Technical Report No. 163

SMALL MAMMAL STUDIES ON THE PAWNEE SITE DURING THE 1971 FIELD SEASON

William E. Grant

Natural Resource Ecology Laboratory

Colorado State University

Fort Collins, Colorado

GRASSLAND BIOME

U.S. International Biological Program

September 1972

TABLE OF CONTENTS

ABSTRACT

Results of small mammal trapping at the Pawnee Site during the 1971 field season are summarized. Population density estimates are made for each small mammal species on each of six treatments for each trapping period. The six treatments are compared with respect to small mammal biomass, and estimates are made concerning the energy needs of each species. Mean summer diets of the five small mammal species are compared. Niche segregation of small mammals at the Pawnee Site is discussed.

METHODS AND MATERIALS

Live trapping was carried out on the heavily- and lightly-grazed treatments and also on the four environmental stress area treatments during the 1971 field season (Table 1). Snap trapping was carried out on a heavily-grazed pasture 2 miles removed from the nearest live-trapping site (Table 1). The two live-trapping grids on the heavily- and lightly-grazed treatments were both 12 × 12 stations, with 15 m between grid stations and one trap per station. The eight live-trapping grids on the environmental stress area treatments were each 6 × 7 stations with 8 m between grid stations and one trap per station (Fig. 1). The snap traps were placed in four rows each approximately 1/8 mile long with traps and rows approximately 10 m apart. Oatmeal was used as bait in the live traps (Sherman type) while oatmeal mixed with peanut butter was used in the snap traps (Museum Special type). Trapping periods were five nights in length, the traps being baited at dusk and checked at dawn.

Animals caught in live traps were identified as to species and sex and were toe-clipped according to the procedure described in Tech. Rep. No. 85 (French, 1971). Animals caught in snap traps were frozen as soon as possible and were dissected at a later date to obtain reproductive data. Stomachs of dissected animals were sent to the laboratory for diet analysis. Eye lenses were also saved.

The live-trapping data were used to estimate population densities for each species on each treatment and date. The Zippin regression estimator (Zippin, 1956) was used when meaningful (that is, when the regression line yielded an R^2 greater than 0.75 or when the probability of capture was greater than 0.25); otherwise the total number of individuals of a species

Table 1. Trapping locations and trapping period dates.

Treatment	Location	Dates
Heavily-grazed treatment (one grid of live traps)	East half of section 12 T10N, R66W	18-22 March
		30 April to 4 May
		26-30 June
		20-24 August
		19-23 October
Lightly-grazed treatment (one grid of live traps)	West half of section 23 T10N, R66W	18-22 March
		30 April to 4 May
		26-30 June
		20-24 August
		19-23 October
Environmental stress area treatments (eight grids of live traps)	South half of section 21 T10N, R66W	29 July to 3 August
		25-29 August
		24-28 October
Heavily-grazed pasture (four lines of snap traps)	West half of section 25 T10N, R66W	18-22 March
		30 April to 4 May
		26-30 June
		20-24 August

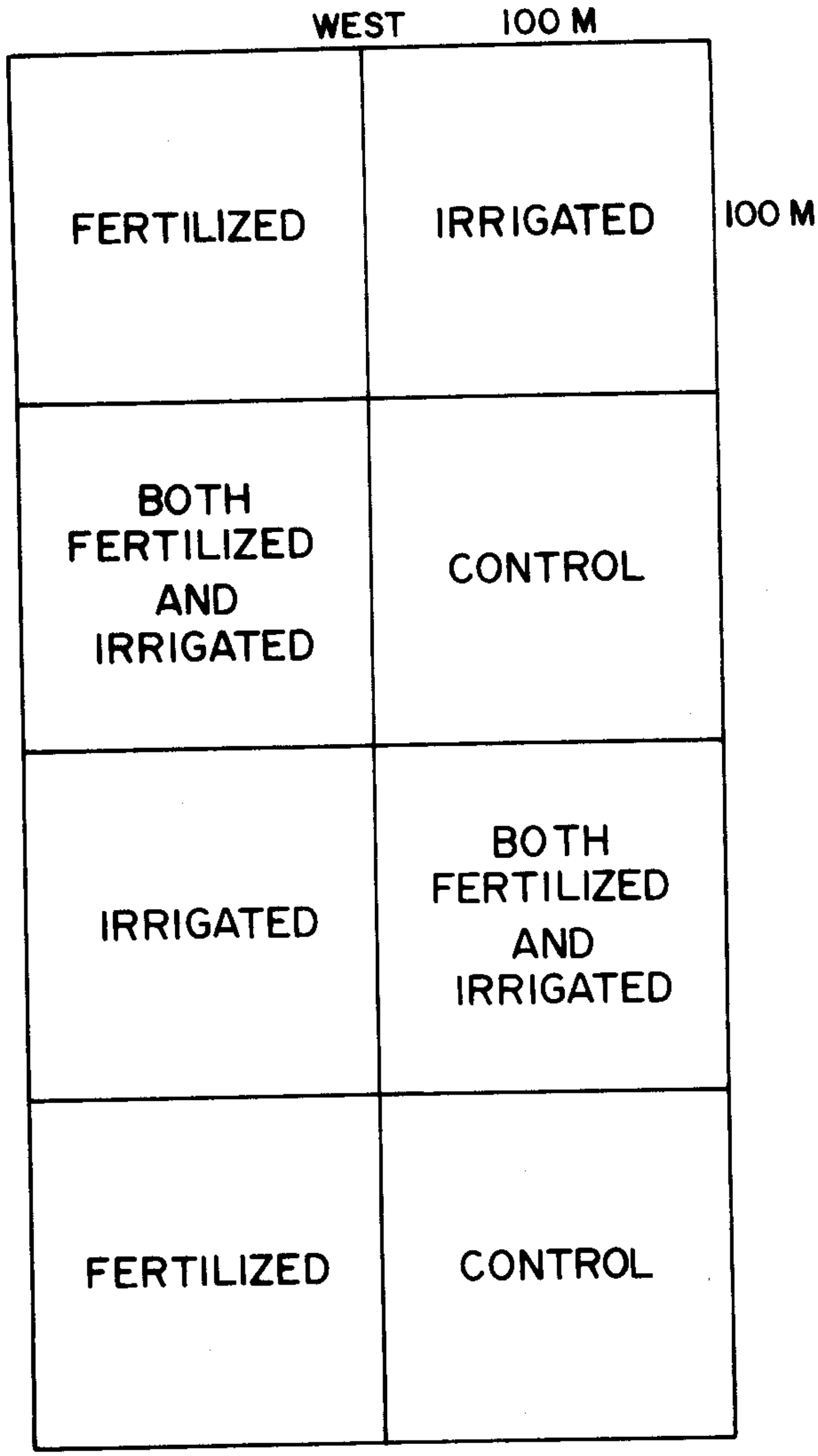

Fig. 1. Diagram of the eight environmental stress area grid locations.

captured was used as a minimum estimate of population size. The effective area sampled (that area from which the trap grid drew animals) was taken to be 3.24 ha for the 12 × 12 station grids and 1 ha for the 6 × 7 station grids for all species.

The snap-trapping data were used in obtaining mean summer weights for each species which were then used in biomass estimates. Results from the stomach analyses were used in dietary comparisons between species. The procedure used in determining stomach contents of small mammals has been described by French (1971).

DESCRIPTION OF TREATMENTS

The six treatments referred to in this report may be described as follows: (i) heavily-grazed--300 lb./acre aboveground plant biomass (live and standing dead) remaining at the end of the grazing season; (ii) lightly-grazed--500 lb./acre aboveground plant biomass; (iii) control--ungrazed by cattle, "natural" shortgrass prairie; (iv) fertilized--fertilized with nitrogen prior to the growing season; (v) irrigated--irrigated throughout the growing season; and (vi) irrigated and fertilized--fertilized with nitrogen prior to the growing season and irrigated throughout the growing season. For a more detailed description of the last three treatments the reader is referred to Lauenroth (Tech. Rep. in progress).

RESULTS

The main objective of the small mammal sampling at the Pawnee Site during 1971 was to estimate the standing crop of rodents on the six treatments described in the previous section. For the sake of obtaining results that would be of use in comparative studies dealing with all of the

Comprehensive Network Sites, the work presented in this report is based on the following assumptions.

1. The modified Zippin regression estimation technique provides reliable population estimates for any grassland small mammal species if either the R^2 for regression is greater than 0.75 or the probability of capture is greater than 0.25. In cases where neither of these conditions are met, a reasonable estimate of any grassland small mammal population can be obtained by regarding the total number of individuals captured as a minimum population estimate.

2. The effective area sampled by a grid of live traps is the same for all species. This area is approximately 3.24 ha for the 12 × 12 station grids and 1.0 ha for the 6 × 7 station grids used in this study.

While the first assumption is shaky at best and the second is almost surely incorrect, they may be justified by the need for integration (and therefore comparability of methods) of consumer studies throughout the IBP Grassland Biome. Realizing that in the field of small mammal population dynamics each researcher is apt to have his own battery of techniques for dealing with trapping data, an attempt has been made to include a summary of the raw live-trapping data (Tables 2 and 3). All data are, of course, compiled and stored at the Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado.

The population density estimates (Table 4) reveal markedly higher densities on the four stress area treatments than found on the heavily- and lightly-grazed treatments. (The data from the stress area treatments may not be strictly comparable to those from the heavily- and lightly-grazed treatments because the trap grids on the former are much more dense.)

Table 2. Number of individuals captured in live traps (does not include recaptures).

a. Heavy and Light Grazing Treatments

Species	Treatment	Dates					Total[a/]
		18-22 March	30 April to 4 May	26-30 June	20-24 August	19-23 October	
Grasshopper mouse	Heavily-grazed	12	8	10	8	11	49
(*Onychomys leucogaster*)	Lightly-grazed	9	5	9	16	6	45
Deer mouse	Heavily-grazed	4	13	7	3	9	36
(*Peromyscus maniculatus*)	Lightly-grazed	4	3	0	1	3	11
Thirteen-lined ground squirrel	Heavily-grazed	0	2	7	7	0	16
(*Spermophilus tridecemlineatus*)	Lightly-grazed	0	4	6	14	0	24
Ord's kangaroo rat	Heavily-grazed	0	0	0	3	8	11
(*Dipodomys ordii*)	Lightly-grazed	1	0	2	3	3	9
TOTALS	Heavily-grazed	16	23	24	21	28	112
	Lightly-grazed	14	12	17	34	12	89

b. Environmental Stress Area Treatments

Species	Treatment	Dates			Total[a/]
		29 July to 3 August	25-29 August	24-28 October	
Grasshopper mouse	Irrigated and fertilized	0	0	0	0
(*Onychomys leucogaster*)	Fertilized	14	14	8	36
	Irrigated	0	2	3	5
	Control	14	13	8	35
Deer mouse	Irrigated and fertilized	15	8	34	57
(*Peromyscus maniculatus*)	Fertilized	1	0	1	2
	Irrigated	10	8	14	32
	Control	9	3	4	16
Thirteen-lined ground squirrel	Irrigated and fertilized	0	0	0	0
(*Spermophilus tridecemlineatus*)	Fertilized	5	6	0	11
	Irrigated	3	2	0	5
	Control	2	7	3	12
Ord's kangaroo rat	Irrigated and fertilized	0	0	0	0
(*Dipodomys ordii*)	Fertilized	0	1	0	1
	Irrigated	0	0	0	0
	Control	0	0	0	0
Prairie vole	Irrigated and fertilized	7	39	50	96
(*Microtus ochrogaster*)	Fertilized	0	0	0	0
	Irrigated	0	0	1	1
	Control	0	0	0	0
TOTALS	Irrigated and fertilized	22	47	84	153
	Fertilized	20	21	9	50
	Irrigated	13	12	18	43
	Control	25	23	15	63

[a/] Individuals were counted once for each trapping period in which they were caught.

Table 3. Total number of captures in live traps (includes recaptures).

a. Heavy and Light Grazing Treatments

Species	Treatment	Dates: 18-22 March	30 April to 4 May	26-30 June	20-24 August	19-23 October	Total
Grasshopper mouse	Heavily-grazed	15	12	28	17	26	98
(*Onychomys leucogaster*)	Lightly-grazed	16	7	16	37	20	96
Deer mouse	Heavily-grazed	7	19	9	3	15	53
(*Peromyscus maniculatus*)	Lightly-grazed	5	3	0	2	5	15
Thirteen-lined ground squirrel	Heavily-grazed	0	2	10	11	0	23
(*Spermophilus tridecemlineatus*)	Lightly-grazed	0	5	9	24	0	38
Ord's kangaroo rat	Heavily-grazed	0	0	0	5	15	20
(*Dipodomys ordii*)	Lightly-grazed	1	0	2	6	12	21
TOTALS	Heavily-grazed	22	33	47	36	56	194
	Lightly-grazed	22	15	27	69	37	170

b. Environmental Stress Area Treatments

Species	Treatment	Dates: 29 July to 3 August	25-29 August	24-28 October	Total
	Irrigated and fertilized	0	0	0	0
Grasshopper mouse	Fertilized	30	32	25	87
(*Onychomys leucogaster*)	Irrigated	0	3	3	6
	Control	23	36	19	78
	Irrigated and fertilized	35	11	47	93
Deer mouse	Fertilized	1	0	1	2
(*Peromyscus maniculatus*)	Irrigated	15	10	18	43
	Control	11	6	4	21
	Irrigated and fertilized	0	0	0	0
Thirteen-lined ground squirrel	Fertilized	10	10	0	20
(*Spermophilus tridecemlineatus*)	Irrigated	3	2	0	5
	Control	3	11	3	17
	Irrigated and fertilized	0	0	0	0
Ord's kangaroo rat	Fertilized	0	2	0	2
(*Dipodomys ordii*)	Irrigated	0	0	0	0
	Control	0	0	0	0
	Irrigated and fertilized	12	77	80	169
Prairie vole	Fertilized	0	0	0	0
(*Microtus ochrogaster*)	Irrigated	0	0	1	1
	Control	0	0	0	0
TOTALS	Irrigated and fertilized	47	88	127	262
	Fertilized	41	44	26	111
	Irrigated	18	15	22	55
	Control	37	53	26	116

Table 4. Population density estimates (individuals per hectare) based on live-trapping data. Entries in parentheses represent densities based on total number of individuals captured; other entries were calculated by the modified Zippin method.

