FOOD HABITS AND DIETARY OVERLAP OF FOUR SPECIES OF RODENTS FROM THE MESQUITE PLAINS OF TEXAS

APPROVED:

Earl G. Zimmerman

Major Professor

Kenneth W. Stewart

Minor Professor

[illegible]

Minor Professor

[illegible]

Director of the Department of Biology

Robert B. Toulouse

Dean of the Graduate School

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The coexistence of *Dipodomys ordii* and *Perognathus hispidus* with *Peromyscus maniculatus* and *Reithrodontomys montanus* was studied in a grassland association of central Texas. The food habits of these species were compared with information from habitat vegetation analysis in an effort to determine food selectivity and the amount and importance of niche overlap and competition among these rodents.

The diet of *D. ordii* and *P. hispidus* showed significant dietary overlap during both seasons, seeds were the major food, making up 74% and 56% by volume, respectively, of their total diet. Seeds which were consumed by both species in large quantities included *Prosopis juliflora*, *Helianthus annuus*, and *Andropogon hallii*. Insects and green vegetation made up a minor portion of both diets. The heteromyid diets showed no significant change between habitats or seasons and different seeds were sometimes selected in greater amounts than would be expected due to chance encounters.

Insect and arthropod material were more important to the diets of *P. maniculatus* and *R. montanus*. Insects and seeds were consumed in approximately equal amounts, 44% and 42%, respectively, by *P. maniculatus* while 33% insects and 44% seeds were taken by *R. montanus*. The diets of both

species shifted from insects during the spring to seeds in the winter and showed more selection for seeds during the latter season.

Food might have been considered limiting during the period of study. Precipitation was lacking during most of the study, and the vegetation was also depauperate. The dietary overlap between the four species of rodents investigated is significant during one or both seasons, and competition for food may be severe during periods of drought that often occur in this region of Texas.

Competition is probably reduced by habitat separation in the case of *D. ordii* which was trapped most often on loose, sandy soils, and *P. hispidus* which was found on heavier, deep soils. This habitat separation is probably not the result of competitive exclusion since there is evidence that the two species probably occur together in large numbers only when these two soil types are present in the same habitat. No such habitat differences were noted between the Heteromyidae and *P. maniculatus* and *R. montanus*. If competition exists between these two species and the heteromyids, it is more severe during the winter when the diets of all four species are chiefly seeds.

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INTRODUCTION

The ability of heteromyid rodents to coexist in the same environment with related species and with species of different families has been documented. Hoffmeister and Goodpaster (1954) observed up to six species of Heteromyidae coexisting on a single acre of upper Sonoran desert in Arizona. Rosenzweig and Winaker (1969) reported the coexistence of heteromyid and cricetine rodents in Arizona. Correlations between relative densities of nocturnal rodents and plant species in the habitat and other biotic variables were assembled and used to construct a model of environmental complexity. This was used to account for the observed rodent species diversities obtained. Body size and seed husking ability of heteromyid rodents have been studied to determine if competition could be acting on this level of resource utilization (Rosenzweig and Sterner, 1970). Smith (1942) observed that in sympatric populations of *Dipodomys heermani* and *Perognathus parvus*, different seeds were selected by each species.

Competition between small rodents and the extent that food resources contribute to niche overlap has been reported between *Neotoma fuscipes* and *Neotoma lepida* (Cameron, 1971). In a comparison of the food habits of *Sigmodon hispidus* and *Microtus ochrogaster* with available food resources of the habitat (Fleharty and Olson, 1969), it was found that competition for space and not competition for food existed between the two species.

The importance of seeds in the diet of heteromyid rodents has been reported from examinations of food caches, seed pouches and stomach analyses. In southern Arizona, Monson (1943) excavated dens of Dipodomys spectabilis and determined from food caches that more grasses were represented than non-grasses, and that this species was not common in areas not providing an unfailing crop of annual grasses and weeds. Reynolds and Haskell (1949) examined the cheek pouch contents of Perognathus pennicillatus and Perognathus baileyi from southern Arizona. They determined that seeds occurred in 90% of the cheek pouches examined. The seeds of shrubs were preferred over forbs, and those of forbs over grasses. The diet of Dipodomys merriami occurring in the Mojave Desert of Nevada was reported by Bradley and Mauer (1971) to consist primarily of seeds. The cheek pouches and burrow food caches of Perognathus hispidus were studied by Blair (1937) and found to contain Gailardia and Opuntia in the highest frequencies. He concluded from habitat studies that availability is the most important factor in the selection of food by Perognathus hispidus. Foods of cricetine rodents are more variable, consisting of insects and seeds (Jameson, 1952; Whitaker, 1966). There are no comprehensive studies of the food of cricetine rodents in the southwestern United States.

The difficulty of identifying finely masticated plant parts from rodent stomachs has caused some investigations to be limited to more general food categories. Bradley and Mauer (1971) separated the stomach contents of *Dipodomys merriami* into seeds, green vegetation, and insects. Food habit determinations for mammals feeding chiefly on green or leafy vegetation have been made utilizing plant microtechniques and histology to separate various food plant species found in stomach and fecal samples (Baumgartner and Martin, 1939; Dusi, 1949). The use of such elaborate techniques are not required to separate finely ground seeds. In most cases, positive identification can be obtained by close examination of seed coats and seed hulls from stomachs of granivorous rodents and subsequent comparison with reference seeds collected from the same habitat. Insect material can be identified by comparing consumed insect parts with preserved specimens of insects collected from the study area.

The purpose of this investigation was to study the coexistence of *Dipodomys ordii* and *Perognathus hispidus* with *Peromyscus maniculatus* and *Reithrodontomys montanus* in a grassland association of central Texas. The food habits of these species were compared with information from habitat vegetation analysis in an effort to determine food selectivity and the amount and importance of niche overlap and competition among these rodents. Due to the seasonal fluxuation of the rodent populations studied, the majority of the data was derived from spring and winter food habits.

DESCRIPTION OF STUDY AREA

The area chosen for study was located in Fisher County, Texas, within the Mesquite Plains Biotic Province (Blair, 1954). Fisher County has a semi-arid climate with an average annual rainfall of 20.61 inches, with rainfall occurring most frequently in the form of thunderstorms (Schwartz, 1966). The monthly and annual precipitation for this region is extremely variable; the lowest recorded annual rainfall was 7.81 in.; the highest recorded annual rainfall was 41.58 in. The average rainfall for Roby, Fisher County, Texas, based on a 23-year record, is 0.84 in. for the lowest month, March, and 3.77 in. for the highest month, May. During the study no rainfall was recorded in the county from November, 1970 until August, 1971, however, during the period from August 1 until August 31, 1971, 22.31 in. were recorded at the county seat of Roby. The summer months of May through September are generally the hottest months of the year with maximum temperatures of 100°F. or higher occurring frequently. Average temperature data are not available for Fisher County, however, Taylor County borders Fisher County on the south and temperature data for Taylor County can be considered fairly representative, although slightly higher than in Fisher County. The hottest month of the year is July with an average maximum temperature of 94.3°F.; the coldest month is January with an average minimum temperature of 32.8°F. The relative humidity is generally low and evaporation is rather high, as would be expected in a semi-arid environment.

Study Area I

This area was located 8 miles east of Roby, Fisher County, Texas. It was intermediate between Study Areas II and III according to soil type and vegetation, and enclosed an area of 8.6 hectares. Approximately one-third of this area consisted of sandy loam type soil of the Miles fine sandy loam series; the soil of the remaining two-thirds was composed of the deep Brownfield fine sands, characteristic of Study Area III (Schwartz, 1966). It was surrounded on all sides by *Quercus stellata* and *Quercus cinerea*. *Aristida purpurea*, *Mulenbergia asperifolia* and *Paspalum stramineum* were the most abundant plants on the loamy soil, although forbs such as *Ambrosia artemisifolia* and *Achillea millefolium* were also numerous. The fine sands supported a different type of vegetation with fewer grasses, such as *Paspalum stramineum* and *Aristida purpurea*, and more numerous forbs, such as *Helianthus annuus*, *Achillea millefolium*, *Croton glandulosus*, and *Yucca treculeana* (Table 1). The difference in available cover was readily observable on sandy and loamy soils, areas of fine sand typically were more sparsely covered with vegetation (50%) than loamy areas (80%).

Table 1. Vegetation analysis for Study Area I, 8 miles east of Roby, Fisher County, Texas.

Plant Species	% Abundance	% Frequency	Density #/m. sq.
Ambrosia artemisifolia	18	73	15.9
Aristida purpurea	17	100	14.9
Mulenbergia asperifolia	15	93	13.8
Achillea millefolium	12	90	10.5
Paspalum stramineum	9	80	8.0
Panicum reverchoni	6	60	5.3
Shrankia uncinata	5	50	4.2
Croton glandulosus	4	60	4.0
Andropogon hallii	4	3	3.2
Sorghum halapense	3	36	2.7
Cnidoscolus texanus	2	53	1.9
Gailardia pulchella	2	23	1.8
Artemisia ludoviciana	2	10	1.2
Stenotaphrum secondatum	1	20	1.3
Prosopis juliflora	1	6	.5
Opuntia lindheimeri	1	4	.7
Helianthus annuus	1	26	.5
Yucca treculeana	1	26	.8
Lepidium alyssoides	1	33	.6
Solanum eleagnifolium	1	23	.5
Cenchrus pauciflorus	1	6	.5

This area yielded a total of eleven mammalian species during the study. More total trap nights were accumulated from this area than either Area II or III, and *Dipodomys ordii* and *Perognathus hispidus* were the two most abundant species taken.

