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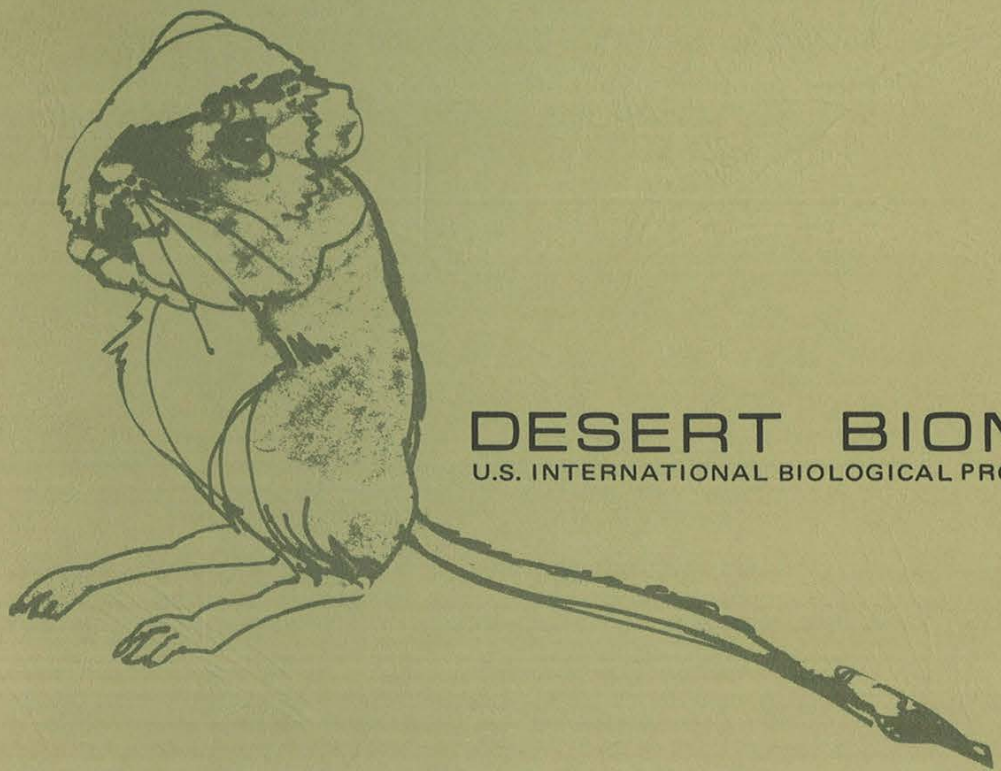

DESERT BIOME
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1972 PROGRESS REPORT

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ABSTRACT

Annual nutrient and energy intake of *Sylvilagus audubonii* were studied under natural conditions for the initial 7 months of the 16-month study. Diets were determined by stomach analysis for three vegetative growth periods from March through September, 1972. Pace transects were used to estimate relative abundance of plant species on the study location, an area equivalent to the Silverbell Validation Site of the Desert Biome. Protein, crude fiber, calcium, phosphorus, and net energy were determined for important plant species.

Twenty-four plant species were identified in the diet. Eight species accounted for 75% of the dry weight consumed: *Eragrostis superba, Opuntia* spp., *Plantago purshii, Tridens pulchellus, Boerhaavia* sp., *Acacia* spp., *Eriogonum* sp., and *Erodium cicutarium*. There were definite changes in the composition of the diet and in preferred species through three sampling periods: March-April, May-June and July-September. Completion of the 16-month span of the study will complete the annual sequence, and thus indicate how desert cottontail dietary requirements are adjusted to seasons of low rainfall.

INTRODUCTION

Desert ecosystems are open systems with ample energy (sunlight) input for their operation. The diversity and abundance of animals depends upon adaptation to a highly variable plant food supply, which is related to rainfall. The desert cottontail, *Sylvilagus auduboni*, a well-adapted primary consumer, is important in some ecosystems because of its relatively large biomass contributions to several secondary consumers (mammalian, avian and reptilian). Quantification of the relation of this important game species to forage plants in terms of energy and important minerals should provide some important ecological insights.