a. Heavy and Light Grazing Treatments

Species	Treatment	Dates: 18-22 March	30 April to 4 May	26-30 June	20-24 August	19-23 October	Average
Grasshopper mouse	Heavily-grazed	4.4	2.6	3.4	1.8	3.3	3.1
(*Onychomys leucogaster*)	Lightly-grazed	2.8	(1.5)	3.3	4.5	1.8	2.8
Deer mouse	Heavily-grazed	0.8	4.3	1.7	1.0	2.3	2.0
(*Peromyscus maniculatus*)	Lightly-grazed	1.3	0.7	(0)	(0.3)	0.7	0.6
Thirteen-lined ground squirrel	Heavily-grazed	(0)	0.4	2.5	2.5	(0)	1.1
(*Spermophilus tridecemlineatus*)	Lightly-grazed	(0)	1.5	2.3	4.6	(0)	1.7
Ord's kangaroo rat	Heavily-grazed	(0)	(0)	(0)	1.1	2.4	0.7
(*Dipodomys ordii*)	Lightly-grazed	(0.3)	(0)	1.0	0.9	0.9	0.6
TOTALS	Heavily-grazed	5.2	7.3	7.6	6.4	8.0	6.9
	Lightly-grazed	4.4	3.7	6.6	10.3	3.4	5.7

b. Environmental Stress Area Treatments

Species	Treatment	Dates: 29 July to 3 August	25-29 August	24-28 October	Average
Grasshopper mouse	Irrigated and fertilized	(0)	(0)	(0)	0
(*Onychomys leucogaster*)	Fertilized	14.1	19.4	9.0	14.2
	Irrigated	(0)	(2)	(3)	1.7
	Control	10.0	12.5	6.9	9.8
Deer mouse	Irrigated and fertilized	20.0	11.6	42.6	24.7
(*Peromyscus maniculatus*)	Fertilized	1.5	(0)	1.0	0.8
	Irrigated	11.8	8.3	15.4	11.8
	Control	9.4	2.9	4.4	5.6
Thirteen-lined ground squirrel	Irrigated and fertilized	(0)	(0)	(0)	(0)
(*Spermophilus tridecemlineatus*)	Fertilized	(5)	(6)	(0)	3.7
	Irrigated	(3)	2.1	(0)	1.7
	Control	(2)	8.4	(3)	4.5
Ord's kangaroo rat	Irrigated and fertilized	(0)	(0)	(0)	(0)
(*Dipodomys ordii*)	Fertilized	(0)	1.0	(0)	0.3
	Irrigated	(0)	(0)	(0)	(0)
	Control	(0)	(0)	(0)	(0)
Prairie vole	Irrigated and fertilized	(7)	52.2	55.4	38.2
(*Microtus ochrogaster*)	Fertilized	(0)	(0)	(0)	(0)
	Irrigated	(0)	(0)	1	0.3
	Control	(0)	(0)	(0)	(0)
TOTALS	Irrigated and fertilized	27.0	63.8	98.0	62.9
	Fertilized	20.6	26.4	10.0	19.0
	Irrigated	14.8	12.4	19.4	15.5
	Control	21.4	23.8	14.3	19.8

The total number of small mammals per hectare on the fertilized, irrigated, and control treatments are approximately two to three times as great as on the heavily- and lightly-grazed treatments. The irrigated and fertilized treatment has a small mammal density, which exceeds that on the heavily- and lightly-grazed treatments by an order of magnitude, and is approximately three times as great as on the other stress area treatments.

When the numbers in Table 4 are multiplied by the appropriate body weights (Table 5) to yield biomass density estimates (Table 6), the relationships between the treatments noted above remain much the same (Fig. 2). However, the irrigated and fertilized treatment supported only approximately six times more small mammal biomass per hectare than did the heavily- and lightly-grazed treatments (as opposed to ten times as many individuals). This is due to differences in species composition as discussed below.

The variation in total small mammal biomass on the various treatments over the summer followed an expected pattern (Fig. 3). In general, biomass density increased during the spring and early summer to a peak in August and then declined during the autumn. There were two exceptions to this pattern. On the irrigated treatment biomass steadily declined on each of the three successive trapping dates from July to August to October. On the irrigated and fertilized treatment, biomass increased markedly from July to August, but then continued to rise to a peak in October. These results are presented diagrammatically by species in Fig. 4a through 4f.

A very interesting aspect of trapping on the six treatments at the Pawnee Site is the degree to which small mammal species composition differs between treatments. This difference in species composition among the

Table 5. Mean summer body weights (including stomach) of small mammals based on snap-trapping data.

Species	Mean Body Weight (g)	Weight Based on X Number of Animals
Grasshopper mouse (*Onychomys leucogaster*)	25.05	26
Deer mouse (*Peromyscus maniculatus*)	18.01	12
Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)	123.29	4
Ord's kangaroo rat (*Dipodomys ordii*)	48.85	10
Prairie vole (*Microtus ochrogaster*)	35.01	2

Table 6. Biomass density estimates (g/ha) based on live- and snap-trapping data.

a. Heavy and Light Grazing Treatments

Species	Treatment	Dates					Average
		18-22 March	30 April to 4 May	26-30 June	20-24 August	19-23 October	
Grasshopper mouse (*Onychomys leucogaster*)	Heavily-grazed	110	65	85	45	83	78
	Lightly-grazed	70	38	83	113	45	70
Deer mouse (*Peromyscus maniculatus*)	Heavily-grazed	14	77	31	18	41	36
	Lightly-grazed	23	13	0	5	13	11
Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)	Heavily-grazed	0	49	308	308	0	133
	Lightly-grazed	0	185	284	567	0	207
Ord's kangaroo rat (*Dipodomys ordii*)	Heavily-grazed	0	0	0	54	117	34
	Lightly-grazed	15	0	49	44	44	30
TOTALS	Heavily-grazed	124	191	424	425	241	281
	Lightly-grazed	108	236	416	729	102	318

b. Environmental Stress Area Treatments

Species	Treatment	Dates			Average
		29 July to 3 August	25-29 August	24-28 October	
Grasshopper mouse (*Onychomys leucogaster*)	Irrigated and fertilized	0	0	0	0
	Fertilized	353	486	225	355
	Irrigated	0	50	75	42
	Control	250	313	173	245
Deer mouse (*Peromyscus maniculatus*)	Irrigated and fertilized	360	209	767	445
	Fertilized	27	0	18	15
	Irrigated	212	149	277	213
	Control	169	52	79	100
Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)	Irrigated and fertilized	0	0	0	0
	Fertilized	616	740	0	452
	Irrigated	370	259	0	210
	Control	246	1036	370	551
Ord's kangaroo rat (*Dipodomys ordii*)	Irrigated and fertilized	0	0	0	0
	Fertilized	0	49	0	16
	Irrigated	0	0	0	0
	Control	0	0	0	0
Prairie vole (*Microtus ochrogaster*)	Irrigated and fertilized	245	1828	1940	1338
	Fertilized	0	0	0	0
	Irrigated	0	0	35	12
	Control	0	0	0	0
TOTALS	Irrigated and fertilized	605	2037	2707	1783
	Fertilized	996	1275	243	838
	Irrigated	582	458	387	476
	Control	665	1401	622	896

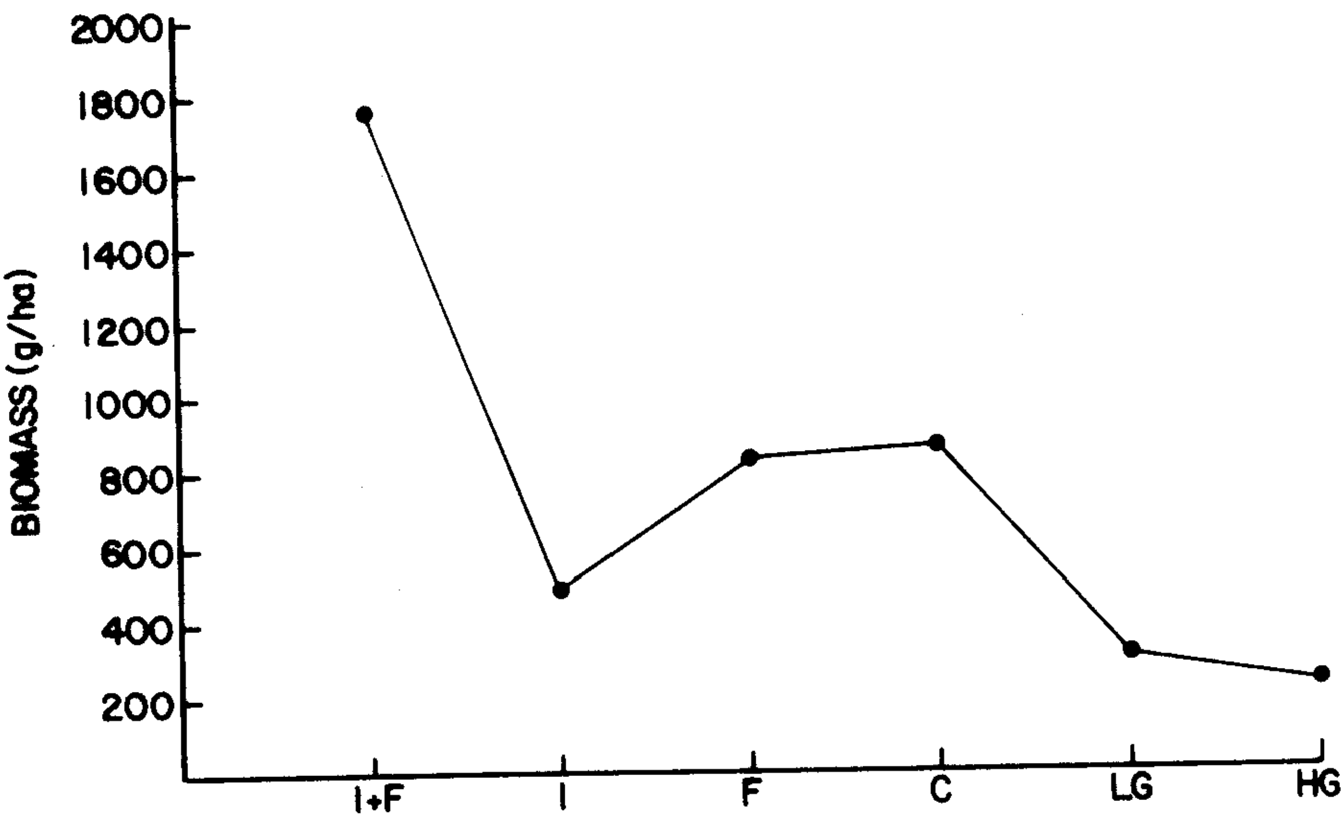

Fig. 2. Mean summer small mammal biomass (g/ha) on the six treatments. (I+F = irrigated and fertilized, I = irrigated, F = fertilized, C = control, LG = lightly-grazed, and HG = heavily-grazed).

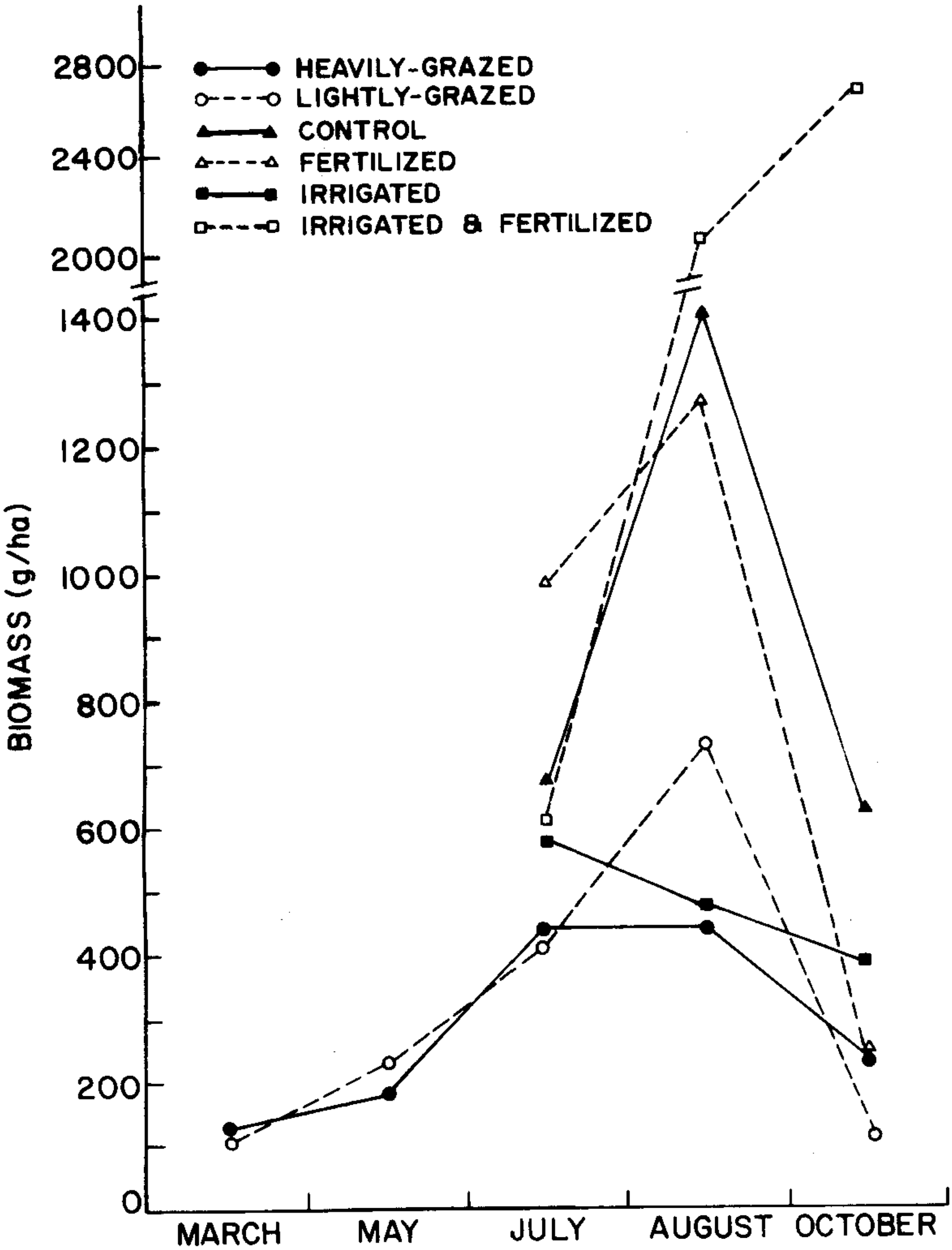

Fig. 3. Variation in total small mammal biomass (all species combined) on the six treatments during the summer.