Study Area II

Located 5 miles east of Sylvester, Fisher County, Texas, this area measured 3.8 hectares and was surrounded by plowed or cultivated fields. During the trapping period, *Sorghum vulgare* was being cultivated on an adjacent field. The soil of this area was a deep, well-drained fine sandy loam, reddish-brown in color of the Carey loam series (Schwartz, 1966). Plant cover was dense in all portions of this area (average 83.4%). The major plants were grasses, *Bouteloua curtipendula*, *Sorghum halapense* and *Setaria verticillata*. The major forbs included *Ambrosia artemisifolia*, *Artemisia ludoviciana*, and *Helianthus annuus* (Table 2). This area yielded seven species of mammals. *Perognathus hispidus* was collected in higher numbers than any other species.

Study Area III

This area was located 3 miles west of Royston, Fisher County, Texas, and encompassed an area of 3.8 hectares. The area was enclosed on all sides by dense stands of *Quercus cinerea* 30 to 130 centimeters high. The soils were composed

Table 2. Vegetation analysis for Study Area II, 5 miles west of Sylvester, Fisher County, Texas.

Plant Species	% Abundance	% Frequency	Density #/m. sq.
Bouteloua curtipendula	22	90	18.1
Sorghum halapense	17	35	13.9
Ambrosia artemisifolia	13	70	10.5
Setaria verticillata	11	70	8.5
Mulenbergia asperifolia	9	55	7.7
Paspalum stramineum	8	55	6.7
Artemisia ludoviciana	6	60	5.1
Panicum reverchoni	5	55	4.1
Aristida purpurea	4	45	3.0
Helianthus annuus	3	30	1.4
Chloris cucullata	2	10	1.3
Solanum eleagnifolium	1	20	1.1
Croton glandulosus	1	10	.1
Lycium sp.	1	20	.2
Cyanopuntia sp.	1	5	.1
Prosopis juliflora	1	5	.2
Amaranthus albus	1	10	.5
Opuntia lindheimeri	1	5	.2
Cenchrus pauciflorus	1	3	.2

of deep, light-colored loose sands of the Brownfield series and consisted partly of stabilized dunes described as gently rolling and undulating with only moderately steep slopes (Schwartz, 1966). The loose, fine sand was about 25 cm deep and lacked a subsoil of sandy clay loam characteristic of the soil types which surrounded the area and isolated it from other soils of the Brownfield series that are present in the county.

The most abundant plants were *Cenchrus pauciflorus*, *Quercus cinerea*, *Helianthus annuus*, and *Croton glandulosus* (Table 3). The average per cent plant cover of the area was 51.3. Of the six species of mammals collected, only *Dipodomys ordii* was consistently taken in high numbers.

Table 3. Vegetation analysis of Study Area III, 3 miles west of Royston, Fisher County, Texas.

Plant Species	% Abundance	% Frequency	Density #/m. sq.
Quercus cinerea	25	85	10.1
Croton glandulosus	24	80	9.7
Cenchrus pauciflorus	20	100	8.3
Helianthus annuus	8	85	3.3
Opuntia lindheimeri	8	85	3.4
Lepidium alyssoides	8	90	3.4
Paspalum stramineum	5	60	2.1
Solanum eleagnifolium	3	50	1.3
Cnidoscolus texanus	3	55	1.3
Mulenbergia asperifolia	2	50	.8
Panicum reverchoni	2	25	.6
Celtis occidentalis	2	15	1.0
Prosopis juliflora	2	8	1.0
Ambrosia artemisifolia	1	10	.5
Quercus stellata	1	4	.5
Yucca treculeana	1	3	.2
Larrea divericata	1	1	.1
Opuntia leptocaulis	1	1	.1
Lycium sp.	1	2	.1
Gailardia pulchella	1	1	.1

METHODS AND MATERIALS

The sampling period extended from March 6, 1971 until January 12, 1972. Initially, two trapping procedures were utilized to determine which method would yield the highest number of mammals from an equal number of traps over the same period of time. One method involved randomly selected plots 25 m x 25 m, consisting of five rows of traps with five traps per row. All traps were separated by a distance of 5 m. The other method, which was found to be a more effective arrangement for traps, utilized four trap lines evenly distributed over the area, each line consisting of 25 traps placed 5 m apart. Traps were baited with a peanut butter-rolled oats mixture and were set for two consecutive nights. The area was sampled bi-monthly for a total of 4,040 trap-nights using 85 museum special snap traps and 15 Victor Rat traps. A total of 83 *D. ordii*, 57 *P. hispidus*, 13 *P. maniculatus*, and 15 *R. montanus* were collected.

Measurements of total length, tail length, hind foot length, and height of left ear were taken to the nearest mm. The skull of each specimen and study skins of certain specimens representing each species were placed in the mammal collection of the Museum of Zoology, Department of Biological Sciences, North Texas State University. The stomachs of all specimens were removed and stored in numbered vials containing 70% isopropyl alcohol.

On examining stomach contents, the endosperm was separated from the seed coats and other materials when necessary, and placed into a petri dish containing 70% isopropyl alcohol. Identification of consumed plant material was facilitated by a reference collection of seeds and other plant parts obtained from the habitats. Seeds were crushed to separate the endosperm and expose the internal and external surfaces of the seed coat. Green vegetation was mascerated before identification to render the cell structure comparable with ingested green material. Reference seeds and vegetation were mounted on glass slides using Permount permanent mounting medium. Each sample was systematically scanned, using a binocular dissecting microscope. The per cent volume of each food item was estimated to the nearest five per cent. Volume and per cent occurrence for plant species and animal foods were calculated for each animal. The number of fields examined to determine this value was dependent upon the diversity of foods of individual stomachs. The cheek pouches of heteromyids were emptied, and materials present were stored in vials.

Species abundance expressed as a percentage, per cent frequency, density, and per cent of cover was determined for each plant species occurring in the study areas. The number of 1 m x 1 m quadrats necessary to adequately characterize the species composition of the habitats was derived by use of a species area curve. Area I required 30 quadrats randomly distributed over the habitat; Areas II and III, being smaller, required 20 randomly distributed quadrats. The number of stems and the per cent cover for each plant species was determined for all quadrats.

The electivity index, proposed by Ivlev (1961), was used to indicate whether a plant was consumed in amounts commensurate with its availability or at a level resulting from active selection of the food resources. The electivity index was calculated using the formula $E = (r_i - p_i)/(r_i + p_i)$, where E = the electivity index, r_i = the percentage abundance of a food in the total ration, and p_i = the percentage abundance of the same organism in the environmental food complex. A value of zero indicates complete randomness in resource selection, a positive index is an indication that the resource is selected in greater amounts than would be expected by chance encounter, a negative index results from consumption of a food organism in quantities lower than would be predicted by complete randomness.

The species diversity of the stomach contents of each species was calculated using the Shannon-Weaver Information Measure

$$H_s = - \sum_{i=1}^{s} p_i \log p_i$$

where H_s = the species diversity of the stomach contents, s = the number of species in the stomachs examined, and p_i = the relative abundance of the species expressed as a percentage.

The overlap measure of Marisita (1959) as modified by Horn (1966) was used to calculate the degree of food overlap between and among species. The formula for the overlap coefficient used by Zaret and Rand (1971) is as follows:

$$C\lambda = \frac{2\sum_{i=1}^{s} X_i Y_i}{\sum_{i=1}^{s} X_i^2 + \sum_{i=1}^{s} Y_i^2}$$

where s is the total number of food categories and x_i is that proportion of total diet of species x taken from food category i. The overlap coefficient varies from zero when the samples are completely distinct, i.e., no food categories in common, to 1 when the samples are identical with respect to food category composition. Values of 0.60 or higher are considered to indicate significant overlap (Zaret and Rand, 1971).

No attempt was made to quantify the absolute abundance of terrestrial invertebrates in each habitat, or determine the amount of selection involved in animal food consumption. However, the relative numbers of the more common insect species were estimated from general observations of the nocturnal invertebrates occurring on the study areas.

RESULTS

Composition of Diets

Perognathus hispidus

Twenty plant foods and four animal foods were identified in the diets of *P. hispidus* from Study Area I (Table 4). The most common foods by volume in the spring diet were *Prosopis juliflora* seed (13.6%), *Prosopis juliflora* leaf (12.5%), *Gailardia pulchella* (11.5%), and *Opuntia lindheimeri* (9.8%). Other foods of *P. hispidus* during the spring months were *Andropogon hallii*, *Yucca treculeana*, *Mammalaria* sp., and *Helianthus annuus*. The most common insects consumed during the spring were adult Carabidae and Lepidoptera larvae, comprising 9.0% and 1.9% by volume, respectively.

Plant foods, which comprised the highest percentage of total volume of food consumed, had high Indices of Electivity (E.I.) in most cases (Table 4). These included *Prosopis juliflora*, *Gailardia pulchella*, and *Opuntia lindheimeri*, all with indices between 0.70 and 0.82. *Ambrosia artemisifolia* and *Paspalum stramineum* were consumed in considerable quantities but had E.I. values of -0.60 and -0.39, respectively, indicating selection against these foods.

