12-1982

Variation of Whole Body Components as an Indicator of Habitat Quality in Geomys Bursarius and Peromyscus Maniculatus

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Nietfeldt, Joseph W., "Variation of Whole Body Components as an Indicator of Habitat Quality in Geomys Bursarius and Peromyscus Maniculatus" (1982). *Dissertations & Theses in Natural Resources*. 192.
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VARIATION OF WHOLE BODY COMPONENTS AS AN INDICATOR OF HABITAT QUALITY IN *GEOMYS BURSARIUS* AND *PEROMYSCUS MANICULATUS*

by

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A THESIS

Presented to the Faculty of
The Graduate College in the University of Nebraska
In Partial Fulfillment of Requirements
For the Degree of Master of Science

MAJOR:
Department of Forestry, Fisheries, and Wildlife

Under the Supervision of Professor Ronald M. Case

Lincoln, Nebraska

December, 1982

ACKNOWLEDGEMENTS

I would like to thank Dr. Ronald Case, my major professor for his guidance and support, both moral and financial, in this effort. I also thank Dr. Royce E. Ballinger for the use of his laboratory facilities and along with Dr. Anthony Joern for their assistance.

I wish to thank Linda Vescio for identifying the plant species and Lola Beach for typing the thesis.

Most of all I thank Diane Nietfeldt for her support and help, not only during this project, but also for the time leading up to it.

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INTRODUCTION

Body components and their relative quanities have been used, for sometime, to determine an organism's physiological condition. Seasonal variation of these components has been shown in a wide variety of species. Components of major concern include proteins, lipids, and water content. There have been, however, a number of other components examined, such as, spleen and adrenal weights (Skryja and Clark 1970), weight of brain case (Kowalska-Dyrcz 1960), hemoglobin concentration (Sealander 1962), brown adipose tissue (Buchalczyk and Korybska 1964, Hissa and Tarckkones 1969), and hormone levels (Bahnak et. al. 1981) among others.

Seasonal variation in lipids may differ according to the animal's life history. Hibernating mammals have a large lipid increase in the months just prior to hibernation (Neal 1965, Skryja and Clark 1970, Weber and Findley 1970, Krulin and Selander 1972). These increases have been reported to be as great as a 3 fold increase in body fat in _Citellus lateralis_ (Jameson and Mead 1964). In nonhibernators the variation appears to be much lower than in comparable hibernating mammals (Neal 1965).

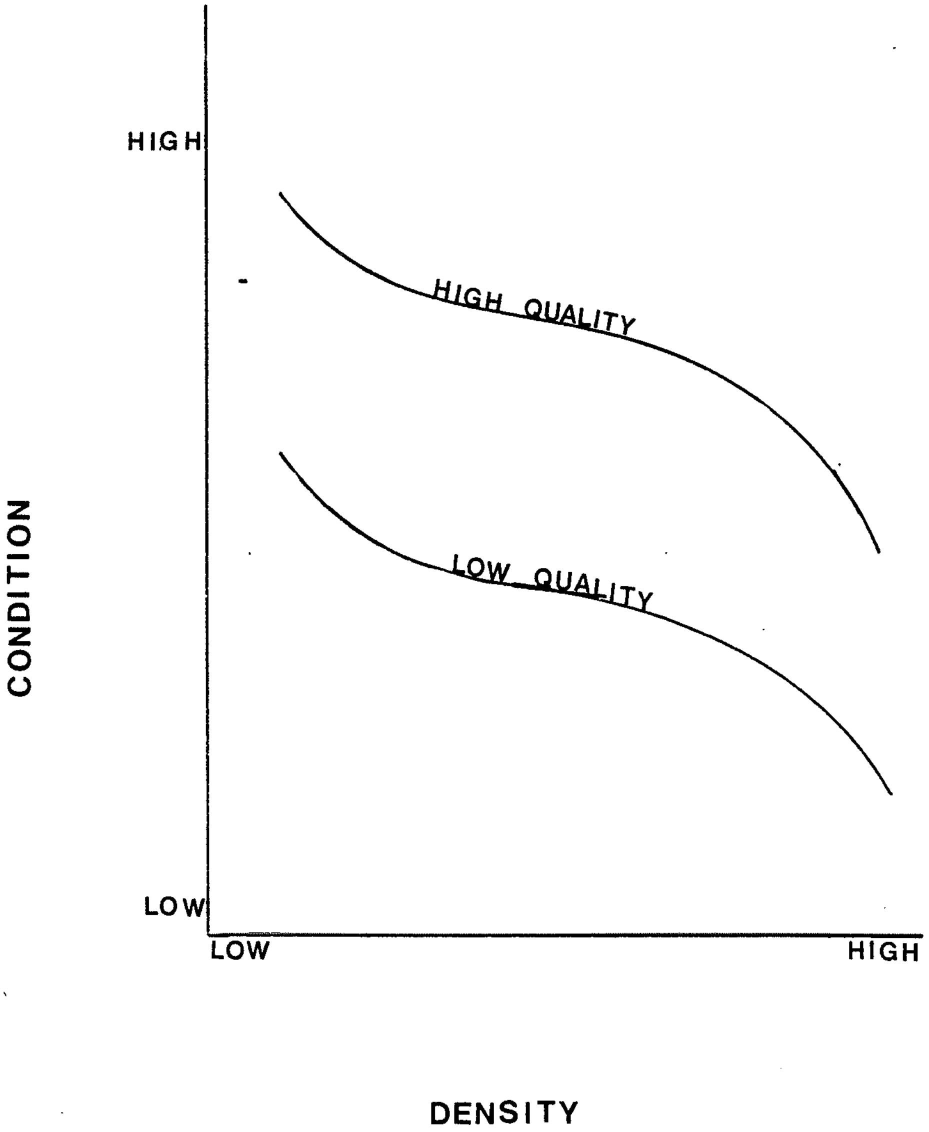
Field (1975) noted that seasonal variation of lipids in equatorial rodents appears to be correlated with rainfall, presumably acting through food supply. This agrees with Cadwell and Connell (1968) who said the food reserves of the environment are very important in determining the degree of fat deposition in the old-field mouse. In contrast, Fehrenbacher and Fleharty (1976) found that reproduction or burrowing were more important than food as factors causing lipid cycles in pocket gophers.

A great deal of work concerning optimal diets has been done (Schulter 1981). For the most part this work has noted the feeding response of animals to foods of high and low energy content (Willson 1971, Foster 1977, Gross-Custard 1977, Zach and Falls 1978). These studies have had mixed results. In some cases the expected high energy foods were taken, whereas in others the lower energy foods were taken. In some cases no preference was shown. These studies do not, however, take into account how these animals respond physiologically on any of the diets.

Abiotic factors in the environment have an effect upon growth and reproduction in animals. Crouse et. al. (1981) demonstrated the influence of sediment on growth of juvenile Coho Salmon, while Howard's (1981) observations on the habitat of lobster populations supports the idea that the maximum size of these animals in certain areas is governed by the topography of the sea bed. Although an organism may be affected by such abiotic factors it could still be in excellent physical and reproductive condition as long as its energy intake is ample.

Considering that abiotic factors influence an organism's growth and knowing that whole body components may vary seasonally and that the most energetically rewarding foods may or may not be preferred raise the question of how food types, a biotic factor, actually affect animals. The concern here is not what foods are better, but are some habitats better than others? If there is a difference in habitat quality in relation to particular species one would expect a population's physical condition, as measured by its individual's whole body components (fats, protein, percent water, and caloric value), to be a reflection of the quality of the habitat in which the population resides. The condition of those individuals in a higher quality habitat will be consistently superior through time. Superior physical condition here is defined as where the energy reserve in lipids, proteins, or measured by caloric value is greater than required for growth, maintenance, and reproduction. Also, the animals should show a constant percentage of water to indicate there is no water stress. Figure 1 depicts this expected relationship between condition and habitat quality along with density. Density is shown here to demonstrate how, even in very good habitats, overpopulation reduces the food supply to a point where quantity of food is more important than quality.

To test this, 2 different mammals, the plains pocket gopher, _Geomys_ _bursarius_, and the deer mouse _Peromyscus_ _maniculatus_, were analyzed from 2 different habitats, prairie and alfalfa. The mammals were chosen to include 2 feeding strategies, _Geomys_ _bursarius_ an herbivore, and _Peromyscus_ _maniculatus_, an omnivore. The habitats also show very sharp contrasts. Alfalfa, though not considered a natural habitat (Bernstein 1966), would be a fine-grained habitat for pocket gophers and a coarse grained habitat for deer mice because of food habits. The prairie situation

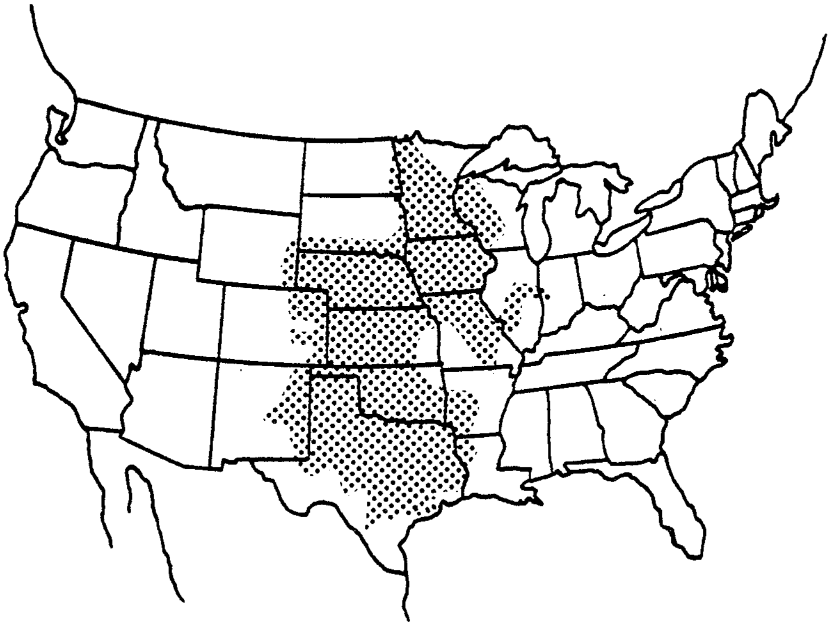

HIGH
LOW
CONDITION
HIGH QUALITY
LOW QUALITY
LOW
HIGH
DENSITY

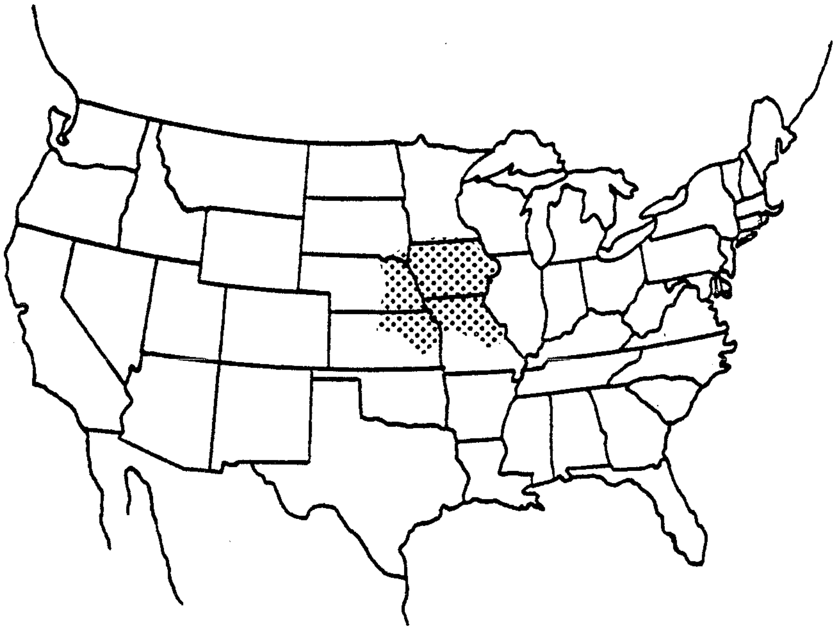
would be just the opposite for both animals. It is predicted that Geomys bursarius will be in superior condition in alfalfa due to the fine-grained nature of the food source. This would in turn mean that for pocket gophers alfalfa is a higher quality habitat. Peromyscus maniculatus will be in superior condition in prairie, since the lack of seeds in alfalfa would create a coarse-grained environment for deer mice, therefore the prairie would be a higher quality habitat for them.