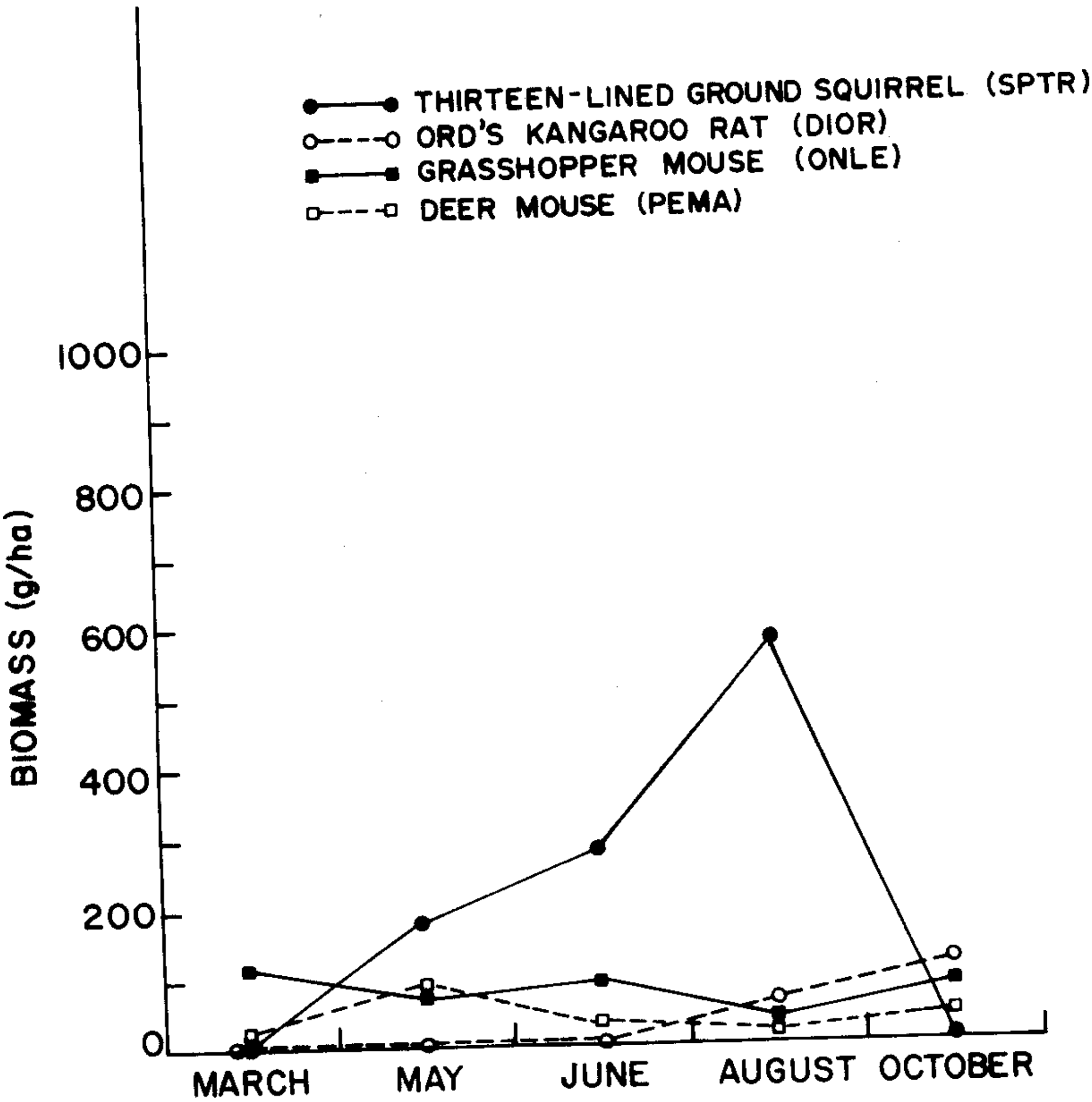

Fig. 4a. Variation in small mammal biomass by species on the heavily-grazed treatment during the summer.

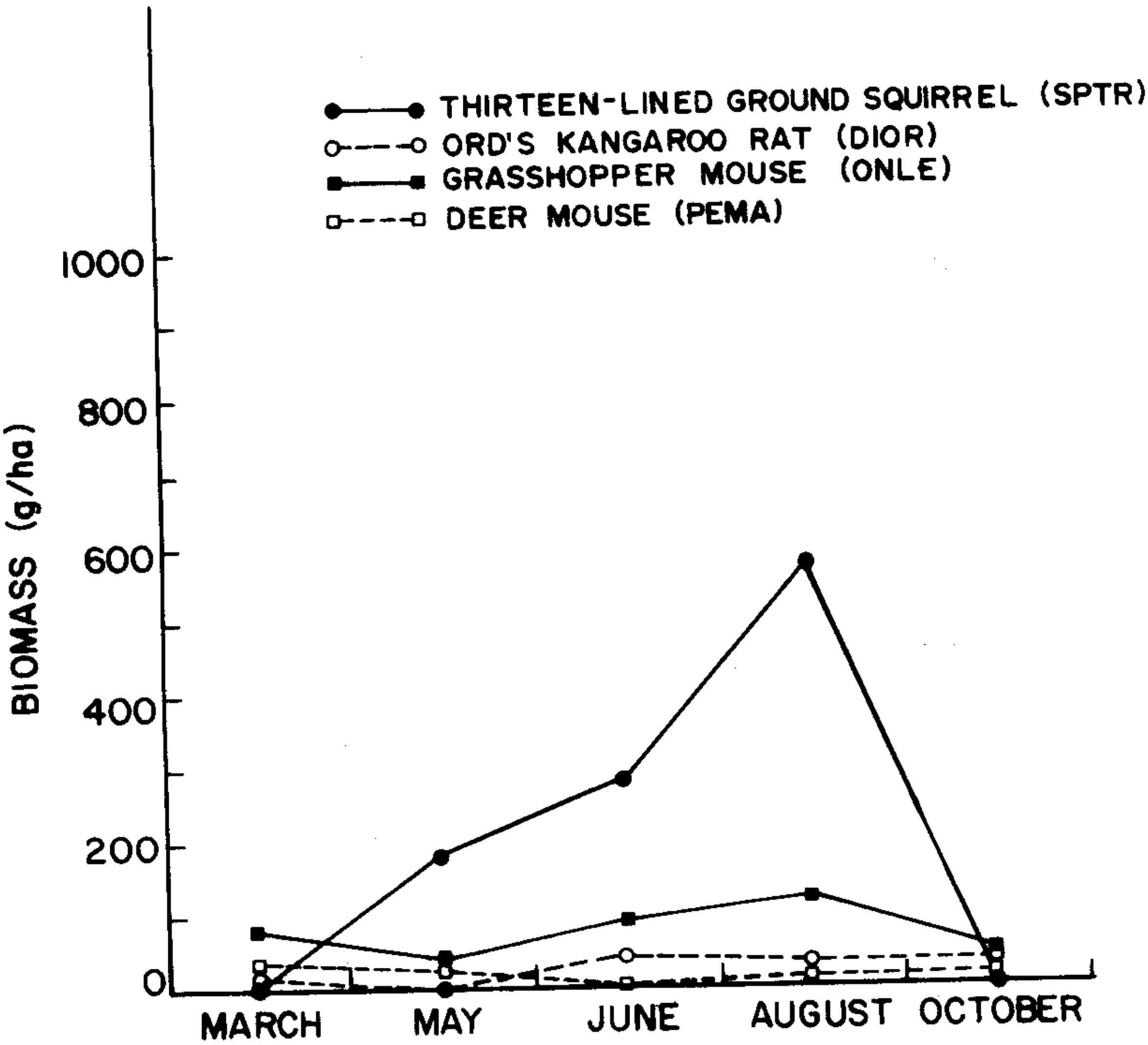

Fig. 4b. Variation in small mammal biomass by species on the lightly-grazed treatment during the summer.

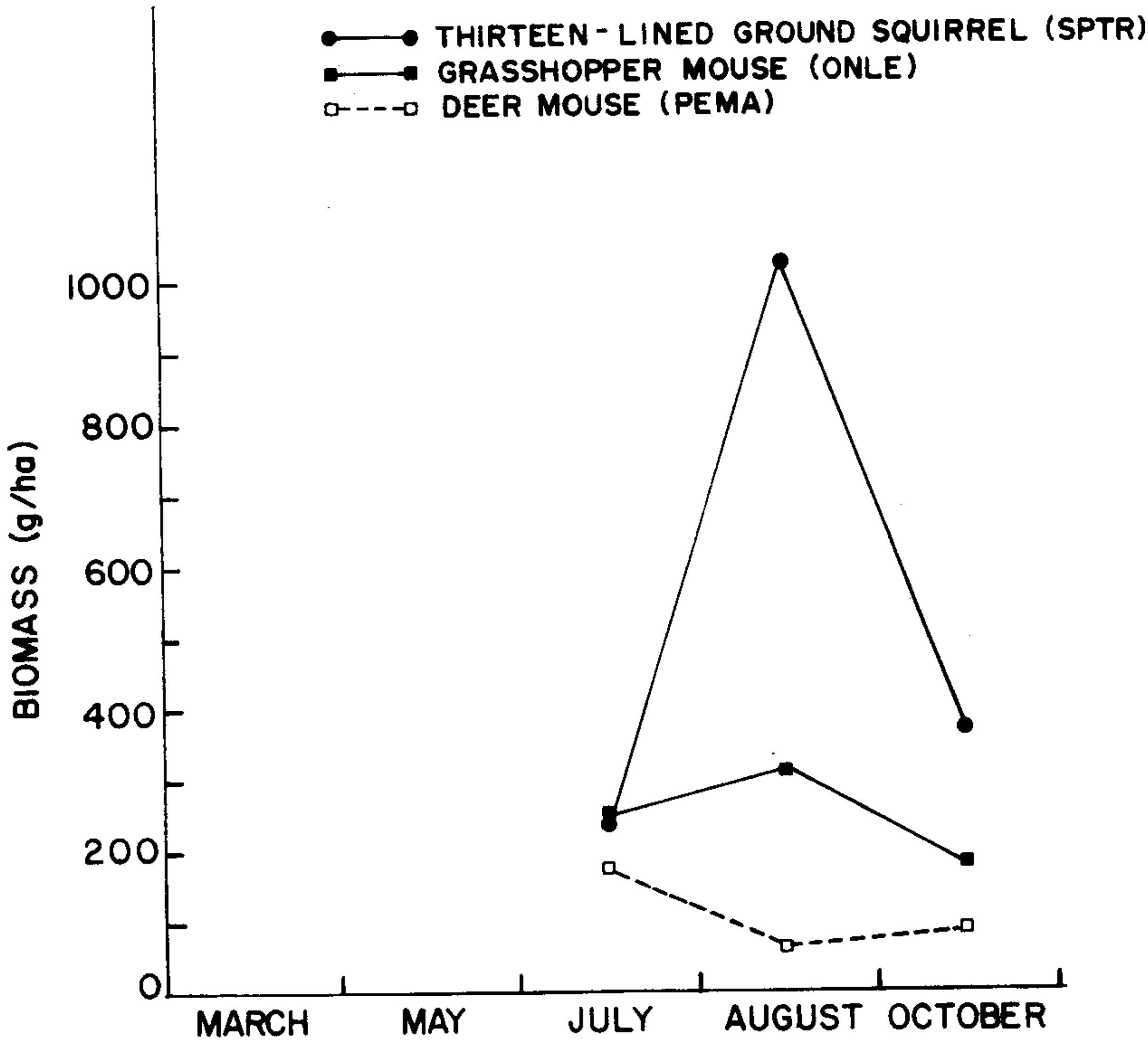

Fig. 4c. Variation in small mammal biomass by species on the control treatment during the summer.

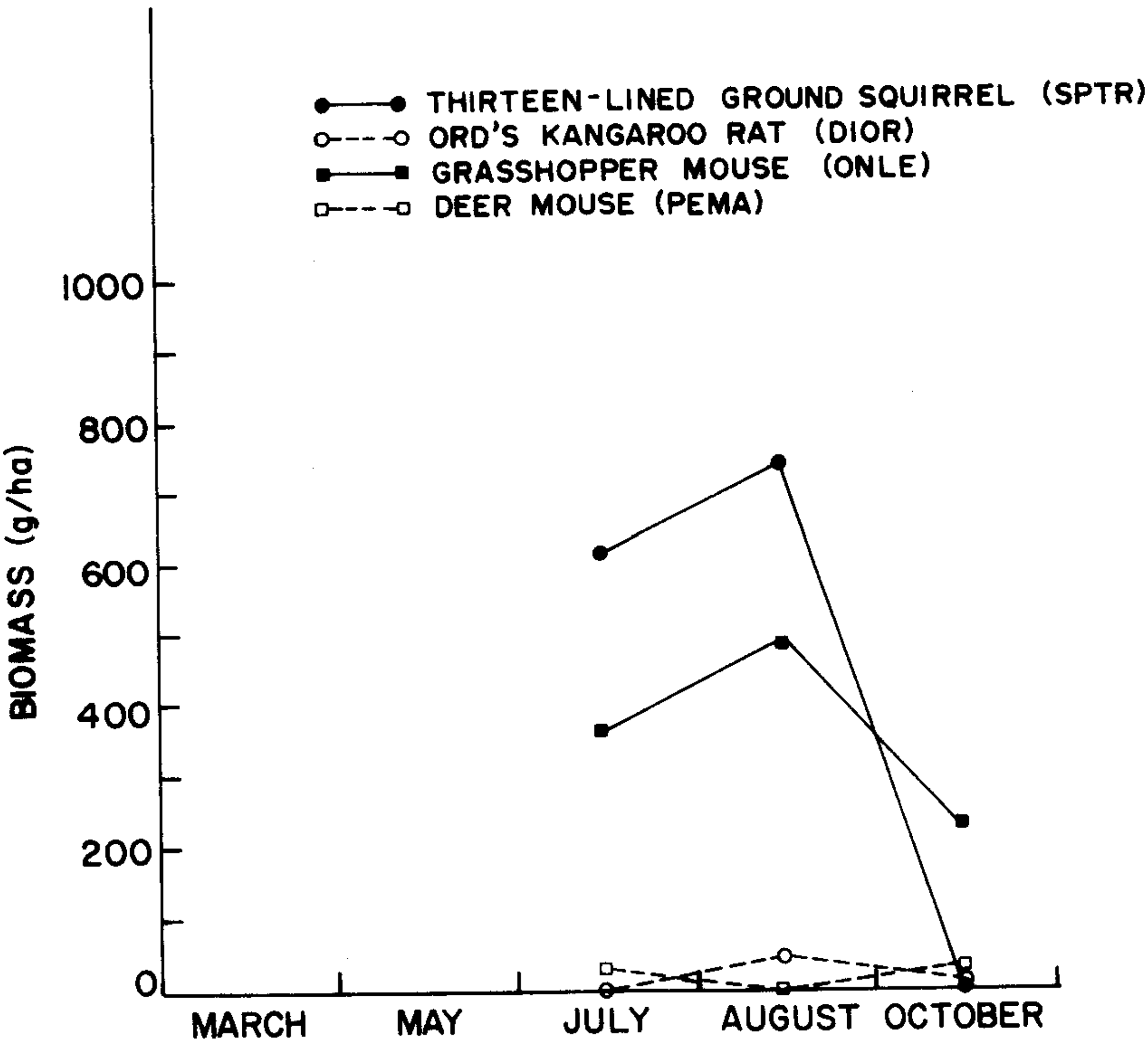

Fig. 4d. Variation in small mammal biomass by species on the fertilized treatment during the summer.

