduced insects. Ecology 12:245-247.

Cwik, M. J. 1970. Identification of insects and density determinations of the stomach contents of small mammals. U.S. IBP Grassland Biome Tech. Rep. No. 53. Colorado State Univ., Fort Collins. 10 p.

Dickinson, C., and J. Leetham. 1971. Aboveground insects on the Pawnee Site, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 123. Colorado State Univ., Fort Collins. 9 p.

Evans, F. C., and W. W. Murdoch. 1968. Taxonomic composition, trophic structure and seasonal occurrence in a grassland insect community. J. Anim. Ecol. 37:259-273.

Franklin, W. T. 1969. Mineralogy of representative soils at the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 30. Colorado State Univ., Fort Collins. 10 p.

French, N. R. 1970. Field data collection procedures for the Comprehensive Network 1970 season (Revised). U.S. IBP Tech. Rep. No. 35. Colorado State Univ., Fort Collins. 37 p.

Haufe, W. O. 1966. The significance of biometeorology in the ecology of insects. Int. J. Biometeorology 10(3):241-252.

Jameson, D. A. [Coordinator]. 1969. General description of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 1. Colorado State Univ., Fort Collins. 32 p.

Kneebone, W. R. 1957. Blue grama seed production studies. J. Range Manage. 10:17-21.

Kumar, R., R. J. Lavigne, J. E. Lloyd, R. E. Pfadt, J. Chu, R. R. Grow, and L. E. Rogers. 1972. Insects of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 172. Colorado State Univ., Fort Collins. 44 p.

Lauenroth, W. K., and P. L. Sims. 1973. Effects of environmental stresses on a shortgrass prairie ecosystem, 1970 and 1971. U.S. IBP Grassland Biome Tech. Rep. Colorado State Univ., Fort Collins. (In preparation).

Lavigne, R. J., and L. E. Rogers. 1970. Effect of insect predators and parasites on grass feeding insects, Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 20. Colorado State Univ., Fort Collins. 38 p.

Lavigne, R. J., L. E. Rogers, and J. Chu. 1971. Data collected on the Pawnee Site relating to western harvester ant and insect predators and parasites, 1970. U.S. IBP Grassland Biome Tech. Rep. No. 107. Colorado State Univ., Fort Collins. 96 p.

Lloyd, J. E., and R. R. Grow. 1971. Soil macro-arthropods of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 104. Colorado State Univ., Fort Collins. 18 p.

McDaniel, B. 1971. Studies of populations of adults and immature insects and mites from two treatments at Cottonwood, South Dakota. U.S. IBP Grassland Biome Tech. Rep. No. 112. Colorado State Univ., Fort Collins. 79 p.

Messenger, P. S. 1959. Bioclimatic studies with insects. Ann. Rev. Entomol. 4:183-206.

Morris, M. G. 1967. Differences between the invertebrate faunas of grazed and ungrazed chalk grassland. I. Responses of some phytophagous insects to cessation of grazing. J. Appl. Ecol. 4:459-474.

Morris, M. G. 1968. Differences between the invertebrate faunas of grazed and ungrazed chalk grassland. II. The faunas of sample turfs. J. Appl. Ecol. 5:601-611.

Nye, I. W. B. 1960. The insect pests of graminaceous crops in East Africa. Colonia Office, Colonia Res. Stud. 31. (Her Majesty's Stationery Office, London). 48 p.

Osborn, Herbert. 1939. Meadow and pasture insects. The Educator's Press. Columbus, Ohio. 288 p.

Pfadt, R. E. 1972. Orthoptera of the Pawnee Site, 1971. U.S. IBP Grassland Biome Tech. Rep. No. 176. Colorado State Univ., Fort Collins. 49 p.

Rasmussen, J. L., G. Bertolin, and G. F. Almeyda. 1971. Grassland Climatology of the Pawnee Grassland. U.S. IBP Grassland Biome Tech. Rep. No. 127. Colorado State Univ., Fort Collins. 79 p.

Reed, R. C. 1972. Insects and other major arthropods of a tallgrass prairie. U.S. IBP Grassland Biome Tech. Rep. No. 166. Colorado State Univ., Fort Collins. 144 p.

Rogers, L., R. Lavigne, and J. L. Miller. 1972. Bioenergetics of the western harvester ant in the shortgrass plains ecosystem. Environmental Entomol. 1(6):763-768.

Rogers, L. E., and R. J. Lavigne. 1972. Asilidae of the Pawnee National Grasslands in northeastern Colorado. Univ. Wyoming Agr. Exp. Sta. Sci. Monogr. 25. 35 p.

Schoonhoven, L. M. 1968. Chemosensory bases of host plant selection. Ann. Rev. Entomol. 13:115-136.

Sims, P. L., D. W. Uresk, D. L. Bartos, and W. K. Lauenroth. 1971. Herbage dynamics on the Pawnee Site: Aboveground and belowground herbage dynamics on the four grazing intensity treatments; and preliminary sampling on the ecosystem stress site. U.S. IBP Grassland Biome Tech. Rep. No. 99. Colorado State Univ., Fort Collins. 95 p.

Thatcher, T. O., G. Inyamah, and J. E. Mitchell. 1970. Sampling insect populations by sweep net on the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 50. Colorado State Univ., Fort Collins. 10 p.

Thorsteinson, A. J. 1960. Host selection in phytophagous insects. Ann. Rev. Entomol. 5:193-218.

Van Haveren, B. P., and A. F. Galbraith. 1971. Some hydrologic and physical properties of the major soil types on the Pawnee Intensive Site. U.S. IBP Grassland Biome Tech. Rep. No. 115. Colorado State Univ., Fort Collins. 46 p.

Van Horn, D. H. 1969. Dry weight biomass data for four abundant grasshopper species of the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 19. Colorado State Univ., Fort Collins. 6 p.

Van Horn, D. H. 1972. Grasshopper population numbers and biomass dynamics on the Pawnee Site from fall of 1968 through 1970. U.S. IBP Grassland Biome Tech. Rep. No. 148. Colorado State Univ., Fort Collins. 70 p.

Webster, F. M. 1915. The chinch bug. U.S. Dep. Agr. Farmer's Bull. 657. 28 p.

Whelan, D. B. 1927. The winter fauna of the bunch grasses in eastern Kansas. Ecology 8(1):94-97.