GEOMYS BURSARIUS

Geomys bursarius is a member of the order Rodentia in the family Geomyidae. This family occurs only in North America from about 54° north latitude in western Canada southward to Panama and coast to coast (Walker 1964). The family has 8 genera with 37 species (Corbet and Hill 1980). Within the 37 species there are a considerable number of subspecies, more than 300 kinds have been formally named (Hall and Kelson 1959). The type species of the genus is Geomys tuza (Barton) = Geomys pinetis Rafinesque. The first Geomys bursarius described was Geomys bursarius bursarius by Shaw in 1800 as Mus bursarius. The type specimen was found somewhere in the upper Mississippi valley (Hall and Kelson 1959). The subspecies for this paper is Geomys bursarius majusculus Swenk 1939, type from Lincoln, Nebraska. One of the main taxonomic characters for Geomys bursarius is 2 distinct grooves on the upper incisors (Burt and Grossenheider 1976).

Geomys bursarius, the plains pocket gopher, (the name pocket gopher comes from the cheek pouches used for carrying food), is the pocket gopher most obviously adapted to a fossorial life (Miller 1967) and is found over most of the central United States (Figure 2). The subspecies Geomys bursarius majusculus is found in eastern Nebraska, Iowa, northern Missouri, and northeastern Kansas (Figure 3). Plains pocket gophers are found in deep, moist, friable soils (Miller 1964, Downhower and Hall 1966, and Best 1973). In these soils individuals





dig burrows up to 91 meters in total length (Burt and Grossenheider 1976) where they lead a solitary life, appropriate to the high energy requirements of fossiorial animals (Kennerly 1958), except during the breeding season (Vaughan 1962). Mound building, which indicates tunneling activity, was most common during this study in the spring and early autumn. There is a general correlation between soil moisture and mound building (Kennerly 1964).

A marked sexual demorphism is observed in pocket gophers with males being much larger than females (Kennerly 1958). There is also a latitudinal gradient in size with the largest animals found in the north (Hall and Kelson 1959). Males may attain a head and body length of 357 mm and a tail length of 107 mm. Corresponding length for females are 316 mm and 102 mm (Hall and Kelson 1959).

Due to the fossorial mode of life, Geomys bursarius activity patterns are unaffected by light and dark (Vaughan and Hansen 1961). Wilkes (1963) stated the major factor controlling activity patterns was soil temperature. Another possible result of this life style is the apparent poor control of body temperature (Kennerly 1964). Because of this lack of control they must keep their fur dry or they could easily die from exposure (Vaughan 1966). The absence of good thermoregulation could be due to the insulating effect of earth. Wilkes (1963) found the variation in air temperature in southern Texas was approximately twice what the gophers experience. Poor control of body temperatures could also conserve energy due to the high energy cost of burrowing, which can require from 360 to 3,400 times the amount of energy required to move the same distance on the surface (Vleck 1979).

Pocket gophers eat enough plant material to equal about one half their own weight each day (Caras 1967). Although some species of pocket gophers prefer forbs, the diet of Geomys bursarius consists mostly of grasses (Myers and Vaughan 1964, Vaughan 1967, Luce et. al. 1980). Pocket gophers have usually been thought to feed primarily on below ground plant parts, but Ward (1960) found that 98% of the stomach contents of Thomomys talpoides in early summer was above ground plant material. Luce et. al. (1980) also demonstrated an increase in above ground plant material usage over roots during the summer. Miller (1964) said that alfalfa was a highly preferred food. For pocket gophers that live in alfalfa, Luce and Case (1977) established that their diets consisted of 98.5% alfalfa. Geomys bursarius have also been known to reingest fecal pellets (Wilkes 1962). Boley and Kennerly (1969) said the reason for this could have been to get back the cellulose digesting bacteria found in the cecum and large intesting of Geomys bursarius. It could also be to further digest the material that had passed through the gut.

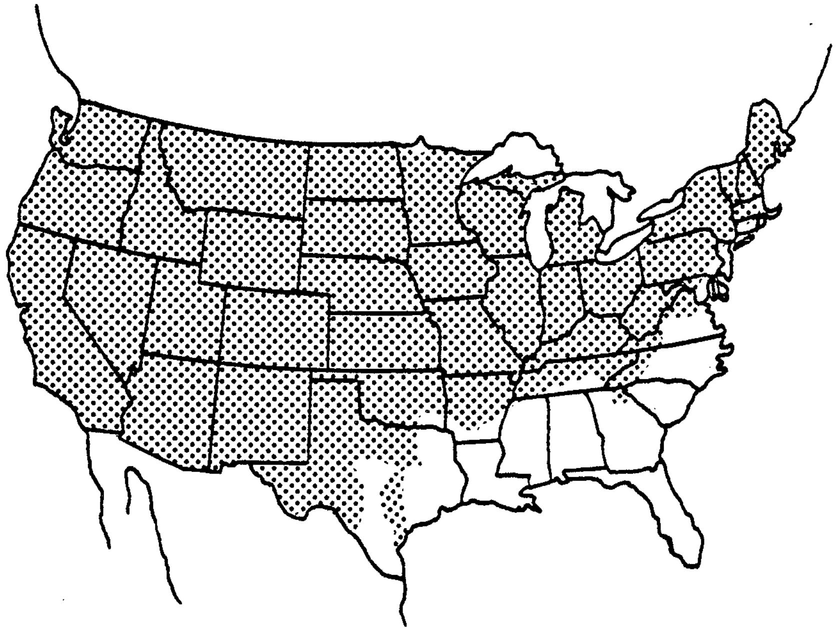
Pocket gophers may have from 1 to 3 broods per year depending on location and species (Miller 1946). Geomys bursarius in northern Kansas and Colorado have only 1 brood per year, with the reproductive season extending from March to June (Vaughan 1962, Downhower and Hall 1966). Gestation is 18 to 19 days after which 1 to 4 young are born (Vaughan 1962, Walker 1964). At birth, the young are about 38 mm head and body length and weigh approximately 4 grams (Wood 1955). New born nurse for about 10 days and remain with their mother for about 2 months before dispersing (Walker 1964). There is evidence that if a female loses her brood she will breed a second time (Desy and Druecker 1979). The animals mature during their first year. Females reach maturity at an average size of 127 grams (Wilkes 1963). Longevity is about 7 years (Downhower and Hall 1966).

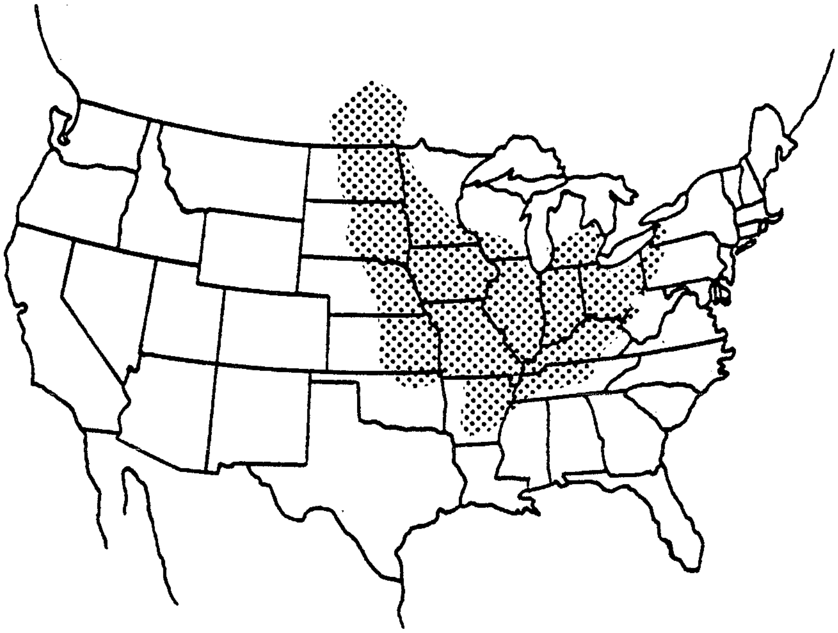
PEROMYSCUS MANICULATUS

Peromyscus maniculatus is a member of the order Rodentia in the family Cricetidae, which has about 100 genera (Walker 1964). The genus Peromyscus was first described by Golger in 1841 and contains 55 species that can be found from extreme northern Columbia northward to Alaska and Labrador (Walker 1964). The subspecies in this area is Peromyscus maniculatus bairdii which was first named Mus bairdii by Hoy and Kennicott in 1857 and changed in 1909 by Osgood to its present name (Hall and Kelson 1959). The type specimen was taken from Bloomington, Illinois (Hall and Kelson 1959).

Although the nocturnal Peromyscus maniculatus ranges over most of the United States (Figure 4), the subspecies Peromyscus maniculatus bairdii is confined to the plains (Figure 5). Deer mice may be found in grasslands and forests (Burt and Grossenheider 1976) but they prefer prairie (Geluso 1971), and the subspecies P. maniculatus bairdii is strictly field dwelling (Weeker 1964). In these fields nesting material is more important in determining where the animals will live than food (Tibbits and Jennings 1972). Hansen and Fleharty (1974) have shown that only new inhabitants of an area will go where there is a lack of dense mulch under the vegetation.

The color of deer mice ranges from grayish buff to reddish brown above and white below and the tail is always sharply bicolored (Burt and Grossenheider 1976). Hall and Kelson (1959) state that these colors identify the 3 pelages (juvenile, post juvenile or





subadult and adult) starting with the gray and becoming darker thereafter. The adults usually molt once annually in late summer or early autumn. In this area *Peromyscus maniculatus* and *Peromyscus leucopus* are often confused. Table 1 shows the distinguishing characteristics between the two.

Peromyscus maniculatus is basically an omnivore whose diet includes seeds, nuts, berries, fruits, insects, amphipods, and coelenterates (Walker 1964, Osborne and Sheppe 1971). However, they rarely, if ever, eat vegetation (Baker 1968, Osborne and Sheppe 1971). Deer mice will store seeds at all times even when food is plentiful, often these caches are left unused (Howard and Evans 1961).

These animals breed at any time, but breeding activities are slowed down in the autumn and winter (Hall and Kelson 1959). Gestation is from 21 to 27 days (Hall and Kelson 1959, Walker 1964). Litter size is from 1 to 9 with an average of 4 (Walker 1964). *Peromyscus maniculatus bairdii* are weaned at 18 days (King et. al. 1963). The young leave their mother at 3 to 6 weeks and are able to breed at 5 to 7 weeks (Walker 1964, Burt and Grossenheider 1976).

Table 1. Differences between *Peromyscus leucopus* and *Peromyscus maniculatus*. From Choate et. al. 1979.

	P. leucopus	*P. maniculatus*
Tail length	> 65 mm	< 65 mm
Tail color	Faintly if at all bicolor	Sharply bicolor
Hind foot	> 21 mm	< 21 mm
Skull	> 22 mm	< 22 mm

METHODS AND MATERIALS

Pocket gophers and deer mice were collected from throughout Lancaster County (Figure 6). Ten females of each species were collected on a seasonal basis from each, a prairie and an alfalfa field. Trapping of specimens began on 20 June 1980 with the summer sample; this took approximately 6 weeks. The autumn and winter collections began on 20 September 1980 and 20 December 1980 respectively, each required about 4 weeks of trapping. The spring sample, taken last, was trapped beginning 20 March 1981 and was finished in 2 weeks. These trapping periods were for pocket gophers. The deer mice, were trapped during the same period and took less time to obtain sufficient samples. Prevalent plants found in the prairie areas are presented in Table 2.

