COYOTE PREDATION ON THE RIO GRANDE WILD TURKEY IN THE TEXAS PANHANDLE AND SOUTHWESTERN KANSAS

by

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ABSTRACT

From January 2000 to August 2004, we collected data on Rio Grande wild turkey (*Meleagris gallapavo intermedia*) survival, cause-specific mortality, movements, habitat use, roost use, and nesting at 4 study sites (3 in the Texas Panhandle: Matador Wildlife Management Area (MWMA) near Paducah, Texas, Salt Fork of the Red River private land holdings (SF) near Clarendon, Texas, and Gene Howe Wildlife Management Area (GHWMA) near Canadian, Texas, and 1 site on the Cimarron National Grasslands (CNG) near Elkhart, Kansas). During 2000-2002 turkey survival across the 4 sites was about 50% (Ballard et al. 2002). Coyotes were the most frequently cited predators of Rio Grande wild turkeys during the first 3 years of our study, identified in 147 out of 313 (47%) predation events (Ballard et al. 2003).

We wanted to further study the impact of coyotes on adult (≥ 1 year old) and juvenile (6 months to 1 year old) Rio Grande wild turkeys in the Texas Panhandle and Southwestern Kansas, by examining and comparing relative abundances and food habits of coyotes at our 4 study sites. To estimate relative abundance of carnivore species at our study sites, we used scent stations as our primary method and scat surveys as a secondary method to corroborate scent stations. We examined the diets of coyotes at our study sites through analysis of scats collected during our scat surveys. Remains of food items in scats were identified and the percent of scats containing food items was noted. We also calculated percent of occurrence.

Coyotes were the most frequent visitors to scent stations. Visitation by coyotes was not different among sites in any season (Fall 2003 χ^2 = 7.5067, P = 0.0574; Spring

2003 χ^2 = 1.6263, P = 0.6535 Summer 2003 χ^2 = 4.4270, P = 0.2189 and Winter 2004 χ^2 = 1.6442, P = 0.6494, Table 2.1). Raccoons (n = 37) were the second-most frequent visitors, and their visitation rates were significantly different among sites during each period (Fall 2003 χ^2 = 17.2083, P = 0.0006; Spring 2003 χ^2 = 8.8584, P = 0.312 Summer 2003 χ^2 = 7.9598, P = 0.0468 and Winter 2004 χ^2 = 8.6458, P = 0.0344). Raccoons were detected more frequently at the SF (χ^2 = 4.5, P = 0.0339) and MWMA (χ^2 = 4.5, P = 0.0339) than the CNG site during the Spring sampling period. During the Summer period, raccoons were detected more frequently at SF scent stations than at MWMA (χ^2 = 4.35, P = 0.0370). Raccoons were detected more frequently in the Fall period at the SF than all other sites (CNG χ^2 = 10.28, P = 0.0013; MWMA χ^2 = 7.02, P = 0.0081; GHWMA χ^2 = 5.11, P = 0.0237). During the Winter period, raccoons were detected more frequently at SF (χ^2 = 5.56, P = 0.0184) and GHWMA (χ^2 = 4.02, P = 0.0450) than MWMA.

Diet composition of coyote scats (n = 374) consisted of 27 foods, primarily small mammal species (n = 11) and vegetation (n = 8), followed by large mammal species (n = 3), medium mammal species (n = 2), avian species (n = 2), reptiles (n = 1), and insects (n = 1). Prey occurrences were primarily small- [n = 194, 40.76 Percent of Occurrence (POO)] and medium-sized (n = 73, 15.33 POO) mammals. The most common prey occurrence across all sites and seasons was Eastern cottontail (*Sylvilagus floridanus*)(n = 69, 14.50 POO), identified in scats at all sites. White-footed (*Peromyscus leucopus*), and deer mice (*Peromyscus maniculatus*), (n = 42, 8.82 POO), and hispid cotton rat (*Sigmodon hispidus*, n = 28, 5.88 POO) were the most common prey types in the small mammal prey category. We detected avian species (n = 13, 2.73 POO) in coyote scats at

SF (n = 6), GHWMA (n = 2), and CNG (n = 4) sites. Turkey was <1% of all food items, detected only at SF (n = 2) and CNG (n = 1).

CHAPTER I

INTRODUCTION

The wild turkey (*Meleagris gallopavo*) historically occupied 39 of the continental United States, as well as the Canadian province of Ontario (Kennamer et al. 1992). Turkey populations declined to near extinction after European settlement (Quinton et al. 1980) due to unrestricted harvest, and habitat loss from the clearing of forests for agriculture (Kennamer et al. 1992). By 1920, wild turkeys remained in only 21 of the states it originally occupied, and was lost from Ontario entirely (Kennamer et al. 1992). Trap and transplant programs by state agencies, along with restoration of forests have increased the occupied range to all of the continental United States (Kennamer and Kennamer 1994).

There are 5 subspecies of the wild turkey in the United States, (from most to least common) the eastern (*M. g. silvestris*), the Rio Grande (*M. g. intermedia*), Merriam's (*M. g. merriami*), Florida (*M. g. osceola*), and Gould's wild turkey (*M. g. mexicana*). The Rio Grande prefers plains grasslands, shinnery (*Quercus havardii*), prairie, oak-hickory (*Quercus* spp.-*Carya* spp.), oak-pine (*Pinus* spp.), pinion-juniper (*Juniperus* spp.), Texas savanna, and southwestern shrubsteppe forest (Beasom and Wilson 1992). Historically, the Rio Grande wild turkey ranged from Mexico north through Texas, western Oklahoma, southern Kansas, and eastern New Mexico, and was estimated to have numbered about 2 million birds within the United States (Beasom and Wilson 1992). In 1940, it was estimated that only about 100,000 Rio Grande wild turkeys remained in Texas, and the subspecies did not occupy Oklahoma or Kansas (Beasom and

Wilson 1992). Due to restocking, establishment of refuges, and legislation, Rio Grande turkeys were restored to their native ranges (Beasom and Wilson 1992). In 1994, the Rio Grande subspecies was estimated at 630,000 birds in the United States (Kennamer and Kennamer 1994).

Most turkey research has been conducted on the eastern subspecies (Peterson 1998). Though the Rio Grande is the second most common subspecies of turkey, there has been more research on other subspecies than the Rio Grande (Holdstock 2003). Due to lack of research and the possible recent decline of turkeys in the Texas Panhandle, a large-scale study on Rio Grande wild turkeys was initiated in January of 2000. The goal was to determine population dynamics of Rio Grande wild turkeys and to understand the effects of land use practices and precipitation on turkey population dynamics.

From January 2000 to August 2004, we collected data on turkey survival, cause-specific mortality, movements, habitat use, roost use, and nesting at 4 study sites (3 in the Texas Panhandle: Matador Wildlife Management Area near Paducah, Texas, Salt Fork of the Red River private land holdings near Clarendon, Texas, and Gene Howe Wildlife Management Area near Canadian, Texas, and 1 site on the Cimarron National Grasslands near Elkhart, Kansas). During 2000-2002 turkey survival across the 4 sites was about 50% (Ballard et al. 2002).

Wild turkeys (*Meleagris gallapavo*) are known to be preyed upon by many species including coyote (*Canis latrans)*, bobcat (*Lynx rufus)*, domestic dog (*Canis familiaris)*, mountain lion (*Puma concolor)*, great horned owl (*Bubo virginianus*), and golden eagle (*Aquila chrysaetos*; Speake 1980, Miller and Leopold 1992). Coyotes were the most frequently noted predators of Rio Grande wild turkeys during the first 3 years of our study, identified in 147 out of 313 (47%) predation events (Ballard et al. 2003).

Coyote History

Distribution of canids across the North American landscapes is varied (Stains 1975). The distribution and interspecific relationships of canid species have changed dramatically during the last 400 years, mostly due to human impacts (Johnson et al. 1996). Competition among canids has contributed to their spatial distribution and morphological patterns throughout evolutionary time and space (Peterson 1995, Johnson et al. 1996). Control and extermination of wolves (*Canis lupus*) in North America has been associated with a coyote range expansion from open habitats on the Great Plains to forested areas and human altered landscapes to the north, west, and east (Gier 1975, Nowak 1978, Sheldon 1992). Gipson (1978) pointed out that coyote remains estimated to be 500 to 1,500 years old were recovered in the east and southeastern United States and suggested that coyotes may have periodically inhabited these places during dry periods. The range of coyotes before European settlement was at least as far east as central Texas, and probably as far south as central Mexico, though the exact limits of the coyote's historical range is unknown (Nowak 1978).

The coyote is considered an "open country" adapted species (Gier 1975). Clearing of large tracts of forest land for timber and agricultural conversion create ideal habitat for coyotes (Gipson 1978). Agricultural crops, pastures, and forest clearcutting support high populations of small rodents, often one of the major food groups within the coyote diet (Atkeson and Johnson 1979; Perkins and Hurst 1988). The coyote is known to be a generalist and opportunistic predator, with a diet varying both seasonally and geographically (Sperry 1941, Fitcher et al. 1955, Gier 1968).

Coyote Predation on Wild Turkeys

Adult wild turkey gobblers are rarely killed by predators (Markley 1967, Godwin et al. 1992). Coyotes are occasionally observed attacking strutting gobblers (Leopold and Miller 1992), but most gobbler mortality is attributed to human hunting (Godwin 1991). Adult wild turkey hens suffer a higher mortality rate during the reproductive season than at other times of the year (Everett et al. 1980, Speake 1980, Palmer 1990, Siess 1990). The reproductive period generally spans from April to June, but early nesting may occur during March, and some brooding and renesting will continue into July (Williams and Austin 1988, Stys 1992). Predation is usually the leading cause of hen mortality during the reproductive period (Everett et al. 1980, Exum et al. 1987, Siess 1989, Palmer 1990).

In a study in north Alabama, 9 of 10 hens lost to predation were killed during the reproductive season (Everett et al. 1980). Predators caused 69% of hen mortality in a Florida study (Exum et al. 1987). Siess (1989) reported predation caused 68% of the known hen mortality in a Mississippi study. The majority of the mortalities occurred during the reproductive season and fall hunting season. The winter and post-brooding seasons were characterized by survival rates > 90%. In a second Mississippi study, 90%

of hen mortality occurred during the nesting and brooding period (Palmer 1990); 76% of this mortality was caused by predation.

In Texas, Ransom et al. (1987) observed coyotes stalking and attacking wintering flocks of turkeys. Beasom (1974) conducted an intensive short-term predator removal experiment in which coyotes constituted the majority of predators removed. Predator removal appeared to improve reproductive success of wild turkey populations. Knowlton (1964) studied coyote diet and population characteristics of white-tailed deer (*Odocoileus virginianus*) and wild turkeys in south Texas. Although wild turkey remains were found in coyote stomachs and scats, Knowlton (1964) did not believe coyote predation limited the wild turkey population. Wagner (1993) also believed that coyotes did not limit or cause declines in wild turkey populations, based on a coyote diet study in the southeastern U.S. Wagner (1993) noted that the effect of coyote predation on wild turkey populations needed to be researched within the context of other interacting variables that affect wild turkey populations, such as food sources, diseases, weather, and other predators.