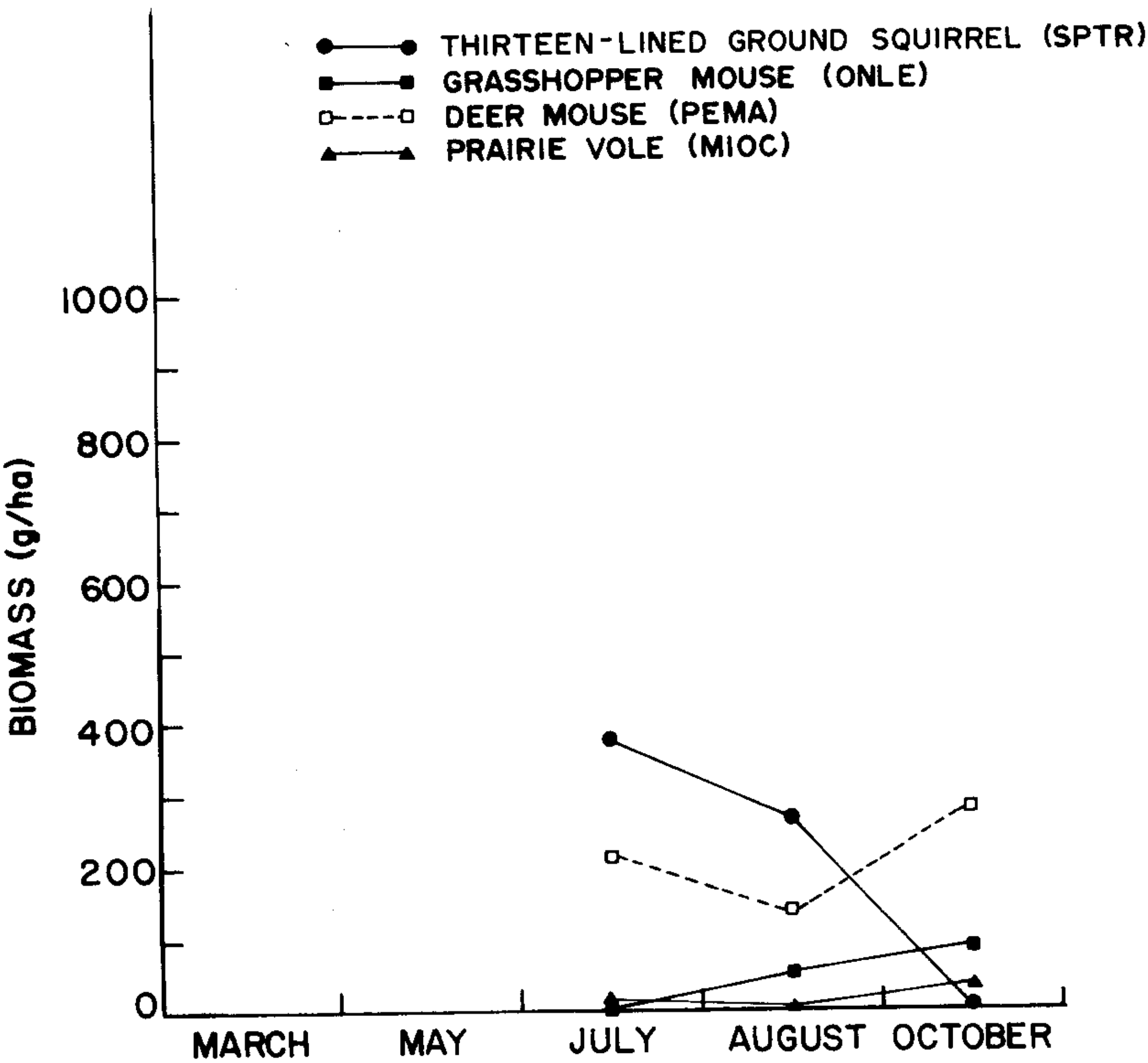

Fig. 4e. Variation in small mammal biomass by species on the irrigated treatment during the summer.

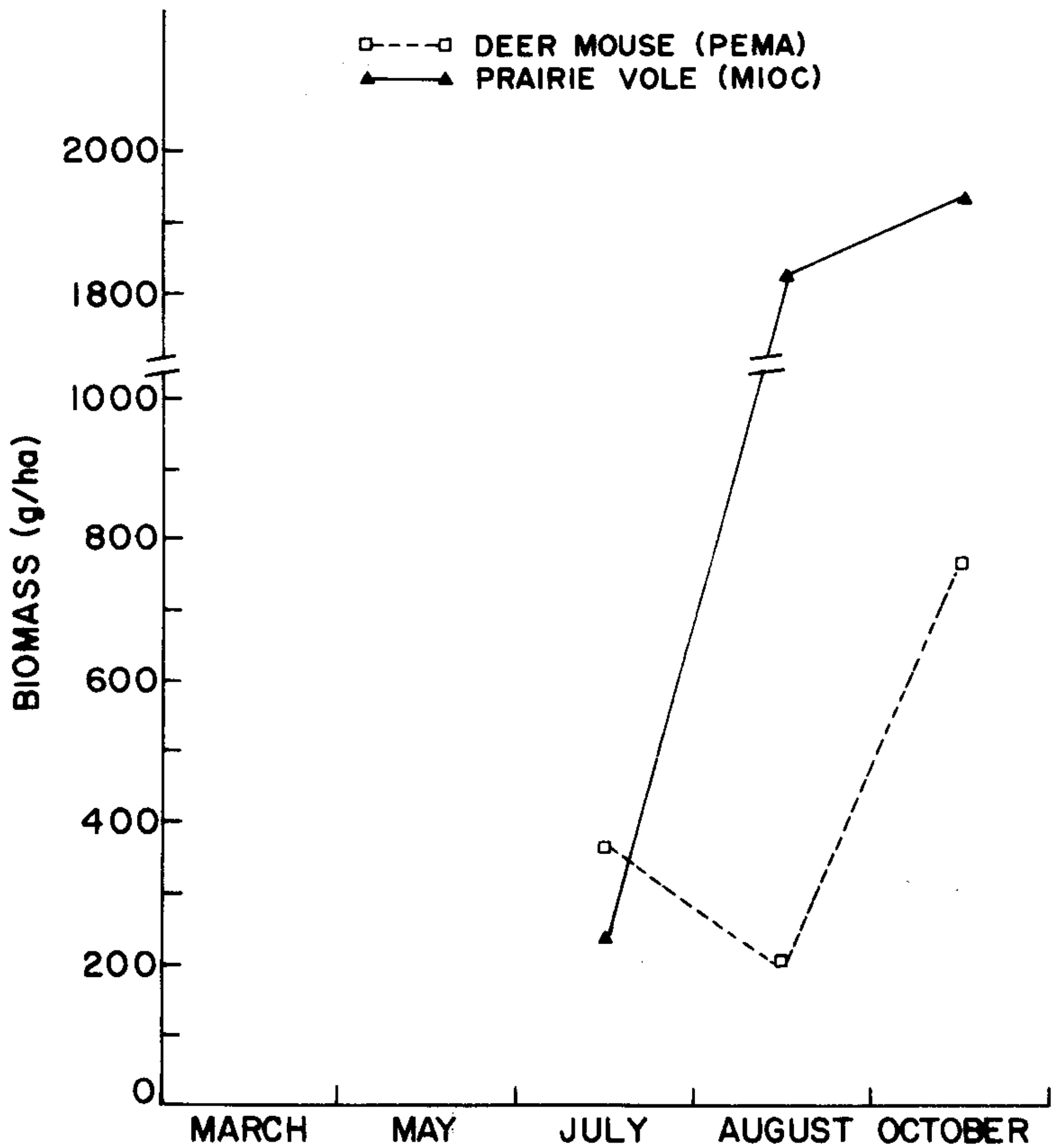

Fig. 4f. Variation in small mammal biomass by species on the irrigated and fertilized treatment during the summer.

environmental stress area treatments is even more surprising when one considers the small size (1 ha) and physical proximity of the plots (Fig. 1).

The R_o similarity index, as described by Horn (1966), was used to compare the six treatments with respect to their proportional small mammal species composition (based on live weight) (Table 7). The heavily-grazed, lightly-grazed, control, and fertilized treatments are all quite similar ($R_o \geq .79$). The irrigated treatment is slightly less similar when compared with the four treatments mentioned above ($.66 \leq R_o \leq .76$). The irrigated and fertilized treatment, however, supports a small mammal fauna that is radically different from all of the other treatments ($R_o \leq .39$). This difference is due to the absence of grasshopper mice (*Onychomys leucogaster*), thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), Ord's kangaroo rats (*Dipodomys ordii*), and the presence of a substantial population of prairie voles (*Microtus ochrogaster*), which are not found in any of the other treatments (Table 6).

The amount of energy channeled through small mammals at the Pawnee Site was calculated in the following manner. The standard algorithm for determining resting metabolic rate of mammals, MR = (70) × (body weight in kg)$^{0.75}$ (Kleiber, 1961), was taken as the starting point. Resting metabolic rate was then multiplied by 2.09 (the activity coefficient) to arrive at the net energy requirement of an active individual (Harris, 1971). This figure (which represents the amount of utilizable energy an animal requires) was corrected for energy losses between ingestion and utilization of foodstuffs (≈73% efficiency for small mammals) to arrive at the gross energy requirement of an individual for 1 day (1.36 × net energy requirement = gross energy requirement) (Harris, 1971). Gross energy requirement per

Table 7. R_o values indicating similarity between the six treatments with respect to the proportional species composition (based on live weight) of their resident small mammal fauna ($0 \leq R_o \leq 1$; higher values indicate more similarity between treatments).

Heavily-Grazed					
.91	Lightly-Grazed				
.79	.81	Control			
.88	.91	.85	Fertilized		
.76	.66	.71	.67	Irrigated	
.13	.04	.15	.04	.39	Irrigated and Fertilized

day times the number of effective active days per year for an individual of a given species (taken from Harris, 1971) yields the total energy requirement for one individual of that species per year. Finally, the proportion of the energy requirement derived from primary production was calculated by multiplying by the percent herbivory (based on 1971 diet data) of a given species. These calculations are summarized in Table 8. In making use of the density estimates (individuals/hectare) in Table 4 and the individual energy requirements (kcal/individual/year) in Table 8, estimates were made of the total small mammal energy requirements (kcal/hectare/year) and the proportion of this that was derived from primary production on each of the six treatments (Table 9 and Fig. 5).

It will be noted that the proportion of total small mammal energy requirements derived directly from primary production was greatest (≈77%) on the irrigated and fertilized plots (Table 9), the treatment with the greatest primary production. However, the small mammals on the irrigated treatment, which has the second highest primary production, do not derive a correspondingly large proportion of their energy directly from primary production (≈45%) (Table 9). This may be another reflection of the markedly different small mammal fauna that is resident on the irrigated and fertilized treatment.

A second, less intense small mammal trapping effort was directed toward securing data amenable to use in examining dietary overlap among the various species. Stomachs of sacrificed animals were used to compare summer diets of the five small mammal species. The diet analyses indicate that grasshopper mice and deer mice are mainly carnivorous, and that prairie

Table 8. A summary of calculations to determine the gross energy requirement per year and the proportion of this requirement derived from primary production for an average individual of each small mammal species trapped at Pawnee in 1971.

Species	$(70)\left(\text{wt in kg}\right)^{0.75}$ = MW[a/]	(2.09)(MW) = NER[b/]	(1.36)(NER) = GER[c/]	(Effective Active Days per Year) (GER) = GER'[d/]	(% Herbivory)(GER') = EDPP[e/]
Onychomys leucogaster	4.34	9.07	12.34	X365 = 4504	X24 = 1081
Peromyscus maniculatus	3.36	7.02	9.55	X365 = 3486	X38 = 1325
Spermophilus tridecemlineatus	14.56	30.43	41.38	X234 = 9683	X66 = 6391
Dipodomys ordii	7.35	15.36	20.89	X274 = 5724	X76 = 4350
Microtus ochrogaster	5.74	12.00	16.32	X365 = 5957	X92 = 5480

a/ MW = Metabolic weight in $kg^{0.75}$, $(\text{wt in kg})^{0.75}$ taken from Kleiber (1961).

b/ NER = Net energy requirement in kcal/individual/day; 2.09 is the activity coefficient taken from Harris (1971).

c/ GER = Gross energy requirement in kcal/individual/day; 1.36 is the overall efficiency (73%) coefficient taken from Harris (1971).

d/ GER' = Gross energy requirement in kcal/individual/year; (effective active days per year) taken from Harris (1971).

e/ EDPP = Energy derived directly from primary production in kcal/individual/year.

Table 9. Yearly energy requirements (kcal/ha/year) of each small mammal species (based on average summer densities) on the six treatments for 1971.