Pocket gophers were collected using DK-1 gopher traps from the P-W Manufacturing Co. of Henryetta, Oklahoma. Traps were set directly in opened burrows and anchored using surveyors flags. They were checked three times daily to avoid decomposition of the specimens. No records on trap nights were kept, but usually, 72 traps were set in 35 tunnels. Once an animal was caught from any burrow system the trap was reset and left for 1 day. Only once in the winter and twice in the spring was more than one animal caught per tunnel system. If there were no captures or visits to an opened mound within 2 to 3 days the traps were placed at a new site.

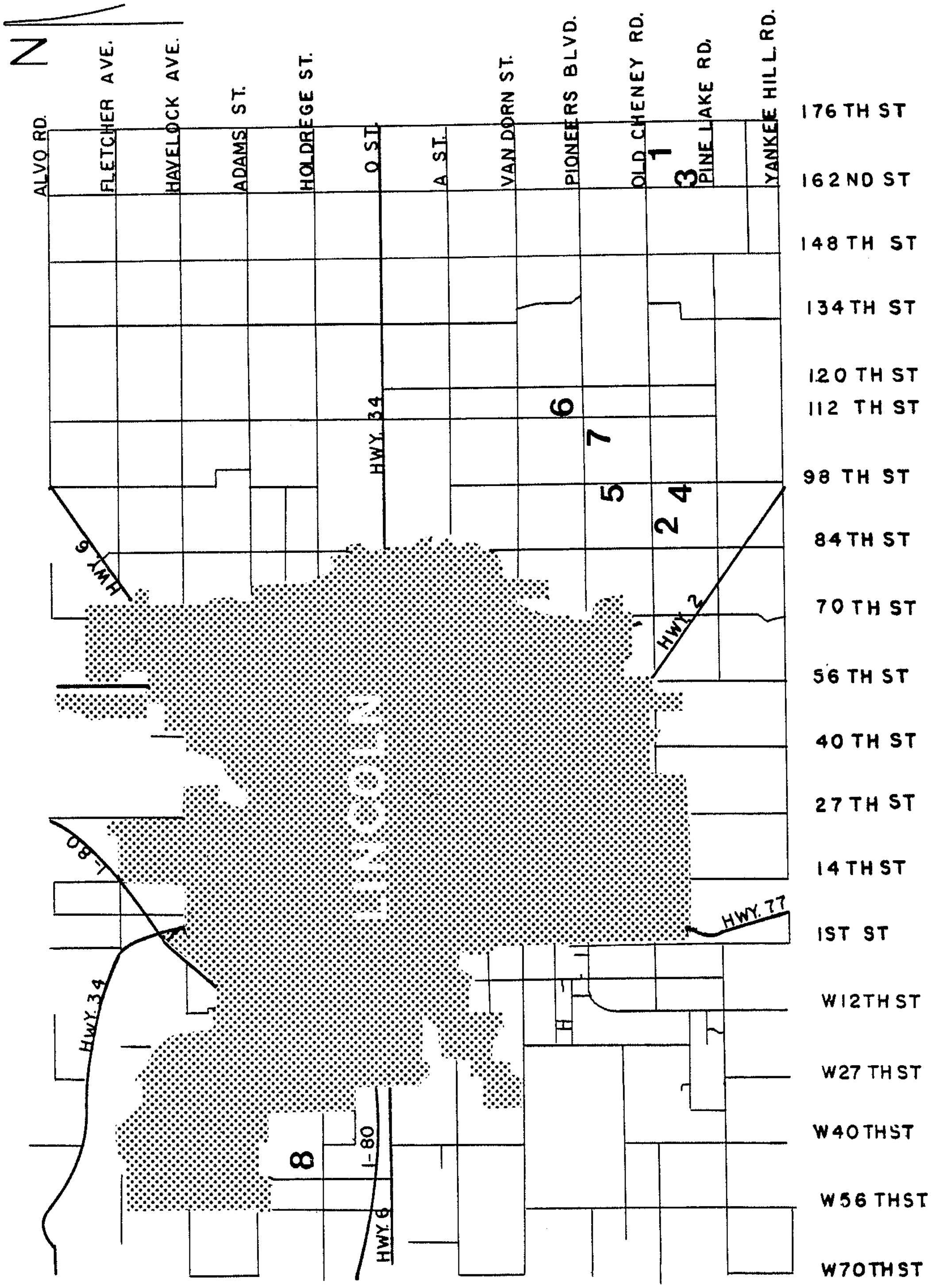

N
ALVO RD.
FLETCHER AVE.
HAVELOCK AVE.
ADAMS ST.
HOLDREGE ST.
O ST.
A ST.
VAN DORN ST.
PIONEERS BLVD.
OLD CHENEY RD.
PINE LAKE RD.
YANKEE HILL RD.
176 TH ST
162 ND ST
148 TH ST
134 TH ST
120 TH ST
112 TH ST
98 TH ST
84 TH ST
70 TH ST
56 TH ST
40 TH ST
27 TH ST
14 TH ST
1ST ST
W12TH ST
W27 TH ST
W40TH ST
W56 TH ST
W70TH ST
HWY. 34
HWY. 6
HWY. 2
HWY. 77
I-80
LINCOLN
1
2
3
4
5
6
7
8

Table 2. Prevalent plants found at the prairie locations. Area 4 was a pasture composed primarily of *Bromus tectorum* (Downy Brome).

SCIENTIFIC NAME	COMMON NAME
Area 1	
Rosa suffulta	Prairie Rose
Psoralea esculenta	Indian Breadroot
Asclopias syriaca	Common Milkweed
Solidago sp.	Goldenrod
Trifolium pratense	Red Clover
Erigeron strigosus	Daisy Fleabane
Helianthus sp.	Sunflower
Cirsium sp.	Thistle
Stipa sp.	Needle and Thread
Carex lasiocarpa	Bull Sedge
Koeleria pyramidata	June Grass
Medicago sativa	Alfalfa
Salsola kali	Russian Thistle
Silphium lacinatum	Compass Plant
Area 8	
Solidago sp.	Goldenrod
Melilotus sp.	Sweet Clover
Psoralea esculenta	Indian Breadroot
Asclepias syriaca	Common Milkweed
Asclepias verticillata	Whorled Milkweed
Cirsium sp.	Thistle
Ratibida columnaris	Prairie Cone-flower
Ambrosia sp.	Ragweed
Bouteloua curtipendula	Gramma
Koeleria pyramidata	June Grass
Bromus tectorum	Downy Brome

Mice were collected using Museum Special snap traps. These were set out only at night since deer mice are nocturnal. Traps were set about 2300 hours each night and picked up about 0600 hours the next morning. This time was chosen when it became obvious that traps picked up later would have specimens that were partially or completely eaten by insects or shrews. Traps were set in both habitats in a line at 30 meter intervals. Again no count of trap nights was made, but it required an average of 10 nights using from 70 to 100 traps per night per area to collect the 20 females per season. Once collections were completed both species were treated the same.

As soon as possible following trapping the animals were taken to the lab. Here they were weighed to the nearest 0.01 gram and measured to the nearest mm (body length and tail length). The gastrointestinal tract was removed and the animals were reweighed. This was done to remove any variation in weight that might be caused by the amount of food present in the animal's gut. This also eliminated variation in percent fat, percent protein, percent ash, and calories per gram due to gut contents. As soon as this was done the specimens were frozen.

Once the animals were throughly frozen they were placed in a Labconco Freeze Dryer-12 Model 75010. Because of their size, only 10 gophers could be dried at one time. They were dried until their weight remained constant over a 24-hour period, which required at least 2 weeks.

After drying, the specimens were reweighed. Specimens were weighed to the nearest 0.0001 gram using a Sauter Analytical balance type 424.

Immediately after weighing, the whole animals were ground in a Wiley Mill model 3383-110. To obtain the desired consistency and mixture a 40-mesh screen was used. After grinding, the material was mixed by hand and reground. For the mice, the whole sample was placed in a vial whereas only a 10 gram sample of each gopher was saved. Vials were placed in a desiccator to prevent the uptake of moisture.

After the samples were prepared the first procedure was to determine the percent ash which when subtracted from the whole gives the percent or proportion burnable (PB). To determine this 2 subsamples were weighed using the Sauter balance to the nearest 0.0001 gram. Next the subsamples were placed in a Thermolyne Type 1300 furnace at 500 to 550 C for 4 hours (Paine 1964). After cooling to room temperature in a desiccator they were again weighed. The difference in weight was then used to determine the percent ash. The average of the 2 subsamples was used as long as they did not differ by more than 2.5% of their mean.

Caloric determinations were made using a Phillipson Micro bomb calorimeter. Again two subsamples were used, each weighed to the nearest 0.00001 gram using a Mettler Balance model P1210. The average sample size was between 10 to 14 milligrams. All caloric determinations were calculated on an ash free basis. The average of the 2 determinations was used if they agreed within ± 2.5% of their mean which is the stated reproducibility for the Phillipson Micro bomb.

In order to make sure the determinations were accurate, three benzoic acid standardizations were performed after every nine samples.

Percent fat was quantified using a Labconco Goldfish Fat Extraction Apparatus. After weighing a subsample to the nearest 0.00001 gram, the material was extracted using ethyl ether for 4 hours. The beakers containing the extracted fat were placed in a vacuum desiccator over night in order to be sure no water was present. The beakers were then reweighed to determine the weight of the fat. Weight of the fat and of the starting material were then used to calculate the percent fat in the animal. Subsample size was kept around 0.05 gram when possible.

Protein analysis was performed by the University of Nebraska Agricultural Biochemistry Lab. Two determinations of each sample were done and their average used.

Statistical Methods

The design of the experiment is a 2 X 4 factorial, area (prairie and alfalfa) versus season (summer, autumn, winter, and spring). To allow for a straightforward analysis, equal sample sizes in the corresponding cells were obtained. This allowed the basic analysis to be performed using the Statistical Analysis Systems (SAS) program Anova (Helwig and Council 1979). The linear model for this design was

$$X_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

a random effects model (Model II), where X_{ijk} denotes one of the following: Length, Tail, WWT, WWTWOGI, DWT, PB, $PCTH_2O$, Calories, PCTFAT, or PCTPROT. An explanation for notations used here and in various tables is given in Table 3. The α_i and β_j are the notations for area and season with $(\alpha\beta)_{ij}$ being the interaction term and ε_{ijk} is the random error that has a normal distribution around a mean of 0. In order to detect which means were different when there was a significant difference in seasons, a Duncan's Multiple Range test (Steel and Torrie 1960) was used. A major assumption in this design is that all sites in their respective classification are equivalent in resource availability.

Since there was a fairly large range in size of the specimens it was decided that after the analysis on the whole data there should be something done to see if age could have any effect on the major body components. To do this the animals had to be divided according to age. Since there is no known method to accurately age either species it was decided that cluster analysis would be useful in separating the animals into approximate age classes. In this analysis it was assumed that size would be a measurement that would be related to age and therefore the total body length was used. Only 1 variable was used to simplify the procedure. To perform this analysis the SAS Cluster procedure was used. This algorithm performs a hierarchical cluster analysis where each observation is a cluster in the beginning, from then on the 2 closest clusters are combined (Helwig and Council 1979). Letting X_i denote the ith observation vector, the distance between 2 observations can be written as

$$d(X_i, X_j) = (X_i - X_j)' (X_i - X_j)$$

Table 3. Notations for variables used in text and in various tables and graphs.

Length = Body length

Tail = Tail length

WWT = Wet weight

WWTWOGI = Wet weight without gastrointestinal tract

DWT = Dry weight

PB = Proportion burnable

$PCTH_2O$ = Percent water

Calories = Calories per gram ash free dry weight

PCTFAT = Percent fat dry weight

PCTPROT = Percent protein dry weight

where the meter is Euclidean (Helwig and Council 1979). With the use of this analysis and the cluster map the number of clusters was determined.

After the cluster analysis the data were divided into the appropriate groups and reanalyzed. The analysis of variance using the same model as previously mentioned was performed. This time, however, the SAS procedure General Linear Models (GLM) was used since ANOVA cannot deal with unbalanced data. To detect differences within seasons when the GLM showed a significant seasonal difference, the Least Square Means test was used. This procedure estimates the means as if the sample sizes were equal and gives a probability as to whether the means are the same but should only be used in preplanned comparisons.