Food habits reports for the desert cottontail are at present limited to general observations. Bailey (1931) commented that cottontails in New Mexico ate a great variety of vegetation, but he did not identify any specific plants. Orr (1940) also made general observations for cottontails in California. Fitch (1947) concluded that the food of cottontails consisted almost entirely of annual grasses and broad-leaf herbs of the Meditarranean-annual type in the Sierra Nevada foothills of southern California. Ingles (1941) observed some of the plant items selected by desert cottontails in an intensively farmed area in the Sacramento Valley, California. These studies are either not quantitative or not within the desert biome.

In this study we hope to combine quantitative information on food consumption with that on population dynamics in order to estimate chemical cycling and energy degradation for desert cottontails within a desert ecosystem. This report covers the results of the first 7 months of the study, which include three growing conditions of vegetation. Precipitation for the first 4 months of the study period was unusually low and the study extension will allow for more complete data collection and thus enhance the validity of the results.

OBJECTIVES

Specific objectives of this study are:

1. To ascertain the kinds of plants consumed by desert cottontails during an annual cycle.
2. To determine the energy, nitrogen, phosphorus and calcium contents of the plant species that form the bulk of the cottontail's diet.
3. To relate plant intake to plant availability.
4. To estimate the energy and nutrient intake of desert cottontails under field conditions.

Only the first three objectives can be reported upon here.

METHODS

The study area

The Sugarloaf Mountain area of the Tonto Forest, 74 km North of Phoenix, is ecologically similar to the Silverbell Validation Site, which lies within what is often termed the palo verde-cacti desert type. *Cercidium microphyllum* is the dominant tree. *Carnegiea gigantea* occurs sparingly. Several species of *Opuntia* are dispersed over the area. The prominent shrub is *Franseria deltoidea*. Other woody plants that give character to the site are *Lycium* spp., *Fouquieria splendens*, *Acacia greggii*, *A. constricta*, and *Encelia farinosa*.

During spring, whenever winter moisture is adequate, numerous annuals are present. Prominent species are *Erodium cicutarium*, *Plantago insularis*, *Schismus barbatus*, *Lupinus* spp., *Lesquerella* spp., *Calochortus* spp. and *Phacelia* spp. During summer, grasses and perennial forbs occupy the intershrub spaces. Abundant annual grasses include *Bouteloua barbata* and *B. aristidoides*. Perennial forbs include *Cucurbita* spp., *Janusia* spp., *Ipomoea* spp., and *Clematis* spp. Tables 1 and 2 list relative abundance of overstory and understory plants on the study area during each sampling period.

Table 1. Overstory plant species -- abundance on Sugarloaf Mountain study area (based on percentage of occurrences in 30-100 pace transects)

Species	Trees and shrubs	% Ground cover
Acacia greggii		2.7
Yucca elata		2.7
Simmondsia chinensis		2.1
Opuntia versicolor		1.9
Haplopappus larcifolius		1.8
Franseria deltoidea		1.6
Cercidium microphyllum		1.6
Opuntia engelmannii		1.4
Thamnosma montana		1.0
Celtis pallida		1.0
Opuntia bigelovii		1.0
Acacia constricta		.9
Krameria parvifolia		.7
Canotia holacantha		.6
Calliandra eriophylla		.5
Condalia lycioides		.3
Lycium pallidum		.2
Prosopis velutina		.2
Larrea divaricata		.1
Lycium velutina		.1
Fouquieria splendens		.1
Encelia farinosa		.1
Carnegiea gigantea		T
Dodonaea viscosa		T
Janusia gracilis		T
Echinocereus sp.		T
Total for shrubs and trees		22.6

Table 2. Herb plant species -- seasonal abundance on Sugarloaf Mountain study area (based on percentage of occurrences in 10-100 pace transects per season)