Species	Treatment	Total Energy Requirements	Energy Demand on Primary Production
Onychomys leucogaster	Heavily-grazed	13,962	3,351
	Lightly-grazed	12,611	3,027
	Irrigated and fertilized	0	0
	Fertilized	63,956	15,349
	Irrigated	7,657	1,838
	Control	44,139	10,593
Peromyscus maniculatus	Heavily-grazed	6,972	2,649
	Lightly-grazed	2,092	795
	Irrigated and fertilized	86,104	32,720
	Fertilized	2,789	1,060
	Irrigated	41,135	15,631
	Control	19,522	7,418
Spermophilus tridecemlineatus	Heavily-grazed	10,651	7,030
	Lightly-grazed	16,461	10,864
	Irrigated and fertilized	0	0
	Fertilized	35,827	23,646
	Irrigated	16,461	10,864
	Control	45,574	28,759
Dipodomys ordii	Heavily-grazed	4,007	3,045
	Lightly-grazed	3,434	2,610
	Irrigated and fertilized	0	0
	Fertilized	1,717	1,305
	Irrigated	0	0
	Control	0	0
Microtus ochrogaster	Heavily-grazed	0	0
	Lightly-grazed	0	0
	Irrigated and fertilized	227,557	209,352
	Fertilized	0	0
	Irrigated	1,787	1,644
	Control	0	0
TOTALS	Heavily-grazed	35,592	16,075
	Lightly-grazed	34,598	17,296
	Irrigated and fertilized	313,661	242,072
	Fertilized	104,289	41,360
	Irrigated	67,040	29,977
	Control	107,235	46,770

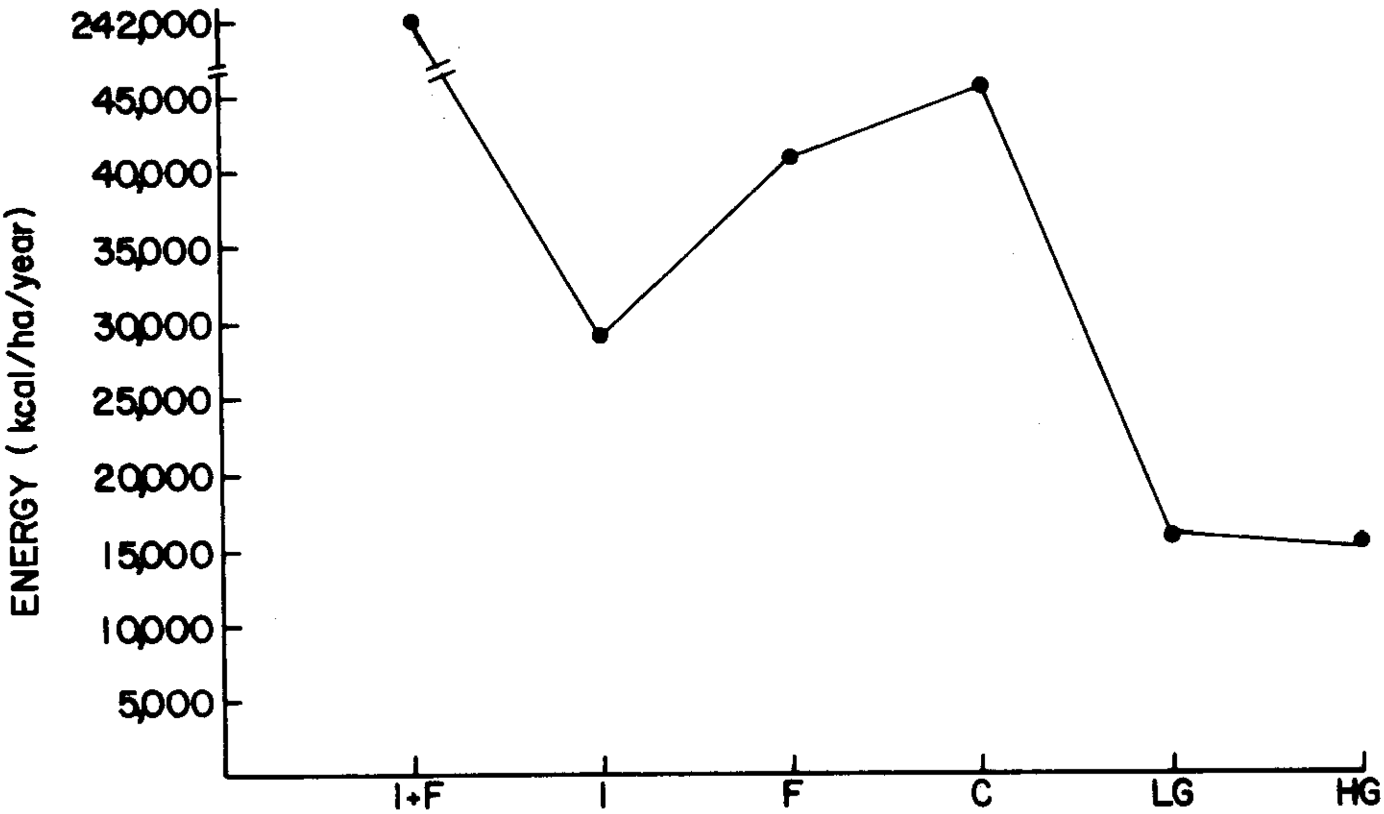

Fig. 5. Energy derived directly from primary production by small mammals (kcal/ha/year) on the six treatments (I+F = irrigated and fertilized, I = irrigated, F = fertilized, C = control, LG = lightly-grazed, and HG = heavily-grazed).

voles, Ord's kangaroo rats, and thirteen-lined ground squirrels are mainly herbivorous (Table 10). The results for the typically granivorous Ord's kangaroo rats are quite surprising in that no seeds were detected in their stomachs. The results for the thirteen-lined ground squirrels are also surprising due to the relatively large proportion of their diets comprised of plant material. Results for the other three species are in agreement with qualitative statements in the literature pertaining to their supposed diets.

Based on these diet analyses, dietary overlap between the five small mammal species was calculated using Horn's (1966) R_o similarity index (Table 11). The greatest dietary overlap occurs between prairie voles and thirteen-lined ground squirrels (R_o = .82), followed by deer mice and thirteen-lined ground squirrels (R_o = .75), grasshopper mice and deer mice (R_o = .74), and grasshopper mice and thirteen-lined ground squirrels (R_o = .65). The greatest niche segregation, based on diet, was between Ord's kangaroo rats and grasshopper mice (R_o = .30) and between Ord's kangaroo rats and deer mice (R_o = .36). To put these values in better perspective, Spearman's correlation coefficients (Siegel, 1956) were computed using all items in Table 10 which contributed greater than 1% of any diet. Each of the first four pairs listed above showed high significantly correlated diets ($p < .01$) while the last two pairs showed no significant correlation between their diets ($p > .05$).

DISCUSSION

Differences in small mammal faunal composition on the six treatments provide an interesting opportunity to gain insight into the ecology of the species involved, their interspecific relationships, and the manner in which

Table 10. Mean summer diets of small mammals based on sacrificed animals. Numbers in parentheses indicate the number of stomachs examined. Numbers in the body of the table indicate the percentage of microscope fields containing a given element.

Food Items	Grasshopper mouse (*Onychomys leucogaster*) (26)	Deer mouse (*Peromyscus maniculatus*) (36)	Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) (10)	Ord's kangaroo rat (*Dipodomys ordii*) (10)	Prairie vole (*Microtus ochrogaster*) (2)
Abronia fragrans			2.64		
Agropyron smithii			.10		
Allium textile			.29		
Aster tanecetifolius		.58			
Astragalus spp.	.03	1.56	4.73		8.60
Bouteloua gracilis	.44	.96	1.77		1.53
Bromus tectorum		.58			
Buchloe dactyloides			.10		
Carex heliophila		.40	.60		
Erigeron bellidiastrum		.68			
Gutierrezia sarothrae		.29			
Kochia scoparia		3.84		7.02	
Mirabilis linearis			1.12		
Oenothera albicaulis		.34			
Opuntia polyacantha		.05			
Oxytropis sericea		.29			
Parmelia chlorochior	.03				
Penstemon albidus		.47			
Salsola kali		3.06			
Sphaeralcea coccinea		1.91	3.23		
Sporobolus cryptandrus			.29	10.00	
Endogen					4.86
Flower parts		.05			
Moss		2.11			
Root		.34			
Seed		4.94	11.19		27.39
Unidentified plant parts	15.39	15.32	40.37	49.42	49.82
Arachnida adult		.15	.12		
Araneida (age undetermined)	.25	.62	.40		
Cicidellidae adult		.28			
Coleoptera adult	15.11	1.32	5.90		
Coleoptera larvae	3.72	1.50	.34		
Cuerna costalis			.17		
Curculionidae adult			.59		
Diptera adult	.10				
Hymenoptera adult	.15	1.33	.39		
Lepidoptera adult			.06		
Lepidoptera larvae	5.45	7.18	.81	3.56	
Orthoptera adult			.63		
Orthoptera nymph	3.89				
Orthoptera (age undetermined)	5.64	.55	.24		.18
Arthropod parts	41.69	49.26	23.95		7.62
Reptile parts	.42				
Bait	.05			20.31	
Hair		.03			
SUMMARY					
Total plants	23.53	32.84	55.21	76.13	64.81
Total arthropods	76.42	62.22	33.60	3.56	7.80
Seeds	0	4.94	11.19	0	27.39
Bait	.05	0	0	20.31	0

Table 11. R_o values indicating summer dietary overlap between small mammal species ($0 \leq R_o \leq 1$, where 0 = completely dissimilar diets and 1 = completely similar diets).

Grasshopper mouse (*Onychomys leucogaster*)				
.74	Deer mouse (*Peromyscus maniculatus*)			
.65	.75	Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)		
.30	.36	.48	Ord's kangaroo rat (*Dipodomys ordii*)	
.41	.57	.82	.50	Prairie vole (*Microtus ochrogaster*)

they are affected and, in turn, affect the structure of the grassland ecosystem. It has already been noted that the irrigated and fertilized treatment supports a unique small mammal fauna relative to the other treatments and that the irrigated treatment is noticeably different from the four "dry" treatments. This points out the dramatic effect of increased precipitation, probably mediated through vegetation, on grassland small mammal populations. Grasshopper mice, thirteen-lined ground squirrels, and Ord's kangaroo rats might be classified as "dry land" species, while prairie voles and deer mice are "wet land" species (Table 2). Of the "dry land" species there appears to be no marked difference in densities between the lightly- and heavily-grazed treatments. Although kangaroo rats, presumably as a result of their mode of locomotion, appeared hindered by dense clumps of vegetation, they were most frequently taken in the lightly-grazed pasture in traps near cowpaths or otherwise open areas. Of the "wet land" species prairie voles undoubtedly need a dense, lush stand of vegetation. All but one of the 97 individual voles captured were taken from the two irrigated and fertilized plots (1 ha each in size), the remaining individual being trapped in one of the irrigated plots (Table 2). Deer mice, while maintaining higher numbers in the wet as opposed to the dry treatments on the environmental stress area, were more abundant on the heavily-grazed than on the lightly-grazed pasture. This indicates that their increased density on the wet plots was perhaps more a function of vegetation succulence (or some factor related to succulence) rather than the amount of vegetative cover.

The availability of arthropods as food might also be expected to influence the summer distribution of deer mice, grasshopper mice, and thirteen-lined ground squirrels. However, mean summer densities on the six treatments of deer mice (Fig. 6a), grasshopper mice (Fig. 6b), and thirteen-lined ground squirrels (Fig. 6c) are not correlated with the corresponding arthropod densities (Fig. 7). The lack of correlation between food supply and density suggests that food may not be a limiting factor for these three species. This hypothesis will be explored further.

Interspecific competition may be one mechanism by which species become established in a given habitat type (Slobodkin, 1961). The process of competitive exclusion, operating over evolutionary time, will alleviate competition for those items that are limiting to population growth. One of the most obvious and easily examined forms of interspecific competition is competition for food. If two species show a high degree of dietary overlap and do not avoid competition by some means of niche differentiation on the food dimension, then food supply cannot be limiting the growth of either population. The dietary similarity values in Table 11 provide a quantitative means of applying this argument to the distribution of small mammals at the Pawnee Site.

One possibility for avoiding food competition is spatial segregation of the species involved. The largest dietary overlap ($R_o = .82$) occurs between thirteen-lined ground squirrels and prairie voles, but these two species are spatially segregated. Grasshopper mice, deer mice, and thirteen-lined ground squirrels all show a considerable degree of dietary overlap ($.65 \leq R_o \leq .75$) (high significantly correlated diets using Spearman's rank correlation coefficient, $p < .01$). On the environmental stress area grasshopper mice and deer mice are segregated fairly well into the dry and wet treatments, respectively; but on the heavily- and lightly-grazed treatments both occur together. Likewise, thirteen-lined ground squirrels occur on all treatments

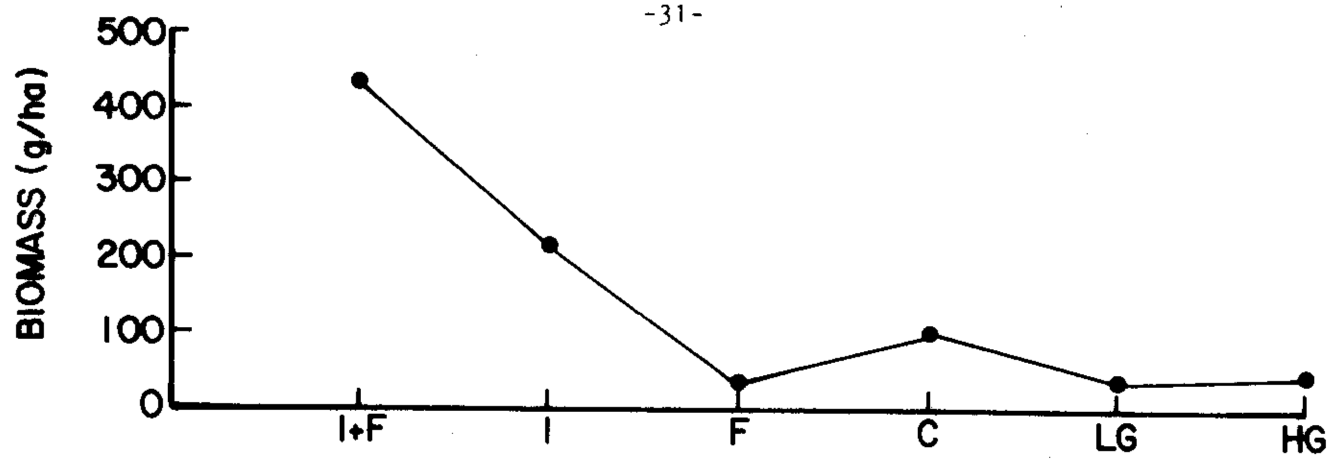

Fig. 6a. Mean summer deer mouse biomass (g/ha) on the six treatments (I+F = irrigated and fertilized, I = irrigated, F = fertilized, C = control, LG = lightly-grazed, and HG = heavily-grazed).