Although all variables were included in this analysis and are presented for the reader's information in the Appendix, only the whole body components that showed a difference in the first analysis were considered important and discussed. This is because the other variables were not planned in the analysis and any differences could be due to over analysis of the data. The reason for this is that after dividing the data into groups some of the season, area, and season by area groups were very small, less than 3 observations. This causes their results to be questionable at best. The data for the groups that are considered must be thought of as exploratory in helping to eliminate interactions and to see where the differences actually lie.

RESULTS AND DISCUSSION

A summary of the means and standard errors of the whole body component variables is presented for Geomys bursarius (Table 4) and for Peromyscus maniculatus (Table 5). The analysis of variance results are presented for the pocket gophers in Table 6 and deer mice in Table 7. Significance of the model will not be considered here, since the main concerns are the effects of the season, area, and the season by area interaction. These tests are legitimate even without a significant model because they were preplanned comparisons (Steel and Torrie 1960).

Although this work is concerned primarily with the whole body components all the variables were analyzed. They are presented in the order of analysis.

Length showed a significant difference ($P < 0.05$) by season in both mice and gophers (Tables 6 and 7). The Duncans Multiple Range test (DMR) showed that, for gophers, the spring sample was shortest and was different ($\alpha = 0.05$) from all other seasons. (The spring mean of 178.4 mm is smaller than the others, Table 3). For mice, the spring sample was different (DMR, $\alpha = 0.05$). Again the spring mean of 84.9 mm was the smallest (Table 4). The reason for this is not clear but it could be due to the fact that with spring being the breeding season there maybe an increase in activity among the smaller individuals. This increase in activity would not only be related to breeding activities, but also to increased foraging required by

Table 4. A summary of means and 2 standard errors for the variables measured on <u>Geomys bursarius</u> .

Season	Area	Length		Tail		WWT		WWTWOGI		Dwt		PB		% H_2O		Calories		% Fat		% Protein	
		$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.	$\bar{x}$	2 S.E.
		187.9	3.54	72.4	2.92	262.1	11.88	214.3	10.26	73.3263	3.9326	.8280	.0054	65.82	0 .76	5918.39	71.72	13.53	1.32	61.44	1.24
	alfalfa	189.8	4.42	74.2	4.36	271.9	16.38	221.9	13.88	76.0223	5.1314	.8301	.0084	65.78	1.00	5926.72	90.36	13.33	1.86	60.66	1.96
	prairie	185.9	5.26	70.6	3.88	252.4	16.86	206.8	14.94	70.6303	5.9018	.8258	.0068	65.86	1.12	5910.05	112.50	13.72	1.90	62.22	1.62
autumn		193.0	9.21	74.8	4.28	277.2	23.74	226.7	20.02	75.7458	6.1126	.8382	.0074	66.50	0 .60	5811.17	105.66	12.26	1.92	63.69	1.26
summer		189.3	5.68	71.6	7.74	251.3	20.62	203.1	17.42	65.1876	7.3828	.8219	.0128	68.12	1.42	5787.86	122.98	10.96	2.06	64.74	1.74
spring		178.4	5.24	71.0	6.82	251.1	22.62	208.2	19.22	75.1288	7.2110	.8302	.0128	63.89	1.12	6049.58	139.76	17.27	3.00	55.82	2.42
winter		190.8	5.04	72.3	4.00	268.9	27.20	219.4	24.64	77.2429	9.7082	.8216	.0084	64.72	1.88	6024.93	166.40	13.62	2.70	61.51	2.20
autumn	alfalfa	189.3	10.82	79.9	5.14	282.0	31.06	230.5	25.50	77.0264	7.7398	.8436	.0132	66.50	1.06	5816.00	146.02	13.90	2.52	63.08	2.28
autumn	prairie	196.6	15.16	69.6	5.22	272.4	37.32	223.0	32.08	74.4652	9.8182	.8328	.0052	66.59	0 .60	5806.34	160.60	10.63	2.61	64.29	1.12
summer	alfalfa	192.3	10.08	66.1	13.68	259.3	38.12	208.7	31.64	69.5044	13.5142	.8199	.0152	67.05	2.51	5933.06	132.58	11.92	3.64	62.28	2.30
summer	prairie	186.3	5.16	77.1	6.20	243.3	16.90	197.4	15.94	60.8709	5.5618	.8239	.0214	69.18	1.06	5642.67	165.92	10.00	1.98	67.20	1.42
spring	alfalfa	181.4	6.32	75.3	5.40	271.1	28.54	223.7	23.02	82.6981	8.7144	.8300	.0224	62.96	1.88	6068.48	236.22	16.84	4.72	53.66	3.62
spring	prairie	175.4	8.22	66.7	12.28	231.0	31.46	192.8	28.58	67.5595	9.6268	.8304	.0114	64.82	.98	6030.68	162.34	17.71	3.92	57.98	2.78
winter	alfalfa	196.2	5.28	75.5	6.36	275.1	18.02	224.8	32.26	74.8602	9.9096	.8268	.0136	66.60	1.34	5889.36	178.32	10.68	2.80	63.60	2.58
winter	prairie	185.4	7.30	69.1	4.24	262.8	42.36	214.0	38.70	79.6256	17.1674	.8163	.0096	62.85	3.16	6160.5	262.26	16.56	3.90	59.41	3.16

Table 5. A summary of means and 2 standard errors for the variables measured on *Peromyscus maniculatus*

Season	Area	Length		Tail		WWT		WWTWOGI		Dwt		PB		% H_2O		Calories		% Fat		% Protein	
		x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.	x̄	2 S.E.
		88.6	1.70	55.1	2.36	18.16	1.30	14.01	0.92	4.7403	0.3058	.8655	.0030	65.93	0.72	6045.78	52.36	14.03	1.00	66.76	1.00
	alfalfa	89.1	2.42	55.6	3.08	18.56	1.84	14.56	1.48	4.8175	0.4976	.8626	.0044	66.76	1.04	6025.02	82.42	14.48	1.38	67.18	1.36
	prairie	88.0	2.40	54.6	3.66	17.77	1.82	13.46	1.12	4.6631	0.3606	.8684	.0040	65.10	0.93	6066.55	64.98	13.58	1.48	66.33	1.48
autumn		88.3	3.18	51.5	5.52	16.28	2.04	12.89	1.26	4.4371	0.4356	.8685	.0048	65.35	1.83	6054.67	71.02	13.92	2.12	67.38	1.90
summer		91.5	4.28	60.7	6.06	18.71	3.76	14.59	2.94	4.8467	0.9762	.8579	.0060	66.59	1.38	5889.97	116.26	13.02	1.38	65.68	1.60
spring		84.9	3.44	49.9	1.94	19.80	2.28	14.71	1.50	5.0649	0.5184	.8749	.0054	65.47	0.91	6125.75	87.98	14.97	2.46	64.94	2.12
winter		89.5	1.68	58.4	2.40	17.86	1.70	13.87	1.16	4.6124	0.3112	.8607	.0048	66.31	1.48	6112.74	108.98	14.20	2.00	69.04	2.00
autumn	alfalfa	89.3	3.88	53.4	2.44	16.28	1.86	13.31	1.70	4.3910	0.6290	.8652	.0060	67.13	1.40	6061.48	126.22	13.75	2.74	68.26	1.72
autumn	prairie	87.3	5.18	49.5	10.94	16.28	3.76	12.47	1.90	4.4833	0.6354	.8745	.0056	63.57	3.05	6047.87	73.42	14.10	3.36	66.50	3.40
summer	alfalfa	93.6	5.62	61.3	10.41	20.23	5.64	16.39	5.04	5.2157	1.7216	.8541	.0082	68.32	1.84	5793.09	173.92	12.13	1.94	66.68	2.44
summer	prairie	89.4	6.50	60.1	6.78	17.18	5.06	12.79	2.90	4.4777	0.9686	.8618	.0084	64.85	1.38	5986.85	135.90	13.91	1.92	64.67	1.96
spring	alfalfa	84.0	5.30	49.3	1.80	19.03	3.32	14.11	1.90	4.9121	0.7372	.8741	.0094	65.23	1.66	6163.06	124.56	17.06	3.20	65.15	2.68
spring	prairie	85.8	4.56	50.5	3.52	20.57	3.22	15.30	2.36	5.2177	0.7556	.8758	.0058	67.71	0.84	6088.45	125.94	12.88	3.38	64.73	2.30
winter	alfalfa	89.5	2.52	58.5	2.98	18.68	3.02	14.44	1.90	4.7500	0.4830	.8598	.0068	66.36	2.86	6082.46	147.10	14.97	2.36	68.64	2.52
winter	prairie	89.5	2.34	58.3	3.92	17.04	1.54	13.29	1.30	4.4736	0.3982	.8616	.0072	66.25	1.06	6143.02	166.42	13.44	3.30	69.43	3.22

Table 6. Results of ANOVA for <u>Geomys bursarius</u>

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	7.6666	2.57	0.0202*
	Season		4.05	0.0102*
	Area		1.45	0.2328
	Season *Area		1.46	0.2312
Tail				
	Model	17.5639	1.65	0.1336
	Season		0.34	0.8021
	Area		1.58	0.2128
	Season *Area		3.00	0.0357*
WWT				
	Model	20.2264	1.06	0.4003
	Season		1.22	0.3097
	Area		2.71	0.1043
	Season *Area		0.35	0.7934
WWTWOGI				
	Model	21.5398	0.88	0.5265
	Season		1.07	0.3666
	Area		2.15	0.1470
	Season *Area		0.27	0.8495
DWT				
	Model	23.2667	1.17	0.1202
	Season		2.08	0.1093
	Area		2.00	0.1093
	Season *Area		1.24	0.3010
PB				
	Model	2.8699	1.26	0.2820
	Season		2.22	0.0923
	Area		0.64	0.4270
	Season *Area		0.51	0.6796
PCTH2O				
	Model	4.2692	5.87	0.0001**
	Season		9.06	0.0001**
	Area		0.02	0.8962
	Season *Area		4.63	0.0052**
Calories				
	Model	4.9528	3.22	0.0051**
	Season		4.43	0.0066**
	Area		0.06	0.7999
	Season *Area		3.07	0.0327*
PCTFAT				
	Model	39.4398	3.48	0.0030**
	Season		5.21	0.0027**
	Area		0.11	0.7452
	Season *Area		2.87	0.0415*
PCTPROT				
	Model	6.5122	11.24	0.0001**
	Season		19.79	0.0001**
	Area		3.06	0.0845
	Season *Area		5.42	0.0021**

Table 7. Results of the ANOVA for *Peromyscus maniculatus*

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	8.3937	1.51	0.1767
	Season		2.77	0.0468*
	Area		0.44	0.5102
	Season *Area		0.60	0.6181
Tail				
	Model	18.1436	2.49	0.0239*
	Season		5.51	0.0020**
	Area		0.21	0.6468
	Season *Area		0.23	0.8733
WWT				
	Model	31.9921	0.86	0.5406
	Season		1.31	0.2786
	Area		0.37	0.5463
	Season *Area		0.59	0.6296
WWTWOGI				
	Model	29.5510	1.03	0.4166
	Season		0.81	0.4927
	Area		1.41	0.2387
	Season *Area		1.12	0.3455
DWT				
	Model	29.3827	0.60	0.7573
	Season		0.77	0.5158
	Area		0.25	0.6216
	Season *Area		0.54	0.6606
PB				
	Model	1.3332	4.96	0.001**
	Season		8.95	0.001**
	Area		5.09	0.0271*
	Season *Area		0.93	0.4346
PCTH2O				
	Model	4.5985	2.29	0.0366*
	Season		0.81	0.4948
	Area		6.03	0.0165*
	Season *Area		2.51	0.0641
Calories				
	Model	3.5902	2.85	0.0112*
	Season		4.99	0.0035**
	Area		0.73	0.3951
	Season *Area		1.42	0.2437
PCTFAT				
	Model	31.9606	1.09	0.3759
	Season		0.64	0.5926
	Area		0.79	0.3760
	Season *Area		1.65	0.1850
PCTPROT				
	Model	6.4797	1.84	0.0925
	Season		3.58	0.0178*
	Area		0.77	0.3824
	Season *Area		0.45	0.7220

lactating females. It could also be that the lower weights are caused by the females being post partum.