Since predation was the most frequent cause of Rio Grande wild turkey mortality during the first 3 years of our study, we initiated a study on the impact of coyotes on adult ($\geq$ 1 year old) and juvenile (6 months to 1 year old) Rio Grande wild turkeys in the Texas Panhandle and Southwestern Kansas. We examined and compared the relative abundances and diets of coyotes on our 4 study sites. The objectives of this study were: 1) to determine the feasibility of using scent stations and scat surveys to estimate relative coyote densities; and 2) to determine coyote diets at our 4 study sites. Chapter II presents results from scent stations and scat surveys implemented over the past 2 years. Chapter

III presents the results of coyote diet analysis from 4 seasons (winter, spring, summer, fall) during 2003 to 2004 at each of the 4 study sites.

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CHAPTER II

USING SCENT STATIONS AND SCAT SURVEYS TO ESTIMATE RELATIVE ABUNDANCE OF PREDATORS IN THE TEXAS PANHANDLE AND SOUTHWESTERN KANSAS

Introduction

Predation was the most commonly identified cause of Rio Grande wild turkey (*Meleagris gallapavo intermedia*) mortality (60%) at 4 study sites in the Texas Panhandle and Kansas from 2000 to 2002 (Ballard et al. 2003). Coyotes (*Canis latrans)* were the most frequent predator of Rio Grande wild turkeys, identified in at least 147 out of 313 (47%) predation events (Ballard et al. 2003, Table 2.1). We wanted to determine an efficient and reliable means for estimating and comparing coyote relative abundances at each of our 4 study sites, in order to identify and quantify potential differences in coyote densities among study sites.

Methods used to estimate densities of coyotes and other wild canids include: direct counts or mark-recapture (including radioisotope markers), radiotelemetry, aerial surveys, removal, counts of dens, tracks, or droppings, questionnaires and bounty payments, and elicited responses (such as frequency of visitation to man-made scent stations and howl responses to sirens) (Linhart and Knowlton 1975, Henke and Knowlton 1995). Due to the secretive behavior and low densities of coyotes, a complete census of local populations was not practical (Henke and Knowlton 1995). We examined the feasibility of using scent stations and scat surveys to estimate relative coyote densities at each of the 4 study sites. Tracks identified at scent-baited stations (scent stations) have been widely used to estimate relative abundance of predator species, and according to some reports they provide reliable, standardized estimates of relative abundance (Cooke 1949, Richards and Hine 1953, Wood 1959, Henke and Knowlton 1995).

We used scat surveys because they are less time consuming and costly than other survey methods, they accumulate information over a period of time (scats deposited per day) without an observer in attendance, and they do not require a behavioral response (howling, visitation to scent stations) from the coyote (Henke and Knowlton 1995). We used scent stations as our primary method of estimating coyote abundances and scat surveys as a secondary method to corroborate scent stations.

Study Areas

The feasibility of using scent stations and scat surveys to estimate relative coyote densities was studied at the 4 study sites of the Rio Grande wild turkey project. Three sites were located in the Rolling Plains physiographic region of Texas, and at 1 site was located on the Kansas-Colorado border, in the High Plains physiographic province of the Great Plains.

The Matador Wildlife Management Area (MWMA) was located about 10 km north of Paducah, Texas, in Cottle county, and was the southern-most study site. The MWMA study site was approximately 11,406 ha of public land. Elevations ranged from 488 to 610 m. Average precipitation was 52.6 cm for the year, with the majority falling in May and June. The Pease River flowed from west to east through the study area. Topography ranged from riparian plains to gently rolling hills and steep-walled canyons. Woody vegetation was dominated by honey mesquite (*Prosopis glandulosa*), redberry juniper (*Juniperus pinchotii*), netleaf hackberry (*Celtis reticulate*), and occasional cottonwoods (*Populus deltoides*).

The Salt Fork of the Red River (SF) study site was located just north of the towns of Clarendon and Hedley, Texas, within Donley and Collingsworth counties. The SF study site was a combination of private land holdings totaling over 20,000 ha. Elevations ranged from 633 to 955 m. Average precipitation was between 52 and 55 cm, with the majority falling from April to October. The Salt Fork of the Red River flowed from west to east through the study area. Characteristic vegetation in rangeland were little bluestem (*Schizachyrium scoparium*), gramma grass (*Bouteloua* spp.), and broom snakeweed (*Gutierrezia sarothrae*), interspersed with honey mesquite, and juniper (*Juniperus* spp.). Characteristic vegetation in riparian areas were wildrye (*Elymus* spp.), western wheatgrass (*Elytrigia smithii*), black locust (*Robinia pseudoacacia*), and eastern cottonwood.

The Gene Howe Wildlife Management Area (GHWMA), located east of Canadian, Texas, in Hemphill county was the northern-most study site in Texas. The GHWMA study site consisted of ca. 2,358 ha of public land. Elevations ranged from 701 to 732 m. Precipitation averaged 53.3 cm per year, with the majority falling in May and June. The Canadian River flowed from west to east through the study area. Dominate vegetation at the GHWMA included sand sagebrush (*Artemsia fififolia*), sandsage-grassland, grassland, and mesquite-grassland. Eastern hackberry (*Celtis* *occidentalis*), Chickasaw plum (*Prunus angustifolia*), Tamarisk (*Tamarix chinensis*), western soapberry (*Sapindus drummondi,* and cottonwood were the dominant tree species in the riparian areas.

The Cimarron National Grassland (CNG), located in Morton county, Kansas, was the center for the Kansas study site, which also extended into Baca county, Colorado. Elevation ranged from 960 to 1128 m. Average precipitation was 48.6 cm per year, with the majority falling from April to September. The Cimarron River flowed from west to east through the study area. Topography included rock cliffs, sand dunes, grassy fields, and the Cimarron River basin. Dominant grasses included sand bluestem (*Andropogon hallii*), blue gramma (*Bouteloua gracilis*), sideoats gramma (*Bouteloua cutipendula*), dropseed (*Sporobolus crptandrus*), sand lovegrass (*Eragrostis trichodes*), and buffalo grass (*Buchloe dactyloides*). These grasses, combined with sagebrush (*Artemsia fififolia*), four-wing saltbush (*Atriplex canescens*), rabbitbrush (*Chrysothamnus* spp.), snakeweed (*Gutierrezia sarothrae*), and plains yucca (*Yucca glauca*) covered the fields and hills surrounding the Cimarron River corridor. Grasses, cottonwood, and tamarisk groves were found in the river basin.

Carnivore species on our study sites included coyote, bobcat (*Lynx rufous*), mountain lion (*Puma concolor*), swift fox (*Vulpes velox*, expected at the CNG and GHWMA sites only), red fox (*Vulpes vulpes*), grey fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), American badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis*), and American mink (*Mustela vison*).

Methods

Scent Stations

We measured relative abundance of coyotes using scent stations at each of the 4 study sites during each of the 4 seasons. We followed the methods of Linhart and Knowlton (1975) as modified by Roughton and Sweeny (1982), including some adjustments as noted. We ran scent stations for 2 consecutive nights once per study site per season. Stations were run for 2 nights in order to increase the potential total number of coyote visits to scent stations. Individual scent stations were placed along alternating sides of unpaved roads at ≥ 2 km intervals, the maximum daily range of coyotes in the southwest (Andelt 1995). Using intervals of ≥ 2 km allowed us to consider each scent station independent, because a single coyote would not be likely to visit successive scent stations. We placed 20 to 25 scent stations per study site. We used Global Positioning System (GPS) locations of turkey mortality events at each study site from 2000-2002 to identify roads most suitable for scent station placement. We plotted Universal Transverse Mercator (UTM) coordinates from mortalities in ArcView GIS (Environmental Systems Research Institute (ESRI), 1969, Redlands, California). We identified roads which occurred in proximity to > 5 turkey mortalities, and established permanent scent stations along those roads identified in the field as accessible, unpaved, and in probable turkey habitat.

Each station consisted of a 1-m diameter circle cleared of vegetation and debris. A thin layer of fine soil (not sand) was sifted over the circle to facilitate identification of tracks. A fatty-acid scent (FAS) capsule (United Stated Department of Agriculture Pocatello Supply Depot, Pocatello, ID) was placed in the center of the circle. Stations were examined the following day for presence of tracks. Tracks were identified to species (Murie 1982, Rezendez 1999). If adverse conditions (strong winds, precipitation, frozen ground, grazing livestock, or vehicular traffic) were expected, operation of scent stations were delayed until conditions improved. We recorded presence of tracks at each scent station by species and date, with a maximum of 1 visit per species at an individual scent station in a period, and a maximum of 25 total visits per species per period at the SF and GHWMA sites, 25 visits at the MWMA and CNG sites in Spring 2003, and 20 visits at the MWMA and CNG sites in other periods (Table 2.1).

Scent stations were analyzed in SAS using a chi-square likelihood ratio contingency-table analysis (G-test; Ott 1988) corrected for continuity (Williams 1976) to determine differences among sites during each season. Tests were considered significant at $P \leq 0.05$. Pairwise comparisons using a student's *t*-test were used for mean separation. Upon a result of no difference ($P \geq 0.05$) for scent station visitation among study sites within a season, we conducted a retrospective power and sample size analysis to determine the order of magnitude of differences that were detectable in our study (Krebs 1999). Sample size was estimated using the binomial equation:

$$n = \frac{t^2 pq}{d^2}.$$

Where n = Total sample size needed to estimate proportion

t = Value for Student's t-distribution (t = 2 conservatively)

p = Proportion of visits

q = Proportion of nonvisits

and d = Desired margin of error.

We used the same equation to determine the order of magnitude of differences in visitation among sites that would have been statistically significant in our study by solving the equation for *d.* The resulting equation for a statistically significant difference was:

$$d = \sqrt{\frac{t^2 pq}{n}} .$$

<u>Scat Surveys</u>

Scat surveys consisted of 4 2-km transects along unpaved roads on each study site, independent of but concurrent with scent station surveys. Roads were walked 2 days prior to survey to remove all scats from transects. Roads were re-walked on the third day to collect scats for analysis. Scats were collected and labeled by species, transect, and date. Scats were identified by presence of tracks and morphological characteristics. We considered all scats ≥ 20 mm diameter to have been deposited by coyote (Green and Flinders 1981, Danner and Norris 1982, Rezendes 1999). We measured the maximum diameter of each scat using 152 mm dial calipers (General Tools Manufacturing Co., LLC, New York, New York). The number of scats deposited on each transect over a 2 day period was recorded. The index for scat surveys was number of scats deposited per study site (since number of transects, transect length and number of days of survey was constant across sites). Scat surveys were analyzed using a repeated measures analysis of variance to test for differences within seasons among study sites.