Species	Grasses and forbs		
	March-April	May-June	July-Aug.-Sept.
	% Ground cover		
Aristida adscensionis (G)	8.8	1.8	5.0
Plantago purshii (F)	4.4	T	---
Bromus rubens (G)	4.1	1.8	---
Erodium cicutarium (F)	2.6	.3	---
Euphorbia polycarpa (F)	1.3	.7	.3
Lepidium lasiocarpum (F)	1.3	---	---
Lupinus sparsiflorus (F)	.9	T	T
Amsinckia intermedia (F)	.8	---	---
Lotus wrightii (F)	.7	---	---
Pectocarya recurvata (F)	.7	---	---
Gilia sp. (F)	.6	---	---
Mahonia repens (F)	.6	---	---
Tridens pulchellus (G)	.6	.5	.3
Eriogonum wrightii (F)	.5	.4	.1
Baileya multiradiata (F)	.2	---	---
Panicum sp. (G)	.1	---	---
Lesquerella sp. (F)	.1	.2	---
Ambrosia deltoidea (F)	T	---	---
Aristolochia watsonii (F)	T	---	---
Cryptantha sp. (F)	T	T	T
Cryptantha pterocarya (F)	T	---	---
Dyssodia porophylloides (F)	T	---	---
Porophyllum gracile (F)	T	---	---
Rumex hymenosephalus (F)	T	---	---
Senecio monoensis (F)	T	---	---
Cucurbita foetidissima (F)	T	---	---
Proboscidea arenaria (F)	---	---	.1
Bouteloua barbata (G)	---	---	.1
Muhlenbergia porteri (G)	.6	.4	---
Aristida arizonica (G)	---	.6	---
Bouteloua hirsuta (G)	---	---	.4
Bouteloua eriopoda (G)	---	---	.5
Monodora sp. (F)	---	---	.1
Allionia incarnata (F)	T	.1	---
Eragrostis superba (G)	T	T	T
Delphinium sp. (F)	T	---	---
Erysimum capitatum (F)	---	T	T
Solanum jamesii (F)	---	---	T
Berberis repens (F)	T	---	---
Grasses and forbs	28.9	6.8	6.9
Shrubs and trees	22.6	22.6	22.6
Total plant cover	51.5	29.4	29.5

G = grass; F = forb; T = trace amount

Elevation of the study area is 850 m. Annual rainfall since 1895 has averaged 18.3 cm. The soil is coarse, shallow, and composed mainly of decomposed granite. Topography is gently rolling with occasional deep ravines and boulder piles. No permanent water is present except that provided for livestock, which graze the area all year.

Procedures

Cottontails were collected on the Sugarloaf Mountain area with at least 15 individuals referenced to each of the phenological periods of vegetation development (16 specimens for May-June), namely: 1) spring growth period (March and April); 2) summer drought season (May and June); and 3) summer growing season (July, August and September). Specimens were stored frozen. Each cottontail was weighed and sexed prior to removal of the stomach.

Relative abundance of plant species for each collecting period on the study area was determined by 10-pace transects for each collecting period (Costello and Schwan, 1946). At each collecting date, as dictated by changes in vegetation, ten random lines of 100 steps were paced across the study area. Each plant encountered at a point on the toe was recorded by species, thus species composition of the total vegetative ground cover was determined. The adequacy of this method for our study is questionable, since some of the species that were important in the diet of our cottontails were not detected in the transects. The transects themselves may be inadequate, or the cottontails may be feeding in areas other than where the transects were made.

Representative samples were collected of each anticipated major plant species in the cottontail habitat coincident with animal collections. The food items that were important for cottontails were analyzed for gross content of protein (nitrogen), calcium, phosphorus, crude fiber, and energy, according to accepted procedures (Assoc. Off. Agr. Chem., 1965). A commercial laboratory in Phoenix, Arizona, did the plant analyses.

Stomach contents of cottontails were analyzed by the microtechnique method pioneered by Dusi (1949). Sparks and Malachek (1968) have also used the technique successfully. Keith et al. (1959) and Flinders and Hansen (1972) further refined the method and applied it to analysis of stomach contents of gophers.

Stomach contents were dried in an oven at 70 C and then ground in a mill over a 1-mm screen. Two microscope slides were prepared from each stomach sample after it had been washed over a 0.1-mm screen (Sparks and Malechek, 1968). Slides were prepared with Hertwig's solution (Baumgartner and Martin, 1939) and Hoyer's solution (Baker and Wharton, 1952) and were dried at 60 C for about 72 hr.