The tail length ANOVA (Table 7) shows that in the deer mice there is a significant difference by season ($P < 0.05$). Autumn and spring are both different from summer and winter (DMR, $\alpha = 0.05$). The tail length in pocket gophers shows a significant interaction ($P < 0.05$). The means in Table 4 show that the overall mean for alfalfa is greater than that for prairie. In looking at the means on a season by area basis it can be seen that the mean for summer alfalfa is the only alfalfa mean that is smaller than its corresponding prairie mean. This is what probably caused the interaction. No explanation on what could be the cause of the tail length difference is known except chance.

The wet weight (WWI), wet weight without gastrointestinal tract (WWTWOGI), and dry weight (DWT) show no difference ($P > 0.05$) for either gophers (Table 6) or mice (Table 7). Although this does not seem to be of any interest at first, it must be remembered that there was a seasonal difference in length. When taking this into account it would seem that during certain periods of the year the animals must be more robust than at other times. To test this would be difficult since it would require ratios such as grams weight per millimeters length and this could lead to confounding that would be difficult to control. Therefore it would seem that a measurement of volume should have been taken. This should be taken into consideration in future studies.

The proportion burnable (PB) shows no difference ($P > 0.05$) in gophers (Table 6). This is, however, a significant difference in both season ($P < 0.01$) and area ($P < 0.05$) in mice (Table 7 and 8). This difference is very slight when the means in Table 4 are examined. In most cases the difference is less than 0.5%. Since this is such a small amount it is not considered to be of any real importance. It would be of interest though to have an analysis of the ash to see if the difference could be in the components of the ash.

The percent water in gophers (Table 6) shows a significant difference by season ($P < 0.01$). Summer and autumn are both different (DMR, $\alpha = 0.05$) from winter and spring. The means in Table 3 show that during summer and autumn the animals had a higher percentage of water. The ANOVA (Table 6) also shows a significant interaction ($P < 0.05$). This is shown graphically in Figure 7. The cause for the interaction is probably in the winter sample where the mean for alfalfa is 66.6% and the prairie mean is 62.9%. This gives an overall seasonal mean of 64.72%. The interaction arises since the winter alfalfa mean is the same as the seasonal mean for autumn and the difference between autumn and winter is caused by the large drop in water in the winter prairie group. Due to the fact this large difference occurs only in the winter and that in all other seasons the prairie groups have a higher mean than alfalfa, there is no significant difference in area. The difference could be due to the warm dry winter (Figures 8 and 9) that occurred, in combination with the habitat structure of the areas. The high accumulation of litter in a prairie situation would retain water and create a greater surface area for evaporation allowing less water to reach the soil. This in turn creates lower soil moisture and therefore lower relative humidity in the burrow system. In

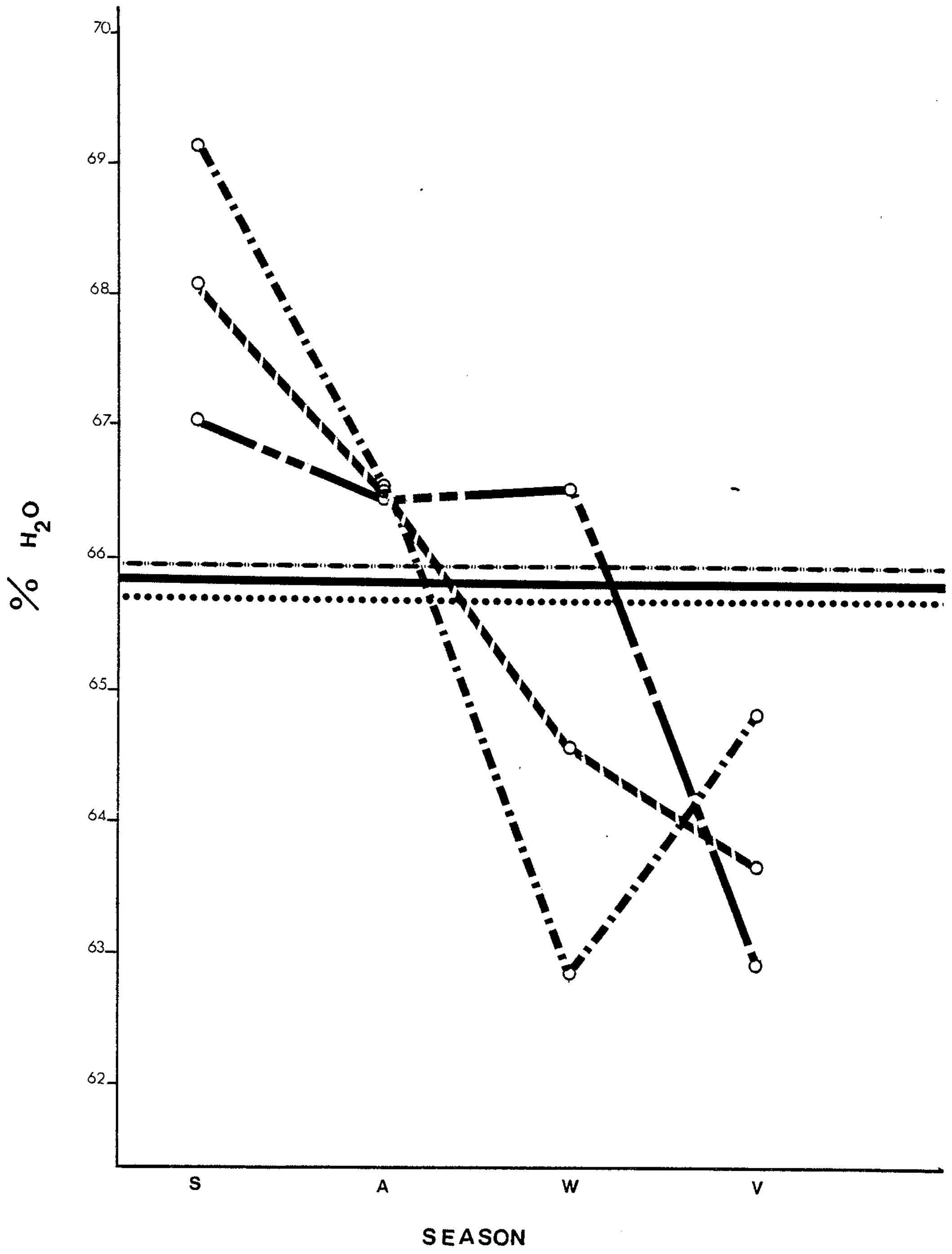
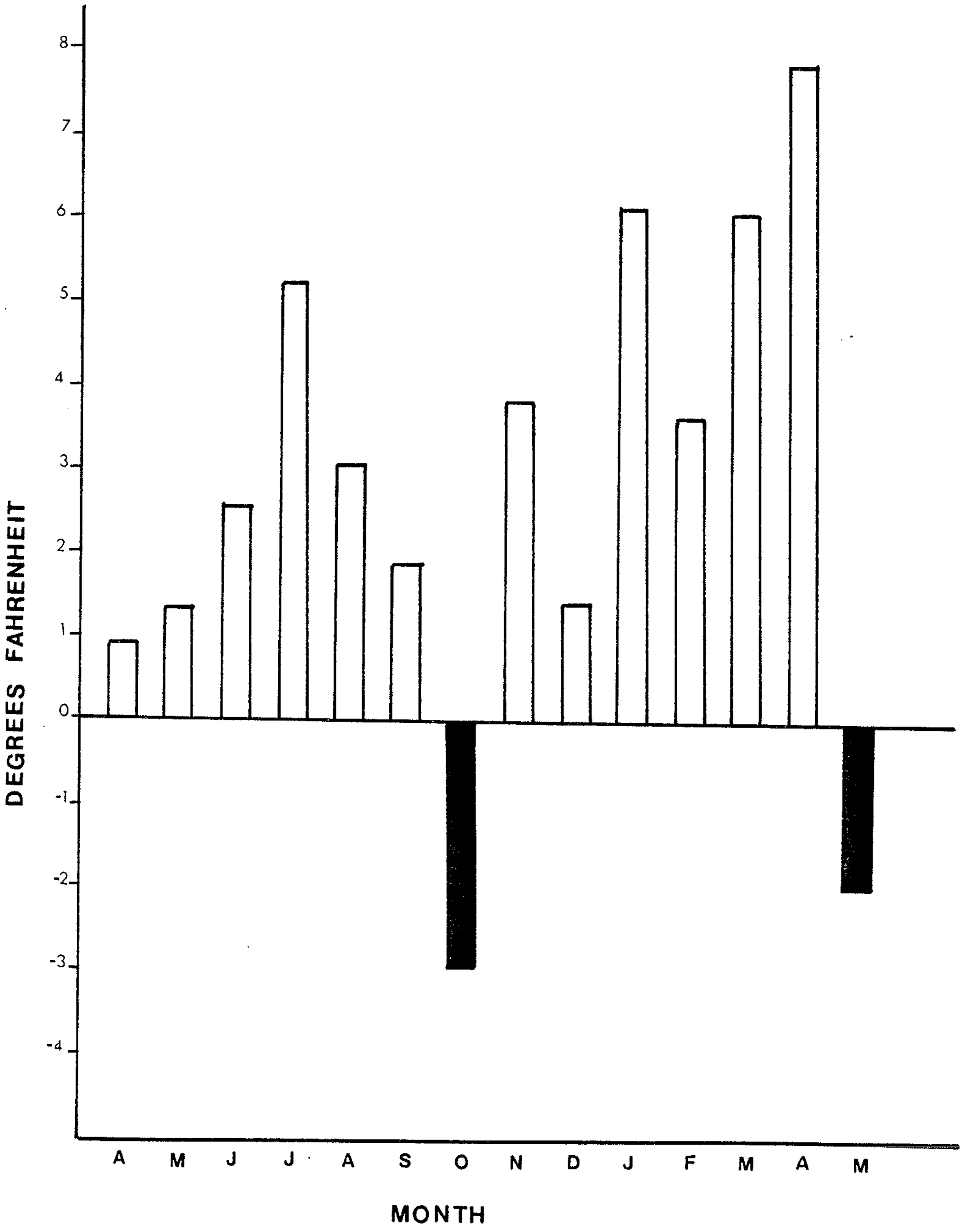
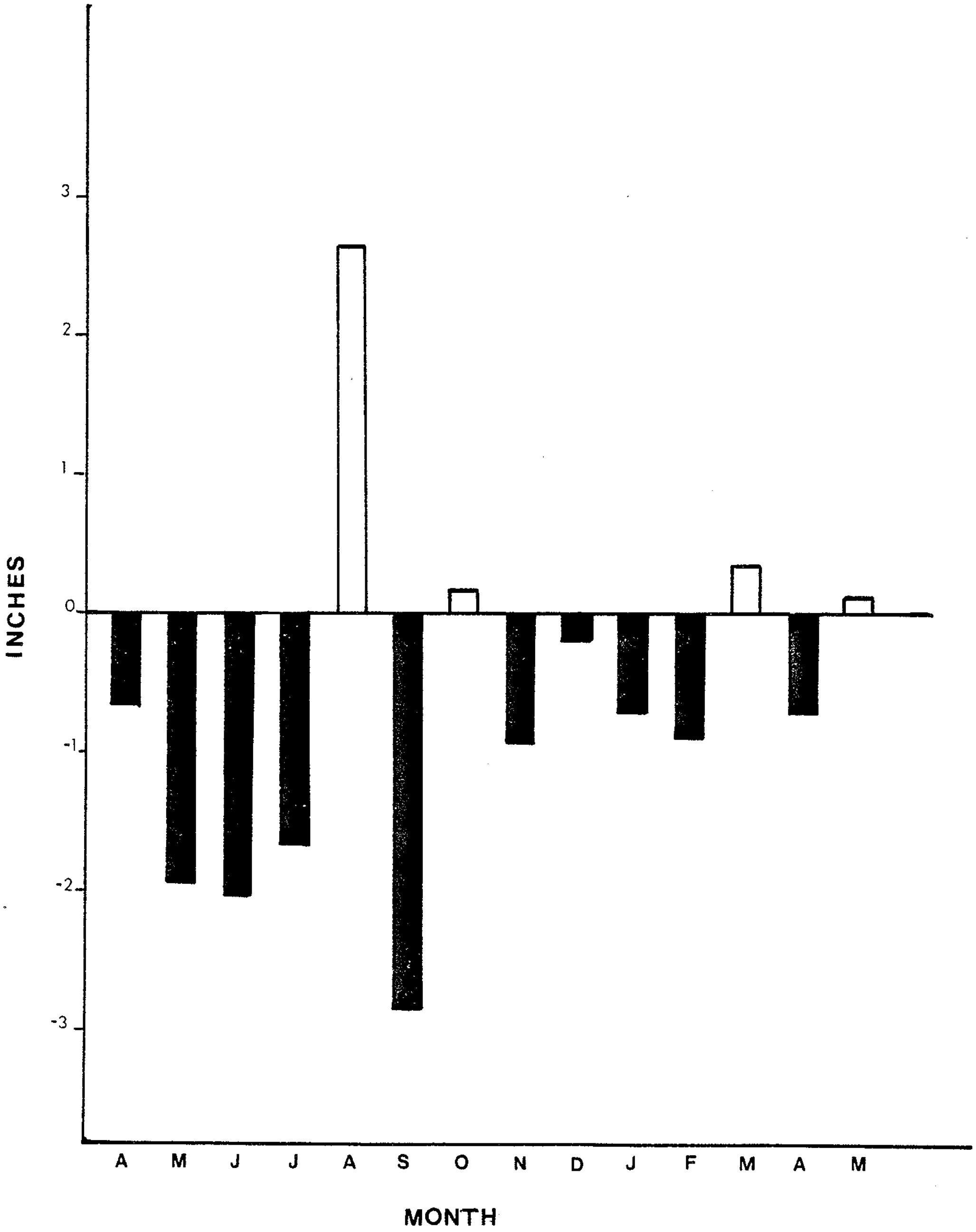