Results

Scent Stations

We ran 20-25 scent stations per night at each study site per season from April 2003 to April 2004 (370 total stations, Table 2.3). Scent stations were visited by coyote, raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), Virginia opossum (*Didelphis virginiana*), bobcat, red fox (*Vulpes vulpes*), grey fox (*Urocyon cinereoargenteus*), swift fox (*Vulpes velox*), badger (*Taxidea taxus*), mountain lion, white-tailed deer (*Odocoileus virginianus*), feral hog (*Sus scrofa)*, cattle, Eastern cottontail (*Sylvilagus floridanus*), nine-banded armadillo (*Dasypus novemcinctus*), birds, and rodents. Deer, feral hog, cattle, Eastern cottontail, armadillo, birds, and rodents were thought to only incidentally visit scent stations, as none of the tracks observed stopped at the FAS tablet (tracks from these species were a straight line through the station). Rabbits and birds may have been using scent stations as dusting stations. Mountain lion ($n = 1$) was detected in the south-middle pasture of the MWMA in Spring 2003. Swift fox ($n = 1$) was detected on County Road 1920 in Canadian, Texas (near the GHWMA) in Summer 2003. Opossum ($n = 1$) was detected only on GHWMA. Badger ($n = 4$) and unknown canid ($n = 1$) were detected only on CNG. The unknown canid track could have been a fox or a juvenile coyote track. Bobcat ($n = 3$) was detected at SF and MWMA. Skunk ($n = 12$) was detected at MWMA, GHWMA, and CNG. Red fox ($n = 5$) was detected at all 4 study sites.

Coyotes ($n = 65$) were the most frequent visitors to scent stations, and were observed at all 4 study sites. Scent station visitation by coyotes was not different among sites in any season (Fall 2003 $\chi^2 = 7.5067$, $P = 0.0574$; Spring 2003 $\chi^2 = 1.6263$, $P =$

0.6535 Summer 2003 χ^2 = 4.4270, P = 0.2189 and Winter 2004 χ^2 = 1.6442, P = 0.6494, Table 2.1). Since we detected no significant difference during any period for coyote visitation among study sites, we calculated estimated power from our data. The minimum number of scent stations needed to be within $\alpha \leq 0.05$ level ranged from 181 to 275 scent stations (MWMA = 181, SF = 275, GHWMA =236, CNG = 204). The detectable differences in scent station visitation at each study site ranged from 0.15 to 0.17 (MWMA = 0.15, SF = 0.17, GHWMA = 0.15, CNG = 0.16).

Raccoons (n = 37) were the second-most frequent visitor, and were observed at all sites (Table 2.2). Raccoon visitation was significantly different among sites during each period (Fall 2003 χ^2 = 17.2083, P = 0.0006; Spring 2003 χ^2 = 8.8584, P = 0.312 Summer 2003 χ^2 = 7.9598, P = 0.0468 and Winter 2004 χ^2 = 8.6458, P = 0.0344). Raccoons were detected more frequently at the SF (χ^2 = 4.5, P = 0.0339) and MWMA (χ^2 = 4.5, P = 0.0339) than the CNG site during the Spring sampling period. During the Summer period, raccoons were detected more frequently at SF scent stations than at MWMA (χ^2 = 4.35, P = 0.0370). Raccoons were detected more frequently in the Fall period at the SF than all other sites (CNG χ^2 = 10.28, P = 0.0013; MWMA χ^2 = 7.02, P = 0.0081; GHWMA χ^2 = 5.11, P = 0.0237). During the Winter period, raccoons were detected more frequently at SF (χ^2 = 5.56, P = 0.0184) and GHWMA (χ^2 = 4.02, P = 0.0450) than MWMA.

Table 2.1. Number of coyote visits (number of stations with ≥1 coyote track) to scent stations lines at 4 study sites in the Texas Panhandle and southwestern Kansas from April 2003 (Spring) to April 2004 (Winter). Number of visits did not differ among sites (*P* > 0.05).

		MWMA[a]	SF[b]	GHWMA[c]	CNG[d]
Spring 2003	Visits	3	3	5	2
	Total stations	25	25	25	25
Summer 2003	Visits	0	2	0	1
	Total stations	20	25	25	20
Fall 2003	Visits	1	9	6	6
	Total stations	20	25	25	20
Winter 2003	Visits	8	8	6	5
	Total stations	20	25	25	20

[a] MWMA = Matador Wildlife Management Area
[b] SF = Salt Fork of the Red River private land holdings
[c] GHWMA = Gene Howe Wildlife Management Area
[d] CNG = Cimarron National Grasslands, Kansas

Table 2.2. Number of raccoon visits (number of stations with ≥1 raccoon track) to scent stations lines at 4 study sites in the Texas Panhandle and southwestern Kansas from April 2003 (Spring) to April 2004 (Winter).

		MWMA[a]	SF[b]	GHWMA[c]	CNG[d]
Spring 2003	Visits[e]	5 AB	5 A	1 AB	0 B
	Total stations	25	25	25	25
Summer 2003	Visits	0 AB	3 A	0 B	0 AB
	Total stations	20	25	25	20
Fall 2003	Visits	2 A	10 B	2 A	0 A
	Total stations	20	25	25	20
Winter 2003	Visits	0 A	5 B	3 B	1 AB
	Total stations	20	25	25	20

[a] MWMA = Matador Wildlife Management Area
[b] SF = Salt Fork of the Red River private land holdings
[c] GHWMA = Gene Howe Wildlife Management Area
[d] CNG = Cimarron National Grasslands, Kansas
[e] Visits with the same letter were not different within a season among sites (Fall 2003 P = 0.0008; Spring 2003 P = 0.0312; Summer 2003 P = 0.0468; Winter 2004 P = 0.0344)

Scat Surveys

Carnivore scats observed along survey lines (*n* = 63) included coyote, raccoon, bobcat, and fox. Bobcat (*n* = 3) scats were observed at only SF and MWMA sites. Raccoon (n = 13) and fox (*n* = 5) scats were observed at every site. Coyote (*n* = 396) was our most common scat, found in every season and every study site. We found no difference in number of coyote scats counted along survey lines among seasons or sites (Table 2.3, $F = 0.97$, $P = .4399$).

Table 2.3. Number of coyote scats collected per survey line at 3 study sites in the Texas Panhandle and 1 site in southwestern Kansas from April 2003 (spring season) to April 2004 (winter season). There were no detectable differences in any season or site ($P > 0.05$).

Season	Line	SF[a]	MWMA[b]	GHWMA[c]	CNG[d]
Spring 2003	1	0	4	9	1
	2	4	0	1	0
	3	2	1	0	1
	4	8	2	1	1
	Total	14	7	11	3
Summer 2003	1	3	0	2	12
	2	1	1	2	2
	3	2	1	1	0
	4	0	0	0	3
	Total	6	2	5	17
Fall 2003	1	4	5	0	8
	2	1	0	6	4
	3	3	0	4	0
	4	3	0	6	5
	Total	11	5	16	17
Winter 2004	1	2	0	1	2
	2	3	0	1	2
	3	0	2	1	0
	4	2	0	3	3
	Total	7	2	6	7

[a] SF = Salt Fork of the Red River private land holdings
[b] MWMA = Matador Wildlife Management Area
[c] GHWMA = Gene Howe Wildlife Management Area
[d] CNG = Cimarron National Grasslands, Kansas

Discussion

Some carnivore managers and researchers have regarded scent stations as a cost-effective and accurate means of monitoring canid populations (Linscombe et al. 1983, Leberg and Kennedy 1987, Travaini et al. 1996, Sargeant et al. 1998). Beasom (1974) successfully used predator track count transects to monitor density of coyotes following predator removal in Texas (188 coyotes and 120 bobcats were removed from two 2,023 ha study areas separated by 8 km). Predator numbers were similar on both areas prior to removal efforts, decreased on the removal site after a few months of control, reached a trough in June, and increased once removal efforts ceased. After a removal of 188 coyotes, differences in track counts could be detected. We do not know the minimum population difference between sites that was detectable using scent stations or track counts.

Other attempts to evaluate and validate scent station methodology (Conner et al. 1983, Minser 1984, LeBerg and Kennedy 1987, Nottingham et al. 1989, Diefenbach et al. 1994, Smith et al. 1994, Sargeant et al. 1998, Warrick and Harris 2001, and others) have produced ambiguous or contradictory results. Potential sources of bias reported in scent station methodology include: coyote behavior in unfamiliar territory, previous adverse experiences, habituation to specific lures, juveniles being more attracted to scents than adults, vehicular traffic, and environmental factors such as wind, precipitation, and frozen ground (Harris 1983, Andelt et al. 1985, Fagre et al. 1983, Fagre et al. 1981, Henke and Knowlton 1995).

We used scent stations and scat surveys to examine relative carnivore abundance at each of our study sites. We found no difference among sites or years in coyote visitation using either scent stations or scat surveys. The primary limitation of scent stations and scat surveys for monitoring carnivore abundance appears to be a lack of a consistent linear relationship between visitation rates and actual population numbers between or within species. The nature and extent of factors that contribute to non-linearity are not fully understood or predictable (Quayle and Westereng 1999). Sargeant and Johnson (1997) concluded that the statistical properties of scent-station data were poorly understood and that long-term trends in visitation rates probably reflect real changes in populations, but poor spatial and temporal resolution, susceptibility to confounding, and low statistical power limited the usefulness of this survey method (Sargeant et al. 1998). We estimated power, sample size, and magnitude of difference for our scent station lines in order to estimate the statistical capabilities of the surveys we were able to run. We conducted both scent stations and scat surveys in an attempt to gain corroborative results. Neither method revealed a statistical difference in coyote visitation among study sites in any season.

Retrospective estimated power analysis results in low power in an experiment with high p-values, regardless of sample size or experimental design (Hoenig and Heisey 2001). Because alpha values and retrospective power analysis are inversely related, in an experiment where actual power is high, retrospective power analysis may show low power (Richardson et al. 2004). At our sampling intensity, we could have detected differences at the $\alpha = 0.20$ level. In order to detect statistical differences in data with the same variances and means we had in our data collection, we needed 181 to 275 stations to detect differences at the standard $\alpha = 0.05$ level. At the Kansas study site, it was difficult to place 20 scent stations at the recommended 2 km distance necessary to consider each station independent. It was impossible to establish 250 stations needed to detect a difference at $\alpha = 0.05$ level.

We did, however, detect differences in raccoon visitation to scent stations among the 4 sites. We suspected the ability to detect differences in raccoon visitations to scent stations but not coyote visitations was due to the SF site containing the majority (> 50%) of raccoon visits in every season (Table2.2) while no site had > 50% of coyote visits in any season (Table 2.1).

Increased raccoon visitation at the SF study site may have been due to a larger raccoon population at the SF site, or raccoons may have visited scent stations at the SF site at a higher rate than other sites. Both of these possibilities could be explained by the SF site being our only site located completely on private lands. A larger raccoon population could be possible at this site due to increased availability of supplemental food sources on the SF private lands. Cooper and Ginnett (2000) identified raccoons as a frequent visitor to deer feeders. Increased food for racoons at SF could have increased raccoon production. Location of feeders close to roads could also have drawn raccoons towards scent station locations. Another possible reason for higher raccoon populations at the SF is the additional number of trees at this site compared to other sites (Schmidly 1994, Wilson 1996, Chamberlain and Leopold 2001). Other factors that might have contributed to increased raccoon visits to scent stations included decreased vehicular traffic, weather interference, station placement, lure attractiveness (and decreased detection by raccoons due to weather, habitat, and geography), and higher number of juvenile raccoons. Vehicular traffic should have been similar at all sites, especially during the night hours when no vehicular traffic was allowed on the Texas Wildlife

Management Areas (MWMA and GHWMA). Since scent stations were delayed during inclement weather, the effects of weather should also have been negligible.

