SUMMER FOOD HABITS OF A SMALL MAMMAL COMMUNITY IN THE PINYON-JUNIPER ECOSYSTEM

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Abstract.— Summer food habits of a small mammal community in the Piceance Basin of Colorado were investigated during 1977 and 1978 using a combination of fecal and stomach content analyses. Three species, deer mice (*Peromyscus maniculatus*), least chipmunks (*Eutamias minimus*), and plains pocket mice (*Perognathus flavescens*) consumed arthropods as the majority of their diets. Bushy-tailed woodrats (*Neotoma cinerea*) consumed predominantly woody vegetation, and the diet of golden-mantled ground squirrels (*Spermophilus lateralis*) consisted primarily of forbs and fungi. Mountain cottontails (*Sylvilagus nuttalli*) depended heavily on grasses, with a mix of woody vegetation and forbs composing the remainder of their diet. Most of the species investigated selected different foods and thus avoided competition for food. Plains pocket mice may have competed with deer mice for arthropods in 1977.

The Piceance Basin of Colorado is an area where oil shale developments are occurring at a rapid rate. The food habits of small mammals occurring in the Piceance Basin are poorly understood. It is important to determine wildlife food habits so that wildlife foods and food chains can be considered in impact assessments. It was therefore considered important to investigate small mammal food habits and foraging relationships in the Piceance Basin. Food habits of deer mice (*Peromyscus maniculatus*), plains pocket mice (*Perognathus flavescens*), golden-mantled ground squirrels (*Spermophilus lateralis*), bushy-tailed woodrats (*Neotoma cinerea*), least chipmunks (*Eutamias minimus*), and mountain cottontails (*Sylvilagus nuttalli*) were investigated during the summers of 1977 and 1978.

Study Area

The Piceance Basin covers an area of approximately 3500 km^2. It is a rolling uplands area consisting of approximately 32% upland sagebrush communities, 35% pinyon-juniper communities, 20% mixed mountain shrub communities, 3% bottomland sagebrush communities, and 9% other associations or uses (Wymore 1974). Mean annual precipitation is 406 mm, and the mean annual temperature is about 7 C (Wymore 1974).

The study area for this investigation was situated along the edge of a chained and a mature, unchained pinyon-juniper woodland (Sec. 3 and 9, T3S, R97W). The area had a slope of 5–10% on a northwesterly aspect at an elevation of 2100–2150 m. Chaining of the area, a process that involves dragging a heavy chain behind two bulldozers to knock down vegetation, was done 10 years prior to this study.

Vegetation on the study area was stratified into two types: the mature pinyon-juniper woodland and the chained area dominated by sagebrush and other shrubs. Vegetative cover was described by use of the line intercept method (Gysel and Lyon 1980). The edge between these two vegetation types was very narrow, lacking a discernible ecotonal area.

In the mature pinyon-juniper woodland, an overstory of pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) accounted for approximately 85% of the total vegetative cover of the area (Table 1). Shrubs in the understory accounted for 10% of the vegetative cover and included big sagebrush (*Artemisia tridentata*), Utah serviceberry (*Amelanchier utahensis*), alder-leaf mountain mahogany (*Cercocarpus montanus*), antelope bitterbrush (*Purshia tridentata*), snowberry (*Symphoricarpus oreophilus*), and several species of rabbitbrush (*Chrysothamnus* spp.). A number of species of grasses and forbs composed the remaining 5% of the vegetative

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cover. Dominant grasses were western wheatgrass (*Agropyron smithii*), prairie junegrass (*Koeleria cristata*), needle-and-thread grass (*Stipa comata*), and downy brome (*Bromus tectorum*). The most abundant forbs included thistle (*Cirsium* sp.), prickly pear (*Opuntia polyacantha*), mallow (*Sphaeralcea coccinia*), fleabane (*Erigeron* sp.), and penstemon (*Penstemon* sp.). It should be noted that 1977 was an exceptionally dry year in the Piceance Basin (Rio Blanco Oil Shale Project 1978), reducing the relative amounts of grasses and forbs.

Chained pinyon-juniper areas contained the same composition of plant species as the mature pinyon-juniper woodlands. Amounts of these species differed considerably, however. Pinyon pine and Utah juniper composed only 21% of the vegetative cover (Table 1). Shrubs composed approximately 63% of the vegetative cover, with big sagebrush, Utah serviceberry, and snowberry the most abundant species.