Tissues of identified plants from the study area were mounted on microscopic slides as described by Brusven and Mulkern (1960). The histological characteristics of the epidermis of these identified plants were used as a basis for the identification of plant fragments that were found in the stomach contents of cottontails.

Relative percent of herbage in the monthly diets of cottontails was estimated by microscopic examination of the slides made from the stomach contents at 100X magnification. Forty fields were examined on the two slides made from each cottontail's stomach contents. Fields were selected in a restricted random manner so that each contained at least one fragment of epidermal tissue. Each recognized plant species within each field was recorded, and the percent frequency was then converted to particle density per field (Fracker and Brischle, 1944). Particle density of each food item was then expressed in relative terms, as the percentage of total number of particles of all plant species (Table 3).

A "preference index" was calculated for each item in the diet as:

$$PI = \frac{\text{average relative density per stomach}}{\text{relative ground cover}}$$

Relative density is as given in Table 4 and relative ground cover was calculated from the data of Tables 1 and 2. An index greater than 1.0 suggests that the item is being eaten in greater proportion than its availability in the habitat, i.e. it is selected for or "preferred". An index of less than 1.0 suggests that the item is being ignored. Of course, the coverage of trees and shrubs does not necessarily represent the leaves and young stems that are physically within reach of the cottontails. Coverage of trees and shrubs may overrepresent availability. The use of the PI index is confounded by the diet items that were not recorded in the plant transects or were present only in trace amounts. In these cases PI = ∞. For each sampling period the preferred dietary items were ranked (Table 4). Those items that had PI = ∞ were ranked according to their relative density, if it was 0.50 or greater. Other items were ranked according to their PI. Items with PI = ∞, but relative density of less than 0.50, and items with PI <1.0, were not ranked.

Table 3. Seasonal occurrences of plants in diets of cottontails, plants listed in order of abundance in stomachs for the total period

Plant Species	March-April		May-June		July-August-September		Total for all periods	
	Frequency of occurrence (% of stomachs)	% Average relative density per stomach	Frequency of occurrence (% of stomachs)	% Average relative density per stomach	Frequency of occurrence (% of stomachs)	% Average relative density per stomach	Frequency of occurrence (% of stomachs)	% Average relative density per stomach
Eragrostis superba (G)	46.66	3.12	68.75	31.85	100.00	56.75	71.74	30.60
Opuntia spp. (S)	40.00	1.09	100.00	32.21	80.00	12.21	73.91	15.54
Plantago purshii (F)	40.00	22.13	37.50	.74	---	--	26.07	7.47
Tridens pulchellus (G)	80.00	15.38	43.75	6.48	13.33	.06	45.65	7.29
Boerhaavia sp. (F)	6.66	.02	18.75	6.16	60.00	14.11	28.26	6.75
Acacia spp. (S)	40.00	7.87	18.75	.76	53.33	7.88	36.96	5.40
Eriogonum wrightii (F)	66.66	15.75	6.00	.06	---	--	23.91	5.16
Erodium cicutarium (F)	66.66	13.80	37.50	1.39	---	--	34.78	4.98
Lupinus sparsiflorus (F)	46.66	5.52	37.50	6.58	6.66	.20	30.43	4.15
Bromus rubens (G)	73.33	5.71	56.25	2.08	26.66	.23	52.17	2.66
Erysimum capitatum (F)	--	--	6.00	4.08	26.66	2.06	10.87	2.09
Aristida spp. (G)	40.00	1.33	50.00	2.22	53.33	2.06	47.83	1.88
Cryptantha spp. (F)	26.66	3.61	37.50	1.85	20.00	.06	28.26	1.84
Sphaeralcea ambigua (F)	13.33	.22	12.50	2.68	20.00	.27	15.21	1.09
Solanum jamesii (F)	--	--	--	--	26.66	2.68	8.70	.87
Calliandra eriophylla (S)	20.00	2.39	--	--	6.66	.06	8.70	.80
Delphinium sp. (F)	26.66	.75	--	--	---	--	8.70	.25
Lepidium lasiocarpum (F)	13.33	.43	--	--	---	--	4.35	.14
Haplopappus laricifolius (S)	13.33	.27	--	--	---	--	4.35	.09
Yucca elata (S)	6.66	.08	12.50	.09	---	--	6.52	.06
Allium sp. (F)	6.66	.08	--	--	---	--	2.18	.02
Lycium velutina (S)	6.66	.06	--	--	---	--	2.18	.02
Berberis repens (F)	6.66	.05	--	--	---	--	2.18	.02
Franseria deltoidea (S)	6.66	.05	--	--	---	--	2.18	.02