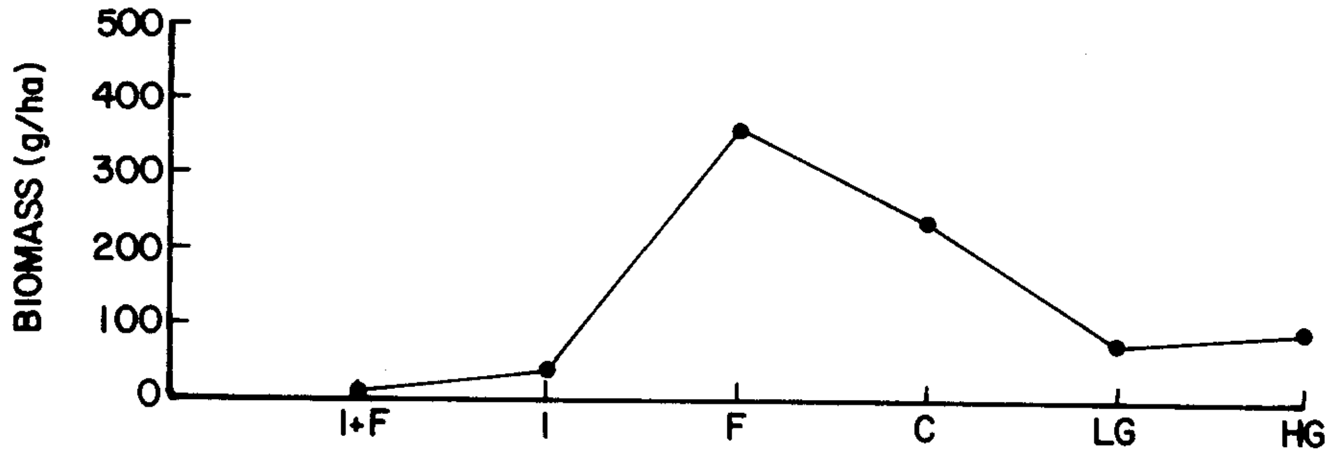

Fig. 6b. Mean summer grasshopper mouse biomass (g/ha) on the six treatments (I+F = irrigated and fertilized, I = irrigated, F = fertilized, C = control, LG = lightly-grazed, and HG = heavily-grazed).

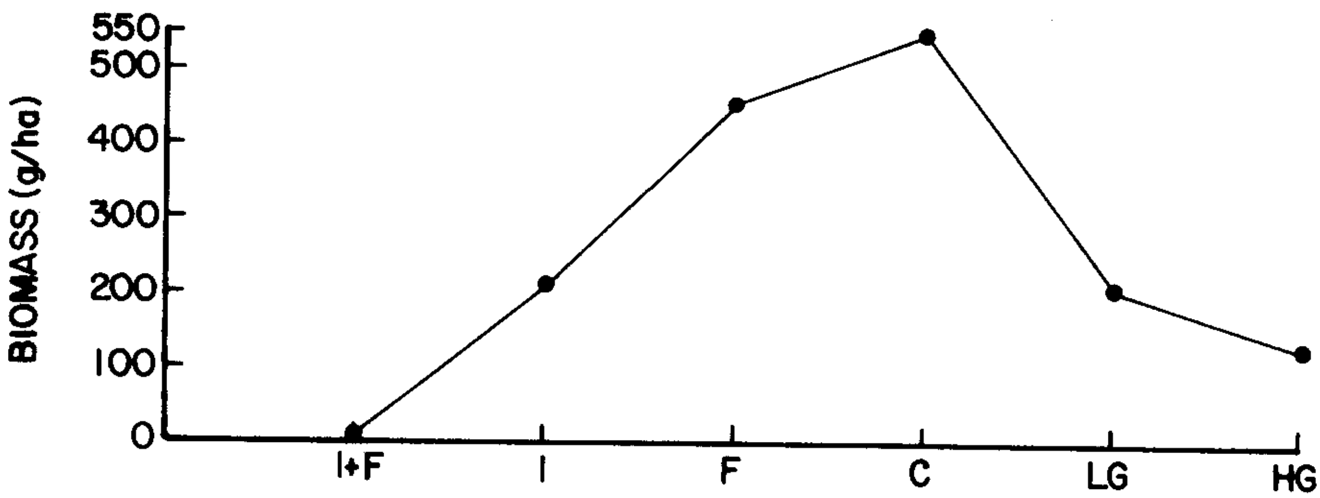

Fig. 6c. Mean summer thirteen-lined ground squirrel biomass (g/ha) on the six treatments (I+F = irrigated and fertilized, I = irrigated, F = fertilized, C = control, LG = lightly-grazed, and HG = heavily-grazed).

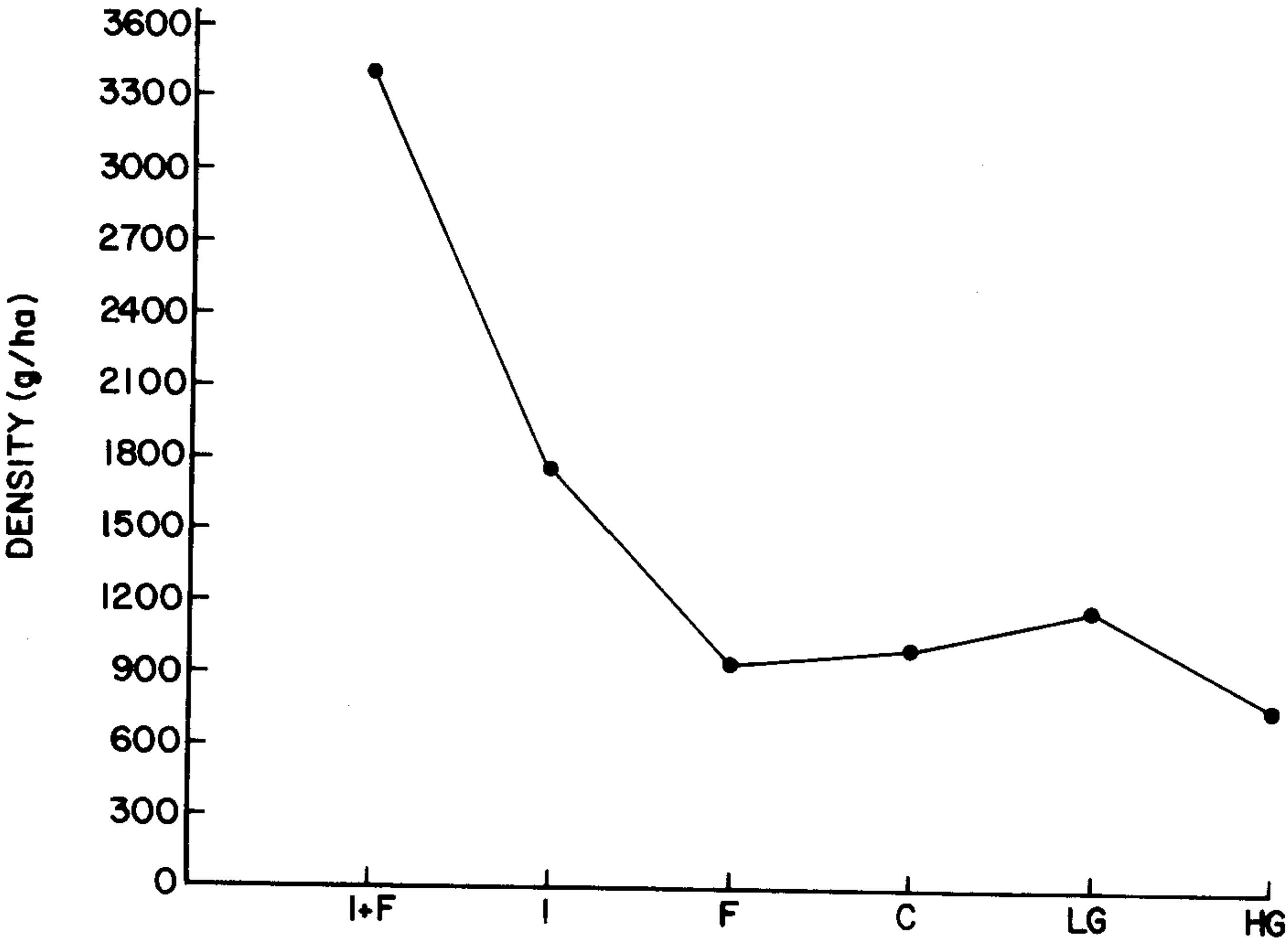

Fig. 7. Arthropod density (g/ha) on the six treatments. (I+F = irrigated and fertilized, I = irrigated, F = fertilized, C = control, LG = lightly-grazed, and HG = heavily-grazed) (Lavigne, 1972).

that contain grasshopper mice, and these two species plus deer mice occur together in substantial numbers on the heavily-grazed, lightly-grazed, and control treatments. These three species are, therefore, not segregated in space.

Another possible mode of niche differentiation on the food dimension is segregation in time. Thirteen-lined ground squirrels were markedly seasonal in abundance (or at least in activity) on the heavily-grazed, lightly-grazed, and control treatments, being seldom seen during early summer, abundant during late summer, and disappearing in the autumn (Fig. 4a, 4b, and 4c, respectively). Grasshopper mice and deer mice maintained relatively constant numbers on these treatments throughout the field season. There were no large declines in numbers of grasshopper mice associated with increases in the prevalence of ground squirrels; in fact, on the lightly-grazed, control, and fertilized treatments these two species reached their peak summer densities simultaneously (Fig. 4b, 4c, and 4d, respectively). Deer mouse population biomass on the heavily-grazed, lightly-grazed, and control treatments declined slightly corresponding to peak densities of ground squirrels and grasshopper mice (Fig. 4a, 4b, and 4c, respectively). Thus, the demand on available food supplies exerted by thirteen-lined ground squirrels and grasshopper mice is not segregated seasonally. While the slight seasonal decline in abundance of deer mice may appear to be a result of increased competition for food, the fact that deer mouse densities also declined during the same period on the irrigated and fertilized treatment (where neither of the other two species were present) (Fig. 4f) suggests that these declines were due to other factors.

Grasshopper mice, deer mice, and thirteen-lined ground squirrels do not appear to be either spatially or seasonally segregated. While ground squirrels are diurnal and deer mice and grasshopper mice are nocturnal, essentially the same food items would be available both day and night in a given area (at least there is no reason to suppose otherwise). It is therefore tentatively concluded that interspecific competition for food is not a critical factor in determining the distribution of small mammal species at the Pawnee Site.

The influence of increased primary production on small mammal species diversity is another factor that may affect grassland community structure. It has been suggested that increased primary production increases consumer species diversity (Connell and Orias, 1964). At Pawnee, however, the irrigated and fertilized treatment (highest primary production) supports only two small mammal species while the heavily-grazed treatment (lowest primary production) supports four. The other treatments are intermediate in primary production (Fig. 8) and contain from two to four rodent species (Table 2). The decrease in small mammal diversity, corresponding to the marked increase in primary production on the irrigated and fertilized treatment, may be interpreted in terms of the species pool available for local colonization (MacArthur and Wilson, 1967). The two irrigated and fertilized plots are essentially an "island" of lush vegetation surrounded by a relatively vast expanse of shortgrass prairie, perhaps with the two irrigated plots acting as a transition zone between these two extremes (Fig. 1). The small mammal species which would be expected to have physical access to this "island" (namely grasshopper mice, thirteen-lined ground squirrels, deer mice, and Ord's kangaroo rats) would also be expected to be physiologically and behaviorally adapted to xeric, sparsely vegetated conditions. It is probable that only a few of these potential colonists would be attracted to the very different habitat conditions of the irrigated and fertilized plots.

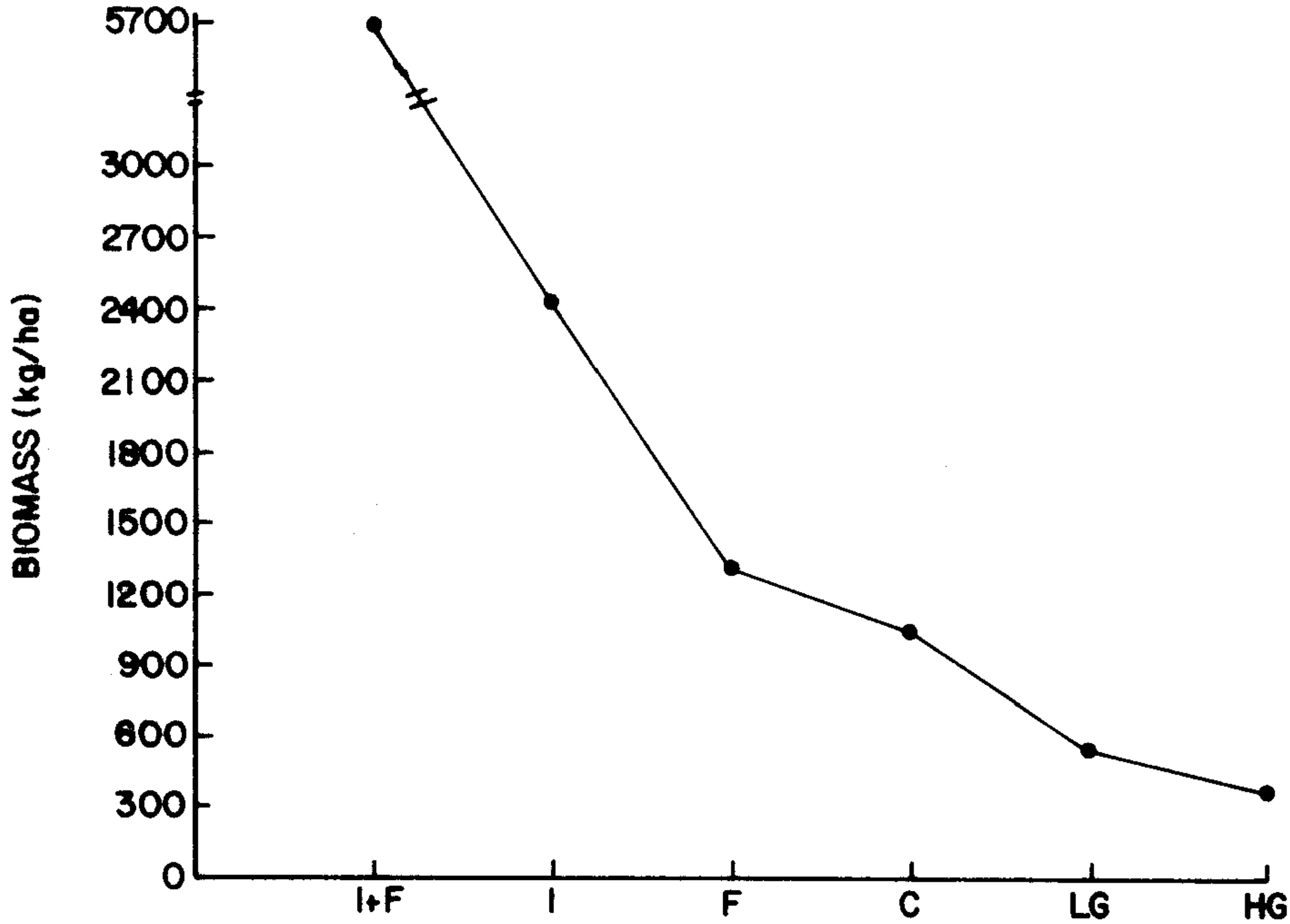

Fig. 8. Aboveground plant biomass (live and standing dead in kg/ha) on the six treatments. (I+F = irrigated and fertilized, I = irrigated, F = fertilized, C = control, LG = lightly-grazed, and HG = heavily-grazed) (Lauenroth, 1972).

