KIT FOX DIET IN SOUTH-CENTRAL ARIZONA

by

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PREFACE

This thesis adopts an abbreviated format for presentation, written essentially as it will be submitted to the Arizona-Nevada Academy of Science for publication.

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ABSTRACT

From April 1980 through March 1981 a study of kit fox (Vulpes macrotis) diet in south-central Arizona indicated that kit foxes fed both opportunistically and selectively. Lagomorphs and round-tailed ground squirrels (Spermophilus tereticaudus) were taken opportunistically, but kangaroo rats (Dipodomys spp.), pocket mice (Perognathus spp.), and white-throated woodrats (Neotoma albigula) appeared to be taken selectively. All major prey items, except kangaroo rats and, to some extent, ground squirrels, were concentrated near riparian areas and stock ponds. It may be that kit foxes were able to exploit some of the relatively food-rich patches in their environment, in this case the stock ponds, because the danger of predation by larger predators was lessened in these more open areas. Selection for kangaroo rats may represent a choice for a preferred food item.

INTRODUCTION

Some studies of kit fox (*Vulpes macrotis*) diet have suggested that kit foxes are opportunistic feeders (Swick 1973, Knapp 1978), while other authors indicate they are selective (Grinnell et al. 1937, Egoscue 1962, 1975, Laughrin 1970). A high frequency of kangaroo rats (*Dipodomys* spp.) in kit fox scats were noted by Hawbecker (1943), Laughrin (1970), and Morrell (1972), while Bailey (1931) and Benson (1938) commented on the parallels of kit fox and kangaroo rat distributions. The question of kit fox diet is particularly interesting in regard to optimal foraging theory, which predicts that as a prey item increases in abundance, the predator should increasingly specialize on that food (Pyke et al. 1977).

Other than studies by Egoscue (1962, 1975), no kit fox diet studies reliably relate prey availability to prey taken. Such a comparison is essential for evaluating the importance of a food source (Korschgen 1971:235). Therefore, I studied kit fox diet in south-central Arizona, hypothesizing that kit foxes are opportunistic feeders and take prey in proportion to its availability.

METHODS

The study area is a homogeneous creosote bush (Larrea divaricata) flat, interspersed with small washes and numerous stock tanks, located approximately 12.5 km southeast of Apache Junction, Pinal County, Arizona, and encompasses 14.4 km^2. Mesquite (Prosopsis glandulosa) and palo verde (Cercidium floridum) are dominant in riparian areas.

I collected kit fox scats twice a month for 12 months, from April 1980 through March 1981. Den sites and secondary roads were systematically searched for samples. On each collecting trip approximately 20 known den sites were examined on foot for scats and other signs of fox activity. Approximately 16 km of secondary roads were driven each time in search of kit fox scats and to locate additional kit fox den sites.

Scats were prepared for analysis according to a slightly modified version of methods described by Johnson and Hansen (1979). Each scat was secured in a nylon bag, then soaked in tap water for about 24 hours. Samples were then agitated in an automatic washing machine for one wash cycle. Any scats that failed to break up were crumbled by hand, then processed through another wash cycle. Scats were then tumbled in a clothes dryer to prevent their contents from matting.

Upon gross examination of each scat, I separated the contents into like piles of hair, feathers, and bone fragments. Items were identified by comparison to reference collections of taxa known to occur on the study area, and by reference to hair descriptions and keys for hair identification presented by Mayer (1952) and Moore et al. (1974). Day's (1966) technique for identifying bird taxa by the characteristics of barbules from the basal downy region of the coverts was followed for feather identification. Frequency of occurrence of prey items in scats was recorded. Black-tailed jackrabbit (*Lepus californicus*) and desert cottontail (*Sylvilagus auduboní*) remains in scats were classed as Lagomorph, unless I could distinguish species by the size of the teeth or bones.

I estimated relative abundance of the prey base by snap-trapping seasonally (400 trap-nights/season) for rodents, and by night-driving transects for lagomorphs. All lagomorph observations while on the study area were recorded.

For the purposes of this study, January through March constitute winter, April through June--spring, July through September--summer, and October through December--fall. These seasonal divisions were adopted so that the discrete summer and winter rains the area receives were confined within marked seasons.