Yount, V. A., and T. O. Thatcher. 1972. Plant/insect interactions of selected insects at the Pawnee Site. U.S. IBP Grassland Biome Tech. Rep. No. 142. Colorado State Univ., Fort Collins. 34 p.

APPENDIX I

FIELD DATA

Aboveground invertebrate data collected at the Pawnee Site were recorded on data form NREL-30. These data are stored as Grassland Biome data set A2U300B. A sample data form and an example of the data are attached.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - INVERTEBRATE

D[illegible] TYPE	SITE	INITIALS	DATF Day	DATF Mo	DATF Yr	TREATMENT	REPLICATE	PLOT SIZE	QUADRAT	TROPHIC	HOST	ORDER	FAMILY	GENUS	SPECIES	SUBSPECIES	LIFE STAGE	TOTAL NO.	DRY WT.	NO. WEIGH
1-2	3-4	5-7	8-9	10-11	12-[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47-48	50-55	57-62	64-66

DATA TYPE
01 Aboveground Biomass
02 Litter
03 Belowground Biomass
10 Vertebrate - Live Trapping
11 Vertebrate - Snap Trapping
12 Vertebrate - Collection
20 Avian Flush Census
21 Avian Road Count
22 Avian Road Count Summary
23 Avian Collection - Internal
24 Avian Collection - External
25 Avian Collection - Plumage
30 Invertebrate
40 Microbiology - Decomposition
41 Microbiology - Nitrogen
42 Microbiology - Biomass
43 Microbiology - Root Decomposition
Microbiology - Respiration

SITE
01 Ale
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

TROPHIC
0 Unknown
1 Plant feeding (tissue)
2 Plant feeding (sap)
3 Plant feeding (pollen and nectar)
4 Plant feeding (seed)
5 Predator
6 Parasitoid
7 Parasite
8 Scavenger
9 Non-feeding stage

TREATMENT
1 Ungrazed
2 Lightly grazed
3 Moderately grazed
4 Heavily grazed
5 Grazed 1969, ungrazed 1970
6
7
8
9

LIFE STAGE
00 Undetermined
10 Adult
20 Pupae
30 Egg
40 Nymph or Larva
41 Nymph or Larva, early
42 Nymph or Larva, middle
43 Nymph or Larva, late
50 Instar
51 Instar, 1st
52 Instar, 2nd
53 Instar, 3rd