The most common plant foods in the winter diet were not the same as in the spring diet and included, by volume, *Helianthus annuus* (10.0%), *Opuntia lindheimeri* (9.3%), and

Table 4. Spring and winter diets of Perognathus hispidus from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Food Categories Consumed	Spring			Winter		
	% Volume	% Frequency	Electivity Index	% Volume	% Frequency	Electivity Index
Prosopis juliflora (s)	13.6	82	0.73	3.8	39	0.29
Prosopis juliflora (l)	12.5	70	0.71	3.4	27	0.24
Gailardia pulchella	11.5	86	0.70	4.8	27	0.41
Opuntia lindheimeri	9.8	68	0.82	9.3	55	0.81
Helianthus annuus	.8	7	-0.11	10.0	44	0.82
Unident. dry stem mat.	3.7	40	-0.69	8.8	66	-0.39
Andropogon hallii	8.5	63	0.42	4.2	39	0.09
Mammalaria sp.	4.7	25	0.65	7.8	66	0.77
Panicum reverchoni	-	-	-	7.8	45	0.14
Artemisia ludoviciana	.4	8	-0.41	6.2	55	0.72
Cenchrus pauciflorus	.3	7	-0.50	6.1	55	0.72
Sorghum halapense	-	-	-	6.0	61	0.33
Ambrosia artemisifolia	4.4	55	-0.60	5.1	39	-0.55
Yucca treculeana	5.1	45	0.22	1.0	11	-
Croton glandulosus	-	-	-	4.4	39	-
Paspalum stramineum	3.9	38	-0.39	3.5	28	-0.44
Solanum eleagnifolium	.4	8	-0.41	1.0	16	-
Achillea millefolium	.4	8	-0.49	-	-	-
Dung	.3	7	-	-	-	-
Unident. vegetation	4.5	58	-	5.1	55	-
Carabidae	9.0	68	-	-	-	-
Lepidoptera larvae	1.9	15	-	-	-	-
Blattidae	1.7	5	-	.2	5	-
Formicidae	.8	13	-	.6	11	-
Unident. Arthropoda	.5	13	-	-	-	-
Endogone	-	-	-	.6	11	-
Nematoda	-	-	-	.3	5	-

Mammalaria sp. (7.8%) (Table 4). Other foods commonly eaten were Artemisia ludoviciana, Cenchrus pauciflorus, Sorghum halapense, Ambrosia artemisifolia, Gailardia pulchella, Croton glandulosus and Andropogon hallii. Insects were consumed in very low amounts during the winter months by P. hispidus.

The most common foods in the winter diet of P. hispidus from Area I all exhibited high E.I. values except for Ambrosia artemisifolia which had an E.I. value of -0.55 and Paspalum stramineum which had an E.I. value of -0.44. The other common foods had E.I. values ranging from 0.77 to 0.82.

Items consumed in the winter and not during the spring months include Panicum reverchoni, Artemisia ludoviciana, Croton glandulosus and Yucca treculeana. Plants with high abundance values in the habitat but not identified in the diet included Aristida purpurea, Mulenbergia asperifolia, Shrankia uncinata, Cnidoscolus texanus, Stenotaphrum secondatum and Lepidium alyssoides. The calculated food overlap for spring and winter diets of P. hispidus from Study Area I was 0.67 and is considered significant.

The winter diet of P. hispidus from Area II was similar to the winter diet of this species from Area I, although the plant associations were dissimilar (Table 5). The most common food items by volume in the diet of P. hispidus from Area II included Helianthus annuus (12.5%), Mammalaria sp. (12.4%), Artemisia ludoviciana (12.0%), and Prosopis juliflora seed (9.6%). Sorghum vulgare, composing 8.6% of the

Table 5. Comparison of the winter diets of *Perognathus hispidus* from Study Area I, 8 miles east of Roby, Fisher County, Texas and Study Area II, 5 miles west of Sylvester, Fisher County, Texas.

Food Categories Consumed	Area I			Area II		
	% Volume	% Frequency	Electivity Index	% Volume	% Frequency	Electivity Index
Helianthus annuus	10.0	44	0.82	12.5	44	0.82
Mammalaria sp.	7.8	66	0.77	12.4	37	0.85
Artemisia ludoviciana	6.2	55	0.72	11.9	53	0.32
Prosopis juliflora (s)	13.6	82	0.73	9.6	40	0.81
Opuntia lindheimeri	9.3	55	0.81	7.0	38	0.74
Unident. dry stem mat.	8.8	66	-0.39	1.5	25	-0.85
Sorghum vulgare	-	-	-	8.6	45	-
Sorghum halapense	6.0	61	0.33	7.4	60	-0.39
Panicum reverchoni	7.8	45	0.14	2.6	38	-0.31
Cenchrus pauciflorus	6.1	55	0.72	1.3	27	0.13
Ambrosia artemisifolia	5.2	39	-0.55	1.4	20	-0.80
Gailardia pulchella	4.8	27	0.41	1.5	2	0.20
Paspalum stramineum	3.5	28	-0.44	4.1	22	-0.34
Croton glandulosus	4.4	39	-	2.9	42	0.49
Andropogon hallii	4.2	39	0.09	.2	2	-0.81
Prosopis juliflora (l)	3.4	27	0.24	4.7	62	0.65
Yucca treculeana	1.0	11	-	1.4	20	0.14
Solanum eleagnifolium	.4	7	-0.50	6.0	61	0.33
Unident. vegetation	5.1	55	-	3.1	45	-
Carabidae	-	-	-	1.2	2	-
Formicidae	.6	11	-	-	-	-
Lepidoptera larvae	-	-	-	.4	5	-
Blattidae	.2	5	-	-	-	-
Unident. Arthropoda	-	-	-	-	-	-
Endogone	.6	11	-	1.0	5	-
Nematoda	.3	5	-	1.8	5	-

volume of food consumed, was not present on the study area, but was under cultivation on an adjacent field during the period of study. Other common foods eaten by _P. hispidus_ from Area II were _Opuntia lindheimeri_, _Sorghum halapense_, _Paspalum stramineum_, _Croton glandulosus_, _Ambrosia artemisifolia_, _Panicum reverchoni_ and _Gailardia pulchella_. Foods consumed but not selected for included _Sorghum halapense_, _Panicum reverchoni_, _Ambrosia artemisifolia_ and _Paspalum stramineum_. Adult Carabidae composed 1.2% of the volume of the diet and were the most common insects consumed.

The E.I. calculated for the most common food items in the diet of _P. hispidus_ from Area II were found to be significant for all but two species, _Artemisia ludoviciana_ and _Sorghum halapense_. _Mammalaria_ sp. was the most selected food (E.I. = 0.85). _Prosopis juliflora_, _Opuntia lindheimeri_ and Helianthus annuus followed with E.I. values of 0.85, 0.81, 0.74 and 0.64, respectively. Plant species which were abundant in the habitat but not found in the diet include _Bouteloua curtipendula_, _Setaria verticillata_, _Mulenbergia asperifolia_, _Aristida purpurea_, _Chloris cucullata_ and _Lycium_ sp. The calculated Dietary Overlap between the spring and winter diets of _P. hispidus_ was 0.67, indicating that the diet of this species does not change significantly with the seasons.

Dipodomys ordii

Fourteen plant foods and four animal foods were identified in the diet of _D. ordii_ from Area I (Table 6). The

Table 6. Spring and winter diets of Dipodomys ordii from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Food Categories Consumed	Spring			Winter		
	% Volume	% Frequency	Electivity Index	% Volume	% Frequency	Electivity Index
Andropogon hallii	12.8	71	0.57	7.1	32	0.34
Ambrosia artemisifolia	11.7	33	-0.20	8.9	48	0.06
Prosopis juliflora (s)	10.5	65	0.67	9.9	61	0.65
Opuntia lindheimeri	9.4	23	0.81	4.1	25	0.61
Gailardia pulchella	8.8	59	0.63	3.6	31	0.29
Unident. dry stem mat.	7.1	42	-0.48	14.0	91	-0.18
Sorghum halapense	4.1	32	0.15	7.8	35	0.44
Yucca treculeana	3.2	32	0.50	.6	10	-0.27
Helianthus annuus	3.7	21	0.40	6.7	40	0.74
Croton glandulosus	2.1	13	-0.35	3.9	30	-0.06
Paspalum stramineum	.3	3	-0.94	6.9	43	-0.13
Prosopis juliflora (l)	.1	3	-0.88	3.5	24	0.25
Panicum reverchoni	1.2	9	-0.66	2.9	28	-0.33
Cenchrus pauciflorus	1.1	18	0.04	2.9	22	0.48
Solanum eleagnifolium	.3	5	-0.60	1.4	15	0.16
Dung	-	-	-	.9	2	-
Unident. vegetation	6.5	55	-	7.5	72	-
Carabidae	9.0	58	-	.4	5	-
Lepidoptera larvae	1.9	20	-	2.9	7	-
Myrmeleonidae larvae	4.4	25	-	.6	8	-
Formicidae	-	-	-	2.5	17	-
Unident. Arthropoda	3.0	55	-	.1	11	-

most common foods by volume present in the spring diet were Andropogon hallii (12.9%), Ambrosia artemisifolia (11.7%), Prosopis juliflora seed (10.5%), and Opuntia lindheimeri (9.4%). Other common foods included Gailardia pulchella, Sorghum halapense, Yucca treculeana, Helianthus annuus, Croton glandulosus, Panicum reverchoni and Cenchrus pauciflorus. The most common insects consumed during the spring months were adult Carabidae (9.0%), Myrmeleonidae larvae (4.4%), and Lepidoptera larvae (1.9%).

Prosopis juliflora, Opuntia lindheimeri and Gailardia pulchella were the only major food plants which had a calculated E.I. value greater than 0.60. The values for these species are 0.67, 0.81 and 0.63, respectively. Ambrosia artemisifolia was consumed in large amounts but had an E.I. value of -0.2. Other foods not selected for but eaten included unidentified dry stem material, Croton glandulosus, and Panicum reverchoni with E.I. values of -0.48, -0.35 and -0.66, respectively.