Methods

Food habits of selected species were determined in both 1977 and 1978 by the use of fecal analysis. Scats for the fecal analyses were collected from first-time captures of animals in live traps located throughout the study area during June and July. Collected scats were dried and stored in envelopes until analysis. In addition, food habits of selected species were determined by the use of stomach content analyses in June 1978. Selected species were collected by trapping or shooting, and their stomach contents were removed and frozen. Both fecal and stomach content analyses were conducted at the Composition Analysis Laboratory in the Department of Range Science at Colorado State University.

Fecal analysis is a procedure in which plant fragments in the feces of herbivores are microscopically identified. Arthropod parts in the feces of an animal can also be identified in this process using lower magnification. The Sparks and Malechek method (1968), using microscopic techniques for estimating percentage of dry weight expressed as percent relative density of each item in a diet, was utilized by the Composition Analysis Laboratory.

Analysis of omnivore feces in 1977 utilized a two-stage analysis. The first stage identified arthropods in the diet using a chosen number of low magnification "fields." The second stage of the analysis used a chosen number of high-power "points" for the identification of plant species.

In 1977 both fields and points were used in sample analyses. In 1978 only the high-power point analysis was used in the fecal analyses. This provided information on amounts of plant species and on the total amounts of arthropods in each diet, but did not break down the arthropod component. Stomach contents of animals collected in 1978 were also analyzed for composition of food items using the point analysis.

Chipmunk food habits were to be determined in both 1977 and 1978, but small chipmunk populations during the sampling period made it unfeasible to collect an adequate sample size in 1978.

Means and standard errors were determined for all food items. Stomach contents and fecal samples were compared by the use of a t test to determine important food items in the diet of deer mice. Comparisons were also made between deer mice food habits in 1977 and 1978.

Results

In 1977, 72 fecal samples from deer mice were collected. These were combined into 24 composite fecal samples of 3 deer mice each. Similarly, fecal samples from 60 least chipmunks were combined to make 20 composite fecal samples of 3 least chipmunks each. Twelve individual fecal samples from golden-mantled ground squirrels were analyzed, as were 8 individual fecal samples from bushy-

TABLE 1. Percent cover of vegetation categories in vegetation types sampled in the Piceance Basin, Colorado, July 1977. Cover values are means and standard errors.

Study area	Unchained pinyon-juniper woodland	Chained area
Grasses	1.23 ± 0.12	1.94 ± 0.17
Forbs	0.94 ± 0.60	0.67 ± 0.10
Shrubs	4.33 ± 0.66	10.44 ± 1.06
Trees	37.69 ± 2.01	3.56 ± 0.54

tailed woodrats and 10 individual fecal samples from plains pocket mice. Means and standard errors of all food items comprising at least 1.0% of the diet of these five species are listed in Table 2. Arthropods identified in the feces of the omnivorous species (deer mice, least chipmunks, plains pocket mice, and golden-mantled ground squirrels) are listed in Table 3.

Stomach contents from 1978 sampling were analyzed for 43 deer mice, 10 cottontails, and 8 golden-mantled ground squirrels. In addition, 62 composite fecal samples of 3 deer mice each were analyzed in 1978.

In 1978, only two food items were found to compose more than 1.0% of the diet of deer mice based on either fecal or stomach analyses. Fecal analyses revealed that arthropods composed 95.8% of the diet of deer mice, with a standard error of 1.0%. Seeds composed 1.60 ± 0.9% (mean and standard error) of the diet based on fecal analyses. Analyses of stomach contents indicated that 83.8 ± 2.4% of the diet was arthropods, and 14.5 ± 2.4% of the diet was seeds. Comparisons of fecal to stomach contents by the use of a t test revealed that estimates of both arthropods and seeds in the diets were different ($p<0.001$). In addition, arthropod and seed estimates determined by fecal analysis were compared between 1977 and 1978. No difference was found in seeds ($p>0.05$), but arthropod estimates were lower in 1977 than in 1978 ($p<0.01$).

Major food items identified in the stomach contents of cottontails and golden-mantled ground squirrels in 1978 are listed in Table 4.

DISCUSSION

In 1977 the diet of deer mice consisted predominantly of arthropods. No other food item composed more than 2.0% of the diet, as determined by fecal analysis. Although past investigations have identified insects as important foods of deer mice, especially in the

TABLE 2. Food habits as determined by fecal analysis of selected small mammals sampled during July–August 1977 in the Piceance Basin, Colorado. Values are means and standard errors of percent relative density of food items accounting for more than 1.0% of the diet of a species.