If increased scent station visitation by raccoons reflected real population differences among the study sites, there could be some important management implications at the study sites. Fewer than 50% of transmittered female turkeys at SF and MWMA were observed nesting, possibly because nests may have been initiated and lost (due to predation, weather, or abandonment) before we were able to detect them (Brunjes et al. 2004). Raccoons are a frequent nest predator (Baker 1979, Ransom et al. 1987, Miller et al. 1998, Hernández et al. 2001, Nelson 2001), and higher raccoon populations (and potential predation of turkey nests) at the SF site may explain reduced detection of nests at this site.

Management Implications

More research is needed to understand the usefulness of scent stations as a survey method for carnivore populations. Some studies have had limited success with use of scent stations to compare relative abundances of predators when used in large areas (i.e., the southwestern U.S., Linhart and Knowlton 1975) or across long periods of time (i.e., > 7 years Sergeant et al.1998). We found differences in raccoon visitation rates, but the relationship between these rates and actual population densities is unknown. In addition, we do not yet understand how large population differences among study sites must be in order to be detected using scent stations and scat surveys.

Scent stations were useful in determining presence or absence of carnivore species. In studies monitoring expansion or compression of home ranges this method may be valuable. Scat surveys are a feasible means of collecting scats for coyote diet analysis, but were not useful for presence-absence or relative abundance estimates in our study due to their passive nature (no lure as in scent stations). Scat surveys may be more useful in presence-absence or relative abundance estimation if they cover a higher proportion of the study sites. We used only 8 km of scat survey lines per site, on sites that were up to 400 km^2, and species detected using scent stations were not detected in scat surveys.

With the amount of variation present in our scent station visitation rates, we found that we would need 181 to 275 scent stations per study site in order to estimate relative abundances of coyote populations. Running 20-25 scent stations at each study site took 1 person 2 days per season, except in winter when shorter days sometimes meant 3 days per site. Running 180 scent stations per site would take 1 person a minimum of 18 days per season per site. In addition to time constraints, we were limited by cost constraints. Scent station FAS tabs cost $50 for 100 tabs, or 0.50 cents per tablet. A final problem with running 180 to 275 scent stations was the issue of independence between stations. We simply did not have enough land present on our study sites to run 180 scent stations while maintaining a 2 km distance between stations in order to consider them independent of one another.

At this point, scent station and scat surveys are practical techniques for most managers to use to estimate relative abundance of carnivore populations. Further research is needed to determine the exact relationship between scent station visitation, scat survey deposition, and actual population abundances, as well as understanding and controlling the biological factors that influence the variation in visitation and deposition rates. With current knowledge, managers would typically need 1 full-time, year-round employee operating scent stations in order to achieve a desired statistically significant result.

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CHAPTER III

COYOTE DIET IN THE TEXAS PANHANDLE AND SOUTHWESTERN KANSAS

Introduction

Diet studies have been used to assess the role animals play in ecosystems. In the case of coyotes (*Canis latrans*), diet studies have provided insight regarding habitat selection (Murray et al. 1994), population density (Clark 1972, Hoffman 1979, Knowlton and Stoddart 1992), movement patterns and home range size (Litvaitis and Shaw 1980, Mills and Knowlton 1991), reproductive rates (Gier 1968, Knowlton 1972), social organization (Bowen 1981, Gese et al. 1996), behavioral budgeting and activity patterns (Bekoff and Wells 1981, Gese et al. 1996), as well as livestock depredation rates (Stoddart et al. 2001).

Coyotes (*Canis latrans*) diets have been studied over most of their range, in a variety of habitats, from Maine (Richens and Hugie 1974, Hilton 1976) to Oregon (Toweill and Anthony 1988) to Texas (Meinzer et al. 1974, Andelt 1985, Windberg and Mitchell 1990). The coyote has been described as a generalist and opportunistic predator (Sperry 1941, Fitcher et al. 1955, Gier 1968). As a generalist, coyote diet varies seasonally and geographically. Vegetation and insects, when available, have been frequent food items in coyote diets during the summer and fall seasons (Fitcher et al. 1955, Meinzer et al. 1975, Bowyer et al. 1983, Parker 1986), and have been primary components of coyote diets in some studies (Hawthorne 1972, Litvaitis and Shaw 1980, Parker 1986). In the northeastern United States, snowshoe hare (*Lepus americanus*) was a primary prey item in coyote diet, and diet was found to fluctuate with the availability of hares (Dibello et al. 1990, O'Connell et al. 1992, Brundige 1993, Patterson et al. 1998). Coyotes frequently fed on raccoons (*Procyon lotor*) on an island in Maine (O'Connell et al. 1992), coastal coyote diets in California included fish (Rose and Polis 1998), and coyotes were observed killing seals and eating seal and seal carrion (both harbor seals *Phoca vitulina* and ringed seals *P. hispida*) carrion (Steiger et al. 1989, Way and Horton 2004) on both the northeastern and northwestern coasts of the United States. Coyote diets are sometimes dominated by large prey items, especially ungulate species (Hawthorne 1972, Andelt et al. 1987, MacCracken 1984, Carrera 2004), though the amount of ungulate remains that come from carrion is unknown. A north-south trend in coyote food habits has been hypothesized due to increased availability of small prey, higher availability of fruit, and higher primary productivity in southern latitudes (Voight and Berg 1987, Gompper and Gittleman 1991).

We suspected coyotes to be the most frequent predator of adult Rio Grande wild turkeys (*Meleagris gallapavo intermedia*) across our 4 study sites during 5 years (2000-2004) of study. However, avian species have been reported as a frequent food item in coyote diet in only 3 studies, 2 reported domestic poultry from poultry farms as a common prey item (Gipson 1974, Litvaitis and Shaw 1980), and the other (Fitcher et al. 1955) reported pheasant (*Phasianus colchicus*) from areas of high pheasant concentrations.

Most coyote diets included poultry, but only in very small quantities (1-3% of total diet) (Andelt et al. 1987, Andelt 1985, Litvaitis and Shaw 1980, Meinzer et al. 1975, Ozoga and Harger 1966, Parker 1986, Windberg and Mitchell 1990). Wagner (1993) examined coyote diet through scat analysis in areas of wild turkey abundance in Arkansas, Mississippi, Alabama, and Florida during the turkey reproductive season, and found that wild turkey occurred in only 1.9% of scats, and equaled 4.0% of prey biomass consumed. Knowlton (1964) examined coyote diet in an area of high wild turkey abundance in south Texas, using both scat and stomach analysis, and found wild turkey in 1.5% of stomachs and ≤ 1% of scats.

There are 4 major methods of assessing carnivore feeding habits: 1) direct observation of prey consumption, 2) examination of prey remains, 3) stomach content analysis, and 4) scat analysis (Kelly 1991, Bartel 2003). The elusiveness of most carnivores precludes direct observation as a useful technique. Documentation of prey remains may not provide a complete diet description because only what is not eaten is quantified (Kelly 1991). Stomach analysis can be useful but requires destruction of the animal (Hoffman 1979, O'Gara 1986). Scat analysis has been the most common tool used to document food habits of coyotes (Murie 1946, Weaver and Hoffman 1979, O'Gara 1986, Kelly 1991, Bartel 2003). Scats are easy to collect, available in large numbers, and cause little disturbance to population and behavioral aspects of the species. Scat analysis appeared to be a practical method to confirm the importance of coyotes as a predator of Rio Grande wild turkeys in our study. Our objective was to determine the diet of coyotes across the Texas Panhandle and southwestern Kansas by scat analysis.

The major problem with quantifying the amount of prey represented by scats is that the relationship between prey remains recovered and actual prey consumed is not known (Kelly 1991). Kelly (1991) recognized that researchers have dealt with this problem in 3 ways: 1) assume the frequency with which prey species occur in a sample of scats corresponds to prey consumed; 2) recognize the short-comings of scat analysis by collecting stomachs and scats concurrently and comparing and contrasting the results of each; and 3) perform feeding trials using prey species similar to those encountered in field collected scats and develop correction factors for predicting actual amounts of prey consumed.

We were unable to collect coyote stomachs or perform feeding trials due to time and monetary constraints. For this reason, we chose to use 2 different consumption estimates: percent of scats, and percent of occurrences. Percent of scats (POS) report the fraction of a sample of scats in which a prey species occurs. Percent of occurrence (POO) reports the number of times a food item occurred in a sample of scats divided by the total number of occurrences of all food items. Percent of occurrence is most commonly reported in other studies and is useful for comparisons to other studies.

Study Areas

Coyote diets were studied at the 4 study sites of the Rio Grande wild turkey project. Three sites were located in the Rolling Plains physiographic region of Texas, and at 1 site was located on the Kansas-Colorado border, in the High Plains physiographic province of the Great Plains.

The Matador Wildlife Management Area (MWMA) was located about 10 km north of Paducah, Texas, in Cottle county, and was the southern-most study site. The MWMA study site was approximately 11,406 ha of public land. Elevations ranged from 488 to 610 m. Average precipitation was 52.6 cm for the year, with the majority falling in May and June. The Pease River flowed from west to east through the study area.

Topography ranged from riparian plains to gently rolling hills and steep-walled canyons. Woody vegetation was dominated by honey mesquite (*Prosopis glandulosa*), redberry juniper (*Juniperus pinchotii*), netleaf hackberry (*Celtis reticulate*), and occasional cottonwoods (*Populus deltoides*).

The Salt Fork of the Red River (SF) study site was located just north of the towns of Clarendon and Hedley, Texas, within Donley and Collingsworth counties. The SF study site was a combination of private land holdings totaling over 20,000 ha. Elevations ranged from 633 to 955 m. Average precipitation was between 52 and 55 cm, with the majority falling from April to October. The Salt Fork of the Red River flowed from west to east through the study area. Characteristic vegetation in rangeland were little bluestem (*Schizachyrium scoparium*), gramma grass (*Bouteloua* spp.), and broom snakeweed (*Gutierrezia sarothrae*), interspersed with honey mesquite, and juniper (*Juniperus* spp.). Characteristic vegetation in riparian areas were wildrye (*Elymus* spp.), western wheatgrass (*Elytrigia smithii*), black locust (*Robinia pseudoacacia*), and eastern cottonwood.

The Gene Howe Wildlife Management Area (GHWMA), located east of Canadian, Texas, in Hemphill county was the northern-most study site in Texas. The GHWMA study site consisted of ca. 2,358 ha of public land. Elevations ranged from 701 to 732 m. Precipitation averaged 53.3 cm per year, with the majority falling in May and June. The Canadian River flowed from west to east through the study area. Dominate vegetation at the GHWMA included sand sagebrush (*Artemsia fififolia*), sandsage-grassland, grassland, and mesquite-grassland. Eastern hackberry (*Celtis occidentalis*), Chickasaw plum (*Prunus angustifolia*), Tamarisk (*Tamarix chinensis*), western soapberry (*Sapindus drummondi,* and cottonwood were the dominant tree species in the riparian areas.