The most common foods of the winter diet were not similar to those identified in the spring, except for Prosopis juliflora which composed approximately the same per cent volume of the diets during both seasons (Table 6). The most common foods present by volume in the winter diet of D. ordii from Area I were unidentified dry stem material (14.0%), Prosopis juliflora seed (9.9%), and Sorghum halapense (7.8%). Other foods of D. ordii from this area included Andropogon hallii, Paspalum stramineum, Helianthus annuus, Opuntia lindheimeri, Croton glandulosus, Gailardia pulchella, Prosopis juliflora leaf, Panicum reverchoni, Cenchrus pauciflorus and Solanum eleagnifolium. Insect material identified from the winter samples included Lepidoptera larvae (2.9%) and adult Formicidae (2.5%). Other insects consumed were not present in volumes greater than 1.0%.

Highly selected foods were less numerous during the winter months. The most common foods of the winter diet exhibited E.I. values that were less than 0.60 except for Prosopis juliflora seed with an E.I. value of 0.65. The other major foods listed had values between 0.44 for Sorghum halapense and -0.18 for the unidentified dry stem material. Moderately consumed foods which were selected for included Helianthus annuus and Opuntia lindheimeri with E.I. values of 0.74 and 0.61, respectively. Foods eaten but not selected for included Paspalum stramineum, Croton glandulosus and Panicum reverchoni with E.I. values of -0.13, -0.06 and -0.33, respectively.

Items consumed in the winter and not during the spring months included Yucca treculeana and adult Formicidae, although the E.I. value for Yucca treculeana was -0.27. Plants with high abundance values in the habitat but not found in the diet of D. ordii were Aristida purpurea, Mulenbergia asperifolia, Shrankia uncinata, Cnidoscolus texanus, Stenotaphrum secondatum and Lepidium alyssoides. The calculated food overlap for D. ordii spring and winter diets was 0.79 and considered to be significant. This indicates that the food habits did not vary with seasonal variations in food resource abundance.

The winter diet of D. ordii from Area III was similar to the winter diet of this species from Area I (Table 7). Prosopis juliflora was the only major food item that was selected for in both of the diets. The most common foods by volume in the diet of D. ordii from Area III included Paspalum stramineum (15.2%), unidentified dry stem material (11.7%), and Croton glandulosus (8.7%). Other foods commonly eaten by D. ordii in this area were Prosopis juliflora seed, Prosopis juliflora leaf, Cenchrus pauciflorus, Sorghum halapense, Opuntia lindheimeri, Helianthus annuus, Ambrosia artemisifolia, and Andropogon hallii. Insects were consumed in higher amounts from this area than Area I. Lepidoptera larvae composed 3.8%; adult Formicidae, 2.9%; Myrmeleonidae larvae, 1.1%; and adult Carabidae, 1.0% of the total volume.

Prosopis juliflora and Sorghum halapense were the only major food items with high E.I. values, 0.60 for both areas. Foods not selected for but eaten in amounts greater than 1.0% by volume were unidentified dry stem material, Cenchrus pauciflorus, Opuntia lindheimeri, and Helianthus annuus with E.I. values of -0.26, -0.65, -0.34 and -0.36, respectively. Plant species which were present in the habitat in high abundance yet not utilized as a food source included Quercus

Table 7. Comparison of the winter diets of *Dipodomys ordii* from Study Area I, 8 miles east of Roby, Fisher County, Texas and Study Area III, 4 miles west of Royston, Fisher County, Texas.

Food Categories Consumed	Area I % Volume	Area I % Frequency	Area I Electivity Index	Area III % Volume	Area III % Frequency	Area III Electivity Index
Paspalum stramineum	6.9	43	-0.13	15.2	81	0.50
Unident. dry stem mat.	14.0	91	-0.18	11.7	73	-0.26
Prosopis juliflora (s)	9.9	61	0.65	6.0	39	0.60
Ambrosia artemisifolia	8.9	48	0.06	2.7	20	0.45
Sorghum halapense	7.8	35	0.44	4.0	36	0.60
Croton glandulosus	3.9	30	-0.06	8.7	54	0.03
Panicum reverchoni	2.9	28	-0.33	6.2	43	0.55
Andropogon hallii	7.1	32	0.34	.6	2	-0.28
Helianthus annuus	6.7	40	0.74	3.7	28	-0.36
Prosopis juliflora (l)	3.5	24	0.25	5.9	46	0.59
Opuntia lindheimeri	4.1	25	0.61	4.0	32	-0.34
Cenchrus pauciflorus	2.9	22	0.48	4.9	41	-0.65
Gailardia pulchella	3.6	31	0.29	.3	2	-0.01
Solanum eleagnifolium	1.4	15	0.16	.6	4	-0.68
Mammalaria sp.	-	-	-	.6	7	-0.25
Yucca treculeana	3.2	32	0.20	.5	10	-0.32
Unident. vegetation	7.5	72	-	7.5	77	-
Dung	.9	2	-	1.4	5	-
Unident. green stem	-	-	-	2.0	17	-
Lepidoptera larvae	2.9	7	-	3.8	24	-
Formicidae	2.9	20	-	2.9	20	-
Myrmeleonidae larvae	.6	8	-	1.4	5	-
Carabidae	1.0	10	-	.4	5	-
Unident. Arthropoda	.9	4	-	.1	11	-
Endogone	-	-	-	4.1	13	-

cinerea, Lepidium alyssoides, Cnidoscolus texanus, Mulenbergia asperifolium and Celtis occidentalis.

Peromyscus maniculatus

Ten plant foods and nine animal foods were identified in the diet of P. maniculatus from Area I (Table 8). The most common plant foods by volume present in the spring diet were Andropogon hallii (8.3%), and Prosopis juliflora seed (6.8%). Other plant foods included Yucca treculeana, Gailardia pulchella and Opuntia lindheimeri. Insect material composed 60% of the total diet in this species in the spring. Adult Carabidae and adult Gryllacrididae were the major insect items and composed 24.4% and 21.2% of the volume, respectively; Lepidoptera larvae composed 15.3% of the total volume and adult Formicidae composed 3.9% of the total diet.

Andropogon hallii and Prosopis juliflora had the highest E.I. values of all plants consumed, 0.41 and 0.53, respectively. Gailardia pulchella, unidentified dry stem material and Opuntia lindheimeri all had negative E.I. values.

The winter plant diet of P. maniculatus differed from the spring diet. The most common foods by volume were Helianthus annuus (10.8%), unidentified dry stem material (10.5%), and Sorghum halapense (10.1%) (Table 8). Other foods commonly found in the diet of P. maniculatus were Opuntia lindheimeri, Andropogon hallii, Cenchrus pauciflorus, Mammalaria sp., Croton glandulosus, Gailardia pulchella and Solanum eleagnifolium. Insects and other arthropods were utilized less

Table 8. Spring and winter diets of Peromyscus maniculatus from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Food Categories Consumed	Spring % Volume	Spring % Frequency	Spring Electivity Index	Winter % Volume	Winter % Frequency	Winter Electivity Index
Helianthus annuus	4.2	44	0.61	10.8	58	0.83
Unident. dry stem mat.	.8	16	-0.92	10.5	58	-0.31
Sorghum halapense	4.2	33	0.18	10.1	83	0.54
Opuntia lindheimeri	.8	11	-0.12	6.7	25	0.75
Andropogon hallii	8.3	44	0.41	6.6	42	0.31
Cenchrus pauciflorus	-	-	-	6.6	58	0.74
Mammalaria sp.	-	-	-	5.1	46	0.67
Croton glandulosus	-	-	-	4.8	33	0.05
Solanum eleagnifolium	-	-	-	2.0	17	0.33
Yucca treculeana	1.4	28	0.16	-	-	-
Aristida purpurea	0	0	0	.8	17	-0.30
Unident. vegetation	5.5	66	-	9.3	30	-
Gailardia pulchella	1.3	11	-0.20	3.2	33	0.23
Carabidae	24.4	88	-	2.1	13	-
Gryllacrididae	21.2	100	-	-	-	-
Lepidoptera larvae	15.3	83	-	6.5	42	-
Hemiptera	-	-	-	4.8	42	-
Formicidae	3.9	44	-	1.3	13	-
Diptera	-	-	-	2.5	17	-
Blattidae	.8	16	-	1.3	13	-
Chaelopoda	-	-	-	.6	13	-
Unident. Arthropoda	1.1	11	-	2.9	29	-

during the winter, however, the diversity of this material was more than twice that of the spring samples. Insect material included Lepidoptera larvae (6.5%), adult Hemiptera (4.8%), adult Diptera (2.5%), adult Formicidae (1.3%) and adult Blattidae (1.3%). The only other arthropods eaten were adult Chaelopoda which composed only 0.6% of the volume of the diet.

Four food items which were present in the winter diet had E.I. values greater than 0.60. These were *Helianthus annuus*, *Opuntia lindheimeri*, *Cenchrus pauciflorus*, and *Mammalaria* sp. with E.I. values of 0.83, 0.75, 0.74, and 0.67, respectively. Unidentified dry stem material was the only plant food which was not selected for and had an E.I. value of -0.31.

Certain plants were abundant on the area but not eaten during any season. These included *Ambrosia artemisifolia*, *Aristida purpurea*, *Mulenbergia asperifolia*, *Achillea millefolium*, *Paspalum stramineum*, *Panicum reverchoni*, *Shrankia uncinata*, *Cnidoscolus texanus*, and *Artemisia ludoviciana*.