+++ EXAMPLE OF DATA +++

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890

3111JWL29047111 0.514 7       HYMEFORMMYR 04  10      2   0156  01 5
3111JWL29047111 0.514 2       HEMILYGA    02  40      1   0022  01 5
3111JWL29047111 0.541 7       HYMEFORMMYR 04  10      1   0156  01 5
3111JWL29047111 0.541 7       HYMEFORMTAP 05  10      1   0046  01 5
3111JWL29047111 0.541 0       LEPI        02  40      1   2702  01 5
3111JWL29047111 0.541 2       HOMOCICAACE 02  10      1   0028  01 5
3111JWL29047111 0.552                                           01 5
3111JWL29047111 0.582 5       ARANGNAP    02  10      1   0028  01 5
3111JWL29047111 0.582 7       HYMEFORM    06  10      1   0040  01 5
3111JWL29047111 0.594 7       HYMEFORMMYR 04  10      1   0156  01 5
3111JWL29047111 0.594 0       COLECOCCUEL 05  10      4   0030  01 5
3111JWL01057112 0.532                                              5
3111JWL01057112 0.551 7       HYMEFORMMON 07  10      9   0038  01 5
3111JWL01057112 0.562 7       HYMEFORMLEP 09  10      2   0045  01 5
3111JWL01057112 0.562 2       HOMOCICAACE 02  10      1   0028  01 5
3111JWL01057112 0.573 0       COLESCAR    05  10      1   0378  01 5
3111JWL01057112 0.573 0       COLETENEELE 05  10      1   7426  01 5
3111JWL01057112 0.582 7       HYMEFORMMON 07  10      3   0038  01 5
3111JWL30047121 0.553 0       COLE        04  10      1   0088  01 5
3111JWL30047121 0.553 0       HEMITING    01  10      1   0060  01 5
3111JWL30047121 0.553 2       HOMOCICAACE 02  10      2   0028  01 5
3111JWL30047121 0.582 0       HYME        01  10      1   0072  01 5
3111JWL30047121 0.582 0       COLE        05  10      1   0153  01 5
3111JWL30047121 0.582 7       HYMEFORMMON 07  10      2   0038  01 5
3111JWL30047121 0.583 7       HYMEFORMMON 07  10      1   0038  01 5
3111JWL30047121 0.592 5       ARANLYCO    03  40      3   0164  01 5
3111JWL30047121 0.595 7       HYMEFORMMON 07  10      2   0038  01 5
3111JWL30047121 0.595 7       HYMEFORM    06  10      1   0040  01 5
3111JWL30047121 0.595 2       HOMOCICAATH 03  10      1   0051  01 5
3111JWL30047122 0.511 7       HYMEFORMTAP 05  10      3   0046  01 5
3111JWL30047122 0.511 1       ORTHACRIPSO 02  10      1   4758  01 5
3111JWL30047122 0.511 1       ORTHACRI    03  10      1  13440  01 5
3111JWL30047122 0.523 2       HOMOCICAATH 03  10      2   0051  01 5
3111JWL30047122 0.523 7       HYMEFORMTAP 05  10      2   0046  01 5
3111JWL30047122 0.555 1       ORTHACRIARP 04  10      1   3142  01 5
3111JWL30047122 0.555 0       DIPT        10  10      1   0078  01E5
3111JWL30047122 0.562 7       HYMEFORMMON 07  10      2   0038  01 5
3111JWL30047122 0.562 2       HEMILYGA    02  40      1   0022  01 5
3111JWL30047122 0.562 2       HOMOCICAATH 03  10      1   0051  01 5
3111JWL30047122 0.562 2       HOMOCICAACE 02  10      5   0028  01 5
3111JWL30047122 0.564 2       HOMOCICAACE 02  40      2   0028  01 5
3111JWL30047122 0.564 2       HOMOCICAATH 03  10      2   0051  01 5
3111JWL30047122 0.564 2       HOMOCICA    04  10      1   0097  01 5
3111JWL30047122 0.564 7       HYMEFORMMON 07  10      1   0038  01 5
3111JWL30047122 0.564 7       HYMEFORMLEP 09  10      1   0045  01 5
3111JWL01057131 0.508 7       HYMEFORMMYR 04  10      1   0158  01 5
3111JWL01057131 0.508 7       HYMEFORMLEP 09  10      2   0045  01 5
3111JWL01057131 0.508 0       COLESCARTRI 01  10      1   0072  01 5
3111JWL01057131 0.508 0       COLE        03  10      2   0030  01 5
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3111JWL01057131	0.516	2	HOMOCICAACE	02	40	1	0028	01 5
3111JWL01057131	0.516	2	HOMOCICAATH	03	10	1	0051	01 5
3111JWL01057131	0.528							5
3111JWL01057131	0.574	2	HOMOCICAATH	03	10	1	0051	01 5
3111JWL01057131	0.574	1	ORTHACRI	05	40	1	0793	01 5
3111JWL01057131	0.594	7	HYMEFORMLEP	09	10	2	0045	01 5
3111JWL01057132	0.506	7	HYMEFORMMON	07	10	11	0038	01 5
3111JWL01057132	0.565	7	HYMEFORMLEP	09	10	1	0045	01 5
3111JWL01057132	0.568	0	LEPI	03	10	1	0708	01 5
3111JWL01057132	0.568	0	DIPT	11	10	1	0122	01E5
3111JWL01057132	0.568	0	COLE	06	10	1	0122	01E5
3111JWL01057132	0.568	0	HEMITING	01	10	1	0080	01 5
3111JWL01057132	0.568	7	HYMEFORMFOR	08	10	1	0070	01 5
3111JWL01057132	0.568	7	HYMEFORMLEP	09	10	3	0045	01 5
3111JWL01057132	0.568	7	HYMEFORMTAP	05	10	1	0046	01 5
3111JWL01057132	0.575	7	HYMEFORMMON	07	10	4	0038	01 5
3111JWL01057132	0.575	7	HYMEFORMLEP	09	10	6	0045	01 5
3111JWL01057132	0.575	7	HYMEFORMSOL	10	10	1	0038	01 5
3111JWL01057132	0.575	0	PSOC	01	10	1	0001	01 5
3111JWL01057132	0.579	0	COLE	07	10	1	0094	01E5
3111JWL01057132	0.579	0	PSOC	01	10	1	0001	01 5
3111JWL01057132	0.579	7	HYMEFORMFOR	08	10	1	0070	01 5
3111JWL01057132	0.579	7	HYMEFORMMON	07	10	7	0038	01 5
3111JWL01057132	0.579	7	HYMEFORMLEP	09	10	2	0045	01 5
3111JWL29047141	0.528	2	HEMILYGA	02	40	1	0022	01 5
3111JWL29047141	0.534							5
3111JWL29047141	0.537	0	COLECURCHYP	07	10	1	0231	01 5
3111JWL29047141	0.547	0	LEPI	01	40	1	0022	01 5
3111JWL29047141	0.589	0	COLE	03	10	1	0030	01 5
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3111JWL30047142	0.513	7	HYMEFORMMON	07	10	2	0038	01 5
3111JWL30047142	0.513	7	HYMEFORMFOR	08	10	1	0070	01 5
3111JWL30047142	0.513	2	HOMOCICAACE	02	40	3	0028	01 5
3111JWL30047142	0.513	2	HOMOCICAATH	03	10	1	0051	01 5
3111JWL30047142	0.552	7	HYMEFORMMON	07	10	1	0038	01 5
3111JWL30047142	0.552	7	HYMEFORMFOR	08	10	1	0070	01 5
3111JWL30047142	0.569	7	HYMEFORMFOR	08	10	3	0070	01 5
3111JWL30047142	0.569	0	COLESCARTRI	01	10	1	0072	01 5
3111JWL30047142	0.569	2	HOMOCICAATH	03	10	1	0051	01 5
3111JWL30047142	0.569	2	HOMOCICAACE	02	40	1	0028	01 5
3111JWL30047142	0.591	7	HYMEFORMFOR	08	10	1	0070	01 5
3111JWL30047142	0.591	2	HOMOCICAATH	03	10	1	0051	01 5
3111JWL30047142	0.591	1	ORTHACRIFSO	02	10	1	4758	01 5
3111JWL30047142	0.591	2	THYSPHLO	01	40	2	0006	01 5
3111JWL30047142	0.598	2	HOMOCICAACE	02	40	2	0028	01 5
3111JWL29047111	0.514	5	ARANLYCO	03	40	1	0164	01 4
3111JWL29047111	0.514	0	COLESCARTRI	01	10	4	0072	01 4
3111JWL29047111	0.514	7	HYMEFORMMYR	04	10	5	0158	01 4
3111JWL29047111	0.514	7	HYMEFORMMON	07	10	1	0038	01 4
3111JWL29047111	0.514	7	HYMEFORMSOL	10	10	1	0036	01 4
3111JWL29047111	0.514	2	HEMILYGABLI	01	40	11	0015	01 4
3111JWL29047111	0.514	2	HOMOCICAATH	03	10	1	0051	01 4
3111JWL29047111	0.541	2	ACARIROM	08	10	1	0020	01 4
3111JWL29047111	0.541	0	COLETENE	06	10	3	0078	01 4
3111JWL29047111	0.541	0	COLESCARTRI	01	10	5	0072	01 4
3111JWL29047111	0.541	7	HYMEFORMMYR	04	10	2	0158	01 4
3111JWL29047111	0.541	2	HEMILYGA	04	40	1	0187	01 4
3111JWL29047111	0.541	2	HEMILYGABLI	01	40	4	0015	01 4