The Cimarron National Grassland (CNG), located in Morton county, Kansas, was the center for the Kansas study site, which also extended into Baca county, Colorado. Elevation ranged from 960 to 1128 m. Average precipitation was 48.6 cm per year, with the majority falling from April to September. The Cimarron River flowed from west to east through the study area. Topography included rock cliffs, sand dunes, grassy fields, and the Cimarron River basin. Dominant grasses included sand bluestem (*Andropogon hallii*), blue gramma (*Bouteloua gracilis*), sideoats gramma (*Bouteloua cutipendula*), dropseed (*Sporobolus crptandrus*), sand lovegrass (*Eragrostis trichodes*), and buffalo grass (*Buchloe dactyloides*). These grasses, combined with sagebrush (*Artemsia fififolia*), four-wing saltbush (*Atriplex canescens*), rabbitbrush (*Chrysothamnus* spp.), snakeweed (*Gutierrezia sarothrae*), and plains yucca (*Yucca glauca*) covered the fields and hills surrounding the Cimarron River corridor. Grasses, cottonwood, and tamarisk groves were found in the river basin.

Potential large mammalian prey within the study areas included white-tailed deer (*Odocoileus virginianus*), domestic cattle (*Bos taurus*), and feral hog (*Sus scrofa*). Potential medium mammalian prey included Eastern cottontail (*Sylvilagus floridanus*), black-tailed jackrabbit (*Lepus californicus*), porcupine (*Erethizon dorsatum*), and skunk (*Mephitus mephitus*). Potential small mammalian prey items included various squirrels (*Sciurus* spp.), rats (*Sigmodon* and *Neotoma* spp.), kangaroo rats (*Dipodymys* spp.), mice (*Peromyscus* spp.), pocket mice (*Perognathus* spp.), harvest mice (*Reithrodontomys* spp.), grasshopper mice (*Onychomys* spp.), gophers (*Geomys* spp.), and voles (*Microtus* spp.). Other potential prey items included Rio Grande wild turkey, bobwhite quail (*Colinus virginianus*), roadrunner (*Geococcyx californiana*), various other bird species, insects, vegetation, and reptiles.

Definitions

Since there is confusion among researchers concerning exact definitions of terms used in scat analysis, we define often confused terms. Definitions were obtained from Kelly (1991) and apply to all discussions within this thesis. See Kelly (1991) for further explanation on the confused nature of terms for quantification of prey remains in scats.

DEFECATION “The discharge of feces from the rectum.”

SCAT: one complete defecation.

RESIDUE: the portion of a scat which persists after washing and drying. For a scat containing mammalian prey, the residue is bone, teeth and hair in the scat.

DISGESTIBILITY: the proportion of *residue* recovered in a scat(s), or the dry weights of a scat(s) relative to the amount of prey ingested.

SCAT ANALYSIS TECHNIQUE: the protocol followed to obtain measurements from a scat; including how scats are prepared and how prey remains are sorted, separated, and measured (e.g., counted, weighed).

SCAT QUANTIFICATION TECHNIQUE: the quantification of prey remains recovered by following a *scat analysis technique*.

NUMBER OF OCCURRENCES: the number of times a prey species occurs in a sample of scats. A prey species can occur no more than once per scat. (The number of times an individual prey species occurs / number of scats examined).

PERCENT OF SCATS (POS): the percent of a sample of scats in which a prey species occurred. [(The number of times a prey species occurs/number of scats examined) X 100].

PERCENT OF OCCURRENCES (POO): the number of times a prey species occurs as a percent of the total number of occurrences for all prey species. {(The number of times a prey species occurs / total number of occurrences of all prey species) X 100]. This could be expressed by taxonomic group also as the percent of mammalian occurrence, or percent insect occurrence, etc.

FREQUENCY DATA: a generic term that refers to *quantifying* scat contents by the frequency with which a prey occurs.

Percent of scats (POS) and percent of occurrences (POO) represent the 2 different measures of prey consumption used in this study. Percent of scats describes how common an item is in a carnivore's diet. P of occurrence measures the frequency with which a prey species occurs in a sample of scats relative to the other prey species detected.

PREY CATEGORY: The most broad classification of food items (5 prey categories in this thesis: Large, medium, and small mammals, vegetation, and other).

PREY TYPE: Finest classification of food items, usually to species, sometimes to genus, order, or class. (27 prey types, Hispid cotton rat, harvest mouse, and deer mouse are all prey types within the small mammal prey category).

PREY OCCURRENCE: Classification of food items on a per scat basis, is the same as number of occurrences, above (476 prey occurrences in this study, a single prey type can occur no more than once per scat, but multiple prey types can occur within one scat).

Methods

We collected 382 coyote scats for diet analysis seasonally from April 2003 to April 2004 along scat survey lines (Table 3.1). Scat surveys consisted of 4 2-km transects along unpaved roadways per study site. Scat transect placement corresponded with Global Positioning System (GPS) location of mortality sites of radio-transmittered Rio Grande wild turkeys (from 2000-2002). We plotted Universal Transverse Mercator (UTM) coordinates from mortalities in ArcView GIS (Environmental Systems Research Institute (ESRI), 1969, Redlands, California). We identified roads which occurred in proximity to > 5 turkey mortalities, and established permanent survey lines along those roads identified in the field as accessible, unpaved, and least frequented by vehicular traffic of all roads on that study site.

We walked roadways 2 days prior to surveys and collected all scats from transects ($n = 206$). We re-walked roads on the third day to provide the index to predator abundance, and these scats were also collected for diet analysis ($n = 171$). We also collected scats opportunistically in the field at turkey mortality sites ($n = 5$). None of the scats from turkey mortality sites contained turkey, so we included them as a non-biased sample of coyote diet.

Scats were collected and labeled by species, transect, and date. Scats were identified to species by presence of tracks and morphological characteristics. We considered all scats over 20 mm diameter to have been deposited by coyote (Green and Flinders 1981, Danner and Norris 1982, Rezendes 1999). Collected scats were placed in individual paper bags labeled with a unique identification code, and allowed to air dry. In the laboratory, we measured the maximum diameter of each dried scat (Scott 1943, Weaver and Fritts 1979, Green and Flinders 1981, Danner and Dodd 1982) using dial calipers (General Tools Manufacturing Co., LLC, New York, New York). We also measured total length and weight of each dried scat. Each scat placed in a nylon knee-high pantyhose for washing, along with a water-proofed label. Scats were soaked in hot water and detergent for 24-30 hours. Scats were washed in a washing machine with detergent on regular cycle. Scats were immediately removed from pantyhose and placed in an open plastic bag labeled with the scat identification code. Scats in open plastic bags were placed in a 120 degree drying room for 24-48 hours.

Each scat was analyzed for species composition. Food items were manually separated from the scats. We identified the undigested food items macroscopically by comparing to a reference collection and reference materials (Sperry 1941). Reference collection was obtained opportunistically at study sites from road kill species. Reference materials included Day (1966), Moore et al. (1974), Schwartz and Schwartz (1981), Schmidly (1994) and Martin et al. (2001). Food items were identified using the following criteria: reptilian species were identified by scales, skin, and claws; mammalian species by bones, hair, skull characteristics, teeth shape and size, jaw morphology, and claws; birds by feathers, bones, beaks, and feet; and plants by bark, seeds, leaves, twigs, fruit, and fruit pods. Scats containing turkey were identified based on size of bone fragments and calumus (the portion of the feather shaft embedded in the skin), as no whole turkey feathers were found in coyote scats. Insect remains consisted of exoskeletons, stingers, claws, wings, legs, and heads, and were not identified beyond class. We identified food items to species when possible, or to genus or class when more specific identification was not possible.

We calculated percent of occurrence (POO) and percent of scats (POS) for each prey species during each season at each study site. We used POO for all statistical analyses. For statistical analysis we pooled food items into 5 categories: small mammals (rodents and sciurids), medium mammals (lagomorphs), large mammals (deer, cattle, hog), vegetation, and other (avian, reptilian, and insect). We conducted a literature search and classified results from previous studies into our 5 prey categories for comparison with our results.

We used chi-square likelihood ratio contingency-table analysis (G-test; Ott 1988) corrected for continuity (Williams 1976) to determine differences in diet composition among seasons, study sites, and prey items. Tests were considered significant at $\alpha = 0.05$. Simple main effects tests were used when interactions between season, study site, and prey items were significant.

Results

Diet composition of coyote scats (n = 374) consisted of 27 prey types, primarily small mammal species (n = 11, Table 3.1) and vegetation (n = 8, Summer Table 3.1, and Spring, Table 3.2), followed by large mammal species (n = 3, Table 3.1), medium mammal species (n = 2, Table 3.3), avian species (n = 2), reptiles (n = 1), and insects (n = 1). Summer and Fall (n = 23, Tables 3.1 and 3.3, respectively) had the highest number of prey types, followed by Winter (n = 17, Table 3.4), and Spring (n = 15, Table 3.2).

We found 476 prey occurrences in 374 scats, resulting in 1.26 prey types per scat (Table 3.5), ranging from a minimum of 1 to a maximum of 4 prey types per scat. Prey occurrences were primarily small- (n = 194, 40.8 POO) and medium-sized (n = 73, 15.3 POO) mammals (Summer Table 3.1, Spring Table 3.2, Fall season Table 3.3, Winter season Table 3.4). The most common prey occurrence across all sites and seasons was Eastern cottontail (n = 69, 14.5 POO), identified in scats at all sites.

Differences in prey categories were not consistent across sites and seasons (G = 104.34, $P < 0.0001$), or across sites within seasons (Spring 2003 G = 29.02, P = 0.0039; Summer 2003 G = 29.65, P = 0.0031; Fall 2003 G = 44.55, $P < 0.0001$; Winter 2004 G = 28.57, P = 0.0046). There was no difference ($P > 0.05$) among prey categories at MWMA during Spring, Summer, or Fall (Table 3.6), or at SF during Winter (Table 3.7). There was a difference among prey categories at CNG (Table 3.8) and GHWMA (Table 3.9) within every season ($P < 0.05$).

Small mammals were either the most frequent prey category, or their frequency of occurrence was not significantly different from more frequent categories, within every site and season, except CNG in Fall, when only vegetation was more frequent (G = 21.69 $P > 0.0001$, Table 3.8). White-footed (*Peromyscus leucopus*), and deer mice (*Peromyscus maniculatus*), (n = 42, 8.8 POO), and hispid cotton rat (*Sigmodon hispidus*, n = 28, 5.9 POO) were the most common prey types in the small mammal prey category.

Medium mammals, particularly Eastern cottontail, were most frequent at GHWMA, where seasons were similar in frequency (Table 3.9). Medium mammals were not frequent at MWMA in any season (Table 3.6), SF in summer (n = 1, 4.0 POO) or winter (n = 1, 5.9 POO, Table 3.7), or CNG in spring (n = 0, 0.0 POO) or fall (n = 3, 5.3 POO).