The coefficient of dietary overlap of *P. maniculatus* from Area I for the spring and winter seasons was 0.28, indicating the diets are significantly different for these seasons.

Reithrodontomys montanus

Thirteen plant foods and eight animal foods were identified in the diet of *R. montanus* from Area I. The most common plant foods by volume in the spring diet were Opuntia lindheimeri (15.0%), Gailardia pulchella (11.3%), and Andropogon hallii (10.0%) (Table 9). Other common plant foods included Sorghum halapense, Ambrosia artemisifolia, Prosopis juliflora seed and Achillea millefolium. A major portion of the spring diet was composed of insect material and other arthropods totaling more than 49% of the total volume consumed. Lepidoptera larvae composed 17.0%, Carabidae 14.5%, Gryllacrididae 7.0%, Formicidae 2.5% and adult Chaelopoda 2.5% of the volume.

Opuntia lindheimeri and Gailardia pulchella were the only two plant species which had a calculated E.I. value greater than 0.60, with values of 0.88 and 0.70, respectively. Ambrosia artemisifolia, Prosopis juliflora seed, and unidentified dry stem material had E.I. values of -0.84, -0.31 and -0.90, respectively, indicating that these species were not selected for in the diet.

The most common plant foods in the winter diet were not similar to those of the spring diet of R. montanus (Table 9). The insect material present in the diet was also distinctly dissimilar. The most common plant foods by volume included unidentified dry stem material (10.0%), Sorghum halapense (9.0%), and Ambrosia artemisifolia (8.0%). Other common foods were Croton glandulosus, Opuntia lindheimeri, Solanum eleagnifolium, Prosopis juliflora, Mammalaria sp., Andropogon hallii, Paspalum stramineum and Panicum reverchoni. Insect

Table 9. Spring and winter diets of Reithrodontomys montanus from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Food Categories Consumed	Spring % Volume	Spring % Frequency	Spring Electivity Index	Winter % Volume	Winter % Frequency	Winter Electivity Index
Opuntia lindheimeri	15.0	80	0.88	5.0	33	0.66
Gailardia pulchella	11.3	85	0.70	-	-	-
Andropogon hallii	10.0	65	0.48	3.4	17	-0.02
Unident. dry stem mat.	1.0	10	-0.90	10.0	83	-0.33
Sorghum halapense	7.4	75	0.42	9.0	83	0.50
Ambrosia artemisifolia	1.5	20	-0.84	8.0	50	-0.38
Croton glandulosus	-	-	-	5.0	50	0.06
Solanum eleagnifolium	-	-	-	4.7	33	0.64
Prosopis juliflora (s)	1.1	10	-0.31	4.5	67	0.36
Mammalaria sp.	-	-	-	4.0	50	0.60
Paspalum stramineum	-	-	-	3.3	33	-0.45
Panicum reverchoni	-	-	-	2.5	17	-0.40
Achillea millefolium	2.0	20	-0.11	-	-	-
Unident. vegetation	1.5	15	-	10.7	10	-
Lepidoptera larvae	17.0	80	-	-	-	-
Carabidae	14.5	95	-	-	-	-
Diptera	-	-	-	14.7	67	-
Gryllacrididae	7.0	40	-	2.5	17	-
Formicidae	2.3	20	-	-	-	-
Chaelopoda	2.3	25	-	2.5	50	-
Hemiptera	1.3	10	-	-	-	-
Acrididae	.8	20	-	-	-	-
Unident. Arthropoda	3.3	65	-	5.0	50	-
Endogone	-	-	-	5.3	17	-

material was not as important in the winter diet as in the spring, and all insects except adult Diptera decreased in per cent volume consumed. Adult Diptera composed 14.7% of the total volume of the diet; Gryllacrididae and Chaelopoda adults both composed 2.5% of the total volume.

Opuntia lindheimeri, Solanum eleagnifolium and Mammalaria sp. had E.I. values of 0.66, 0.64 and 0.60, respectively. Food items which were not selected for were unidentified dry stem material, Ambrosia artemisifolia, Paspalum stramineum and Panicum reverchoni, with E.I. values of -0.33, -0.38, -0.45 and -0.40, respectively.

Gailardia pulchella and Achillea millefolium were eaten by R. montanus during the spring but not in the winter months. Food items which were not eaten during the spring but utilized during the winter were Croton glandulosus, Solanum eleagnifolium, Mammalaria sp., Paspalum stramineum and Panicum reverchoni. Lepidoptera larvae, adult Carabidae, adult Formicidae, adult Hemiptera and adult Acrididae were utilized during the spring months but not in the winter. The only insect foods utilized only during the winter were adult Diptera.

Plants which were abundant in the habitat but never utilized as a food source were Aristida purpurea, Mulenbergia asperifolia, Shrankia uncinata, Cnidoscolus texanus, Artemisia ludoviciana and Stenotaphrum secondatum.

The dietary overlap coefficient calculated for *R. montanus* for the spring and winter seasons was 0.40, indicating significant seasonal variation in food habits.

Comparison of the Spring Diets of *Dipodomys ordii* and *Perognathus hispidus* from Study Area I

The dietary overlap coefficient between the diets of *D. ordii* and *P. hispidus* for the spring was 0.79. There were twenty-six food categories identified in the diets of these two species, of these, 50% were shared by both (Table 10). Items which were commonly shared and selected for by both species included *Prosopis juliflora* seed, *Opuntia lindheimeri*, and, to a lesser extent, *Andropogon hallii*. Adult Carabidae and Lepidoptera larvae were the only items shared which occurred in similar proportions. *P. hispidus* selected against *Cenchrus pauciflorus*, *Ambrosia artemisifolia*, and *Achillea millefolium* in the spring; while *D. ordii* did not select against any food during this season. Foods eaten by *D. ordii* and not shared with *P. hispidus* were *Croton glandulosus*, *Panicum reverchoni*, *Achillea millefolium*, dung, Myrmeleonidae larvae and adult Formicidae. Foods taken by *P. hispidus* but not shared by *D. ordii* included *Gailardia pulchella*, *Mammalaria* sp., *Artemisia ludoviciana* and adult Blattidae.

Comparison of the Winter Diets of *Dipodomys ordii* and *Perognathus hispidus* from Study Area I

The dietary overlap coefficient for these two diets was 0.80 which is significant and represents a slight increase

Table 10. Comparison of the spring diets of *Dipodomys ordii* and *Perognathus hispidus* from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Spring Food Categories Consumed	*Dipodomys ordii* % Volume	*Dipodomys ordii* % Frequency	*Dipodomys ordii* Electivity Index	*Perognathus hispidus* % Volume	*Perognathus hispidus* % Frequency	*Perognathus hispidus* Electivity Index
Prosopis juliflora (s)	10.5	65	0.67	13.6	83	0.73
Andropogon hallii	12.9	71	0.57	8.5	63	0.42
Ambrosia artemisifolia	11.7	33	-0.20	4.4	55	-0.60
Gailardia pulchella	-	-	-	11.5	86	0.72
Opuntia lindheimeri	9.4	23	0.81	9.8	68	0.82
Yucca treculeana	3.2	32	0.50	5.1	45	0.22
Unident. dry stem mat.	7.1	42	-0.48	3.7	40	-0.69
Mammalaria sp.	-	-	-	4.7	25	0.65
Sorghum halapense	4.1	32	0.15	-	-	-
Paspalum stramineum	.3	3	-0.94	3.9	38	-0.39
Helianthus annuus	2.4	21	0.40	.8	7	-0.11
Croton glandulosus	2.1	13	-0.35	-	-	-
Panicum reverchoni	1.2	9	-0.66	-	-	-
Cenchrus pauciflorus	1.1	18	0.04	.3	7	-0.50
Prosopis juliflora (l)	.1	3	-0.88	12.5	70	0.71
Artemisia ludoviciana	-	-	-	.4	8	-0.41
Solanum eleagnifolium	.3	5	-0.60	.4	8	-0.41
Achillea millefolium	.4	8	-0.72	-	-	-
Dung	.3	7	-	-	-	-
Unident. vegetation	6.5	55	-	4.5	58	-
Carabidae	9.0	58	-	9.0	68	-
Lepidoptera larvae	1.9	20	-	1.9	15	-
Myrmeleonidae larvae	4.4	25	-	-	-	-
Blattidae	-	-	-	1.7	5	-
Formicidae	.8	13	-	-	-	-
Unident. Arthropoda	2.0	28	-	.5	13	-

in the amount of overlap compared with the spring diets. Twenty-six food categories were identified in the diets of *D. ordii* and *P. hispidus* for the winter (Table 11). Of these foods, 69% were shared by both species. Shared food items which were selected for by both species included *Helianthus annuus*, *Opuntia lindhsimeri*, and, to a lesser extent, *Cenchrus pauciflorus*. *Ambrosia artemisifolia* was the only plant species which was selected against by either *D. ordii* or *P. hispidus* during the winter. The items found only in the diet of *D. ordii* were dung, Lepidoptera larvae, Myrmeleonidae larvae, and adult Carabidae. Items found only in the diet of *P. hispidus* were *Mammalaria* sp., *Endogone*, and adult Blattidae.