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3111JWL29047111	0.552 2	ACARTROM	08	10	1	0020	01 4
3111JWL29047111	0.552 0	COLECURCCAL	01	10	1	0141	01 4
3111JWL29047111	0.552 0	COLECURCAPI	05	10	1	0032	01 4
3111JWL29047111	0.552 0	COLECURCGEM	06	10	1	1318	01 4
3111JWL29047111	0.552 0	COLESCARTRI	01	10	10	0072	01 4
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3111JWL29047111	0.552 2	HOMOCICAACE	02	40	2	0158	01 4
3111JWL29047111	0.582 2	ACARTROM	08	40	1	0028	01 4
3111JWL29047111	0.582 0	COLETENE	03	40	1	7704	01 4
3111JWL29047111	0.582 0	COLETENEBLA	01	10	1	0385	01 4
3111JWL29047111	0.582 0	COLETENE	07	40	1	0524	01 4
3111JWL29047111	0.582 0	COLETENE	06	10	1	0078	01 4
3111JWL29047111	0.582 0	COLESCARTRI	01	10	7	0072	01 4
3111JWL29047111	0.582 7	HYMEFORMMYR	04	10	5	0158	01 4
3111JWL29047111	0.582 0	LEPI	12	40	1	0172	01 4
3111JWL29047111	0.594 0	COLECURCHYP	07	10	1	0231	01 4
3111JWL29047111	0.594 0	COLETENEBLA	01	10	1	0385	01 4
3111JWL29047111	0.594 0	COLESCARTRI	01	10	3	0072	01 4
3111JWL29047111	0.594 0	COLE	10	10	2	0030	01 4
3111JWL29047111	0.594 0	COLE	11	11	9	0088	01 4
3111JWL29047111	0.594 8	COLESTAP	01	10	1	0054	01 4
3111JWL29047111	0.594 7	HYMEFORMMYR	04	10	2	0158	01 4
3111JWL29047111	0.594 7	HYMEFORMSOL	10	10	3	0036	01 4
3111JWL29047111	0.594 2	HEMILYGABLI	01	40	1	0015	01 4
3111JWL29047111	0.594 5	NEURMYRM	01	40	1	0082	01 4
3111JWL01057112	0.532 5	ARANLYCO	03	40	1	0164	01 4
3111JWL01057112	0.532 2	ACARERYT	07	10	6	0008	01 4
3111JWL01057112	0.532 2	ACARTETR	04	40	7	0000	01 4
3111JWL01057112	0.532 0	COLECURC	13	10	1	0062	01 4
3111JWL01057112	0.532 0	COLECURCCAL	12	10	8	0063	01 4
3111JWL01057112	0.532 5	COLECARAHAR	02	10	1	1424	01 4
3111JWL01057112	0.532 0	COLETENEBLA	01	10	2	0385	01 4
3111JWL01057112	0.532 1	COLECHRY	01	10	34	0120	01 4
3111JWL01057112	0.532 7	HYMEFORMMYR	04	10	1	0158	01 4
3111JWL01057112	0.532 0	LEPI	21	40	3	0024	01 4
3111JWL01057112	0.532 2	HEMILYGABLI	01	40	9	0015	01 4
3111JWL01057112	0.532 0	HEMILYDN	01	10	3	0391	01 4
3111JWL01057112	0.532 0	DIPTCECI	01	10	1	0011	01 4
3111JWL01057112	0.532 0	DIPT	16	40	4	0078	01 4
3111JWL01057112	0.551 5	ARANLYCO	03	40	1	0164	01 4
3111JWL01057112	0.551 5	ACARERYT	07	40	12	0008	01 4
3111JWL01057112	0.551 5	ACARTETR	04	40	2	0000	01 4
3111JWL01057112	0.551 0	COLE	12	10	1	0358	01 4
3111JWL01057112	0.551 0	COLE	13	10	1	0122	01E4
3111JWL01057112	0.551 0	COLECURCCAL	12	10	2	0063	01 4
3111JWL01057112	0.551 0	COLESCARTRI	01	40	30	0060	01 4
3111JWL01057112	0.551 0	COLEELAT	08	40	1	0082	01 4
3111JWL01057112	0.551 2	HOMOPSEU	01	40	1	0040	01 4
3111JWL01057112	0.551 0	HEMIFHYM	01	40	1	0086	01 4
3111JWL01057112	0.551 2	HEMILYGABLI	01	40	1	0015	01 4
3111JWL01057112	0.562 2	ACARERYT	07	10	9	0008	01 4
3111JWL01057112	0.562 2	ACARERYT	07	40	20	0008	01 4
3111JWL01057112	0.562 0	COLECURCCAL	12	10	2	0063	01 4
3111JWL01057112	0.562 1	COLECHRY	01	40	7	0120	01 4
3111JWL01057112	0.562 0	COLESCARTRI	01	10	17	0072	01 4
3111JWL01057112	0.562 0	COLEELAT	09	40	1	0088	01 4