This explanation, of course, gives rise to the question of how prairie voles were able to become established in the new habitat. This is an interesting zoogeographical problem since *Microtus* are completely absent from the surrounding shortgrass prairie. The closest possible refugium from which they might have dispersed is 3 miles away.

The relationship between small mammal biomass and primary production is unclear. Small mammal biomass, while by far the greatest on the irrigated and fertilized treatment, and generally decreasing with decreasing primary production, was disproportionately low on the irrigated treatment (Fig. 2). The energy derived by small mammals directly from primary production on each of the treatments (incorporating the effect of percent herbivory of the resident fauna) follows the same trend as does biomass (Fig. 5). This suggests that neither total small mammal biomass nor the proportion of herbivores is a direct function of primary production.

It is unlikely that the low small mammal numbers on the irrigated plots were the result of a limited food supply. In addition to having the second highest primary production of the six treatments, the irrigated plots also supported the second highest arthropod density (Fig. 7). Interspecific competition should not be a limiting factor because of the arguments presented above and also because four of the species occur together on other treatments. Soil conditions are similar on all of the treatments. It would appear that some microenvironmental factors which differ from the surrounding area limit small mammal numbers and diversity on these two plots. The result is a "reverse edge effect" where the ecotonal irrigated plots support a less diverse small mammal fauna than either the more xeric fertilized and control treatments, or the more lush irrigated and fertilized treatment. A satisfactory explanation for this paucity of small mammals on the irrigated treatment is lacking.

Information such as that reported above is necessary to evaluate the role of small mammals in the grassland ecosystem. Indeed, prerequisite to the delineation of any species' or group's role in the ecosystem is a knowledge of their abundance and distribution and their position in the community food web. But this background information, while perhaps sufficient to make some statements concerning energy flow on a seasonal basis, is inadequate to provide insight into the manner in which the given group may affect ecosystem structure and function over the years.

Small mammals, if evaluated solely on the basis of data contained in this report, are relatively unimportant components of the grassland ecosystem because they are involved in only a small portion of total ecosystem energy flow. In terms of energy flow, the only important consumers on the grasslands are domestic cattle. For example, the gross energy intake for cattle on the Pawnee Site has been estimated as 515.5 Mcal/ha/year under a light grazing regime and 983.2 Mcal/ha/year under a heavy grazing regime (Rice, Nagy, and Peden, 1972). Gross energy intake for small mammals on the Pawnee Site is, perhaps, 34.6 Mcal/ha/year on a lightly-grazed pasture and 35.6 Mcal/ha/year on a heavily-grazed pasture (Table 9). Of this, about 17.3 and 16.0 Mcal/ha/year, respectively, come directly from primary production (Table 9). If one were to evaluate some of the figures for grasshoppers, the following energy flow calculations might result:

1. $\approx$120 mg (ovendry weight)/10 m^2 is the total grasshopper biomass at the Pawnee Site. They are active for 8 months of the year (Van Horn, 1972).

2. ≈.04 to .24 kcal/g dry wt/day is the gross energy intake of a grasshopper (Wiegert, 1965).

Therefore, the gross energy intake for grasshoppers on the Pawnee Site = (120 g/ha) (say, .20 kcal/g/day) (245 active days) = 5.88 Mcal/ha/year. From this, it can be seen that cattle might process two orders of magnitude more energy than grasshoppers, and greater than an order of magnitude more energy than small mammals in a given year.

As a result of the firm indication that small mammals are relatively unimportant processors of energy, the scientific community has recently been tending to think and speak in terms of the possible "functional" role of small mammals in ecosystems (Golley, 1971; Chew and Chew, 1970). Odum (1971) has categorized organisms into two categories relative to energy flow: (i) processors of energy, i.e., cattle and (ii) regulators of community energy flow rates, i.e., small mammals. There is, of course, a danger inherent in this categorization of presuming that if an organism is not an important processor of energy, it must perform a regulatory function. But if one accepts the concept of ecosystems as highly integrated, evolving entities, then the possibility that so prevalent a group as small mammals might be only incidently integrated into community function seems remote. It would, therefore, appear that a fruitful field for future study would be in the realm of quantitatively identifying interactions between small mammals and the rest of the ecosystem in areas other than energy processing. For example, perhaps small mammals affect grassland hydrology via their burrowing activities, rates of decomposition via alteration of microclimatic conditions in the soil adjacent to their burrows, or on a longer time scale, soil genesis and community succession via their soil mixing activities. The U.S. IBP Grassland

Biome project provides a unique opportunity to undertake the investigation of such questions by making available a wealth of coordinated data sets from grassland communities, pertaining to many important system variables. There is a potential here for a significant contribution to the field of ecology.

ACKNOWLEDGMENTS

My thanks to Vicki Keith and Richard Shipley for performing various computer analyses on the live- and snap-trapping data, respectively, and to Sarah Woodmansee and Terry Foppe who were responsible for analysis of the small-mammal stomach contents. I wish to thank Dr. James E. Ellis and Dr. Norman R. French for critically reviewing this manuscript. I also wish to thank Dr. R. Kirk Steinhorst for his suggestions pertaining to the statistical analyses used herein. Finally, my thanks to Ray Souther, the Pawnee Site caretaker, who smoothed over many problems with regard to field logistics.

LITERATURE CITED

Chew, R. M., and A. E. Chew. 1970. Energy relationships of the mammals of a desert shrub (*Larrea tridentata*) community. Ecol. Monogr. 40:1-21.

Connell, J. H., and E. Orias. 1964. The ecological regulation of species diversity. Amer. Natur. 98:399-414.

French, N. R. [Coordinator]. 1971. Basic field data collection procedures for the Grassland Biome 1971 season. U.S. IBP Grassland Biome Tech. Rep. No. 85. Colorado State Univ., Fort Collins. 87 p.

Golley, F. B. 1971. Impact of small mammals on temperate forest and grassland ecosystems. Presented at joint meeting of Amer. Inst. Biol. Sci. (AIBS) and Ecol. Soc. Amer., September 1, Colorado State Univ., Fort Collins.

Harris, L. D. 1971. A précis of small mammal studies and results in the Grassland Biome, p. 213-240. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Horn, H. S. 1966. Measurement of "overlap" in comparative ecological studies. Amer. Natur. 100:419-424.

Kleiber, M. 1961. The fire of life. John Wiley & Sons, Inc., New York. 454 p.

Lauenroth, W. 1972. Environmental stresses on a shortgrass prairie ecosystem. U.S. IBP Grassland Biome Tech. Rep. Colorado State Univ., Fort Collins. (In preparation).

Lavigne, R. J. 1972. U.S. IBP Grassland Biome Data Set A2U300B. Colorado State Univ., Fort Collins.

MacArthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography. Princeton Univ. Press, New Jersey. 203 p.

Odum, H. T. 1971. Environment, power, and society. John Wiley & Sons, Inc., New York. 331 p.

Rice, R. W., J. G. Nagy, and D. G. Peden. 1972. Functional interaction of large herbivores on grasslands, p. 241-265. *In* N. R. French [ed.] Preliminary analysis of structure and function in grasslands. Range Sci. Dep. Sci. Ser. No. 10. Colorado State Univ., Fort Collins.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., Inc., New York. 312 p.

Slobodkin, L. B. 1961. Growth and regulation of animal populations. Holt, Rinehart, and Winston, Inc., New York. 184 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.

Wiegert, R. G. 1965. Energy dynamics of the grasshopper populations in old field and alfalfa field ecosystems. Oikos 16:161-176.

Zippin, C. 1956. An evaluation of the removal method of estimating animal populations. Biometrika 12:163-189.

APPENDIX I

FIELD DATA

Small Mammal Sacrifice Trapping

Data obtained from small mammals collected by sacrifice trapping at the Pawnee Site in 1971 is Grassland Biome Data Set A2U102B and were recorded on forms NREL-12A and NREL-14. An example of these forms and an example of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - MAMMAL COLLECTION

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	TRAP DAY	HOUR	GRID TRAP		GENUS	SPECIES	SUBSPECIES	SPECIMEN NUMBER	MARK	LENGTH	TAIL	FOOT	EAR	WEIGHT	MOLT	PARASITES	STOMACH WEIGHT	FOOD	EYE LENS	SPECIMEN	MAP REFERENCE		
			Day	Mo.	Yr.						Row	Col																	TWN	RNG	S
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	20-22	23-26	27-28	29-30	31-32	33-34	35	36-42	43	44-47	48-50	51-53	54-56	57-61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MARK
- 0 None
- 1 Snap-trap grid, unmarked
- 2 Snap-trap grid, marked
- 3 Live-trap grid, unmarked
- 4 Live-trap grid, marked
- 5 Other trapping

MOLT
- 0 No evidence
- 1 Post-juvenile
- 2 Post-subadult
- 3 Adult (vernal)
- 4 Adult (autumnal)
- 5 Molt of unknown stage
- 6 Undetermined

PARASITES - EYE LENS
- 0 Not saved
- 1 Preserved

SPECIMEN
- 0 Not saved
- 1 Skin
- 2 Skull
- 3 Skin and skull
- 4 Skeleton
- 5 Liquid preservative

FOOD
- 0 None
- 1 Stomach only
- 2 Cheek pouch only
- 3 Both

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Mammal - Collection
- 13 Snap Trap Effort
- 14 Mammal Reproductive
- 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
- 44 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

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

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOL)ICAL PROGRAM

FIELD DATA SHEET - MAMMAL REPRODUCTIVE

DATA TYPE	SITE	INITIALS	DATE Day	DATE Mo.	DATE Yr.	TREATMENT	REPLICATE	PLOT SIZE	TRAP DAY	HOUR	GRID TRAP Row	GRID TRAP Col	GENUS	SPECIES	SUBSPECIES	SPECIMEN NUMBER	MALE EXTERNAL	MALE TESTES LN	MALE TESTES WD	MALE EPIDID	MALE SEM VES	FEMALE EXTERNAL	FEMALE MAMMARY	FEMALE PUBIC SEM	FEMALE NORMAL EMBRYOS L	FEMALE NORMAL EMBRYOS R	FEMALE EMBRYO LENGTH	FEMALE RESORB L	FEMALE RESORB R	FEMALE SCARS NEW L	FEMALE SCARS NEW R	FEMALE SCARS OLD L	FEMALE SCARS OLD R	FEMALE CORPORA LUTEA L	FEMALE CORPORA LUTEA R	FEMALE TRACT WEIGHT	FEMALE CORP ALB	FEMALE SPEC SOURCE

MALE
- 0 Adult, non-breeding
- 1 Subadult, non-breeding
- 2 Juvenile, non-breeding
- 3 Adult breeding ?
- 4 Subadult breeding ?
- 5 Juvenile breeding ?
- 6 Adult breeding
- 7 Subadult breeding
- 8 Juvenile breeding
- 9 Undetermined

FEMALE
- 0 Adult, vulva inactive
- 1 Subadult, vulva inactive
- 2 Juvenile, vulva inactive
- 3 Adult, vulva turgid
- 4 Subadult, vulva turgid
- 5 Juvenile, vulva turgid
- 6 Adult, vulva cornified
- 7 Subadult, vulva cornified
- 8 Juvenile, vulva cornified
- 9 Undetermined

SEMINAL VESICLES
- 0 No observation
- 1 Minute
- 2 Small
- 3 Well developed

EPIDIDYMUS
- 0 No observation
- 1 Not convoluted
- 2 Slightly convoluted
- 3 Convoluted

MAMMARY
- 0 No observation
- 1 Small
- 2 Large
- 3 Lactating

SOURCE
- 1 Snap trap grid
- 2 Live trap grid
- 3 Other trap line
- 4 Misc. collection

PUBLIC SYMPHASIS
- 0 No observation
- 1 Closed
- 2 Slightly open
- 3 Open

DATA TYPE
- 01 Aboveground Biomass
- 02 Litter
- 03 Belowground Biomass
- 10 Vertebrate - Live Trapping
- 11 Vertebrate - Snap Trapping
- 12 Mammal - Collection
- 13 Snap Trap Effort
- 14 Mammal Reproductive
- 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
- 44 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