Food item	Deer Mice N = 24	Chipmunks N = 20	Bushy-tailed woodrat N = 8	Plains pocket mice N = 10	Golden-mantled ground squirrel N = 12
Grasses					
Agropyron					1.5 ± 1.5
Koeleria					2.7 ± 2.7
Stipa					1.1 ± 1.0
Bromus				2.9 ± 2.0	
Forbs					
Astragalus			1.5 ± 0.9		6.2 ± 3.9
Erigeron		2.8 ± 1.0	1.2 ± 0.7		6.4 ± 2.7
Cirsium	1.1 ± 0.6	6.1 ± 2.2			31.2 ± 11.0
Phlox				5.1 ± 4.8	
Spaeralcea			11.5 ± 5.1		2.9 ± 1.2
Balsamorhiza					3.9 ± 2.5
Opuntia		1.9 ± 1.9			
Woody vegetation					
Purshia tridentata			65.5 ± 4.2		16.6 ± 6.8
Artemisia		1.3 ± 0.5			
Symphoricarpos			10.2 ± 4.2		
Cercocarpus	1.1 ± 0.3	2.2 ± 1.5			
Amelanchier					9.0 ± 3.7
Quercus				3.2 ± 3.2	
Pinus	1.3 ± 0.3	4.0 ± 0.9	2.3 ± 2.0	3.2 ± 2.1	
Juniperus	1.0 ± 0.3	4.3 ± 1.2	4.4 ± 1.7	16.8 ± 9.0	
Lichen		1.3 ± 0.7			6.3 ± 5.6
Moss	1.7 ± 0.4	2.2 ± 0.8		1.6 ± 1.6	
Seed				3.5 ± 2.1	1.5 ± 0.8
Arthropods	90.8 ± 1.5	70.6 ± 3.1		59.5 ± 12.7	7.3 ± 1.9

spring, only Jameson (1952) found insects composing a comparable amount of the diet of deer mice. Shepard (1972), investigating deer mice food habits in the pinyon-juniper ecosystem, reported insects to compose about 62% of the diet of deer mice in the spring and summer. Goodwin and Hungerford (1979) found that deer mice ate 13% insects and 70% forbs in the ponderosa pine ecosystem. It was first hypothesized that the high level of arthropods in the diet of deer mice in 1977 might have been caused by dry conditions that year and a corresponding lack of seed production. Growth of grasses and forbs was very poor, with many species failing to flower or seed. Analysis of deer mice food habits in 1978, a more normal year in terms of precipitation, discredited this hypothesis. Deer mice consumption of arthropods in 1978 was significantly greater than in 1977, even though abundant amounts of seeds and vegetation were present. Johnson (1961), Shepard (1972), and Vaughan (1974) reported that insects were the preferred diet of deer mice when available, which agrees with the findings of this study.

In 1978 arthropods composed about 84% of the diet of deer mice as determined by stomach content analysis. This amount was significantly lower than the percentage identified in the fecal analysis. Thus it appears that fecal analysis may overemphasize the importance of arthropods in the diet, because the stomach contents were felt to be a more accurate sampling method than the fecal samples. Stomach contents composed of 84% arthropods, however, still reflect a large amount compared to other studies. It may be that the large amount of slash present in the study area in the Piceance Basin supported sizable arthropod populations, increasing deer mice use of these food items. The high percentage of Coleoptera and Formicidae identified in the diet of the deer mice in 1977 would support this explanation.

In 1977 chipmunks depended heavily on arthropods. Like the deer mice, they ate a high percentage of Coleoptera. They ate appreciably more Lepidoptera larvae than deer mice, however. This may have reflected the availability of arthropods during the period when the diurnal chipmunks were most active as opposed to when the nocturnal deer mice were most active. This difference may also have been influenced by the different foraging areas of deer mice and chipmunks reported by Johnson (1961). The high percentage of arthropods eaten by chipmunks may have been caused by the scarcity of plant foods due to the dry conditions in 1977 (approximately 30% of their diet was composed of plant matter in 1977). The number and amount of plant species eaten support Vaughan's (1974) observation that chipmunks were a more generalized feeder than deer mice.

Table 3. Important orders of arthropods in the diets of omnivorous small mammals during July–August 1977 in the Piceance Basin, Colorado. Values are means and standard errors of percent relative density of food items.