3111JWL01057112	0.562	2	HEMILYGABLI	01	40	1	0015	01 4
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3111JWL01057112	0.573	5	ARAN	07	10	2	0185	01 4
3111JWL01057112	0.573	5	ARANLYCO	03	40	1	0164	01 4
3111JWL01057112	0.573	5	ARAN	06	40	1	0018	01 4
3111JWL01057112	0.573	5	ARAN	04	40	2	0017	01 4
3111JWL01057112	0.573	5	ARAN	02	40	1	0022	01E4
3111JWL01057112	0.573	2	ACARTETR	04	40	1	0000	01 4
3111JWL01057112	0.573	2	ACARTROM	08	40	1	0020	01 4
3111JWL01057112	0.573	2	ACAR	09	10	1	0002	01 4
3111JWL01057112	0.573	2	ACARBELA	10	10	3	0002	01 4
3111JWL01057112	0.573	0	COLECURCAPI	05	10	7	0032	01 4
3111JWL01057112	0.573	0	COLECURCCAL	12	10	4	0063	01 4
3111JWL01057112	0.573	0	COLE	04	10	1	0088	01 4
3111JWL01057112	0.573	0	COLETENEBLA	01	10	1	0385	01 4
3111JWL01057112	0.573	0	COLE	14	10	4	0123	01 4
3111JWL01057112	0.573	5	COLECARAMIC	05	10	1	0036	01 4
3111JWL01057112	0.573	1	COLEANTH	04	10	1	0049	01 4
3111JWL01057112	0.573	0	COLE	16	10	1	0023	01 4
3111JWL01057112	0.573	7	HYMEFORMSOL	10	10	3	0036	01 4
3111JWL01057112	0.573	7	HYMEFORMTAP	05	10	6	0046	01 4
3111JWL01057112	0.573	7	HYMEFORMFOR	08	10	1	0070	01 4
3111JWL01057112	0.573	7	HYMEFORMMON	07	10	1	0038	01 4
3111JWL01057112	0.573	0	LEPI	22	40	2	0010	01 4
3111JWL01057112	0.573	0	DIPT	16	40	6	0078	01 4
3111JWL01057112	0.573	0	DIPTCHIR	01	10	2	0080	01 4
3111JWL01057112	0.573	2	HOMOCICAACP	02	40	3	0028	01 4
3111JWL01057112	0.573	2	HEMICORI	01	10	1	0767	01 4
3111JWL01057112	0.573	2	HEMILYGA	02	40	1	0022	01 4
3111JWL01057112	0.573	2	HEMILYGABLI	01	40	1	0015	01 4
3111JWL01057112	0.582	5	ARAN	07	40	1	0185	01 4
3111JWL01057112	0.582	2	ACARERYT	07	40	5	0008	01 4
3111JWL01057112	0.582	0	COLESCARTRI	01	10	6	0072	01 4
3111JWL01057112	0.582	0	COLETENE	03	40	1	7704	01 4
3111JWL01057112	0.582	0	COLETENEBLA	01	10	1	0385	01 4
3111JWL01057112	0.582	0	COLE	04	10	1	0088	01 4
3111JWL01057112	0.582	7	HYMEFORMFOR	08	10	4	0070	01 4
3111JWL01057112	0.582	7	HYMEFORMLEP	09	10	1	0045	01 4
3111JWL01057112	0.582	0	DIPT	18	10	1	0098	01 4
3111JWL01057112	0.582	0	DIPT	19	10	1	0170	01E4
3111JWL01057112	0.582	0	DIPTCULI	01	10	1	0062	01 4
3111JWL30047121	0.553	5	ARANLYCO	02	40	1	0164	01 4
3111JWL30047121	0.553	5	ARAN	03	40	1	0026	01 4
3111JWL30047121	0.553	2	ACARTETR	04	10	1	0000	01 4
3111JWL30047121	0.553	2	ACARHAPL	24	10	5	0000	01 4
3111JWL30047121	0.553	0	COLESCARTRI	01	10	7	0072	01 4
3111JWL30047121	0.553	0	COLETENEBLA	01	10	2	0385	01 4
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3111JWL30047121	0.553	5	COLECARASEL	04	10	4	0193	01 4
3111JWL30047121	0.553	5	COLECARAHAR	02	10	1	1424	01 4
3111JWL30047121	0.553	5	COLECARADYS	07	10	1	0073	01 4
3111JWL30047121	0.553	0	COLECURCCAL	01	10	1	0141	01 4
3111JWL30047121	0.553	0	COLECURCAPI	05	10	1	0032	01 4
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3111JWL30047121	0.553	8	COLESTAP	01	10	2	0054	01 4
3111JWL30047121	0.553	1	COLECHRY	01	40	2	0120	01 4
3111JWL30047121	0.553	7	HYMEFORMLEP	09	10	3	0045	01 4
3111JWL30047121	0.553	7	HYMEFORMMYR	04	10	32	0158	01 4
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3111JWL30047121	0.553	2	HEMILYGABLI	01	40	53	0015	01 4
3111JWL30047121	0.553	2	HEMILYGA	02	40	93	0022	01 4
3111JWL30047121	0.553	2	HEMILYGA	02	10	1	0022	01 4
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3111JWL30047121	0.553	0	HEMITING	01	10	1	0060	01 4
3111JWL30047121	0.553	0	HEMICYGA	01	10	7	0391	01 4
3111JWL30047121	0.582	2	ACARERYT	02	10	1	0025	01 4
3111JWL30047121	0.582	2	COLETENEBLA	01	10	1	0385	01 4
3111JWL30047121	0.582	0	COLECURCCAL	01	10	1	0141	01 4
3111JWL30047121	0.582	0	COLECURCAPI	05	10	3	0032	01 4
3111JWL30047121	0.582	7	HYMEFORMLEP	09	10	1	0045	01 4
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3111JWL30047121	0.583	0	COLECURCHAY	11	10	1	0058	01 4
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3111JWL30047121	0.583	0	COLE	11	10	1	0048	01 4
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3111JWL30047121	0.583	0	COLE	04	10	1	0088	01 4
3111JWL30047121	0.583	7	HYMEFORMSOL	10	10	3	0036	01 4
3111JWL30047121	0.583	7	HYMEFORMTAP	05	10	1	0046	01 4
3111JWL30047121	0.583	7	HYMEFORMLEP	09	10	3	0045	01 4
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3111JWL30047121	0.583	2	HOMOCICA	04	40	1	0097	01 4
3111JWL30047121	0.583	0	DIPTCECI	01	10	2	0011	01 4
3111JWL30047121	0.592	5	ARAN	08	10	1	0162	01 4
3111JWL30047121	0.592	0	COLETENEBLA	01	10	1	0385	01 4
3111JWL30047121	0.592	0	COLETENE	07	40	1	0524	01 4
3111JWL30047121	0.592	7	HYMEFORMMYR	04	10	1	0158	01 4
3111JWL30047121	0.592	7	HYMEFORMLEP	09	10	1	0045	01 4
3111JWL30047121	0.592	0	LEPI	10	40	1	0642	01 4
3111JWL30047121	0.592	2	HEMILYGABLI	01	40	2	0015	01 4
3111JWL30047121	0.595	5	ARAN	07	40	1	0185	01 4
3111JWL30047121	0.595	5	ARANLYCO	03	40	2	0164	01 4
3111JWL30047121	0.595	0	COLECURCCAL	01	10	1	0141	01 4
3111JWL30047121	0.595	0	COLESCARTRI	01	10	20	0072	01 4
3111JWL30047121	0.595	7	HYMEFORMSOL	10	10	1	0036	01 4
3111JWL30047121	0.595	2	HEMILYGABLI	01	40	3	0015	01 4
3111JWL30047122	0.511	2	ACARTROM	06	10	2	0004	01 4
3111JWL30047122	0.511	0	COLETENE	03	40	2	7704	01 4
3111JWL30047122	0.511	0	COLESCARTRI	01	10	2	0072	01 4
3111JWL30047122	0.511	0	COLECURCGER	08	10	5	1318	01 4
3111JWL30047122	0.511	0	COLECURCCAL	01	10	1	0141	01 4
3111JWL30047122	0.511	7	HYMEFORMLEP	09	10	1	0045	01 4
3111JWL30047122	0.511	7	HYMEFORMMYR	04	10	2	0158	01 4
3111JWL30047122	0.511	0	LEPI	04	40	1	0046	01 4
3111JWL30047122	0.511	0	HEMITING	01	10	1	0060	01 4
3111JWL30047122	0.511	2	HOMOPSEU	01	40	1	0040	01 4
3111JWL30047122	0.523	5	ARANGNAP	02	10	1	0028	01 4
3111JWL30047122	0.523	5	ARANLYCO	02	10	1	0164	01 4
3111JWL30047122	0.523	2	ACARERYT	07	10	5	0008	01 4
3111JWL30047122	0.523	0	COLECURCCAL	01	10	1	0141	01 4
3111JWL30047122	0.523	0	COLESCARTRI	01	10	1	0072	01 4
3111JWL30047122	0.523	5	COLECARASEL	04	10	1	0193	01 4
3111JWL30047122	0.555	2	ACARERYT	07	40	2	0008	01 4