Large mammals were detected in scats infrequently (n=36, 7.6 POO), although we did detect cattle (n = 23, 4.8 POO) and feral hog (n = 8, 1.7 POO) in scats during every season and at every site. Deer was present (n = 5, 1.1 POO) in every season except winter, and at all sites except SF. Large mammals were a primary component in coyote scats only in the spring at MWMA (*n* = 4, 44.4 POO), however there was no difference among prey items within this site and season (G = 3.23, *P* = 0.0723, Table 3.6).

Vegetation was an important food category, particularly prickly pear (*Opuntia* spp.) fruit during the fall season at CNG (*n* = 35, 7.4 POO, Table 3.3). However, vegetation was not important at every study site, or within every season. At CNG, vegetation was the primary component of coyote diet in Fall (*n* = 38, 66.7 POO), but was not frequent in other seasons (Table 3.8). At SF (*n* = 71), vegetation was a primary component of coyote diet in the Summer (*n* = 9, 37.5 POO), Fall (*n* = 11, 31. POO), and Winter (*n* = 7, 41.2 POO), but not in Spring (*n* = 2, 8.3 POO, Table 3.7). At MWMA, vegetation was high in Summer (*n* = 6, 37.5 POO) and Fall (*n* = 4, 44.4 POO), but low in Spring (*n* = 2, 22.2 POO), and almost absent in Winter (*n* = 1, 10.0 POO, Table 3.6). The GHWMA had very little vegetation (*n* = 18 across seasons, 12.7 POO), with vegetation most frequent in Winter (*n* = 6, 18.8 POO, Table 3.9), and Fall (*n* = 9, 18.0 POO), but almost absent in Spring (*n* = 1, 6.3 POO) and Summer (*n* = 2, 4.5 POO).

The final prey category, other, was comprised of insects, reptiles, and avian species. Insects (*n* = 40, 8.4 POO) were found most frequently in summer and fall seasons. No insects were found during the winter season, and only 1 scat contained insects in the spring season. We detected avian species (*n* = 13, 2.7 POO) in coyote scats at SF (*n* = 6), GHWMA (*n* = 2), and CNG (*n* = 4) sites. Turkey was <1% of all food items, detected only at SF (*n* = 2) and CNG (*n* = 1). Reptiles (*n* = 7, 8.9 POO) were detected at only the CNG site in the summer season and consisted entirely of box turtles (*Terrapene carolina carolina).*

Table 3.1. Food items (n = 162) found in coyote (*Canis latrans*) scats (n = 118) during Summer, in the Texas Panhandle and Southwestern Kansas, June to July, 2003. Comparison values are expressed as percent of scats (POS) and percent of occurrence (POO).

	MWMA[a]			SF[b]			GHWMA[c]			CNG[d]		
Prey Item	No.	POS	POO	No.	POS	POO	No.	POS	POO	No.	POS	POO
Large Mammals	1	9.09	6.25	2	15.38	8.33	2	5.71	4.55	3	5.08	3.85
Deer (*Odocoileus virginianus*)	--			--			1	2.86	2.27	1	1.69	1.28
Cattle (*Bos taurus*)	1	9.09	6.25	2	15.38	8.33	1	2.86	2.27	1	1.69	1.28
Feral hog (*Sus scrofa*)	--			--			--			1	1.69	1.28
Medium Mammals	1	9.09	6.25	1	7.69	4.17	9	25.71	20.45	13	22.03	16.67
Eastern cottontail (*Syvilagus floridanus*)	1	9.09	6.25	1	7.69	4.17	9	25.71	20.45	13	22.03	16.67
Small Mammals	5	45.45	31.25	8	61.54	33.33	21	60.0	47.73	28	47.46	35.90
Black-tailed prairie dog (*Cynomys ludovicianus*)	--			--			--			1	1.69	1.28
Deer or white-footed mouse (*Peromyscus* spp.)	--			2	15.38	8.33	5	14.29	11.36	5	8.47	6.41
Fox squirrel (*Sciurus niger*)	--			3	23.08	12.50	2	5.71	4.55	2	3.39	2.56
Harvest mouse (*Reithrodontomys* spp.)	1	9.09	6.25	--			1	2.86	2.27	1	1.69	1.28
Hispid cotton rat (*Sigmodon hispidus*)	--			2	15.38	8.33	4	11.43	9.09	2	3.39	2.56
House mouse (*Mus musculus*)	--			--			1	2.86	2.27	1	1.69	1.28
Kangaroo rat (*Dipodomys* spp.)	1	9.09	6.25	--			1	2.86	2.27	7	11.86	8.97
Pocket gopher (*Geomys* spp.)	--			--			1	2.86	2.27	1	1.69	1.28
Pocket mouse (*Perognathus* spp.)	--			--			1	2.86	2.27	1	1.69	1.28
Vole (*Microtus* spp.)	--			--			1	2.86	2.27	1	1.69	1.28
Unknown rodent	3	27.27	18.75	1	7.69	4.17	4	11.43	9.09	6	10.17	7.69
Vegetation	6	54.55	37.50	9	69.23	37.50	2	5.71	4.55	8	13.56	10.26
Cattle cake	--			--			--			1	1.69	1.28
Chickasaw plum (*Prunus angustifolia*)	1	9.09	6.25	8	61.54	33.33	2	5.71	4.55	--		
Prickly pear (*Opuntia* spp.)	2	18.18	12.50	--			--			3	5.08	3.85
Unknown vegetation	3	27.27	18.75	1	7.69	4.17	--			4	6.78	5.13
Insect	3	27.27	18.75	--			9	25.72	20.45	15	25.42	19.23
Avian	--			4	30.77	16.67	1	2.86	2.27	4	6.78	5.13
Turkey (*Meleagris gallapavo*)	--			1	7.69	4.17	--			1	1.69	1.28
Unknown avian	--			3	23.08	12.50	1	2.86	2.27	3	5.08	3.85
Reptile	--			--			--			7	11.86	8.97
Eastern box turtle (*Terrapene carolina Carolina*)	--			--			--			7	11.86	8.97
Total number of food items	16			24			44			78		
Total number of scats	11			13			35			59		

[a] MWMA = Matador Wildlife Management Area, Texas
[b] SF = Salt Fork of the Red River private land holdings, Texas
[c] GHWMA = Gene Howe Wildlife Management Area, Texas
[d] CNG = Cimarron National Grasslands, Kansas

Table 3.2. Food items (*n* = 52) found in coyote (*Canis latrans*) scats (*n* = 43) during Spring, in the Texas Panhandle and Southwestern Kansas, April, 2003. Comparison values are expressed as percent of scats (POS) and percent of occurrence (POO).

	MWMA			SF			GHWMA			CNG		
Prey Item	No.	POS	POO	No.	POS	POO	No.	POS	POO	No.	POS	POO
Large Mammals	4	57.14	44.44	4	20.00	16.67	2	15.38	12.50	--		
Deer (*Odocoileus virginianus*)	1	14.29	11.11	--			1	7.69	6.25	--		
Cattle (*Bos taurus*)	2	28.57	22.22	3	15.0	12.5	--			--		
Feral hog (*Sus scrofa*)	1	14.29	11.11	1	5.0	4.17	1	7.69	6.25	--		
Medium Mammals	1	14.29	11.11	4	20.0	16.67	6	46.15	37.50	--		
Eastern cottontail (*Syvilagus floridanus*)	1	14.29	11.11	4	20.0	16.67	6	46.15	37.50	--		
Small Mammals	1	14.29	11.11	14	70.0	58.33	7	53.85	43.75	3	100.0	100.0
Deer or white-footed mouse (*Peromyscus* spp.)	--			5	25.0	20.83	--			1	33.33	33.33
Fox squirrel (*Sciurus niger*)	--			1	5.0	4.17	1	7.69	6.25	--		
Hispid cotton rat (*Sigmodon hispidus*)	--			2	10.0	8.33	2	15.38	12.50	--		
House mouse (*Mus musculus*)	--			--			--			1	33.33	33.33
Kangaroo rat (*Dipodomys* spp.)	--			1	5.0	4.17	1	7.69	6.25	--		
Pocket gopher (*Geomys* spp.)	1	14.29	11.11	1	5.0	4.17	--			--		
Pocket mouse (*Perognathus* spp.)	--			--			1	7.69	6.25	--		
Unknown rodent	--			4	20.0	16.67	2	15.38	12.50	1	33.33	33.33
Vegetation	2	28.57	22.22	2	10.0	8.33	1	7.69	6.25	--		
Peanuts	--			1	5.0	4.17	--			--		
Unknown vegetation	2	28.57	22.22	1	5.0	4.17	1	7.69	6.25	--		
Insect	1	14.29	11.11	--			--			--		
Total number of food items	9			24			16			3		
Total number of scats	7			20			13			3		

[a] MWMA = Matador Wildlife Management Area, Texas
[b] SF = Salt Fork of the Red River private land holdings, Texas
[c] GHWMA = Gene Howe Wildlife Management Area, Texas
[d] CNG = Cimarron National Grasslands, Kansas

Table 3.3. Food items (n = 151) found in coyote (*Canis latrans*) scats (n = 122) during Fall, in the Texas Panhandle and Southwestern Kansas, October to November, 2003. Comparison values are expressed as percent of scats (POS) and percent of occurrence (POO).

		MWMA			SF			GHWMA			CNG	
Prey Item	No.	POS	POO	No.	POS	POO	No.	POS	POO	No.	POS	POO
Large Mammals	1	11.11	11.11	1	3.70	2.86	8	19.51	16.0	2	4.44	3.51
Deer (*Odocoileus virginianus*)	--			--			1	2.44	2.0	--		
Cattle (*Bos taurus*)	1	11.11	11.11	1	3.70	2.86	5	12.20	10.0	2	4.44	3.51
Feral hog (*Sus scrofa*)	--			--			2	4.88	4.0	--		
Medium Mammals	--			6	22.22	17.14	11	26.83	22.0	3	6.67	5.26
Eastern cottontail (*Syvilagus floridanus*)	--			6	22.22	17.14	10	24.39	3	6.67	5.26	
Black-tailed jackrabbit (*Lepus californicus*)	--			--			1	2.44	2.0	--		
Small Mammals	1	11.11	11.11	12	44.44	34.29	16	39.02	32.0	14	31.11	24.56
Deer or white-footed mouse (*Peromyscus* spp.)	--			3	11.11	8.57	3	7.32	6.0	3	6.67	5.26
Fox squirrel (*Sciurus niger*)	--			--			1	2.44	2.0	--		
Harvest mouse (*Reithrodontomys* spp.)	--			--			1	2.44	2.0	--		
Hispid cotton rat (*Sigmodon hispidus*)	--			4	14.81	11.43	--			--		
House mouse (*Mus musculus*)	--			--			1	2.44	2.0	3	6.67	5.26
Kangaroo rat (*Dipodomys* spp.)	--			--			1	2.44	2.0	1	2.22	1.75
Pocket gopher (*Geomys* spp.)	1	11.11	11.11	2	7.41	5.71	--			1	2.22	1.75
Pocket mouse (*Perognathus* spp.)	--			--			1	2.44	2.0	1	2.22	1.75
Unknown rodent	--			3	11.11	8.57	8	19.51	16.0	5	11.11	8.77
Vegetation	4	44.44	44.44	11	40.74	31.43	9	21.95	18.0	38	84.44	66.67
Black locust (*Robinia pseudoacacia*)	--			--			5	12.20	10.0	--		
Chickasaw plum (*Prunus angustifolia*)	--			3	11.11	8.57	--			--		
Honey mesquite (*Prosopis glandulosa*)	--			1	3.70	2.86	--			--		
Prickly pear (*Opuntia* spp.)	1	11.11	11.11	--			--			35	77.78	61.40
Peanuts	--			3	11.11	8.57	2	4.88	4.0	--		
Seeds	--			1	3.70	2.86	--			--		
Unknown vegetation	3	33.33	33.33	3	11.11	8.57	2	4.88	4.0	3	6.67	5.26
Insect	3	33.33	33.33	3	11.11	8.57	6	14.63	12.0	--		
Avian (unknown species)	--			2	7.41	5.71	--			--		
Total number of food items	9			35			50			57		
Total number of scats	9			27			41			45		

[a] MWMA = Matador Wildlife Management Area, Texas
[b] SF = Salt Fork of the Red River private land holdings, Texas
[c] GHWMA = Gene Howe Wildlife Management Area, Texas
[d] CNG = Cimarron National Grasslands, Kansas

Table 3.4. Food items (n = 111) found in coyote (*Canis latrans*) scats (n = 90) during Winter, in the Texas Panhandle and Southwestern Kansas, February to March, 2004. Comparison values are expressed as percent of scats (POS) and percent of occurrence (POO).