Comparison of the Spring Diets of *Peromyscus maniculatus* and *Reithrodontomys montanus* from Study Area I

The dietary overlap coefficient for the spring diets of *P. maniculatus* and *R. montanus* was 0.72, which was significant. Nineteen food categories were identified in the spring diets of these species, and, of these foods, 57% were shared by both (Table 12). No plant food highly selected for by one species was highly selected for by the other. *P. maniculatus* did not select highly against any plant species and *R. montanus* selected against only two species, *Prosopis juliflora* seed and *Ambrosia artemisifolia*. The major arthropod components of the two diets were shared, and included Lepidoptera larvae, adult Carabidae, adult Gryllacrididae, and adult

Table 11. Comparison of the winter diets of *Dipodomys ordii* and *Perognathus hispidus* from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Winter Food Categories Consumed	*Dipodomys ordii* % Volume	*Dipodomys ordii* % Frequency	*Dipodomys ordii* Electivity Index	*Perognathus hispidus* % Volume	*Perognathus hispidus* % Frequency	*Perognathus hispidus* Electivity Index
Helianthus annuus	6.7	40	0.74	10.0	44	0.82
Opuntia lindheimeri	4.1	25	0.61	9.3	55	0.81
Unident. dry stem mat.	14.0	91	-0.18	8.8	66	-0.39
Ambrosia artemisifolia	8.9	48	0.06	5.1	39	-0.55
Sorghum halapense	7.8	35	0.44	6.0	61	0.33
Mammalaria sp.	-	-	-	7.8	66	0.77
Panicum reverchoni	2.9	28	-0.33	7.8	45	0.14
Andropogon hallii	7.1	32	0.34	4.2	39	0.09
Artemisia ludoviciana	-	-	-	6.2	55	0.72
Paspalum stramineum	6.9	43	-0.13	3.5	28	-0.44
Cenchrus pauciflorus	2.9	22	0.48	6.1	55	0.72
Croton glandulosus	3.9	30	-0.06	4.4	39	-
Gailardia pulchella	3.6	31	0.29	4.8	27	0.41
Prosopis juliflora (s)	9.9	61	0.65	3.8	39	0.29
Solanum eleagnifolium	1.4	15	0.16	1.0	16	-
Prosopis juliflora (l)	3.5	24	0.25	3.4	27	0.24
Yucca treculeana	.6	10	-0.27	1.0	11	-
Dung	.9	2	-	-	-	-
Unident. vegetation	7.5	72	-	5.1	55	-
Lepidoptera larvae	2.9	7	-	-	-	-
Formicidae	2.5	17	-	.6	11	-
Myrmeleonidae larvae	.6	8	-	-	-	-
Carabidae	.4	5	-	-	-	-
Blattidae	-	-	-	.2	5	-
Unident. Arthropoda	.1	11	-	-	-	-
Endogone	-	-	-	.6	11	-
Nematoda	-	-	-	.3	5	-

Table 12. Comparison of the spring diets of *Peromyscus maniculatus* and *Reithrodontomys montanus* from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Spring Food Categories Consumed	*Peromyscus maniculatus* % Volume	*Peromyscus maniculatus* % Frequency	*Peromyscus maniculatus* Electivity Index	*Reithrodontomys montanus* % Volume	*Reithrodontomys montanus* % Frequency	*Reithrodontomys montanus* Electivity Index
Opuntia lindheimeri	.8	11	-0.12	15.0	80	0.88
Gailardia pulchella	1.3	11	-0.20	11.3	85	0.70
Andropogon hallii	8.3	44	0.41	10.0	65	0.48
Prosopis juliflora (s)	6.8	72	0.53	1.1	10	-0.90
Sorghum halapense	-	-	-	7.4	75	0.42
Helianthus annuus	4.2	33	0.61	-	-	-
Ambrosia artemisifolia	-	-	-	1.5	20	-0.84
Yucca treculeana	1.4	28	0.16	-	-	-
Unident. dry stem mat.	.8	16	-0.92	1.0	10	-0.90
Unident. vegetation	5.5	66	-	1.5	15	-
Lepidoptera larvae	17.0	80	-	15.3	83	-
Carabidae	24.4	88	-	14.5	95	-
Gryllacrididae	21.1	100	-	7.0	40	-
Formicidae	3.9	44	-	2.3	20	-
Chaelopoda	-	-	-	2.3	25	-
Hemiptera	-	-	-	1.3	10	-
Acrididae	-	-	-	.8	50	-
Blattidae	.8	16	-	-	-	-
Unident. Arthropoda	1.1	11	-	3.3	65	-

Formicidae, however, Lepidoptera larvae and adult Formicidae were the only items consumed in similar proportions. Food items consumed only by P. maniculatus included Helianthus annuus, Yucca treculeana and adult Blattidae. Foods consumed only by R. montanus were Sorghum halapense, Ambrosia artemisifolia, adult Chaelopoda, Hemiptera and Acrididae.

Comparison of the Winter Diets of Peromyscus maniculatus and Reithrodontomys montanus from Study Area I

The dietary overlap coefficient for the winter diets of P. maniculatus and R. montanus was 0.55 and is not significant. Twenty-five food categories were identified in the winter diets of P. maniculatus and R. montanus, and, of these foods, 44% were shared by both species (Table 13). Food items which were shared and selected for included Sorghum halapense, Opuntia lindheimeri, and Mammalaria sp. No food items were highly selected against during the winter season. Foods taken only by P. maniculatus were Helianthus annuus, Cenchrus pauciflorus, Endogone, Lepidoptera larvae, adult Hemiptera, Carabidae, Formicidae and Blattidae. Foods consumed only by R. montanus included Ambrosia artemisifolia, Prosopis juliflora seed, Paspalum stramineum, Panicum reverchoni, and adult Gryllacrididae.

Comparison of the Winter Diets of Dipodomys ordii and Reithrodontomys montanus from Study Area I

These two diets exhibited a dietary overlap coefficient of 0.62 which can be considered significant for this season.

Table 13. Comparison of the winter diets of *Peromyscus maniculatus* and *Reithrodontomys montanus* from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Winter Food Categories Consumed	*Peromyscus maniculatus*			*Reithrodontomys montanus*		
	% Volume	% Frequency	Electivity Index	% Volume	% Frequency	Electivity Index
Helianthus annuus	10.8	58	0.83	-	-	-
Unident. dry stem mat.	10.5	58	-0.31	10.0	83	-0.33
Sorghum halapense	10.1	83	0.54	9.0	83	0.50
Ambrosia artemisifolia	-	-	-	8.0	50	-0.38
Opuntia lindheimeri	6.7	25	0.75	5.0	33	0.66
Andropogon hallii	6.6	42	0.31	3.3	17	-0.02
Cenchrus pauciflorus	6.6	58	0.74	-	-	-
Mammalaria sp.	5.1	46	0.67	4.0	50	0.60
Croton glandulosus	4.8	33	0.05	5.0	50	0.06
Gailardia pulchella	3.2	33	0.23	-	-	-
Solanum eleagnifolium	2.0	17	0.33	4.7	33	0.64
Prosopis juliflora (s)	-	-	-	4.5	67	0.36
Paspalum stramineum	-	-	-	3.3	33	-0.45
Panicum reverchoni	-	-	-	2.5	17	-0.40
Unident. vegetation	5.5	66	-	10.7	10	-
Diptera	14.7	67	-	2.5	17	-
Lepidoptera larvae	6.5	42	-	-	-	-
Hemiptera	4.8	42	-	-	-	-
Gryllacrididae	-	-	-	2.5	17	-
Carabidae	2.1	13	-	-	-	-
Formicidae	1.3	13	-	-	-	-
Blattidae	1.3	13	-	-	-	-
Chaelopoda	.6	13	-	2.5	50	-
Unident. Arthropoda	2.9	29	-	5.0	50	-
Endogone	-	-	-	5.3	17	-

Of the twenty-seven food categories identified in the diets of *D. ordii* and *R. montanus* for this season, 62% were shared by both species (Table 14). *Opuntia lindheimeri* was the only plant species selected for by both species during this season. No food categories were selected against by either species during this season. Foods present only in the winter diet of *D. ordii* were *Gailardia pulchella*, Lepidoptera and Myrmeleonidae larvae, and adult Carabidae and Formicidae. Foods found only in the diet of *R. montanus* for this season included *Mammalaria* sp., *Endogone*, and adult Diptera, Gryllacrididae, Chaelopoda, Hemiptera and Acrididae.