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3111JWL30047122	0.555	0	COLECURCCAL	01	10	2	0141	01	4
3111JWL30047122	0.555	0	COLECURCGER	08	10	2	1318	01	4
3111JWL30047122	0.555	0	COLECURCHYP	10	10	1	0353	01	4
3111JWL30047122	0.555	0	COLESCARTRI	01	10	6	0072	01	4
3111JWL30047122	0.555	0	COLETENE	06	10	1	0078	01	4
3111JWL30047122	0.555	7	HYMEFORMMYR	04	10	4	0158	01	4
3111JWL30047122	0.555	2	HEMILYGA	02	40	1	0022	01	4
3111JWL30047122	0.555	0	HEMICORI	01	10	1	0767	01	4
3111JWL30047122	0.562	0	COLESCARTRI	01	10	2	0072	01	4
3111JWL30047122	0.562	0	COLECURCHYP	10	10	1	0353	01	4
3111JWL30047122	0.562	0	COLETENE	03	40	1	7704	01	4
3111JWL30047122	0.562	0	COLETENEBLA	01	10	2	0385	01	4
3111JWL30047122	0.562	5	COLECARASEL	04	10	1	0193	01	4
3111JWL30047122	0.562	0	COLE	09	40	1	0048	01	4
3111JWL30047122	0.562	0	HEMITING	01	10	1	0060	01	4
3111JWL30047122	0.562	2	HEMILYGABLI	01	40	16	0015	01	4
3111JWL30047122	0.562	2	HEMILYGA	02	40	11	0022	01	4
3111JWL30047122	0.562	2	HOMOCICA	02	10	1	0028	01	4
3111JWL30047122	0.564	2	ACARERYT	07	40	2	0008	01	4
3111JWL30047122	0.564	0	COLECURCCAL	01	10	1	0141	01	4
3111JWL30047122	0.564	0	COLESCARTRI	01	10	1	0072	01	4
3111JWL30047122	0.564	0	COLETENEBLA	01	10	1	0385	01	4
3111JWL30047122	0.564	0	COLETENE	06	10	1	0078	01	4
3111JWL30047122	0.564	5	COLECARASEL	04	10	1	0193	01	4
3111JWL30047122	0.564	0	LEPI	04	40	1	0040	01	4
3111JWL30047122	0.564	7	HYMEFORMFOR	08	10	1	0070	01	4
3111JWL30047122	0.564	2	HEMILYGABLI	01	40	1	0015	01	4
3111JWL30047122	0.564	2	HOMOCICAACE	02	10	1	0028	01	4
3111JWL01057131	0.508	0	COLESCARTRI	01	10	7	0072	01	4
3111JWL01057131	0.508	7	HYMEFORMMYR	04	10	1	0158	01	4
3111JWL01057131	0.516	5	ARANLYCO	03	10	1	0164	01	4
3111JWL01057131	0.516	2	ACARERYT	07	10	5	0008	01	4
3111JWL01057131	0.516	2	ACARERYT	02	10	2	0025	01	4
3111JWL01057131	0.516	0	COLETENEBLA	01	10	1	0385	01	4
3111JWL01057131	0.516	0	COLECURCCAL	01	10	1	0141	01	4
3111JWL01057131	0.516	0	COLESCARTRI	01	10	4	0072	01	4
3111JWL01057131	0.516	0	COLE	11	10	1	0068	01	4
3111JWL01057131	0.516	2	HOMOCICA	04	40	1	0097	01	4
3111JWL01057131	0.528	5	ARAN	07	10	2	0185	01	4
3111JWL01057131	0.528	5	ARANLYCO	03	40	2	0164	01	4
3111JWL01057131	0.528	5	ARANLYCO	02	40	1	0434	01	4
3111JWL01057131	0.528	2	ACARERYT	02	10	1	0025	01	4
3111JWL01057131	0.528	5	LITH	01	10	2	0493	01	4
3111JWL01057131	0.528	0	COLECURCCAL	01	10	2	0141	01	4
3111JWL01057131	0.528	0	COLECURCAPI	05	10	1	0032	01	4
3111JWL01057131	0.528	5	COLECARAHAR	02	10	1	1424	01	4
3111JWL01057131	0.528	5	COLECARASEL	04	10	1	0193	01	4
3111JWL01057131	0.528	5	COLECARADYS	07	10	2	0073	01	4
3111JWL01057131	0.528	0	COLESCARTRI	01	10	5	0072	01	4
3111JWL01057131	0.528	8	COLESTAP	01	10	2	0054	01	4
3111JWL01057131	0.528	7	HYMEFORMLEP	09	10	2	0045	01	4
3111JWL01057131	0.528	0	LEPI	15	40	1	0070	01	4
3111JWL01057131	0.528	0	HEMICORI	01	10	1	0767	01	4
3111JWL01057131	0.528	2	HEMIMIRI	01	10	1	0176	01	4