A 4 x 5 chi-square contingency analysis was used to test for simple overall change in diet throughout the year. To test for seasonal fluctuations of a single prey item in the kit fox scats, I used chi-square, but generated expected values somewhat differently. Here the expected value represents the number of scats a prey item would appear in, if kit foxes were taking that prey in direct proportion to its relative abundance, as indicated by my prey base sampling. For example, if 50% of all ground squirrels captured during the year were caught in the spring, then the expected value will show that 50% of all counts of ground squirrel remains in kit fox scats during the year also occurred in the spring. This assumes that my estimates of rodent and lagomorph abundance are accurate.

I used correlation procedures to further clarify relationships between prey availability and prey taken. Correlation was used on three prey categories: round-tailed ground squirrels (*Spermophilus tereticaudus*), lagomorphs (grouped, but representing *Lepus californicus* and *Sylvilagus auduboni*), and nocturnal rodents (also grouped, but representing *Neotoma albigula*, *Dipodomys merriami*, *Perognathus* spp., *Peromyscus maniculatus*, and *Mus musculus*). For ground squirrels and nocturnal rodents the x-axis represented the percent occurrence of that prey item in the scats. For logomorphs the x-axis represented the number of lagomorph sightings, and the y-axis the number of occurrences of lagomorphs in the scats.

RESULTS

Round-tailed ground squirrels and lagomorphs represented the largest component of kit fox diet in spring and summer, followed by white-throated woodrats (Neotoma albigula), heteromyids, and birds (Table 1). In fall, ground squirrels became negligible in the diet, lagomorphs increased, and other prey items in the diet held in approximately similar abundances. In winter, ground squirrels increased considerably in the diet, birds increased slightly, while woodrats and lagomorphs decreased.

The frequency of occurrence of major prey items in kit fox scats changed during the year ($p < 0.10$). The incidence of ground squirrels in kit fox scats showed a strong correlation with their relative abundance ($r = 0.93$, $p < 0.05$), as did lagomorphs ($r = 0.96$, $p < 0.01$). The collective frequency of nocturnal rodents in scats and their relative abundance showed no correlation ($r = -0.01$). Table 2 shows these same trends for nocturnal rodents, ground squirrels, and lagomorphs using chi-square. The hypothesis that kit foxes take prey items in proportion to their availability was rejected for kangaroo rats ($p < 0.01$), pocket mice (Perognathus spp.) ($p < 0.10$), and white-throated woodrats ($p < 0.005$).

I did not attempt to measure the relative abundance of birds, reptiles, or arthropods on the study area, except for general observations. Most of the birds I observed were concentrated about stock

Table 1.

Occurrence of Prey Items in 228 Kit Fox Scats
Collected Over 12 Months in South-Central Arizona.

Food Item	1980 Spr N = 78	1980 Sum N = 63	1980 Fal N = 40	1981 Win N = 47
	%	%	%	%
Nocturnal Rodents				
Neotoma albigula	20.5	34.9	30.0	17.0
Dipodomys spp.	24.4	14.3	17.5	17.0
Perognathus spp.	7.7	7.9	10.0	8.5
Heteromyids combined	32.1	22.2	27.5	25.5
Peromyscus maniculatus	1.3	-	2.5	25.5
Mus musculus	-	-	2.5	2.1
Unknown rodent	7.7	6.3	7.5	8.5
Diurnal Rodents				
Spermophilus tereticaudus	39.7	46.0	5.0	23.4
Lagomorphs				
Sylvilagus auduboni	12.8	4.3	7.5	6.4
Lepus californicus	3.8	-	2.5	-
Lagomorphs combined	47.4	33.3	42.5	31.9
Bird	29.5	22.2	20.0	25.5
Eggshell	6.4	3.2	-	-
Snake	1.3	-	-	-
Lizard	0.0	3.2	-	-
Arthropods	29.5	17.5	25.0	27.7
Canis spp.	-	-	-	2.1
Unknown domestic animal	-	-	-	2.1
Plant fragments	65.4	77.8	67.5	72.3
Mesquite pods	-	-	25.0	-
Paper	-	-	-	2.1

Table 2.