G = grass; F = forb; S = shrub or tree

Table 4. Preference indices (PI) of various taxa of plants in the three collecting periods

Category	Species	March-April PI	March-April Rank	May-June PI	May-June Rank	July-Sept. PI	July-Sept. Rank
F	*Cryptantha* spp.	∞	(1)	∞	(6)	---	
G	*Eragrostis superba*	∞	(2)	∞	(1)	∞	(1)
F	*Delphinium* sp.	∞	(3)	---		---	
F	*Eriogonum* sp.	16.24	(4)	0.04	---	---	
G	*Tridens pulchellus*	13.25	(5)	3.81	(8)	0.06	---
F	*Lupinus sparsiflorus*	3.15	(6)	∞	(2)	a	---
F	*Erodium cicutarium*	2.73	(7)	1.36	(10)	---	
F	*Plantago purshii*	2.59	(8)	∞	(7)	---	
S	*Calliandra eriophylla*	2.46	(9)	---		0.04	---
S	*Acacia* spp.	1.13	(10)	0.06	---	0.65	---
F	*Boerhaavia* sp.	a*	---	∞	(3)	∞	(2)
F	*Erysimum capitatum*	-----		∞	(4)	∞	(4)
F	*Sphaeralcea ambigua*	a	---	∞	(5)	a	---
S	*Opuntia* spp.	0.13	---	2.20	(9)	0.83	---
F	*Solanum jamesii*	-----		----		∞	(3)
G	*Bromus rubens*	0.72	---	0.61	---	a	---
G	*Aristida* spp.	0.08	---	0.39	---	0.41	---
F	*Lepidium lasiocarpa*	0.17	---	----		----	
F	*Allium* sp.	a	---	----		----	
F	*Berberis repens*	a	---	----		----	
S	*Haplopappus larcifolium*	0.08	---	----		----	
S	*Yucca elata*	0.02	---	----		----	
S	*Lycium velutina*	0.32	---	----		----	
S	*Franseria deltoidea*	0.02	---	----		----	
	All forbs	1.93		2.16		10.12	
	All grasses	1.08		3.58		2.77	
	All shrubs	0.27		0.43		0.26	

G = grass; F = forb; S = shrub or tree.
*a: PI = ∞, but relative density <0.50, therefore not ranked

RESULTS

Forty-six cottontails were collected in the three vegetative periods from March 1 to September 30, 1972. The sex ratio was 0.90 male to 1.0 female; the difference is not significant by a group-comparison t-test. Of the females, 50% were pregnant in the March-April period, 43% in May-June and 20% in July-September.

General food habits

The coverage of plant species in the study area is given in Tables 1 and 2. The mean number of species identified per stomach varied with sampling period (Table 5).

The most species were recorded for the March-April period and progressively fewer were found the next two periods. The greatest dietary difference between sexes was in March-April, when females ate an average of 9.8 species, which is 1.4 times the number eaten by males. The period of greatest plant diversity and cover coincided with that of greatest reproduction by cottontails. Fifty percent of the females were pregnant in the March-April period, 43% in May-June, and only 20% in July-September.

Table 5. Average number of plant species detected in seasonal diets of desert cottontails from March to September, 1972

	March-April	May-June	July, August, Sept.	Overall average
Males & Females	7.8	5.4	5.1	6.1
Males	7.2	5.2	6.0	5.7
Females	9.8	5.3	4.4	7.0

Twenty-four species or genera were identified in the stomach contents of the cottontails (Table 3): 4 grasses, 7 shrubs and trees, and 13 forbs. Only 16 of the 24 species individually made up at least 1% of the dry weight of the diet in at least one of the three sampling periods. Seven species accounted for 78% of the dry weight of the diet for the 7 months covered by Table 3.