3111JWL01057131	0.528	2	HOMOPSEU	01	40	1	0040	01	4
3111JWL01057131	0.528	8	ISOPRHIA	01	10	1	0045	01	4
3111JWL01057131	0.574	5	ARAN	07	40	1	0185	01	4
3111JWL01057131	0.574	0	COLETENEBLA	01	10	1	0355	01	4
3111JWL01057131	0.574	0	COLETENE	03	40	1	7704	01	4
3111JWL01057131	0.574	0	COLESCARTRI	01	10	14	0072	01	4
3111JWL01057131	0.574	7	HYMEFORMMON	07	10	1	0038	01	4
3111JWL01057131	0.594	1	COLECHRYPSY	02	10	2	0071	01	4
3111JWL01057132	0.506	0	COLECURCHYP	07	10	1	0231	01	4
3111JWL01057132	0.506	5	COLECARASEL	04	10	1	0193	01	4
3111JWL01057132	0.506	0	COLESCARTRI	01	10	2	0072	01	4
3111JWL01057132	0.506	2	HEMILYGABLI	01	40	1	0015	01	4
3111JWL01057132	0.506	0	LEPI	13	40	1	0485	01	4
3111JWL01057132	0.506	0	LEPI	14	40	1	0082	01	4
3111JWL01057132	0.565	5	ARANLYCO	03	40	1	0164	01	4
3111JWL01057132	0.565	5	COLECARASEL	04	10	1	0193	01	4
3111JWL01057132	0.565	0	COLETENEBLA	01	10	3	0385	01	4
3111JWL01057132	0.565	0	COLESCARTRI	01	10	13	0072	01	4
3111JWL01057132	0.565	7	HYMEFORMFOR	08	10	1	0070	01	4
3111JWL01057132	0.565	2	HEMILYGABLI	01	40	15	0015	01	4
3111JWL01057132	0.568	5	ARANLYCO	03	40	1	0164	01	4
3111JWL01057132	0.568	0	COLESCARTRI	01	10	6	0072	01	4
3111JWL01057132	0.568	5	COLECARASEL	04	10	1	0193	01	4
3111JWL01057132	0.568	7	HYMEFORMLEP	09	10	1	0045	01	4
3111JWL01057132	0.568	0	HEMICYDN	01	10	1	0391	01	4
3111JWL01057132	0.568	0	DIPTCHCI	01	10	1	0011	01	4
3111JWL01057132	0.575	2	ACARERYT	07	40	1	0008	01	4
3111JWL01057132	0.575	0	COLECURC	11	10	2	0068	01	4
3111JWL01057132	0.575	5	COLECARASEL	04	10	1	0193	01	4
3111JWL01057132	0.575	0	COLETENEBLA	01	10	1	0385	01	4
3111JWL01057132	0.575	0	COLESCARTRI	01	10	12	0072	01	4
3111JWL01057132	0.575	0	COLE	11	10	2	0088	01	4
3111JWL01057132	0.575	0	COLE	04	10	1	0088	01	4
3111JWL01057132	0.575	7	HYMEFORMLEP	09	15	1	0045	01	4
3111JWL01057132	0.575	2	HEMILYGABLI	01	40	2	0015	01	4
3111JWL01057132	0.575	2	HOMOAPHI	01	40	1	0008	01	4
3111JWL01057132	0.575	8	ISOPRHIA	01	10	1	0045	01	4
3111JWL01057132	0.575	0	COLESCARTRI	01	10	1	0072	01	4
3111JWL01057132	0.575	0	COLECURCCAL	01	10	1	0141	01	4
3111JWL01057132	0.575	0	COLE	04	10	1	0088	01	4
3111JWL01057132	0.575	0	LEPI	16	40	1	0226	01	4
3111JWL01057132	0.575	0	HEMIPHYM	01	40	1	0086	01	4
3111JWL29047141	0.528	5	ARANLYCO	03	40	1	0164	01	4
3111JWL29047141	0.528	0	COLE	04	10	1	0088	01	4
3111JWL29047141	0.528	8	COLESTAP	01	10	1	0054	01	4
3111JWL29047141	0.528	2	HOMOPSEU	01	40	4	0040	01	4
3111JWL29047141	0.528	2	HOMOCICAATH	03	10	1	0051	01	4
3111JWL29047141	0.528	2	HOMOAPHI	01	10	9	0008	01	4
3111JWL29047141	0.534	5	COLECARASEL	04	10	1	0193	01	4
3111JWL29047141	0.534	7	HYMEFORMLEP	09	10	1	0045	01	4
3111JWL29047141	0.534	2	HOMOPSEU	01	40	1	0040	01	4
3111JWL29047141	0.534	2	HOMOPSEU	02	10	1	0038	01	4
3111JWL29047141	0.534	0	HEMIPIES	01	10	1	0042	01	4
3111JWL29047141	0.534	0	LEPI	18	40	1	0114	01	4
3111JWL29047141	0.537	2	ACARERYT	07	40	1	0008	01	4
3111JWL29047141	0.537	8	COLESTAP	01	10	1	0054	01	4
3111JWL29047141	0.537	8	COLESTAP	03	10	1	0158	01	4
3111JWL29047141	0.537	0	LEPI	19	40	1	1462	01	4