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

+++ EXAMPLE OF DATA +++

```
                   1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890123456789

1211WEG1803714      010600    PEMA WEG0001513.55.82.11.618.1600.4111010N66W25
1211WEG1803714      011700    PEMA WEG0002513.55.71.91.719.3200.4611010N66W25
1211WEG1803714      011700    ONLE WEG0003513.33.31.91.534.7600.7211010N66W25
1211WEG1903714      020600    PEMA WEG0004513.65.72.61.319.4900.5611010N66W25
1211WEG1903714      020600    PEMA WEG0005513.15.51.91.620.2300.7011010N66W25
1211WEG1903714      020600    PEMA WEG0006512.96.31.91.423.08001.311010N66W25
1211WEG1903712      0206300303PEMA WEG2113409.34.51.51.309.0800.2011010N66W23
1211WEG2103714      040600    PEMA WEG0007515.36.91.91.832.53001.411010N66W25
1211WEG2103714      040600    PEMA WEG0008513.14.91.81.619.35001.311010N66W25
1211WEG2103714      040600    PEMA WEG0009513.65.41.81.520.08000.811010N66W25
1211WEG2103714      040600    PEMA WEG0010508.83.91.41.109.89000.411010N66W25
1211WEG2203712      0507000103ONLE WEG2114409.74.02.21.521.94000.711010N66W23
1211WEG2203712      0507300601DIOR WEG2215323.215.4.21.372.94000.431010N66W23
1211WEG2203714      050600    PEMA WEG0011514.86.11.41.727.30001.911010N66W25
1211WEG2203714      0506300412PEMA WEG1111412.16.22.01.515.71000.411010N66W23
1411WEG1803714      010600    PEMA WEG0001 00.9.633                            3
1411WEG1803714      011700    PEMA WEG0002 00.9.533                            3
  11WEG1803714      011700    ONLE WEG0003 01.9.933                            3
1411WEG1903714      020600    PEMA WEG0004 01.0.633                            3
1411WEG1903714      020600    PEMA WEG0005 30.9.633                            3
1411WEG1903714      020600    PEMA WEG0006 30.7.533                            3
1411WEG1903712      0206300303PEMA WEG2113         000330.3          .09 2
1411WEG2103714      040600    PEMA WEG0007         020340.7          1.3 3
1411WEG2103714      040600    PEMA WEG0008         020             22.08 3
1411WEG2103714      040600    PEMA WEG0009 00.9.533                            3
1411WEG2103714      040600    PEMA WEG0010         000230.3          .11 3
1411WEG2203712      0507000103ONLE WEG2114         010             44.07 2
1411WEG2203712      0507300601DIOR WEG2215         030             00.10 2
1411WEG2203714      050600    PEMA WEG0011         020             75.07 3
1411WEG2203712      0506300412PEMA WEG1111 00.9.533                            2

1211WEG3004714      010600    PEMA WEG1003513.65.61.81.517.3400.6311010N66W25
1211WEG3004714      010630    PEMA WEG1004514.35.71.81.828.42001.711010N66W25
1211WEG3004714      010630    PEMA WEG1005514.35.41.81.417.6800.8711010N66W25
1211WEG3004714      011600    SPTR WEG1006524.48.63.30.9129.3005.611010N66W25
1211WEG3004714      011600    SPTR WEG1007523.37.93.41.0123.8008.711010N66W25
1211WEG0105714      020600    PEMA WEG1001514.05.92.01.520.56002.011010N66W25
1211WEG0105714      020600    SPTR WEG1002521.45.43.41.1142.70019.11010N66W25
1211WEG0105714      021600    SPTR WEG1008522.67.23.41.0133.4003.211010N66W25
1211WEG0105714      0206300311PEMA WEG3312413.56.32.11.514.3900.4511010N66W23
1211WEG0105714      0206301212PEMA WEG3324414.76.51.71.820.3300.3711010N66W23
1211WEG0105714      0206301208ONLE WEG3114414.84.02.11.728.5600.9411010N66W23
1211WEG0205714      030600    PEMA WEG1009513.66.02.01.721.5800.5011010N66W25
  11WEG0205714      0307001212PEMA WEG3323412.38.61.91.613.0500.4011010N66W23
1211WEG0305714      041600    SPTR WEG1010523.56.93.20.7114.9003.211010N66W25
```

```
 11WEG0305714        04063004020NLE WEG4113413.44.01.61.525.8300.7611010N66W23
1211WEG0305714       0406301212PEMA WEG3342411.95.21.81.413.3300.3411010N66W23
1211WEG0405714       050600    PEMA WEG1011513.45.21.81.517.0400.4411010N66W25
1411WEG3004714       010600    PEMA WEG1003 90.8.422
1411WEG3004714       010630    PEMA WEG1004        92 141.6         3.5
1411WEG3004714       010630    PEMA WEG1005        91 430.4         .14
1411WEG3004714       011600    SPTR WEG1006 92.0.933
1411WEG3004714       011600    SPTR WEG1007        91 640.9         3.4
1411WEG0105714       020600    PEMA WEG1001 91.0.633
1411WEG0105714       020600    SPTR WEG1002 92.1.933
1411WEG0105714       021600    STTR WEG1008 92.11.33
1411WEG0105714       0206300311PEMA WEG3312 90.7.4129
1411WEG0105714       0206301212PEMA WEG3324 91.1.6339
1411WEG0105714       02063012080NLE WEG3114        32 231.3         .07
1411WEG0205714       030600    PEMA WEG1009 91.2.633
1411WEG0205714       0307001212PEMA WEG3323        01 00          00.04
1411WEG0305714       041600    SPTR WEG1010 91.6.933
1411WEG0305714       04063004020NLE WEG4113        32 400.1         .06
1411WEG0305714       0406301212PEMA WEG3342 90.9.522
1411WEG0405714       050600    PEMA WEG1011        91 240.6         .37

1211WEG2606714       010630    DIOR WEG2001526.315.3.81.366.78001.331010N66W25
1211WEG2706714       020630    PEMA WEG2002514.26.41.71.721.40002.411010N66W25
1211WEG2706714       020630    PEMA WEG2003513.76.11.61.622.9500.5811010N66W25
1211WEG2706714       020630    ONLE WEG4223514.03.81.91.436.65002.111010N66W23
1211WEG2706714       020430    SPTR WEG2004515.06.02.80.643.0200   11010N66W25
. 11WEG2806714       030630    PEMA WEG2005514.76.61.71.520.5500.6111010N66W25
1211WEG2806714       030630    ONLE WEG2006513.74.11.91.528.7100.7811010N66W25
1211WEG2806714       031700    SPTR WEG2007519.27.13.00.655.2400   11010N66W25
1211WEG2806714       031700    SPTR WEG2008518.06.62.80.752.07002.211010N66W25
1211WEG2906714       040700    ONLE WEG4254510.83.42.01.412.6700.6811010N66W23
1211WEG2906714       040700    ONLE WEG4215511.33.61.91.416.2200.5111010N66W23
1211WEG2906714       040630    PEMA WEG2009515.26.81.81.626.94002.611010N66W25
1211WEG3006714       050630    PEMA WEG2010513.95.41.81.726.90003.411010N66W25
1411WEG2606714       010630    DIOR WEG2001        31 211.6         2.5 3
1411WEG2706714       020630    PEMA WEG2002 60.9.533                    3
1411WEG2706714       020630    PEMA WEG2003        32 321.2         2.8 3
1411WEG2706714       020630    ONLE WEG4223 62.10132                    2
1411WEG2706714       020430    SPTR WEG2004        2                    3
1411WEG2806714       030630    PEMA WEG2005 61.0.733                    3
1411WEG2806714       030630    ONLE WEG2006 31.8.912                    3
1411WEG2806714       031700    SPTR WEG2007         5                   3
1411WEG2806714       031700    SPTR WEG2008 20.4.210                    3
1411WEG2906714       040700    ONLE WEG4254 20.8.411                    3
1411WEG2906714       040700    ONLE WEG4215 20.9.522                    3
1411WEG2906714       040630    PEMA WEG2009        92 221.5         2.8 3
1411WEG3006714       050630    PEMA WEG2010         2                   3
```

Small Mammal Live Trapping

Data obtained from small mammals collected by box trapping at the Pawnee Site in 1971 is Grassland Biome Data Set A2U10BB and were recorded on form NREL-10. An example of this form and a listing of a sample of the data follow.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET - VERTEBRATE - LIVE TRAPPING

DATA TYPE	SITE	INITIALS	DATE			TREATMENT	REPLICATE	PLOT SIZE	GENUS	SPECIES	SUBSPECIES	CONDITION	MARK	NUMBER	MALE	FEMALE	WEIGHT	MOLT	LOCATION		PREVIOUS NO.
			Day	Mo	Yr														Row	Col	
1-2	3-4	5-7	8-9	10-11	12-13	14	15	16-19	21-22	23-24	25	27	29	31-34	36	38	40-44	46	48-49	51-52	54-57

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
44 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

FEMALE
0 Adult, vulva inactive
1 Subadult, vuvla inactive
2 Juvenile, vulva inactive
3 Adult, vulva turgid
4 Subadult, vulva turgid
5 Juvenile, vulva turgid
6 Adult, vulva cornified
7 Subadult, vulva cornified
8 Juvenile, vulva cornified
9 Pregnant

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

CONDITION
0 Normal
1 Escaped
2 Torpid
3 Dead

MOLT
0 No evidence
1 Post-juvenile
2 Post-subadult
3 Adult (vernal)
4 Adult (autumnal)
5 Molt of unknown stage
6 Undetermined

MALE
[illegible]
1 Subadult, non-breeding
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

MARK
0 Normal
1 [illegible]
2 [illegible]
3 [illegible]
4 [illegible]
5 [illegible]

+++ EXAMPLE OF DATA +++

```
         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012345678

1011WEG2606712 02.8 ONLE  0 3 4215 3         0 01 08
1011WEG2606712 02.8 ONLE  0 3 4221   0       0 10 03
1011WEG2606712 02.8 ONLE  0 3 3221 6         0 10 09 3221
1011WEG2706712 02.8 ONLE  0 3 4234 5         0 01 10
1011WEG2706712 02.8 ONLE  0 3 1115 6         0 04 01 1115
1011WEG2706712 02.8 SPTR  0 3 4235 3         0 06 09
1011WEG2706712 02.8 SPTR  0 3 4241 6         0 09 08
1011WEG2706712 02.8 SPTR  0 3 4242   2       0 12 10
1011WEG2806712 02.8 ONLE  0 3 4252 3         0 01 10
1011WEG2806712 02.8 ONLE  0 3 4215 3         0 02 10 4215
1011WEG2806712 02.8 SPTR  0 3 4235 3         0 04 10 4235
1011WEG2806712 02.8 SPTR  0 3 3333 6         0 05 01 3333
1011WEG2806712 02.8 ONLE  0 3 4253   3       0 05 02
1011WEG2806712 02.8 DIOR  0 3 4244 0         5 05 04
1011WEG2806712 02.8 ONLE  0 3 4254 2         0 06 12
1011WEG2806712 02.8 DIOR  0 3 4255 2         0 07 08
1011WEG2806712 02.8 SPTR  0 3 4311   2       0 11 10
1011WEG2806712 02.8 ONLE  0 3 1115 6         0 11 06 1115
1011WEG2906712 02.8 ONLE  3 3 4254 2         0 02 12 4254
1011WEG2906712 02.8 ONLE  3 3 4215 3         0 06 12 4215
1011WEG2906712 02.8 ONLE  0 3 1115 6         0 09 04 1115
1011WEG3006712 02.8 ONLE  0 3 4322 3         0 01 04
1011WEG3006712 02.8 ONLE  0 3 3221 6         0 02 12 3221
1011WEG3006712 02.8 SPTR  0 3 4323   2       0 04 12
1011WEG3006712 02.8 SPTR  0 3 3333 6         0 07 04 3333
1011WEG3006712 02.8 ONLE  0 3 1115 6         0 07 02 1115
1011WEG3006712 02.8 SPTR  0 3 4241 6         0 12 10 4241

1011WEG2606714 02.8 ONLE  0 3 4211 2         0 10 07
1011WEG2606714 02.8 ONLE  0 3 4212 6         0 09 08
1011WEG2606714 02.8 ONLE  0 3 4213   9       0 12 09
1011WEG2606714 02.8 ONLE  0 3 4214 2         0 12 05
1011WEG2706714 02.8 SPTR  2 3 4222 2         0 01 10
1011WEG2706714 02.8 ONLE  3 3 4223 3         0 03 02
1011WEG2706714 02.8 SPTR  0 3 4224 2         0 05 05
1011WEG2706714 02.8 ONLE  0 3 4211 2         0 09 06 4211
1011WEG2706714 02.8 PEMA  1                    10 11
1011WEG2706714 02.8 SPTR  0 3 4225   6       0 12 11
1011WEG2706714 02.8 ONLE  0 3 4212 6         0 12 09 4212
```

11WEG2706714	02.8	PEMA	0	3	4231		5	0	11	08	
.011WEG2706714	02.8	ONLE	0	3	4213		9	0	12	05	4213
1011WEG2706714	02.8	ONLE	0	3	4232		3	0	12	04	
1011WEG2706714	02.8	ONLE	0	3	4233		6	0	12	01	
1011WEG2806714	02.8	SPTR	2	3	4224	2		0	03	09	4224
1011WEG2806714	02.8	ONLE	0	3	4243	3		0	05	07	
1011WEG2806714	02.8	PEMA	0	3	4244		2	0	08	04	
1011WEG2806714	02.8	ONLE	0	3	4232		3	0	10	01	4232
1011WEG2806714	02.8	ONLE	0	3	4212	6		0	09	10	4212
1011WEG2806714	02.8	ONLE	0	3	4245		6	0	10	10	
1011WEG2806714	02.8	PEMA	1						11	11	
1011WEG2806714	02.8	ONLE	0	3	4214	2		0	11	09	4214
1011WEG2806714	02.8	ONLE	0	3	4251	3		0	12	05	
1011WEG2906714	02.8	ONLE	0	3	4232		3	0	02	04	4232
1011WEG2906714	02.8	ONLE	2	3	4212	6		0	02	07	4212
1011WEG2906714	02.8	SPTR	0	3	3433		9	0	05	01	3433
1011WEG2906714	02.8	ONLE	0	3	4233		6	0	06	02	4233
1011WEG2906714	02.8	SPTR	2	3	4224	2		0	05	08	4224
1011WEG2906714	02.8	SPTR	0	3	4312	3		0	07	11	
1011WEG2906714	02.8	ONLE	0	3	4243	3		0	10	05	4243
1011WEG2906714	02.8	PEMA	0	3	4313	6		0	09	12	
1011WEG2906714	02.8	PEMA	0	3	4314	3		0	11	12	
1011WEG2906714	02.8	PEMA	0	3	4315		6	0	12	11	
1011WEG2906714	02.8	SPTR	0	3	4321	6		0	12	10	
1011WEG2906714	02.8	ONLE	0	3	4213		9	0	12	09	4213
011WEG2906714	02.8	ONLE	0	3	4211	2		0	12	07	4211
11WEG2906714	02.8	ONLE	0	3	4214	2		0	12	03	4214
1011WEG3006714	02.8	ONLE	0	3	4243	3		0	03	03	4243
1011WEG3006714	02.8	SPTR	0	3	3434		9	0	06	02	3434
1011WEG3006714	02.8	SPTR	2	3	4224	2		0	05	08	4224
1011WEG3006714	02.8	ONLE	0	3	4214	2		0	06	09	4214
1011WEG3006714	02.8	ONLE	0	3	4251	3		0	08	05	4251
1011WEG3006714	02.8	ONLE	0	3	4233		6	0	07	02	4233
1011WEG3006714	02.8	PEMA	0	3	4314	3		0	12	12	4314
1011WEG3006714	02.8	PEMA	0	3	4313	6		0	12	11	4313
1011WEG3006714	02.8	ONLE	0	3	4232		3	0	12	05	4232