70
69
68
67
66
65
64
63
62
% H_2O
S
A
W
V
SEASON

Figure 8. The average temperature deviation from the accepted normal for Lincoln, Nebraska from April 1980 to May 1981. Data from


8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
DEGREES FAHRENHEIT
A
M
J
J
A
S
O
N
D
J
F
M
A
M
MONTH


INCHES
3
2
1
0
-1
-2
-3
A
M
J
J
A
S
O
N
D
J
F
M
A
M
MONTH

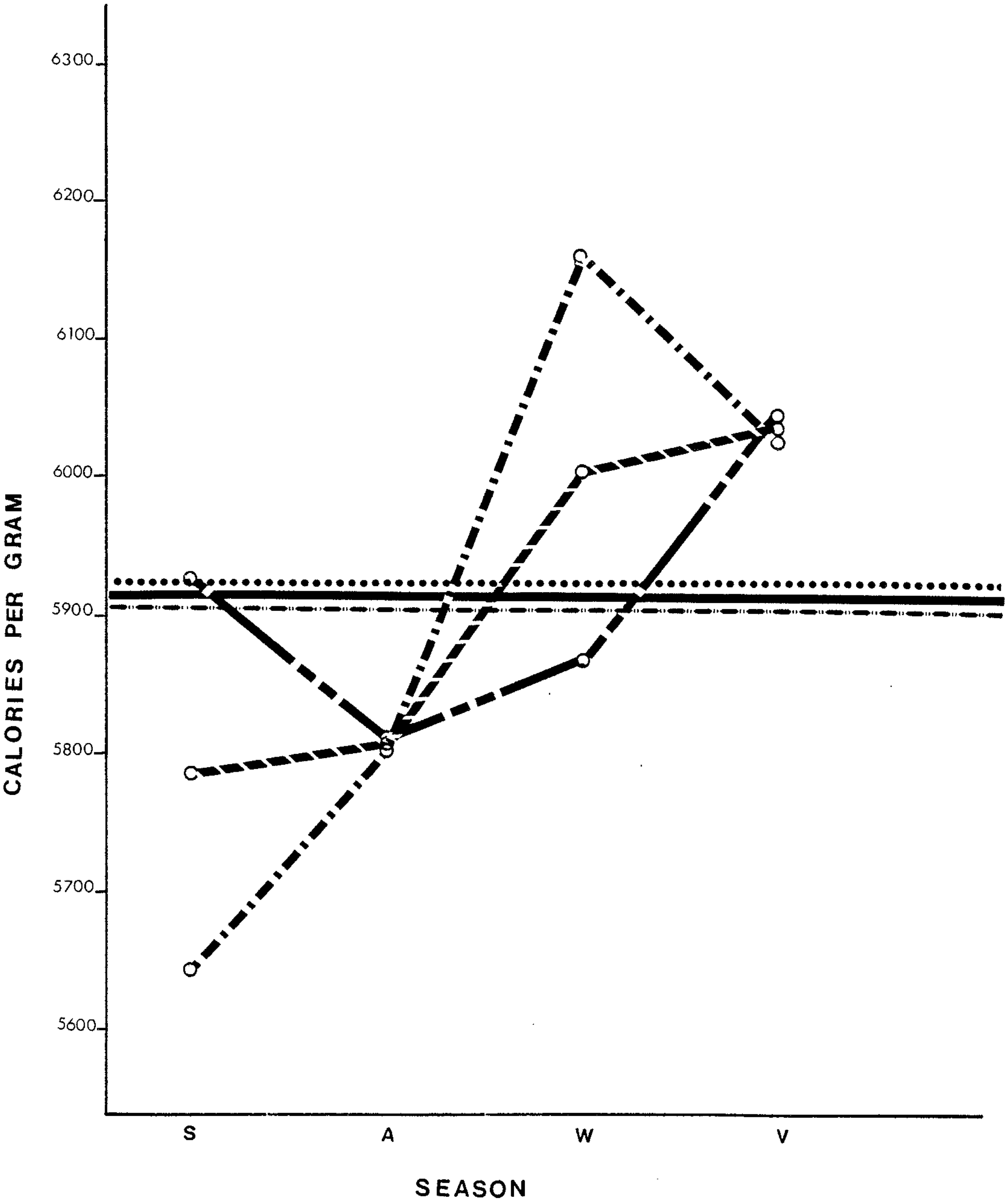
alfalfa the lack of litter would allow available moisture to go directly into the soil and have the opposite effect. This is even more important when you consider that colder temperatures in winter cause a lower amount of moisture in the air, which would increase evaporation. In periods of high precipitation and higher temperatures the results would be the opposite. The area with more litter would still have an insulating effect on the soil below, but in this case it would allow for less evaporation from the soil and therefore higher soil moisture. This would explain what is going on in all seasons shown in Figure 7.

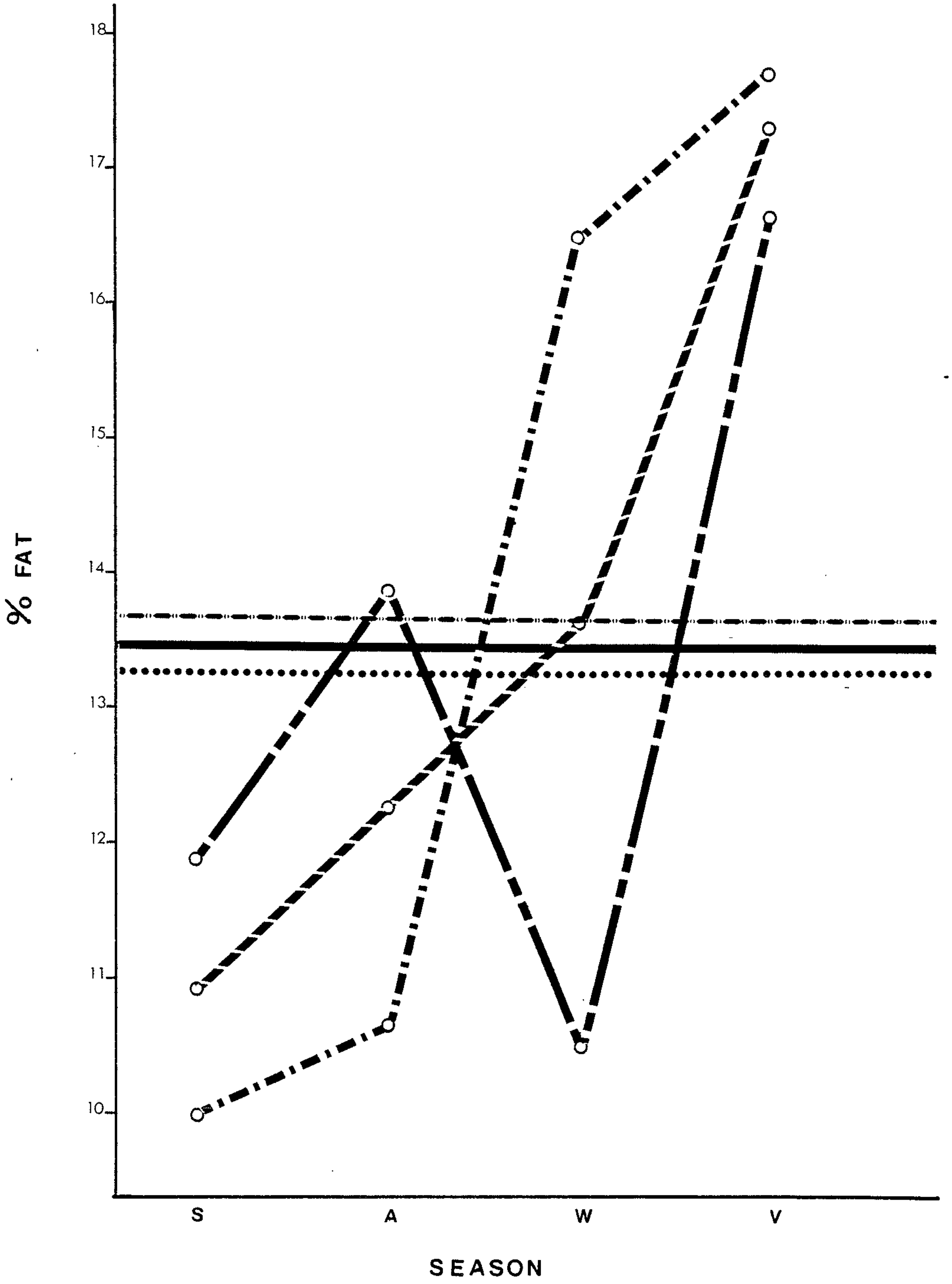
The percent water for mice shows no seasonal variation, but does have a significant difference ($P < 0.05$) between areas (Table 7). The mean, 66.67% in alfalfa and 65.10% in prairie, though close to the same, show that alfalfa is higher. Since these means are very close and consistent the reason for this difference very well could be that trapped mice on the alfalfa site were always picked up before the prairie site. This was because the alfalfa site was nearest. The reason this would cause a difference would be that the prairie animals were left out, exposed to the weather for a longer period of time than the alfalfa animals.

Ash free caloric value (Calories) in the gophers was significantly different ($P < 0.01$) by season and there is also a significant ($P < 0.05$) F value for the season by area interaction (Table 6). Spring and winter are both different (DMR, $\alpha = 0.05$) from autumn and summer. Looking at the graph of the interaction (Figure 10) it can be seen that the mean values for summer and autumn are both lower than those for winter and spring. The interaction is demonstrated by the low degree of variation among the alfalfa samples compared to the variation of the prairie seasonal means. The overall impression is that alfalfa represents a more constant environment. The notably larger fluctuations in the prairie samples does not necessarily indicate a harsher environment in the prairie, but one where seasonal changes in food types may have an effect on the animals.