Chi-Square Analysis of the Observed Number of Occurrences of Three Food Items in Kit Fox Scats Compared to an Expected Value Based on the Trap Success or Number Seen of That Food Item. The Null Hypothesis is that Kit Foxes Take These Food Items In Proportion To Their Availability.

Food Item	1980 Spr O/E*	1980 Sum O/E	1980 Fal O/E	1981 Win O/E	Calculated χ^2	Tabular χ^2	% Probability
Nocturnal Rodents	48/26	40/28	28/45	25/43	37.70	12.83	99.5
Spermophilus	31/36	29/31	2/0	11/6	4.99	4.11	75.0
Lagomorph	37/33	21/25	17/16	15/16	1.24	1.21	25.0

*O = observed value
E = expected value

ponds and washes. Birds appeared more plentiful in the spring and fall, during migration. The occurrence of bird remains in scats did not vary much throughout the year. Eggshell was present in scats only in spring and summer, presumable when ground nesters would be vulnerable to predation.

Reptile populations appeared quite low on the study area, as was their incidence in scats. The frequency of arthropods in kit fox scats held in approximately similar proportions throughout the year, but did decrease in summer. Plant fragments were frequently noted in scats, but appeared in trace amounts. In the fall a few scats contained mostly plant matter, primarily mesquite pods.

Trap success of nocturnal rodents was low. I trapped 76 rodents in 1600 trap-nights (4.8% success). Of these, 44% were Merriam's kangaroo rats (*Dipodomys merriami*), 22% Bailey's pocket mice (*Perognathus baileyi*), 18% white-throated woodrats, 7% desert pocket mice (*P. penicillatus*), 5% deer mice (*Peromyscus maniculatus*), and 3% house mice (*Mus musculus*). The desert kangaroo rat (*Dipodomys deserti*) was observed on the study area, but none was trapped.

Trap success of diurnal rodents was relatively high. I trapped 444 round-tailed ground squirrels in 1200 trap-nights (37.0% success). Traps were set in the fall, but no ground squirrels were captured, because they were hibernating. Table 3 summarizes all the rodent trap success.

Sightings of lagomorphs were highest in the spring, decreased in the summer and fall, then remained at low levels through the fall and

Table 3.

Seasonal Rodent Trap Success (400 Trap-Nights/Season) Over 12 Months in South-Central Arizona.

Species	1980 Spr %	1980 Sum %	1980 Fal %	1981 Win %
Nocturnal Rodents				
Neotoma albigula	0.5	1.0	1.5	0.5
Dipodomys merriami	2.0	1.8	2.3	2.5
Perognathus baileyi	0.8	1.0	1.0	1.5
Perognathus penicillatus	-	-	0.5	0.8
Peromyscus maniculatus	0.3	-	0.5	0.3
Mus musculus	-	-	0.3	0.3
TOTAL	3.6	3.8	6.1	5.9
Diurnal Rodents				
Spermophilus tereticaudus	54.8	46.5	-	9.8

winter. Slightly more black-tailed jackrabbits than desert cottontails were seen in all seasons except summer (Table 4).

Table 4.

Number of Lagomorph Sightings on the Kit Fox Study Area.

Species	1980 Spr	1980 Sum	1980 Fal	1981 Win
Lepus californicus	13	8	7	6
Sylvilagus auduboni	10	9	4	5
TOTAL	23	17	11	11

DISCUSSION

During this study it became clear that the prey base was undergoing sharp fluctuations, thus providing an unusual opportunity to study kit fox diet. Precipitation patterns and possibly overgrazing led to these fluctuations. High rainfall for much of southern Arizona in 1977-78 and 1978-79 led to increased rodent populations (Yar Petryszyn, personal communication). Rainfall decreased in 1980 and rodent populations crashed, presumably in response to fewer annuals. However, ground squirrel and woodrat numbers did not decline immediately because they rely more on perennials and succulents for feed (Drabek 1970, Yar Petryszyn, personal communication). This study indicates that ground squirrels and possibly woodrats did decrease in 1981, and a woodrat decline was documented during 1981 in southern Arizona (Yar Petryszyn, personal communication). A recent history of overgrazing on the study area may have also influenced prey base numbers. Linsdale (1946) stated that ground squirrel populations increase on overgrazed range.