	Deer mice	Chipmunks	Plains pocket mice	Golden-mantled ground squirrel
Sample size	24	20	10	12
Total percentages in the diet	90.8 ± 1.5	70.6 ± 3.1	59.5 ± 12.7	7.3 ± 1.9
	Relative density of arthropods			
Class Arachnida				
Order: Araneida	2.1 ± 0.4	0.1 ± 0.1		
Class Insecta				
Order: Coleoptera	53.0 ± 4.9	52.2 ± 5.8	11.2 ± 9.9	6.3 ± 4.1
Order: Hymenoptera				
Family: Formicidae	21.3 ± 4.4	2.3 ± 0.9	2.1 ± 1.1	8.9 ± 4.8
Others	2.1 ± 1.1	3.9 ± 1.3	11.9 ± 8.7	11.6 ± 8.0
Order: Lepidoptera	13.8 ± 2.9	25.5 ± 4.3	30.0 ± 13.5	
Order: Orthoptera	4.6 ± 0.8	8.1 ± 3.2	2.4 ± 2.4	
Other insects	0.1	0.2	11.5	10.6
Plant material	2.5 ± 0.7	7.9 ± 4.0	30.8 ± 26.4	55.7 ± 20.6
Hair				6.8

Plains pocket mice were also found to consume a large percentage of arthropods in 1977. This result is contrary to the seed-eating food habits usually attributed to pocket mice (Martin et al. 1951). In 1977 they were found to eat 59% arthropods, based on fecal analysis. Undoubtedly, the lack of seed production in 1977 influenced the food habits of this species, and may have caused increased competition for food between the pocket mice and deer mice and chipmunks.

Golden-mantled ground squirrel diets were determined for both 1977 and 1978. Statistical comparisons between the two years were not deemed valid, however, because fecal analysis was used in 1977 and stomach content analysis was used in 1978.

In 1977, golden-mantled ground squirrels depended heavily on the relatively few types of forbs available. Thistle, a fairly drought-tolerant plant, was available in 1977. This plant composed about 30% of the diet of ground squirrels as indicated by fecal analysis. Bitterbrush also was consumed in large amounts. Arthropods composed only about 7% of the diet of the ground squirrels. This diet was similar to that reported by Goodwin and Hungerford (1979), with the exception of the bitterbrush component.

In 1978 the diet determined for golden-mantled ground squirrels was quite different

TABLE 4. Food items composing greater than 1.0% of identified stomach contents of cottontails and golden-mantled ground squirrels collected in the Piceance Basin, Colorado, during June 1978. Values are means and standard errors of percent relative densities determined by high-power microscopic analysis.

Food item	Cottontail N = 10	Golden-mantled ground squirrel N = 8
Bromus	30.7 ± 2.9	
Carex	4.1 ± 1.3	
Oryzopsis	1.0 ± 0.5	
Poa	2.8 ± 1.3	
Stipa	8.4 ± 3.9	
Amelanchier	17.3 ± 5.0	
Antennaria	2.2 ± 1.6	6.2 ± 6.2
Astragalus	10.4 ± 2.7	8.0 ± 6.8
Crepis		2.1 ± 2.1
Erigeron	1.5 ± 0.5	
Flower parts		6.6 ± 6.6
Fungus		64.1 ± 13.9
Lupinus		5.3 ± 3.6
Sphaeralcea	14.6 ± 6.6	
Unknown forb	2.4 ± 1.4	
Arthropod		6.3 ± 4.5

than that determined for 1977. Fungi composed about 64% of the stomach contents. No fungi were identified in the feces in 1977. Two reasons could explain this. First, fungi are readily digested and are therefore hard to distinguish in feces. Alternatively, the drought conditions in 1977 would preclude the growth of most fungi, making them unavailable as a food; growing conditions in 1978 were more favorable.

Forbs were a preferred food of ground squirrels in the Piceance Basin, with woody vegetation apparently of low palatability but eaten to some extent. Tevis (1952) reported seeds as an important component of the diet, as did Martin et al. (1951), but these were not identified as a major food item in this investigation, composing only about 1% of the diet. McKeever's (1963) findings were similar to those of this investigation. Arthropods have been reported to be a small but consistent component of the diet of golden-mantled ground squirrels, a finding supported by the results of both years of this investigation.

Bushy-tailed woodrats were found to be herbivorous, eating plant foods even in the dry year of 1977. This supports the findings of Findley (1958). In 1977 woody plants accounted for over 75% of the diet, with bitterbrush being the predominant food item identified. Forbs were also eaten, but composed less than 15% of the diet in 1977. It is possible that in years with more rainfall than 1977 had, a greater amount of forbs might be eaten. By eating woody vegetation, however, bushy-tailed woodrats may avoid competition with other forb-eating small mammals.

Cottontail rabbits were herbivorous, depending upon grasses for nearly half their diet in 1978. Forbs and serviceberry composed the remainder of their diet. These foods would not place cottontails in significant competition with the other small mammals.

CONCLUSION

Most of the species investigated appeared to avoid competition for food by selecting different food items as the main component of their diets. A possible exception was the arthropod component of the diet of plains pocket mice. The dry condition in 1977 may