For mice there is again a seasonal difference ($P < 0.01$) in calories (Table 7). Summer is different (DMR, $\alpha = 0.05$) from the other seasons. The mean value for summer, 5889.97 (Table 5) is lower than all others, which in turn is related to either percent fat or percent protein, which is discussed next.

The percent fat shows a significant difference for season ($P < 0.05$) and for season by area interaction ($P < 0.05$) in pocket gophers (Table 6). Spring is different from all other seasons (DMR, $\alpha = 0.05$). From the mean values in Table 4 and by looking at the graph of the interaction (Figure 11) it is noted that the spring mean is higher than the others. The trend in the seasonal means in calories and percent fat (Figures 10 and 11) show the direct relationship between these two variables. The overall trend is percent fat is probably related to the relative abundance of preferred foods. Another factor would be the effects of reproduction on the individuals. This would explain the large drop in fat from spring to summer samples. The interaction is caused by the overall upward trend in percent fat in prairie animals (Figure 11) in contrast to the sharp autumn to winter drop in the alfalfa populations. This sharp drop of fat in alfalfa gophers would make one think that these animals primarily feed on

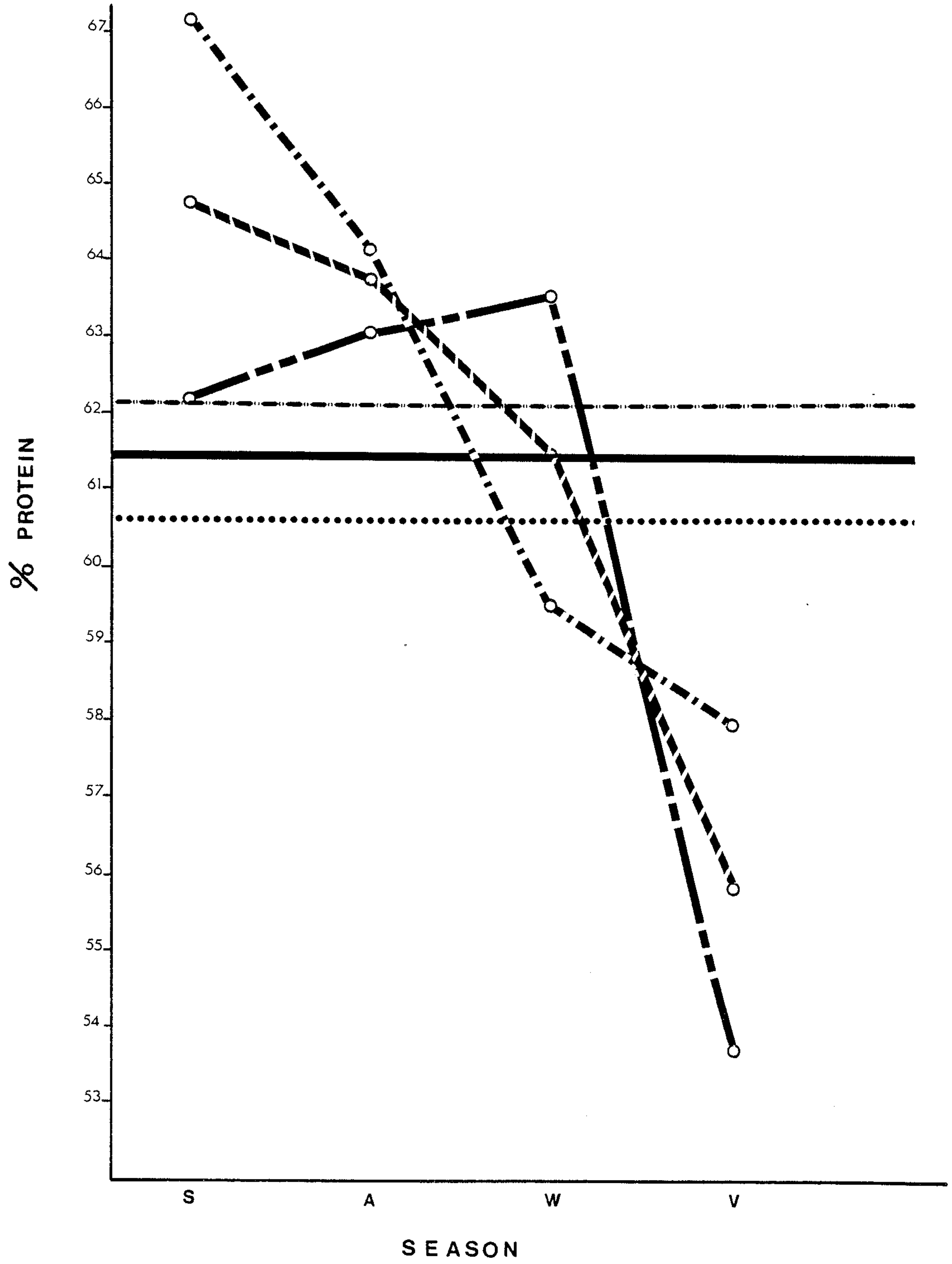

CALORIES PER GRAM
6300
6200
6100
6000
5900
5800
5700
5600
S
A
W
V
SEASON


18
17
16
15
14
13
12
11
10
% FAT
S
A
W
V
SEASON

above ground plant parts when possible, which would explain a drop in winter. This idea is supported by Luce et. al. (1980) who demonstrated that there was a higher percentage of root material ingested by pocket gophers in rangeland during the late fall and winter months. This would mean that the roots of prairie grasses and forbs are a better food source than the roots of alfalfa. This is not to say they are necessarily of a higher caloric value, but it could be due to digestibility of the material or availability of non-caloric materials which affect fat deposition.

There is no difference in the percent fat in deer mice. This is true for season and area (Table 7). The probable reason for this is the year round reproduction of these animals. This would not allow a high build up of fat at any time of the year.

Percent protein for pocket gophers was significantly different for both the season ($P < 0.01$) and the season by area interaction ($P < 0.05$) (Table 6). Summer and spring were different from autumn and winter as well as between each other (DMR, $\alpha = 0.05$). From looking at the means and their relationship (Figure 12) it can be seen that spring has the lowest percentage of protein, autumn and winter are intermediate, and summer the highest. Basically the results are what would be expected when you consider that fat and protein are both percentages of the whole and when one goes up the other must go down. The interaction (Figure 12) is basically the same as for percent fat in reverse. This would mean that these 2 variables, for the most part, confirm each other. In order to see


67
66
65
64
63
62
61
60
59
58
57
56
55
54
53
% PROTEIN
S
A
W
V
SEASON

if it is true that only one of these, percent fat or percent protein, is actually changing it would be necessary to see if the average grams protein or fat change. Unfortunately this is not possible here since there is a significant difference in a size measurement, which would confound the results.

Deer mice show a significant difference ($P < 0.05$) in protein between the areas (Table 7). The mean of alfalfa is 67.18% and for prairie it is 66.33%. This difference is most likely explained in that the animals actively foraging in alfalfa would feed primarily on insects due to the lack of seeds in alfalfa fields.

Cluster Results

The cluster analysis on body length was used to create groups which would reflect the age of the animals. The groups were based mainly on the cluster map and somewhat on the ratio of the number of distances within a cluster < = maximum to the number of distances in all clusters < = maximum. Hence gophers were divided into 3 groups; group 1 - the largest (greater than 196 mm), group 2 - medium sized (180 to 196 mm), and group 3 - the smallest (less than 180 mm). Four groups of mice were selected: group 1 - greater than 95 mm, group 2 - 90 to 95 mm, group 3 - 89 to 90 mm, and group 4 less than 80 mm. The results of the analysis on these groups are presented in the appendix. These results show that the groupings did eliminate the differences that had been found in length. This does not mean, however, that these groups are real or that no other groupings are better.

In the deer mice only group 2 shows a significant difference ($P < 0.01$) in proportion burnable as seen before. There is no longer a difference in area. The seasonal difference is attributable to significantly higher spring mean than winter. It is not possible to estimate the summer mean because of the small sample size. As before the differences are slight and probably of no importance.

Percent water is significantly different ($P < 0.05$) by season in group 1 gophers. LS Means show that autumn and summer are different than spring. Winter is also different than autumn. The difference between this and the whole analysis is that winter is not different than summer. Group 2 gophers show a significant difference ($P < 0.01$) by season also. There the LS Means show that summer is significantly higher in percent water than other seasons. A difference ($P < 0.05$) by area for mice is the only one detected previously for percent water. This is evident only in group 4, the smallest mice.

In gophers,calories are significantly different by season in group 1 ($P < 0.01$) and group 3 ($P < 0.05$) as is the percent protein, while percent fat shows no seasonal difference. This would imply that the change in protein is causing the change in calories. In group 1 gophers there is also a significant difference ($P < 0.01$) in the area means. The higher mean for prairie (62.72%) could signify either a lower fat content or a higher protein content than alfalfa (58.43%) populations.

In deer mice there is no difference in calories per gram. This is different from what was seen in the whole analysis which indicates that the groups could be legitimate and the cause for the first difference was due to size or age.

The percent fat in mice only shows a significant difference ($P < 0.05$) in group 2 for area. Since there was no difference to start with this is probably an artifact of over analysis.

The percent protein in mice shows a seasonal difference ($P < 0.05$) in group 1 only. The LS means show that the sample size for spring is too small to estimate and this is the cause of the difference.

CONCLUSION

Food quality and quantity have been previously shown to affect the life histories of organisms (Mautz 1978, Schwartz and Ballinger 1980, Taitt 1981, Taitt and Krebs 1981). In these studies the caloric value of food and the ability to handle the food affected longevity and reproduction. These factors in turn could be a direct reflection of body composition or fitness in a physical sense. In other studies the digestibility of food types, which could be considered an element of quality, has been shown to have an effect on foraging behavior (Cederlund and Nystrom 1981, and Hobbs et. al. 1981). Digestibility not only affects food selection but also whether or not the animal will feed. If the digestibility is very low it is energetically more efficient to not feed since it would require more energy to find and digest the food than to sit and not feed.

Overall the results of this study on the whole body components are confirmed by previously reported results for pocket gophers and deer mice (Hayward 1964, Fleharty et. al. 1973, and Fehrenbacher and Fleharty 1976). It is interesting that the difference between the two populations of *Geomys bursarius* in seasonal means are at times greater than Fehrenbacher and Fleharty (1976) showed between *Geomys bursarius* and *Pappogeomys castanops*.

For *Peromyscus maniculatus* there does not seem to be any real differences between the 2 habitats. This might be due to the reproductive nature of deer mice. That is, when extra food is available reproduction increases and when food is scarce reproduction halts. This gives cycles in numbers of individuals within the population (Taitt 1981). This cycling precludes variation in whole body components. If this is true, the way to look for habitat differences in this species is to not only look at whole body components but also density and home range size.

The hypothesis that alfalfa is a higher quality habitat for Geomys bursarius is not supported since there is no year round superior condition for the alfalfa animals. There is, however, enough dissimiliarity between areas to make it appear there definitely is a difference here. From the caloric values and percent fat data the alfalfa populations seem to be in better condition in the summer and fall. In the spring the populations look about equal and in the winter the prairie population appears to be in much better condition. This low condition in winter alfalfa is probably due to the low digestibility of alfalfa roots, while the superiority of alfalfa in summer and autumn would be caused by the high availability of preferred food, the stems and leaves. Spring in alfalfa would also be considered extremely good for the gophers because of the quick recovery from their poor winter condition.

Although the superior condition hypothesis was not fulfilled here, the observation that alfalfa is more densely population by pocket gophers is more than likely explained by what is seen. The reason that gophers prefer alfalfa could be that the period of the year when the young animals are dispersing or older animals are just moving to new areas would be the spring, summer, or fall. At these times alfalfa would attract the individuals with its abundance of preferred stems and leaves. In the winter the animals cannot move out due to frozen ground and their inability to withstand cold temperatures.