	MWMA			SF			GHWMA			CNG		
Prey Item	No.	POS	POO	No.	POS	POO	No.	POS	POO	No.	POS	POO
Large Mammals	2	28.57	20.0	3	27.27	17.65	--			1	2.22	1.92
Cattle (*Bos taurus*)	1	14.29	10.0	2	18.18	11.76	--			1	2.22	1.92
Feral hog (*Sus scrofa*)	1	14.29	10.0	1	9.09	5.88	--			--		
Medium Mammals	2	28.57	20.0	1	9.09	5.88	7	25.93	21.88	7	15.56	13.46
Eastern cottontail (*Syvilagus floridanus*)	2	28.57	20.0	1	9.09	5.88	7	25.93	21.88	5	11.11	9.62
Black-tailed jackrabbit (*Lepus californicus*)	--			--			--			2	4.44	3.86
Small Mammals	5	71.43	50.0	5	45.45	29.41	18	66.67	56.25	35	77.78	67.31
Deer or white-footed mouse (*Peromyscus* spp.)	--			1	9.09	5.88	1	3.70	3.13	13	28.89	25.00
Fox squirrel (*Sciurus niger*)	--			1	9.09	5.88	5	18.52	15.63	--		
Harvest mouse (*Reithrodontomys* spp.)	--			--			--			2	4.44	3.85
Hispid cotton rat (*Sigmodon hispidus*)	--			2	18.18	11.76	7	25.93	21.88	3	6.67	5.77
House mouse (*Mus musculus*)	--			--			1	3.70	3.13	3	6.67	5.77
Kangaroo rat (*Dipodomys* spp.)	2	28.57	20.0	--			1	3.70	3.13	6	13.33	11.54
Pocket gopher (*Geomys* spp.)	2	28.57	20.0	--			--			--		
Pocket mouse (*Perognathus* spp.)	--			--			1	3.70	3.13	2	4.44	3.85
Unknown rodent	1	14.29	10.0	1	9.09	5.88	2	7.41	6.25	6	13.33	11.54
Vegetation	1	14.29	10.0	7	63.64	41.18	6	22.22	18.75	6	13.33	11.54
Peanuts	--			4	36.36	23.53	2	7.41	6.25	--		
Unknown vegetation	1	14.29	10.0	3	27.27	17.65	4	14.81	12.50	6	13.33	11.54
Avian	--			1	9.09	5.88	1	3.70	3.13	--		
Turkey (*Meleagris gallapavo*)	--			1	9.09	5.88	--			--		
Unknown avian	--			--			1	3.70	3.13	--		
Total number of food items	9			35			50			57		
Total number of scats	9			27			41			45		

[a] MWMA = Matador Wildlife Management Area, Texas
[b] SF = Salt Fork of the Red River private land holdings, Texas
[c] GHWMA = Gene Howe Wildlife Management Area, Texas
[d] CNG = Cimarron National Grasslands, Kansas

Table 3.5 Number of coyote scats collected seasonally at 3 study sites in the Texas Panhandle and 1 study site in Southwestern Kansas from April 2003 to April 2004.

Season	*n*	MWMA[a]	SF[b]	GHWMA[c]	CNG[d]	TOTAL
Spring	Scats	7	20	13	3	43
	Prey items	9	24	16	3	52
	Prey items per scat	1.29	1.20	1.23	1.00	1.21
Summer	Scats	11	13	35	59	118
	Prey items	16	24	44	78	162
	Prey items per scat	1.45	1.85	1.26	1.32	1.37
Fall	Scats	9	27	41	45	122
	Prey items	9	35	50	57	151
	Prey items per scat	1.00	1.30	1.22	1.27	1.24
Winter	Scats	7	11	27	45	90
	Prey items	10	17	32	52	111
	Prey items per scat	1.43	1.55	1.19	1.16	1.23

[a] MA = Matador Wildlife Management Area
[b] SF = Salt Fork of the Red River Private Land Holdings
[c] GH = Gene Howe Wildlife Management Area
[d] KS = Cimarron National Grasslands, Kansas

Table 3.6. Coyote diet composition at Matador Wildlife Management Area, Paducah, Texas, within seasons (*n* = 4) found in coyote scats (*n* = 43) collected from April 2003 to April 2004. Scats were identified by traditional field methods (i.e. diameter, and sign). Food items were combined as small mammals (rodents and sciurids), medium mammals (lagomorphs), large mammals (deer, cattle, feral hog), vegetation, and other (avian, insect, reptilian). Comparison values are expressed as percent of occurrence (POO).

	Spring 2003			Summer 2003			Fall 2003			Winter 2003		
Prey Category	n	POO (%)		n	POO (%)		n	POO (%)		n	POO (%)	
Small Mammals	1	11	A[a]	5	31	A	1	11	A	4	40	A
Medium Mammals	1	11	A	1	6	A	0	0	A	2	20	AB
Large Mammals	4	44	A	1	6	A	1	11	A	2	20	AB
Vegetation	2	22	A	6	38	A	4	44	A	1	10	B
Other	1	11	A	3	19	A	3	33	A	0	0	B
TOTAL	9			16			9			10		

[a] POO's within a season followed by the same letter are not significantly different from each other ($P \geq 0.05$).

Table 3.7. Coyote diet composition at Salt Fork study site, Clarendon, Texas, within seasons (n = 4) found in coyote scats (n = 71) collected from April 2003 to April 2004. Scats were identified by traditional field methods (i.e. diameter, and sign). Food items were combined as small mammals (rodents and sciurids), medium mammals (lagomorphs), large mammals (deer, cattle, feral hog), vegetation, and other (avian, insect, reptilian). Comparison values are expressed as percent of occurrence (POO).

	Spring 2003			Summer 2003			Fall 2003			Winter 2003		
Prey Category	n	POO (%)		n	POO (%)		n	POO (%)		n	POO (%)	
Small Mammals	14	58	A	8	33	A	12	34	A	5	29	A
Medium Mammals	4	17	B	1	4	B	6	17	A	1	6	A
Large Mammals	4	17	B	2	8	AB	1	3	B	3	18	A
Vegetation	2	8	BC	9	38	A	11	31	A	7	41	A
Other	0	0	C	4	17	A	5	15	AB	1	6	A
TOTAL	24			24			35			17		

[a] POO's within a season followed by the same letter are not significantly different from each other ($P \geq 0.05$).

Table 3.8. Coyote diet composition at Cimarron National Grasslands, Kansas within seasons (n = 4) found in coyote scats (n = 152) collected from April 2003 to April 2004. Scats were identified by traditional field methods (i.e. diameter, and sign). Food items were combined as small mammals (rodents and sciurids), medium mammals (lagomorphs), large mammals (deer, cattle, feral hog), vegetation, and other (avian, insect, reptilian). Comparison values are expressed as percent of occurrence (POO).

	Spring 2003			Summer 2003			Fall 2003			Winter 2003		
Prey Category	n	POO (%)		n	POO (%)		n	POO (%)		n	POO (%)	
Small Mammals	3	100	A	28	36	A	14	25	B	35	71	A
Medium Mammals	0	0	B	13	17	B	3	5	BC	7	14	B
Large Mammals	0	0	B	3	4	C	2	4	CD	1	2	C
Vegetation	0	0	B	8	10	BC	38	67	A	6	12	BC
Other	0	0	B	26	33	AB	0	0	D	0	0	C
TOTAL	3			78			57			49		

[a] POO's within a season followed by the same letter are not significantly different from each other ($P \geq 0.05$).

Table 3.9. Coyote diet composition at Gene Howe Wildlife Management Area, Canadian, Texas, within seasons (*n* = 4) found in coyote scats (*n* = 116) collected from April 2003 to April 2004. Scats were identified by traditional field methods (i.e. diameter, and sign). Food items were combined as small mammals (rodents and sciurids), medium mammals (lagomorphs), large mammals (deer, cattle, feral hog), vegetation, and other (avian, insect, reptilian). Comparison values are expressed as percent of occurrence (POO).

	Spring 2003			Summer 2003			Fall 2003			Winter 2003		
Prey Category	n	POO (%)		n	POO (%)		n	POO (%)		n	POO (%)	
Small Mammals	7	44	A	21	48	A	16	32	A	18	56	A
Medium Mammals	6	38	A	9	20	B	11	20	AB	7	22	B
Large Mammals	2	13	AB	2	5	C	8	16	BC	0	0	C
Vegetation	1	6	B	2	5	C	9	18	BC	6	19	B
Other	1	6	B	10	22	B	6	12	C	1	3	BC
TOTAL	16			44			50			32		

[a] POO's within a season followed by the same letter are not significantly different from each other (P≥0.05).

Discussion

We found that coyote diets in the Texas Panhandle and Southwestern Kansas were comprised primarily of small- and medium-sized mammals, with vegetation important seasonally. These results were similar to previous diet studies (Appendix). Coyote diets depend on season, study area location, and prey availability. The wide variety of food items in our coyote diet analysis, combined with the frequency of which food items were detected seasonally and among study sites supports the idea of coyotes as a generalist feeder, opportunistically feeding on the most available prey items.

Although we did not assess food availability in our study, differences in seasons can probably be attributed to the high variability of food availability. Insects were frequently detected in coyote scats in the summer diet, but were absent in winter. Prickly pear and other fruits were common in coyote scats during summer and fall, but were absent in winter and spring. Differences within seasons across study sites were probably due to lack of prickly pear at SF study site in any season, and higher proportions of insects at the GHWMA and CNG than SF and MWMA sites, which may be related to habitat differences between these sites.