Comparison of the Spring Diets of *Dipodomys ordii* and *Reithrodontomys montanus* from Study Area I

The dietary overlap coefficient between the diets of *D. ordii* and *R. montanus* was 0.65 and is significant. Twenty-eight food categories were identified in the diets of *D. ordii* and *R. montanus*. Of these foods, 54% were shared by both species (Table 15). Shared food items which were selected for by both species included *Opuntia lindheimeri* and *Gailardia pulchella*. *R. montanus* selected against *Ambrosia artemisifolia* during the spring while *D. ordii* selected against *Paspalum stramineum*, *Prosopis juliflora* leaf, *Panicum reverchoni*, and *Solanum eleagnifolium*. The items taken only by *D. ordii* during this season included *Croton glandulosus*, *Panicum reverchoni*, *Cenchrus pauciflorus*, *Solanum eleagnifolium* and Myrmeleonidae larvae. Items found only in the diet of *R. montanus*

Table 14. Comparison of the spring diets of Dipodomys ordii and Reithrodontomys montanus from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Food Categories Consumed	Dipodomys ordii			Reithrodontomys montanus		
	% Volume	% Frequency	Electivity Index	% Volume	% Frequency	Electivity Index
Prosopis juliflora (s)	10.5	65	0.67	1.1	10	-0.90
Andropogon hallii	12.9	71	0.57	10.0	65	0.48
Ambrosia artemisifolia	11.7	33	-0.20	1.5	20	-0.84
Gailardia pulchella	-	-	-	11.3	85	0.70
Opuntia lindheimeri	9.4	23	0.81	15.0	80	0.88
Yucca treculeana	3.2	32	0.50	-	-	-
Unident. dry stem mat.	7.1	42	-0.48	1.0	10	-0.90
Sorghum halapense	4.1	32	0.15	7.4	75	0.42
Paspalum stramineum	0.3	3	-0.94	-	-	-
Helianthus annuus	2.4	21	0.40	-	-	-
Croton glandulosus	2.1	13	-0.35	-	-	-
Panicum reverchoni	1.2	9	-0.66	-	-	-
Cenchrus pauciflorus	1.1	18	0.04	-	-	-
Prosopis juliflora (l)	0.1	3	-0.88	-	-	-
Achillea millefolium	0.4	8	-0.72	-	-	-
Solanum eleagnifolium	0.3	5	-0.60	-	-	-
Dung	0.3	7	-	-	-	-
Unident. vegetation	6.5	55	-	1.5	15	-
Carabidae	9.0	58	-	14.5	95	-
Lepidoptera larvae	1.9	20	-	15.3	83	-
Gryllacrididae	-	-	-	7.0	40	-
Myrmeleonidae	4.4	25	-	-	-	-
Formicidae	0.8	13	-	2.3	20	-
Chaelopoda	-	-	-	2.3	25	-
Hemiptera	-	-	-	1.3	10	-
Acrididae	-	-	-	0.8	50	-
Unident. Arthropoda	2.0	28	-	3.3	65	-

Table 15. Comparison of the winter diets of Dipodomys ordii and Reithrodontomys montanus from Study Area I, 8 miles east of Roby, Fisher County, Texas

Winter Food Categories Consumed	Dipodomys ordii			Reithrodontomys montanus		
	% Volume	% Frequency	Electivity Index	% Volume	% Frequency	Electivity Index
Helianthus annuus	6.7	40	0.74	-	-	-
Opuntia lindheimeri	4.1	25	0.61	5.0	33	0.66
Unident. dry stem mat.	14.0	91	-0.18	10.0	83	-0.33
Ambrosia artemisifolia	8.9	48	0.06	8.0	50	-0.38
Sorghum halapense	7.8	32	0.34	9.0	83	0.50
Mammalaria sp.	-	-	-	4.0	50	0.60
Panicum reverchoni	2.9	28	-0.33	2.5	17	-0.40
Andropogon hallii	7.1	32	0.34	3.3	17	-0.02
Paspalum stramineum	6.9	43	-0.13	3.3	33	-0.45
Cenchrus pauciflorus	2.9	22	0.48	-	-	-
Croton glandulosus	3.9	30	-0.06	5.0	50	0.06
Gailardia pulchella	3.6	31	0.29	-	-	-
Prosopis juliflora (s)	9.9	61	0.65	4.5	67	0.36
Solanum eleagnifolium	1.4	15	0.16	4.7	33	0.64
Prosopis juliflora (l)	3.5	24	0.25	-	-	-
Yucca treculeana	0.6	10	-0.27	-	-	-
Dung	0.9	2	-	-	-	-
Unident. vegetation	7.5	72	-	10.7	10	-
Lepidoptera larvae	2.9	7	-	-	-	-
Diptera	-	-	-	2.5	17	-
Formicidae	2.5	17	-	-	-	-
Gryllacrididae	-	-	-	2.5	17	-
Carabidae	0.4	5	-	-	-	-
Chaelopoda	-	-	-	2.5	50	-
Unident. Arthropoda	0.1	11	-	5.0	50	-
Endogone	-	-	-	5.3	17	-

were *Achillea millefolium*, adult Gryllacrididae, Hemiptera, Acrididae, and Chaelopoda.

Comparison of the Winter Diets of *Dipodomys ordii* and *Peromyscus maniculatus* from Study Area I

The dietary overlap coefficient between these diets was 0.80 for the winter months which shows significant overlap. Twenty-eight food categories were identified from the diets of *D. ordii* and *P. maniculatus* for the winter season, of these, 54% were shared by both species (Table 16). Shared food items which were selected for by both species were *Helianthus annuus* and *Opuntia lindheimeri*. Neither species selected against any food consumed during the winter months. The food items found only in the diet of *D. ordii* for this season included *Ambrosia artemisifolia*, *Prosopis juliflora* seed, *Paspalum stramineum*, *Panicum reverchoni*, *Prosopis juliflora* leaf, and Myrmeleonidae larvae. Food items found only in the diet of *P. maniculatus* were *Mammalaria* sp., *Aristida purpurea*, adult Hemiptera, Diptera, Blattidae and Chaelopoda.

Comparison of Dietary Overlap

Significant dietary overlap occurred between the spring diets of *D. ordii* and *P. hispidus* (C = 0.79), *D. ordii* and *R. montanus* (C = 0.65) and *R. montanus* and *P. maniculatus* (C = 0.72) (Table 17). The winter diets which showed significant overlap were those of *D. ordii* and *P. hispidus* (C = 0.66), *D. ordii* and *P. maniculatus* (C = 0.80), *D. ordii* and *R. montanus* (C = 0.62), and *P. hispidus* and *P. maniculatus*

Table 16. Comparison of the winter diets of *Dipodomys ordii* and *Peromyscus maniculatus* from Study Area I, 8 miles east of Roby, Fisher County, Texas.

Winter Food Categories Consumed	*Dipodomys ordii*			*Peromyscus maniculatus*		
	% Volume	% Frequency	Electivity Index	% Volume	% Frequency	Electivity Index
Helianthus annuus	6.7	40	0.74	10.8	58	0.83
Opuntia lindheimeri	4.1	25	0.61	6.7	25	0.75
Unident. dry stem mat.	14.0	91	-0.18	10.5	58	-0.31
Ambrosia artemisifolia	8.9	48	0.06	-	-	-
Sorghum halapense	7.8	32	0.34	10.1	83	0.54
Mammalaria sp.	-	-	-	5.1	46	0.67
Panicum reverchoni	2.9	28	-0.33	-	-	-
Andropogon hallii	7.1	32	0.34	6.6	42	0.31
Paspalum stramineum	6.9	42	-0.13	-	-	-
Cenchrus pauciflorus	2.9	22	0.48	6.6	58	0.74
Croton glandulosus	3.9	30	-0.06	4.8	33	0.05
Gailardia pulchella	3.6	31	0.29	3.2	33	0.23
Prosopis juliflora (s)	9.9	61	0.65	-	-	-
Solanum eleagnifolium	1.4	15	0.16	2.0	17	0.33
Prosopis juliflora (l)	3.5	24	0.25	-	-	-
Yucca treculeana	.6	10	-0.27	-	-	-
Dung	.9	2	-	-	-	-
Unident. vegetation	7.5	72	-	5.5	66	-
Lepidoptera larvae	2.9	7	-	6.5	42	-
Diptera	-	-	-	14.7	67	-
Hemiptera	-	-	-	4.8	42	-
Carabidae	.4	5	-	2.1	13	-
Formicidae	2.5	17	-	1.3	13	-
Blattidae	-	-	-	1.3	13	-
Chaelopoda	-	-	-	.6	13	-
Unident. Arthropoda	.1	11	-	2.9	29	-

(C = 0.78) (Table 17). Significant overlap did not occur between P. maniculatus and R. montanus during the winter months when both diets were made up largely of plant material. The diet of P. maniculatus shifted from insect to plant material during the winter, as did the diet of R. montanus, however, the food items consumed were not similar. Both species of Heteromyidae show significant overlap with P. maniculatus, but only during the winter season. P. hispidus and R. montanus were the only species which did not show significant dietary overlap during any season examined. A brief discussion of dietary overlap between the four species follows.

Species Diversity of Diets

The species diversity for the spring and winter diets from Study Area I were 1.03 and 1.13 for D. ordii; 1.06 and 1.15 for P. hispidus; 0.64 and 1.01 for P. maniculatus and 0.90 and 1.19 for R. montanus. The species diversity of the winter diet of D. ordii from Area III was 0.91; this value was 0.87 for P. hispidus from Area II during the same season. The diversity of the food items in the diets of all species was higher during the winter season than in the spring. This variation was least evident in the diets of heteromyid species which had an average difference in diversity of 9.9% between the spring and winter diets. The average seasonal difference in diversity in the cricetine diets was 24.3%, or

Table 17. Comparison of the Dietary Overlap Coefficients for four species of rodents from Fisher County, Texas.