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Appendix

Results of the ANOVA for Group 1 *Geomys bursarius*, n = 26.

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	6.9123	0.53	0.8028
	Season		0.79	0.5139
	Area		0.03	0.8761
	Season *Area		0.29	0.8311
Tail				
	Model	17.9448	1.94	0.1219
	Season		1.33	0.2962
	Area		2.47	0.1333
	Season *Area		1.89	0.1676
WWT				
	Model	13.9439	1.29	0.3101
	Season		1.58	0.2292
	Area		0.00	0.9457
	Season *Area		2.35	0.1062
WWTWOGI				
	Model	15.3778	1.30	0.3075
	Season		1.69	0.2044
	Area		0.29	0.5988
	Season *Area		2.35	0.1067
DWT				
	Model	15.2239	3.18	0.0226*
	Season		3.64	0.0327*
	Area		0.05	0.8237
	Season *Area		6.59	0.0034**
PB				
	Model	2.3190	4.64	0.0040**
	Season		8.17	0.0012**
	Area		11.28	0.0035**
	Season *Area		1.54	0.2387
PCTH2O				
	Model	4.8433	2.14	0.0918
	Season		3.27	0.0455*
	Area		0.89	0.3589
	Season *Area		3.07	0.0544
Calories				
	Model	4.3874	3.13	0.0242*
	Season		6.01	0.0051**
	Area		3.48	0.0783
	Season *Area		2.05	0.1433
PCTFAT				
	Model	45.0723	1.12	0.3938
	Season		2.17	0.1269
	Area		1.58	0.2245
	Season *Area		0.33	0.8013
PCTPROT				
	Model	4.1206	9.95	0.0001**
	Season		21.46	0.0001**
	Area		13.06	0.0020**
	Season *Area		2.03	0.1454

Results of the ANOVA for Group 2 Geomys bursarius, n = 34.

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	2.4144	0.64	0.7196
	Season		0.95	0.4289
	Area		0.01	0.9160
	Season *Area		0.74	0.5396
Tail				
	Model	18.2246	1.55	0.1952
	Season		0.65	0.5903
	Area		0.04	0.8405
	Season *Area		2.78	0.0610
WWT				
	Model	12.9982	1.32	0.2820
	Season		1.37	0.2743
	Area		0.80	0.3781
	Season *Area		0.53	0.6666
WWTWOGI				
	Model	14.2569	1.36	0.2653
	Season		1.57	0.2203
	Area		0.55	0.4653
	Season *Area		0.53	0.8027
DWT				
	Model	15.1495	4.47	0.0022**
	Season		4.46	0.0118*
	Area		0.95	0.3397
	Season *Area		1.49	0.2404
PB				
	Model	3.1891	0.89	0.5261
	Season		1.81	0.1701
	Area		0.26	0.6135
	Season *Area		0.32	0.8097
PCTH2O				
	Model	3.2357	7.97	0.0001**
	Season		8.58	0.0004**
	Area		0.65	0.4283
	Season *Area		3.56	0.0277*
Calories				
	Model	4.8554	1.06	0.2214
	Season		0.11	0.9554
	Area		0.15	0.6993
	Season *Area		1.99	0.1397
PCTFAT				
	Model	39.0526	2.09	0.0813
	Season		1.56	0.2224
	Area		1.61	0.2157
	Season *Area		2.24	0.1075
PCTPROT				
	Model	6.6203	8.43	0.0001**
	Season		2.50	0.0821
	Area		2.21	0.1490
	Season *Area		7.43	0.0009**

Results of the ANOVA for Group 3 *Geomys bursarius*, n = 20.

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	3.3552	1.76	0.1837
	Season		1.46	0.2703
	Area		3.97	0.0678
	Season *Area		1.58	0.2439
Tail				
	Model	8.9848	2.43	0.0843
	Season		0.95	0.4466
	Area		0.66	0.4296
	Season *Area		3.36	0.0666
WWT				
	Model	16.2482	1.72	0.1933
	Season		0.07	0.9733
	Area		0.75	0.4025
	Season *Area		2.76	0.0999
WWTWOGI				
	Model	17.7175	1.84	0.1677
	Season		0.14	0.9351
	Area		0.98	0.3412
	Season *Area		3.05	0.0822
DWT				
	Model	15.1828	2.30	0.0985
	Season		0.33	0.8041
	Area		1.36	0.2638
	Season *Area		2.71	0.1042
PB				
	Model	1.9439	0.52	0.7863
	Season		0.64	0.6003
	Area		0.10	0.7598
	Season *Area		0.06	0.9414
PCTH2O				
	Model	4.8889	0.44	0.8417
	Season		0.79	0.5223
	Area		0.05	0.8297
	Season *Area		0.25	0.7853
Calories				
	Model	4.1561	3.36	0.0318*
	Season		5.63	0.0107*
	Area		0.13	0.7213
	Season *Area		0.14	0.8742
PCTFAT				
	Model	39.103	1.01	0.4583
	Season		1.86	0.1860
	Area		1.66	0.2202
	Season *Area		0.50	0.6157
PCTPROT				
	Model	5.4546	3.10	0.0411*
	Season		5.49	0.0117*
	Area		2.11	0.1698
	Season *Area		2.45	0.1253

Results of the ANOVA for Group 1 Peromyscus maniculatus, n = 14.

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	4.9158	0.66	0.6866
	Season		0.30	0.8241
	Area		0.10	0.7615
	Season *Area		1.13	0.3758
Tail				
	Model	27.8624	0.32	0.9046
	Season		0.07	0.9742
	Area		0.04	0.8444
	Season *Area		0.20	0.8250
WWT				
	Model	44.6186	0.23	0.9535
	Season		0.25	0.8583
	Area		0.04	0.8502
	Season *Area		0.50	0.6279
WWTWOGI				
	Model	44.8611	0.22	0.9574
	Season		0.02	0.9943
	Area		0.11	0.7521
	Season *Area		0.19	0.8343
DWT				
	Model	45.4199	0.12	0.9893
	Season		0.03	0.9939
	Area		0.13	0.7317
	Season *Area		0.04	0.9577
PB				
	Model	1.5241	4.17	0.0417*
	Season		1.69	0.2552
	Area		1.13	0.3225
	Season *Area		1.54	0.2792
PCTH2O				
	Model	2.1629	5.90	0.0172*
	Season		1.76	0.2415
	Area		0.06	0.8129
	Season *Area		10.85	0.0072
Calories				
	Model	3.3373	1.78	0.2342
	Season		1.74	0.2459
	Area		1.82	0.2190
	Season *Area		0.84	0.4721
PCTFAT				
	Model	18.4359	1.39	0.3361
	Season		0.90	0.4880
	Area		0.00	0.9591
	Season *Area		0.27	0.7687
PCTPROT				
	Model	4.8070	5.08	0.0255*
	Season		5.35	0.0313*
	Area		3.79	0.0925
	Season *Area		10.72	0.0074**

Results of the ANOVA for Group 2 Peromyscus maniculatus, n = 30.

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	1.3505	2.03	0.1032
	Season		1.48	0.2452
	Area		4.44	0.0463
	Season *Area		1.09	0.3543
Tail				
	Model	18.3893	1.79	0.1460
	Season		1.92	0.1551
	Area		1.36	0.2550
	Season *Area		0.96	0.3977
WWT				
	Model	11.3078	4.99	0.0021**
	Season		6.31	0.0028**
	Area		7.33	0.0126*
	Season *Area		1.27	0.2995
WWTWOGI				
	Model	8.2548	3.18	0.0201*
	Season		4.35	0.0145*
	Area		2.78	0.1092
	Season *Area		1.31	0.2887
DWT				
	Model	10.5137	2.57	0.0472*
	Season		4.62	0.0114*
	Area		0.30	0.5915
	Season *Area		0.80	0.4603
PB				
	Model	0.9647	5.45	0.0012**
	Season		5.42	0.0057**
	Area		3.51	0.0736
	Season *Area		4.55	0.0217*
PCTH2O				
	Model	4.3254	1.99	0.1086
	Season		2.25	0.1091
	Area		0.70	0.4119
	Season *Area		0.20	0.8212
Calories				
	Model	3.5211	2.27	0.0720
	Season		3.48	0.0324
	Area		0.07	0.7869
	Season *Area		0.51	0.6099
PCTFAT				
	Model	32.6869	2.02	0.1039
	Season		0.63	0.6017
	Area		7.20	0.0133*
	Season *Area		4.36	0.0248*
PCTPROT				
	Model	6.9404	0.93	0.4916
	Season		1.46	0.2514
	Area		0.19	0.6656
	Season *Area		0.18	0.8399

Results of the ANOVA for Group 3 *Peromyscus maniculatus*, n = 23.

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	2.6220	1.53	0.2316
	Season		0.79	0.5165
	Area		0.87	0.3665
	Season *Area		2.52	0.0976
Tail				
	Model	12.8768	0.93	0.5109
	Season		1.35	0.2945
	Area		1.61	0.2235
	Season *Area		0.17	0.9144
WWT				
	Model	11.6992	12.46	0.0001**
	Season		19.82	0.0001**
	Area		3.71	0.0731
	Season *Area		4.63	0.0174*
WWTWOGI				
	Model	12.4609	8.84	0.0002**
	Season		16.14	0.0001**
	Area		0.68	0.4221
	Season *Area		3.03	0.0621
DWT				
	Model	11.4867	9.06	0.0002**
	Season		16.51	0.0001**
	Area		0.53	0.4763
	Season *Area		3.11	0.0583
PB				
	Model	1.1061	0.72	0.6550
	Season		0.83	0.4971
	Area		1.08	0.3154
	Season *Area		0.29	0.8342
PCTH2O				
	Model	4.0773	0.60	0.7502
	Season		0.76	0.5338
	Area		0.03	0.8742
	Season *Area		0.73	0.5491
Calories				
	Model	3.9959	1.11	0.4043
	Season		1.57	0.2375
	Area		0.00	0.9946
	Season *Area		1.01	0.4158
PCTFAT				
	Model	30.8130	1.07	0.4299
	Season		2.02	0.1542
	Area		0.73	0.4050
	Season *Area		0.66	0.5915
PCTPROT				
	Model	6.1268	0.38	0.8978
	Season		0.73	0.5501
	Area		0.00	0.9867
	Season *Area		0.14	0.9336

Results of the ANOVA for Group 4 *Peromyscus maniculatus*, n - 13.

Variable	Source	C.V.	F Value	PR > F
Length				
	Model	5.6320	0.63	0.6836
	Season		0.76	0.5525
	Area		0.39	0.5498
	Season *Area		1.81	0.2202
Tail				
	Model	10.3599	2.42	0.1398
	Season		1.79	0.2370
	Area		2.32	0.1717
	Season *Area		2.62	0.1498
WWT				
	Model	37.2919	0.57	0.7221
	Season		0.51	0.6906
	Area		0.36	0.5684
	Season *Area		0.15	0.7063
WWTWOGI				
	Model	30.3903	0.50	0.7690
	Season		0.39	0.7629
	Area		0.51	0.4984
	Season *Area		0.22	0.6505
DWT				
	Model	26.8620	0.39	0.8406
	Season		0.60	0.6324
	Area		0.02	0.8809
	Season *Area		0.02	0.8968
PB				
	Model	0.9567	3.98	0.0497*
	Season		4.12	0.0561
	Area		2.06	0.1944
	Season *Area		0.83	0.3915
PCTH20				
	Model	5.5757	2.59	0.1238
	Season		1.57	0.2796
	Area		7.72	0.0273*
	Season *Area		4.77	0.0654
Calories				
	Model	2.8309	1.14	0.4230
	Season		1.85	0.2265
	Area		0.15	0.7103
	Season *Area		2.47	0.1600
PCTFAT				
	Model	37.7173	0.86	0.5482
	Season		0.92	0.4793
	Area		3.20	0.1169
	Season *Area		0.01	0.9174
PCTPROT				
	Model	3.7022	4.51	0.0371*
	Season		2.62	0.1325
	Area		2.65	0.1476
	Season *Area		5.52	0.0511