3111JWL29047141 0.537 7	HYMEFORMLEP	09	10	2	0045	01	4
3111JWL29047141 0.537 0	DIPT	16	40	5	0076	01	4
3111JWL29047141 0.547 2	ACARERYT	07	10	3	0008	01	4
3111JWL29047141 0.547 0	DIPT	17	10	1	0130	01	4
3111JWL29047141 0.547 2	HEMILYGABLI	01	40	1	0015	01	4
3111JWL29047141 0.547 2	HOMOPSEU	01	40	7	0040	01	4
3111JWL29047141 0.547 2	HOMOPSEU	02	40	1	0036	01	4
3111JWL29047141 0.589 5	ARANLYCO	03	40	1	0164	01	4
3111JWL29047141 0.589 2	ACARERYT	07	10	3	0008	01	4
3111JWL29047141 0.589 0	COLETENEBLA	01	10	2	0385	01	4
3111JWL29047141 0.589 0	COLECURCGER	08	10	2	1318	01	4
3111JWL29047141 0.589 0	DIPT	16	40	2	0078	01	4
3111JWL29047141 0.589 0	DIPT	17	10	1	0130	01	4
3111JWL29047141 0.589 2	HOMOPSEU	01	40	8	0040	01	4
3111JWL29047141 0.589 2	HOMOAPHI	01	40	5	0008	01	4
3111JWL29047141 0.589 2	THYS	02	10	1	0006	01	4
3111JWL29047141 0.589 2	THYS	03	10	1	0004	01	4
3111JWL30047142 0.513 5	ARANLYCO	03	40	2	0164	01	4
3111JWL30047142 0.513 0	COLESCARTRI	01	10	12	0072	01	4
3111JWL30047142 0.513 0	COLETENEBLA	01	10	1	0385	01	4
3111JWL30047142 0.513 7	HYMEFORMLEP	09	10	6	0045	01	4
3111JWL30047142 0.513 7	HYMEFORMSOL	10	10	3	0036	01	4
3111JWL30047142 0.513 7	HYMEFORMMON	07	10	1	0038	01	4
3111JWL30047142 0.513 0	DIPT	12	10	1	0160	01E4	
3111JWL30047142 0.513 0	HEMITING	01	10	1	0081	01	4
3111JWL30047142 0.513 2	HEMILYGABLI	01	10	2	0015	01	4
3111JWL30047142 0.513 2	HOMOPSEU	01	40	1	0040	01	4
3111JWL30047142 0.513 2	HOMOPSEU	01	10	1	0040	01	4
3111JWL30047142 0.552 5	ARANLYCO	03	40	1	0164	01	4
3111JWL30047142 0.552 5	ARAN	04	40	1	0017	01	4
3111JWL30047142 0.552 2	ACARERYT	02	10	2	0025	01	4
3111JWL30047142 0.552 2	ACARVEIG	03	10	2	0001	01	4
3111JWL30047142 0.552 0	COLEELAT	05	40	1	0042	01	4
3111JWL30047142 0.552 0	COLETENEBLA	01	10	7	0385	01	4
3111JWL30047142 0.552 0	COLECURCGER	08	10	1	1318	01	4
3111JWL30047142 0.552 0	COLECURC	09	10	1	0042	01	4
3111JWL30047142 0.552 0	DIPT	13	40	6	0076	01E4	
3111JWL30047142 0.552 7	HYMEFORMMYR	04	10	1	0158	01	4
3111JWL30047142 0.552 7	HYMEFORMTAP	05	10	3	0046	01	4
3111JWL30047142 0.552 2	HOMOPSEU	01	40	2	0040	01	4
3111JWL30047142 0.552 0	HEMITING	01	10	1	0080	01	4
3111JWL30047142 0.552 2	HEMILYGABLI	01	40	17	0015	01	4
3111JWL30047142 0.569 5	ARANLYCO	03	10	1	0164	01	4
3111JWL30047142 0.569 5	ARAN	06	40	1	0018	01	4
3111JWL30047142 0.569 0	COLETENE	03	40	2	7704	01	4
3111JWL30047142 0.569 0	COLETENEBLA	01	10	6	0385	01	4
3111JWL30047142 0.569 0	COLESCARTRI	01	10	5	0072	01	4
3111JWL30047142 0.569 0	COLECURCGER	08	10	1	1318	01	4
3111JWL30047142 0.569 0	COLECURCCAL	01	10	1	0141	01	4
3111JWL30047142 0.569 7	HYMEFORMMYR	04	10	1	0158	01	4
3111JWL30047142 0.569 7	HYMEFORMFOR	11	10	2	0160	01	4
3111JWL30047142 0.569 7	HYMEFORMLEP	09	10	3	0045	01	4
3111JWL30047142 0.569 7	HYMEFORMFOR	08	10	1	0070	01	4
3111JWL30047142 0.569 9	ISOPRHIN	01	10	1	0045	01	4
3111JWL30047142 0.569 2	HOMOPSEU	01	40	1	0040	01	4
3111JWL30047142 0.569 2	HEMILYGABLI	01	40	2	0015	01	4
3111JWL30047142 0.591 2	ACAR	04	10	3	0000	01	4
3111JWL30047142 0.591 2	ACARHAPL	24	10	1	0000	01	4

3111JWL30047142	0.591	0	COLE	04	40	1	0096	01E4
3111JWL30047142	0.591	1	COLECHRY	01	40	1	0120	01 4
3111JWL30047142	0.591	0	COLECURCGER	08	10	3	1318	01 4
3111JWL30047142	0.591	0	COLETENEBLA	01	10	5	0385	01 4
3111JWL30047142	0.591	0	COLECURCCAL	01	10	3	0141	01 4
3111JWL30047142	0.591	0	COLECURCHYR	07	10	1	0231	01 4
3111JWL30047142	0.591	0	COLE	06	40	1	0122	01E4
3111JWL30047142	0.591	7	HYMEFORMFOR	08	10	7	0070	01 4
3111JWL30047142	0.591	2	HOMOPSEU	01	40	7	0040	01 4
3111JWL30047142	0.591	2	HOMOCICAACE	02	10	1	0028	01 4
3111JWL30047142	0.591	2	HEMILYGABLI	01	40	1	0015	01 4
3111JWL30047142	0.591	0	DIPTCECI	01	10	3	0011	01 4
3111JWL30047142	0.598	5	ARANLYCO	03	40	2	0164	01 4
3111JWL30047142	0.598	5	ARAN	07	10	1	0185	01 4
3111JWL30047142	0.598	2	ACAR	05	10	1	0001	01 4
3111JWL30047142	0.598	2	ACAR	04	40	1	0000	01 4
3111JWL30047142	0.598	0	COLETENEBLA	01	10	9	0385	01 4
3111JWL30047142	0.598	0	COLESCARIRT	01	10	8	0072	01 4
3111JWL30047142	0.598	8	COLESTAP	01	10	1	0054	01 4
3111JWL30047142	0.598	0	COLECURCGER	08	10	2	1318	01 4
3111JWL30047142	0.598	0	COLECURCCAL	01	10	4	0141	01 4
3111JWL30047142	0.598	5	COLECARAMIC	05	10	1	0036	01 4
3111JWL30047142	0.598	0	COLETENE	03	10	1	7704	01 4
3111JWL30047142	0.598	7	HYMEFORMMYR	04	10	1	0156	01 4
3111JWL30047142	0.598	7	HYMEFORMLEP	09	10	1	0045	01 4
3111JWL30047142	0.598	0	HOMOPSEU	01	40	1	0040	01 4
3111JWL30047142	0.598	2	HEMILYGABLI	01	40	2	0015	01 4