The results of this study indicated that kit foxes fed opportunistically on some prey items, such as ground squirrels and lagomorphs, but selectively on others, such as kangaroo rats, pocket mice, and woodrats. During this study, it became apparent that all of the major prey items except kangaroo rats and, to some extent, ground squirrels were concentrated near the stock ponds and riparian areas. Kit foxes tend to avoid heavily vegetated riparian areas, but not the more open stock pond areas (Richard Golightly, personal communication). It is possible that the danger of predation for kit foxes is lessened around the stock ponds, thus making exploitation of these relatively resource-rich patches possible. This would explain the apparent selection for woodrats and pocket mice. Kit foxes may select kangaroo rats as a preferred food item, perhaps because of the possible low search and handling costs associated with these rodents.

The presence of items in kit fox scats like domestic animals, eggshell, reptiles, arthropods, vegetation, and paper supports the hypothesis that kit foxes are opportunistic feeders. It is unknown of what importance arthropods and plant material are in kit fox diet, partly because it is difficult to tell when these items have been secondarily ingested.

Fifty-seven kit fox scats which I collected several miles south of the study area and near agricultural fields contained a higher incidence of lagomorphs than scats collected on the study area. Observation of these agricultural areas indicated that lagomorphs were more abundant. Scats on the study area appeared to be scarce during fall, 1980, and winter, 1980 and 1981. I suspected that this was due to the availability of ground squirrels, which are inactive during October, November, and December (Drabek 1970). It is plausible that some or all of this kit fox population periodically moved south to exploit lagomorphs associated with the agriculture. Richard Golightly (personal communication) tracked a radio-collared kit fox from the study area south to a den near agriculture, a 4.8-6.4 km movement.

This study indicates that kit foxes have an ability to adjust to changes in the prey base. Particularly notable was a switch to diurnal prey at a time when nocturnal rodent populations were low. I conclude that kit foxes fed primarily opportunistically during this 12-month study, and note that foxes may even have moved to exploit relatively prey-rich agricultural areas when prey on the study area became scarce.

APPENDIX A

VEGETATION ANALYSIS OF THE STUDY AREA

Table A-1.

Percent Cover, Relative Cover, Frequency, and Relative Frequency of Shrubs, Trees, and Other Perennial Vegetation on the Study Area.*

Species	Cover %	Rel. Cover %	Frequency %	Rel. Frequency %
Larrea divaricata	6.1	59.2	37.5	54.3
Prosopsis glandulosa	2.7	26.3	10.0	14.5
Cercidium floridum	0.5	4.8	3.8	5.5
Lycium exsertum	0.3	2.7	5.0	7.2
Atriplex sp.	0.3	2.7	6.3	9.1
Happlopappus acradenius	0.2	1.9	3.8	5.5
Baccharis sarothroides	0.1	1.2	1.3	1.9
Ambrosia psilostachya	0.1	1.2	1.3	1.9
TOTAL	10.3		69.0	

*Estimated using the line-intercept technique, as described by Cox (1976).

Table A-2.

Frequency (% Occurrence/75 plots) and % Cover for Annuals on 75 Daubenmire Plots* (7.5 m^2), Sampled in Spring and Summer, 1980.

Species	Spring Cover %	Spring Frequency %	Species	Summer Cover %	Summer Frequency %
Schismus barbatus	11.6	97.0	Dead annuals	38.6	99.0
Pectocarya platycarpa	9.3	63.0	*Euphorbia abramsiana*	1.8	8.0
Plantago insularis	7.8	77.0	*Euphorbia arizonica*	1.3	7.0
Plagiobothrys arizonicus	7.5	63.0	*Ambrosia confertiflora*	0.2	3.0
Filago arizonica	1.5	13.0	*Ditaxis serrata*	0.1	1.0
Herniaria cinerea	1.3	33.0	TOTAL	42.0%	
Erodium cicutarium	0.6	25.0			
Lepidium lasiocarpum	0.4	15.0			
Calandrinia ciliata	0.3	10.0			
Vulpia octoflora	0.2	7.0			
TOTAL	40.5%				

*Annuals estimated using Daubenmire's canopy-coverage method (1959).

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