The most abundant plant in the diet was a grass, *Eragrostis superba*, which accounted for 30.6% of the dry weight of the diet for the 7 months and occurred in 71% of the stomachs. A shrub-cactus, *Opuntia* spp., was second in abundance at 15.5% of total diet. *Opuntia* had the highest frequency of occurrence, 73.9%. It was not determined what portions of the cactus were consumed. However, the purple color that is characteristic of the fruits was observed in several stomachs. A forb, *Plantago purshii*, was the third most abundant dietary item (7.5% total weight), although it occurred in only 12 stomachs and was significant only in the first sampling period. One grass, 2 forbs and 1 shrub made up lesser amounts of the diet, but all were >5% of the total.

Seasonal food habits

Table 3 gives the composition of the diet for the three sampling periods, which were chosen to represent phases of plant reproduction. There was a successive decrease in the number of species in the diet and a greater concentration of dietary dominance in fewer species with each period.

In the March-April period 22 items were identified in the diet. Five plant species made up 75% of the diet, in order: *Plantago purshii*, *Eriogonum* sp., *Tridens pulchellus*, *Erodium cicutarium* and *Acacia* spp. *P. purshii* was a minor item in the second period and was not recorded in the third period.

In May-June only 15 items were identified, and four of these made up 77% of the diet: *Opuntia* spp., *Eragrostis superba*, *Lupinus sparsiflorus* and *T. pulchellus*. *Opuntia* was always available as 8 to 15% of the total plant cover, but in this period the fruits were beginning to ripen. Bailey (1923) determined that *Opuntia* fruits are 80% water, and since May-June, 1972, was exceptionally dry, the cactus may have been eaten for its moisture content.

In the July-September period there were only 13 plant items in the diet and only three species made up 83% of the diet: *E. superba*, *Boerhaavia* sp., and *Opuntia* spp. *E. superba* increased in quantity and frequency of occurrence from the first to third period, when it was present in all stomachs and averaged 57% of the diet.

Food preferences

Preference indices are summarized in Table 4 for individual species and genera and for general categories (forbs, grasses, shrubs). In the March-April period forbs are 6 of the first 8 in the ranking. The grass category is barely preferred, but two grasses ranked second and fifth: *E. superba* and *T. pulchellus*. The shrub category was not preferred, but two species ranked ninth and tenth among the 10 preferred species.

In the May-June period grass is the most preferred category, due to the preeminence of *E. superba* in the diet, although only trace amounts were detected in the transects. Seven forbs and 1 shrub are also preferred. There was a shift in shrub preference from *Acacia* and *Calliandra* in the first period to *Opuntia* in the second period.

In July-September forbs are again predominantly preferred over grasses, and shrubs as a category are ignored. None of the ranked species was found in more than a trace amount in the plant transects. All the plants found in the transects in more than trace amounts are not preferred, according to the PI.

Only two grasses ever achieved "preferred" status. *Eragrostis superba* was consistently first or second in the rankings. *Tridens pulchellus* went from high preference to low preference to ignored, in successive periods, although there was no significant change in its relative cover. Forbs showed a changing pattern of preference. Six species were preferred in the first or the first and second periods, but not the third period. Four other species were preferred in the second and/or third period, but not the

first. Three species of shrubs were preferred in the first or second period. Among the 24 species in the diet, only 15 rated as preferred in one period or another.

Nutrient and energy content of food plants

The species included in the analyses comprised at least 85% of the 7-month diet. Unfortunately we did not anticipate that *E. superba* would be an important food plant, but this species will be collected and analyzed in 1973. Various analyses are given in Tables 6 to 10.