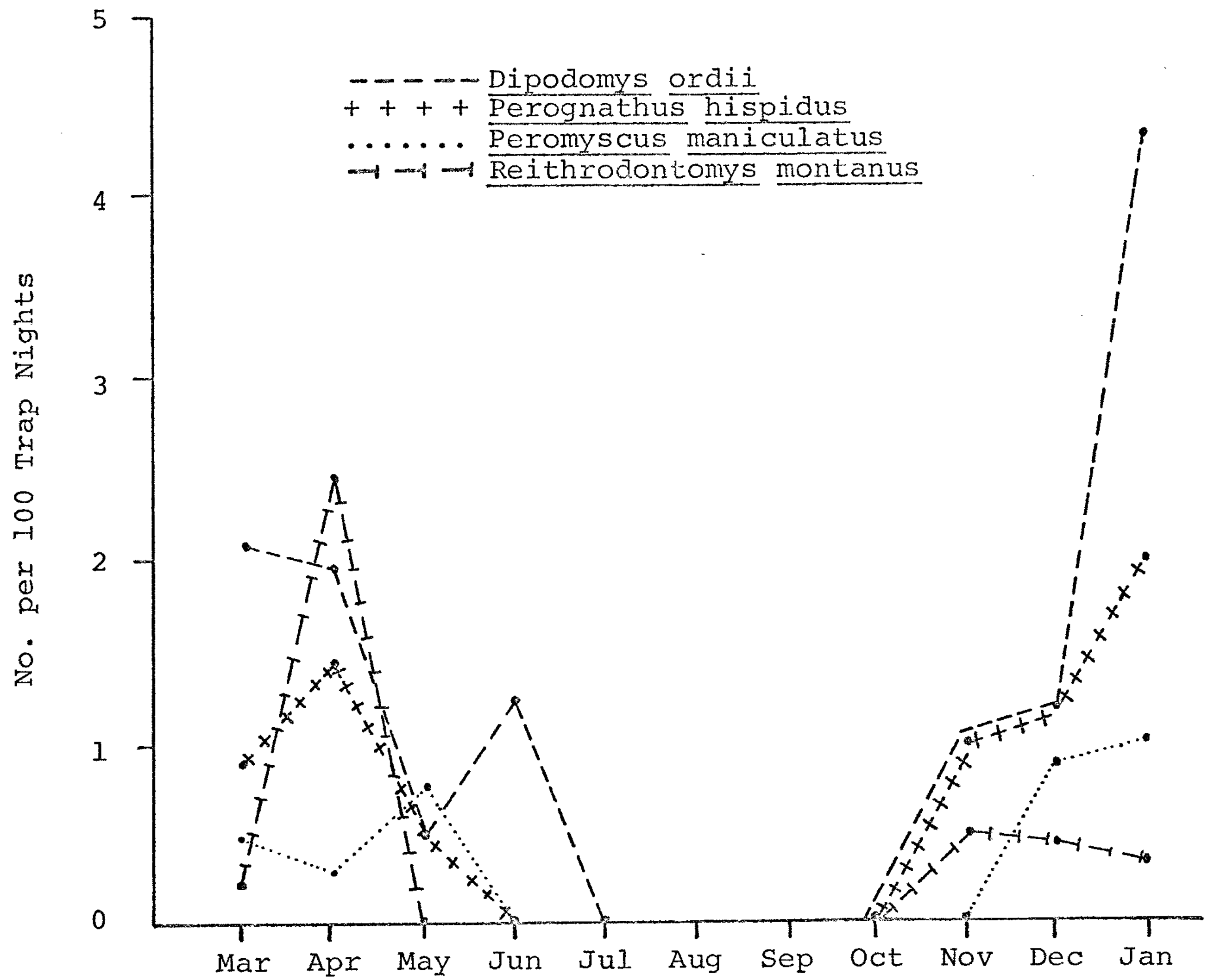
	D. ordii Spring	D. ordii Winter	P. hispidus Spring	P. hispidus Winter	P. maniculatus Spring	P. maniculatus Winter	R. montanus Spring	R. montanus Winter
D. ordii Spring	1.00	0.79	0.79	0.75	0.43	0.42	0.65	0.57
D. ordii Winter		1.00	0.66	0.79	0.28	0.80	0.51	0.62
P. hispidus Spring			1.00	0.67	0.25	0.38	0.48	0.36
P. hispidus Winter				1.00	0.13	0.78	0.37	0.55
P. maniculatus Spring					1.00	0.28	0.72	0.14
P. maniculatus Winter						1.00	0.53	0.55
R. montanus Spring							1.00	0.40
R. montanus Winter								1.00

two and one-half times the variation exhibited by the Heteromyidae from the same habitat. The increase in food diversity of all four species probably resulted from an increase in diversity of seeds during the winter months and the increase in seed utilization by P. maniculatus and R. montanus.

Population Densities

The variation in the number of animals taken per 100 trap nights can be used to evaluate the seasonal fluxuation of population densities for the rodents studied (Fig. 1). On Study Area I, the Heteromyidae were most abundant during the winter months, while the cricetine rodents were most abundant during the spring. The number of animals per 100 trap nights for the wpring and winter varied from 1.5 to 7.0 for D. ordii; 3.7 to 4.7 for P. hispidus; 2.0 to 0.9 for P. maniculatus; and from 5.5 to 1.3 for R. montanus. Area II yielded 9.1 P. hispidus per 100 trap nights and Area III yielded 15.1 D. ordii per 100 trap nights.

Fig. 1. Seasonal fluxuation of population densities of four species of rodents from Fisher County, Texas.



DISCUSSION

Previous studies of the food habits of _P. hispidus_ indicate the major diet consists of seeds (Blair, 1937). To this author's knowledge, there are no studies of the natural foods of _D. ordii_, although studies of other species in the genus _Dipodomys_ also indicate seeds as a primary food (Tappe, 1941; Smith, 1942; Bradley and Mauer, 1971). This study agrees with previous studies, and seeds made up 74% of the diet of _P. hispidus_ and 56% of the diet of _D. ordii_. Green vegetation made up a smaller portion of the diets, although Bradley and Mauer (1971) reported this as a major food item in the diet of _D. merriami_. Insects were taken in relatively small amounts, agreeing with the study of Bradley and Mauer for _D. merriami_, however, Blair (1937) did not consider insects as a food of _P. hispidus_. Seasonal differences in the diets of both species of heteromyids were not observed.

The diet of _P. maniculatus_ has been reported by several workers, notably Jameson (1952), Whitaker (1966) and Osborne and Sheppe (1971). Whitaker (1966) reported 32.9% of the food of _P. maniculatus_ from Indiana was animal material with cultivated and wild seeds and green vegetation comprising the remainder of the diet. The present study indicates that _P. maniculatus_ consumed seeds and insect material in nearly equal amounts, 44% and 42%, respectively. Green vegetation composed the remainder of the diet.

Food habits of *R. montanus* have not been reported. Insect material is important in the diet of this species also, comprising 33% of the diet. Seeds and green vegetation comprised 44% and 11% of the diet, respectively. The difference between the diets of *R. montanus* and *P. maniculatus* in the amount of insects and green vegetation is especially evident during the winter, resulting in no significant dietary overlap during these months. Both species also tend to shift their diets from insect material to seeds during the winter months. As a result, the diets of both species vary significantly between seasons.

Rodents are generally considered to be opportunistic in reference to their food habits. Certain studies indicate little selection for specific foods, with utilization of plant and animal material commensurate with availability (Whitaker, 1966; Zimmerman, 1965; Tappe, 1941; Blair, 1937). Studies of heteromyid rodents, however, tend to indicate some selection for seeds depending on seed size (Rosenzweig and Sterner, 1970). The present study clearly indicates preference for certain seeds. If the measurement of seed availability is correct, from 33% to 50% of the seeds eaten by *P. hispidus* and *D. ordii* were taken in larger amounts than might be expected on the basis of availability. In the cricetine rodents, seed preference of *P. maniculatus* and *R. montanus* was less evident with the greatest amount of selection occurring during winter months. In the case of the latter two species, a change in diet from insects during the spring to seeds in the winter may have resulted in the increased selectivity.

The significance of dietary overlap as an indicator of competition among herbivores appears to be an important question. On one hand, Slobodkin *et al.* (1967) have indicated that food is not limiting to herbivores, based on the assumption that food of herbivores is always plentiful. Studies by Odum *et al.* (1962) and Fleharty and Olson (1969) appear to substantiate this concept. On the other hand, Hansen and Ueckert (1970) support the concept that microsympatric species whose diets are similar are ecologically similar and are in intense competition. The main argument appears to lie in the realm of whether food of herbivorous species is limiting, and this probably depends on the habitat and local, environmental conditions.

Food may have been a limiting resource during the period of this study. The fact that precipitation was lacking during a period of 9 months probably accounted for the dramatic drop in rodent populations on the study areas during summer months. Indeed, the vegetation was depauperate during this period of time, and food might be considered to have been limiting. The dietary overlap between the four species of rodents investigated is significant during one or both seasons, and competition for food may be severe during periods of drought that often occur in this region of Texas.

Competition is probably reduced by habitat separation in the case of _D. ordii_ and _P. hispidus_. During the periods of collecting at Study Area I, a given trap-line often traversed areas of differing soil types. It was noted that _D. ordii_ was trapped most often on loose, sandy soils, and _P. hispidus_ was found on the heavier, deep soils, a phenomenon noted by Blair (1937). Perhaps _D. ordii_ and _P. hispidus_ avoid intense competition by utilizing different areas of the habitat as has been noted for other organisms (Andrews, 1971; Orians and Horn, 1969; Rosenzweig and Winaker, 1969). This habitat separation is probably not a result of competitive exclusion. There is ample evidence to indicate that _D. ordii_ is normally found in sandy soils and _P. hispidus_ occurs in areas of deeper soils, and the two species probably occur together in large numbers only when these two soil types are present in the same habitat.

No such habitat differences were noted between the two species of heteromyids and _P. maniculatus_ and _R. montanus_. The latter two species were present in such low numbers throughout the year that little can be concluded. It is apparent that _P. maniculatus_ and _R. montanus_ shift their spring diets of insect material to seeds during the winter. If competition exists between these two species and the heteromyids, it is more severe during the winter, when the diets of all four species are chiefly seeds. It is reasonable to conclude that the degree of competition between these four species of rodents changes seasonally and is most severe during the winter, especially those winters following droughts.

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