Table 6. Protein content (%) of cottontail food plants collected on the Sugarloaf Mountain study area, 1972

Species	March April	May June	July Aug. Sept.
Opuntia sp.	---	2.72	9.30
Plantago purshii	11.37	--	--
Tridens pulchellus	7.43	4.46	7.63
Acacia sp.	21.25	15.04	18.0
Eriogonum sp.	9.34	7.11	--
Erodium cicutarium	22.00	7.95	--
Lupinus sparsiflorus	7.79	14.00	--
Bromus rubens	7.40	8.69	--
Aristida sp.	6.81	4.59	6.42
Cryptantha sp.	10.72	--	--
Sphaeralcea	12.58	--	--
Calliandra eriophylla	---	10.79	14.67
Lepidium lasiocarpum	14.62	--	--
Haplopappus larcifolius	11.55	--	--

Table 7. Seasonal crude fiber content (%) of cottontail food plants collected on the Sugarloaf Mountain study area, 1972

Species	March April	May June	July Aug. Sept.
Opuntia sp.	---	19.84	19.50
Tridens pulchellus	26.80	25.72	18.15
Acacia sp.	22.04	19.11	26.32
Eriogonum sp.	23.39	16.34	--
Erodium cicutarium	24.20	14.44	--
Lupinus sparsiflorus	23.80	37.70	--
Bromus rubens	31.10	28.80	--
Aristida sp.	28.72	25.33	28.49
Cryptantha sp.	18.98	--	--
Calliandra eriophylla	---	36.19	15.11
Lepidium lasiocarpum	27.54	--	--
Haplopappus larcifolius	26.94	--	--

Table 8. Seasonal calcium content (%) of cottontail food plants collected on the Sugarloaf Mountain study area, 1972

Species	March April	May June	July Aug. Sept.
Opuntia sp.	---	4.130	2.530
Tridens pulchellus	.625	.438	.562
Acacia sp.	1.125	1.938	.212
Eriogonum sp.	1.406	1.438	--
Erodium cicutarium	.066	1.062	--
Lupinus sparsiflorus	1.180	1.170	--
Bromus rubens	.625	.750	--
Aristida sp.	---	.500	.500
Cryptantha sp.	2.812	--	--
Calliandra eriophylla	---	.750	1.688
Lepidium lasiocarpum	1.312	--	--
Haplopappus larcifolius	1.312	--	--

Table 9. Seasonal phosphorus content (%) of cottontail food plants collected on the Sugarloaf Mountain study area, 1972

Species	March April	May June	July Aug. Sept.
Opuntia sp.	---	.090	.110
Tridens pulchellus	.140	.090	.120
Acacia sp.	.310	.150	.110
Eriogonum sp.	.175	.120	--
Erodium cicutarium	.160	.210	--
Lupinus sparsiflorus	.540	.350	--
Bromus rubens	.215	.145	--
Aristida sp.	---	.100	.140
Cryptantha sp.	.405	--	--
Calliandra eriophylla	---	.110	.190
Lepidium lasiocarpum	.310	--	--
Haplopappus larcifolius	.180	--	--

Table 10. Seasonal net energy (therms. per 100 pounds) of cottontail food plants collected on the Sugarloaf Mountain study area, 1972

Species	March April	May June	July Aug. Sept.
Tridens pulchellus	38.66	40.42	52.76
Acacia sp.	46.41	51.19	--
Eriogonum sp.	44.21	55.71	--
Erodium cicutarium	---	58.80	--
Brumus rubens	31.65	35.40	--
Aristida sp.	35.53	41.05	36.23
Cryptantha sp.	51.40	--	--
Calliandra eriophylla	---	--	57.71
Lepidium lasiocarpum	37.45	--	--
Haplopappus larcifolius	38.43	--	--

DISCUSSION

Plant quality and diet composition

It would be enlightening to be able to see some relationships between plant quality and quantity consumed and preference ranking. This is difficult because the analyses incompletely covered the dietary spectrum. Even with a complete series of analyses such comparisons might be hopelessly confounded by unknown factors of palatability, such as odor, taste and physical nature of the food.

In five of the seven cases in which comparison is possible, protein content was lower in May-June than March-April; in all five cases protein content was higher in July-September than May-June (Table 6). This suggests that protein content was high during the spring growth period, decreased during the dry May-June period, and increased again after the late summer rains. It is reasonable to expect that protein content will affect food selection by rabbits. *Acacia* had the consistently highest protein content; it was exceeded only by *Erodium cicutarium* in March-April. *Erodium* did rank second in quantity eaten and *Acacia* fifth. The interpretation of ranking of *Acacia* is confounded by the fact that this species usually did not have low-growing branches, and cottontails would have to stand on their hind legs to feed upon it. *Acacia* and *Erodium* ranked tenth and seventh in preference in March-April (Table 4). *Tridens pulchellus* ranked third and fourth in quantity and fifth and eighth in preference in March-April and May-June, respectively, although its protein content was relatively low. This grass was ignored as a food in July-September although its protein content was higher than before and its relative coverage was the same. There is no clear evidence that cottontails were selecting food on the basis of protein content.

Opuntia was the most abundant item in the diet (32%) in May-June, and it was a preferred species (ninth ranking), although its protein content was the lowest of all the values. This suggests *Opuntia* was being chosen for water content during this exceptionally dry period.

Crude fiber content had the same seasonal changes as protein content (Table 7.) In general there was an inverse relationship between protein content and crude fiber. Energy content (Table 10) was in all cases higher in the dry May-June period than in March-April, which is opposite to the trend for protein and crude fiber. In March-April the species that ranked high in energy content (Table 10) also ranked high in preference (Table 5), as far as comparisons can be made between the two different lists of species. This is not true in May-June; comparisons are not possible for July-September.

In general, phosphorus content was least in the dry May-June period (Table 9) and calcium was higher in May-June than March-April. It may be meaningful that *Cryptantha* ranked second in phosphorus and first in preference in March-April, and *Lupinus* ranked first in phosphorus and second in preference in May-June. Phosphorus is a limiting element for reproduction in some rodents. *Cryptantha* ranked first in calcium and preference in March-April. The very high calcium content of *Opuntia* may be related to its characteristic high oxalate content.

Other studies on different species of cottontails indicate that they usually preferred plants in the pre-seed growth stages, although some plants were important in all stages (Dusi, 1952; Bailey, 1969). Bailey reported that foods that are preferred and nutritious at one growth stage may be poor foods at other stages.

Diet composition, quantity and preference

Cottontails consumed about half the grasses and forb genera present in their habitat, indicating a moderate degree of dietary flexibility. Only one third of the shrub and tree genera that were present were detected in the diet.

Spring was clearly the time of greatest diversity of forbs (31 species were present in the transects); only 15 and 14 were present the other two periods. This diversity was repeated in the diet except that there were fewer dominants in the July-September diet. As is to be expected, the ranking of foods by their abundance in the diet is quite different from that of preference ranking. The difference between the quantity in the diet and preference in the diet and coverage in the plant transects suggests that the rabbits were very selective of some rare items or they were feeding part of the time in areas other than where the transects were taken.

There are several interesting changes in the status of a plant species from period to period, which are probably related to changes in its state of growth, or its condition relative to other plants. In successive sampling periods *Opuntia* goes from ignored, to low preference, to ignored; *Acacia* from very low preference in the first period to ignored in the last. Apparently *Opuntia* was preferred only in time of seasonal drought. *Tridens* goes from high preference, to low preference, to ignored in successive periods, although there was no significant change in its relative cover. Possibly the grass lost its succulence with time; judging from the protein contents, this grass did show new growth in August-September. Some forbs such as *Plantago* and *Lupinus* maintained a preferred status although their cover diminished. *Eriogonum* dropped from highly preferred to ignored, although its relative coverage increased.

EXPECTATIONS

Continuation of the proposed study during 1973 will yield at least the following: 1) A quantitative estimate of the kinds and relative amounts of plants consumed by the desert cottontail during five different seasons (the results of three seasons given in this report) in an environment such as the Silverbell Validation Site, 2) a quantitative estimate of the chemical levels of energy, nitrogen, calcium, and phosphorus on which desert cottontails are surviving on the validation site, 3) a quantitative estimate of the portion of the plant environment of importance to desert cottontails as food, 4) repeating analysis of the March-April and May-June periods will indicate how cottontails adjust to unusually dry periods, and 5) knowledge of all of the above-mentioned parameters will be available for a continuous 16-month period.

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