Coyote diets as determined through scat analysis in the Rolling Plains of Texas were composed mainly of vegetation (48.5 POO), small mammals (24.5 POO), and medium-sized mammals (10.8 POO), dependent on season and year (Meinzer et al. 1975, Table 3.10). In south Texas, lagomorphs, woodrats (*Neotoma* spp.), and cotton rats (*Sigmodon* spp.) comprised 70% of food items (Windberg and Mitchell 1990). Our results were similar to these studies, with small mammals, vegetation, and medium-sized mammals combined comprising 84% of our prey types. It was likely that the variation in diets between other studies and our own can be attributed to potential food and their use and availability to coyotes in the study areas. The previous study in the Rolling Plains was conducted further south than our study. Honey mesquite (*Prosopis glandulosa*) was 15.6% of all prey types in their study, and ranked as the 2nd most important prey type (Meinzer et al. 1975), while we found honey mesquite in only 1 coyote scat, and was our least important individual prey type (Table 3.3).

We did a thorough literature search of previous coyote diet studies across the United States. We compiled POS data from each of the studies that used scat analysis to determine coyote diet (Appendix). When compared to previous diet studies, our results are similar, with coyote diets depend on season, study area location, and prey availability. Similar results (food items of greatest importance to coyote diet being small mammals, vegetation, and medium mammals, respectively) were also found in the Wichita Mountains in Oklahoma (Litvaitis and Shaw 1980), the Nebraska sandhills (Fitcher et al. 1955), the National Bison Range in western Montana (Reichel et al. 1991), the chaparral of San Diego, California (Bowyer et al. 1983), and in the Cascade Mountains of Oregon (Toweill and Anthony 1998). Most other studies found a combination of small and medium-sized mammals with seasonal vegetation to be the primary component of coyote diet (Johnson and Hansen 1977, Johnson and Hansen 1979, Ortega 1987, Snyder 2003). However, several studies have found very little (< 3%) of the coyote diet to be comprised of vegetation (Hawthorne 1972, MacCracken 1981, MacCracken and Hansen 1982, Leopold and Krausman 1986, Cypher et al. 1996, Arjo et al. 2002).

Large mammals have been the primary component of coyote diet in forested areas (Berg and Chesness 1978, Hilton 1978, MacCracken 1984, Major and Sherburne 1987, Cypher et al. 1993, Carrera 2004). In these areas, ungulates were the most common prey item. Often when large prey items are found in coyote diet it is assumed the coyotes were feeding on carrion (Hilton 1978), however Gese et al. (1988) reported that 71% of the variation in the volume of large prey (e.g. adult ungulates) could be explained by coyote group size, with scats from coyotes in larger groups containing higher proportions of large prey than scats from coyotes in smaller groups or alone. Recent studies have shown that coyotes do feed on larger prey, especially young, sick, or old prey animals (Teer et al. 1991, Crabtree and Sheldon 1999).

We found large mammals to be a small proportion of coyote diet, possibly explained by differences in habitat, prey availability, and coyote group size at our study sites compared to other studies. Coyotes in northeastern North America switched primary prey species from snowshoe hare to white-tailed deer in times of hare decline (Patterson et al. 1998). If coyotes in our study primarily preyed upon the most abundant species, our results may reflect population dynamics of rodent species, and a longer term diet analysis at our study sites might obtain results with higher proportions of large mammals.

Murie (1940) thought that birds were taken accidentally by coyotes in Yellowstone Park, meaning that birds were a prey item only when easily caught. In Nebraska, Fitcher et al. (1955) felt that it was probable that coyotes rarely hunted small bird prey with the persistence used to track other species such as pocket gophers and meadow mice, and felt that most of the bird species (pheasant, grouse and domestic chicken) eaten by coyotes were scavenged carrion. Habituation of coyotes to domestic poultry has been suggested in areas where farmers dispose of dead poultry in a constant, traditional area (Fitcher et al. 1955, Gipson 1974). Over time, habituation to carrion may lead to actual predation on live birds (Fitcher et al. 1955, Gier 1968, Gipson 1974).

We found coyotes were the most frequent predator on adult Rio Grande wild turkeys, however we attributed very little of coyote diet to avian species (2.73 POO), and < 1% to turkey. We suspected coyotes as our primary predator, however results from our diet analysis do not reflect this.

The first possibility for our contradictory results is that we misidentified the causative factor or predator species at turkey mortality sites. Determination of the specific predator at a turkey mortality site is often speculative, and the final decision is a "best guess" obtained from limited evidence. In most cases, we cannot differentiate predation from scavenging, and we have little knowledge of what portions of the turkey were eaten, with regard to food versus non-food parts of turkey.

The second possibility for our contradictory results is that coyotes do not ingest non-food portions of turkey in proportions equal to other species, thus turkeys are not detectable in coyote scats. Feathers, bones, beak, feet, and feet scales are used in identification of avian species in coyote scats. There have been no studies conducted which examine coyote feeding behavior on large avian species, regarding consumption and digestion of non-food parts. Kelley (1991) fed magpies (*Pica pica*) to captive coyotes in a series of feeding trials and was able to differentiate scats containing magpie from those containing other species. Fitcher et al. (1955) detected avian species in 11.7%

of food items, however over half of these were thought to be songbirds. We do not know if coyote feeding behavior is similar among avian species of different sizes.

The third possibility for our contradictory results builds on our second theory. Turkey may have been an important source of protein to coyotes and feathers, particularly barbules of covert feathers and all of smaller feathers such as semiplume, filoplume, down, and powder down, may be completely digested. The 2 studies that found domestic turkey as a frequent food item in coyote diet both analyzed coyote stomachs, not scats (Gipson 1974, Litvaitis and Shaw 1980). Fitcher et al. (1955) detected higher avian presence in coyote stomachs (18.99% of all food items) than in scats (11.69%). They also found 6.85% of stomachs, but only 0.64% of scats contained Galliformes, including pheasant, grouse (*Falcipennis* spp.), and undetermined species. Meals high in protein increased gastric retention time of non-digestible material (hair, bones) in coyote feeding studies (Hinder and Kelly 1977, Kelly 1991), and resulted in lower recovery of teeth in coyote scats (Kelly 1991). However, hair recovery in scats was the same in coyotes fed high protein and low protein meals (Kelley 1991). Potentially, higher protein available to coyotes when feeding on larger avian species such as turkey increases digestion of feathers and decreases detectability in scats. This could explain why Fitcher et al. (1955) obtained higher avian presence in stomachs than scats, and why our scats with turkey evidence contained only large bones and feather shafts, which are thicker and would be less digestible than the barbules of feathers. Wagner (1993) found that ranks of wild turkey among other prey items in coyote diet increased when viewed from a biomass perspective rather than a frequency of occurrence perspective.

A fourth possible cause for our contradictory results is twofold. Turkey mortality at our study sites was found to be highest in the spring (approximately March 21st to June 21st) (Figure 1), and predation was highest in the months of February, April, May and June (Figure 2). Our scat collections occurred seasonally, with spring collections in April, and summer collections in late July to early August. Spring was the season of lowest scat collection (Table 3.5), for unknown reasons. We collected only 12% of our scats during the spring season, and may have unintentionally biased our results against turkey presence.

We feel that coyotes on our study sites may actually consume higher proportion of mid- and large-sized prey than indicated by out scat analysis. An increase in the relative importance of these prey items might be indicated if percent fresh weights of prey items consumed were available for analysis. If prey items ranked according to frequency data (our results) were ranked according to percent fresh weight of prey consumed (results from feeding trials), relative ranks of large-sized prey would be higher using percent fresh weight of prey (Wagner 1993). This change occurs because the non-flesh component bias has been corrected by the ratio estimator or kilogram of prey consumed/scat ratio. Prey, such as insects and passerines, that typically occur frequently, but contribute very little volume to a scat, decline in rank. The importance of mid-sized animals, such as raccoons, opossums, and wild turkeys, and large-sized animals, such as deer and cattle, would probably increase in rank in our study.

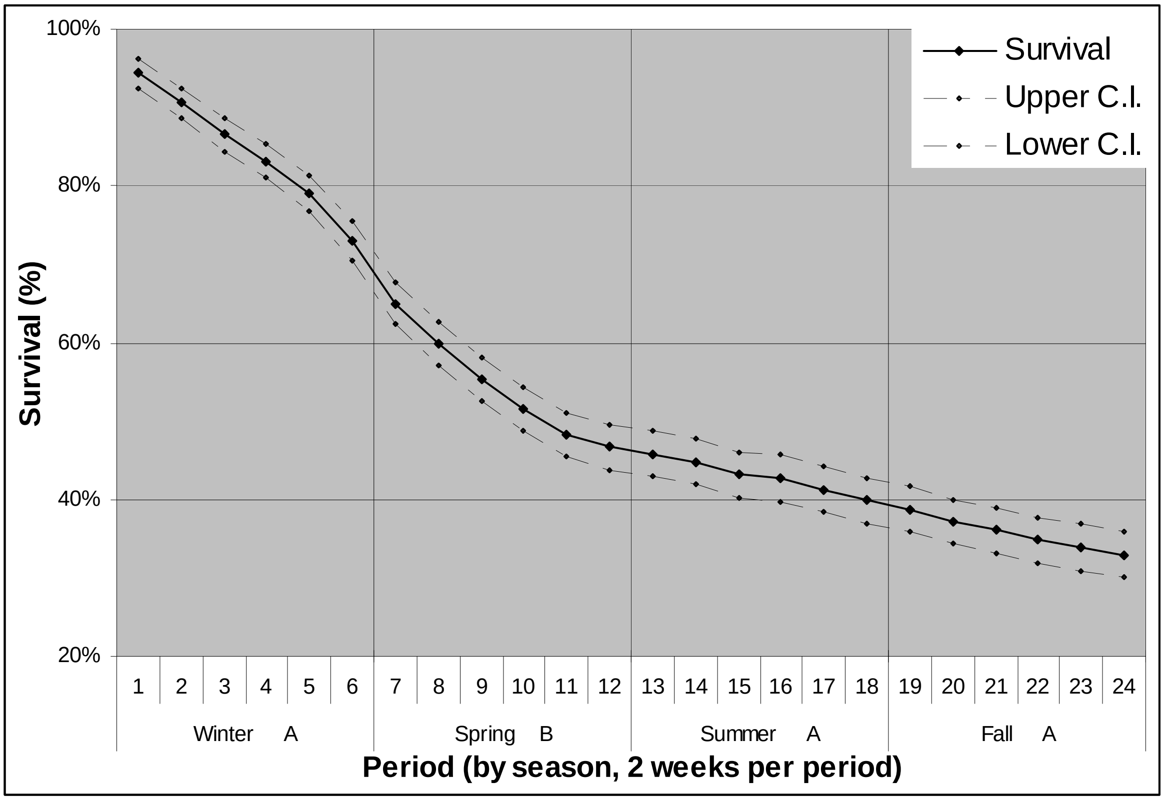

Figure 1. Mean Kaplan-Meier survival rates of Rio Grande wild turkeys (age classes and sexes combined) by two-week periods in the Texas Panhandle and southwestern Kansas 2000-2004. Seasons followed by the same letters are not different (*P* > 0.05).

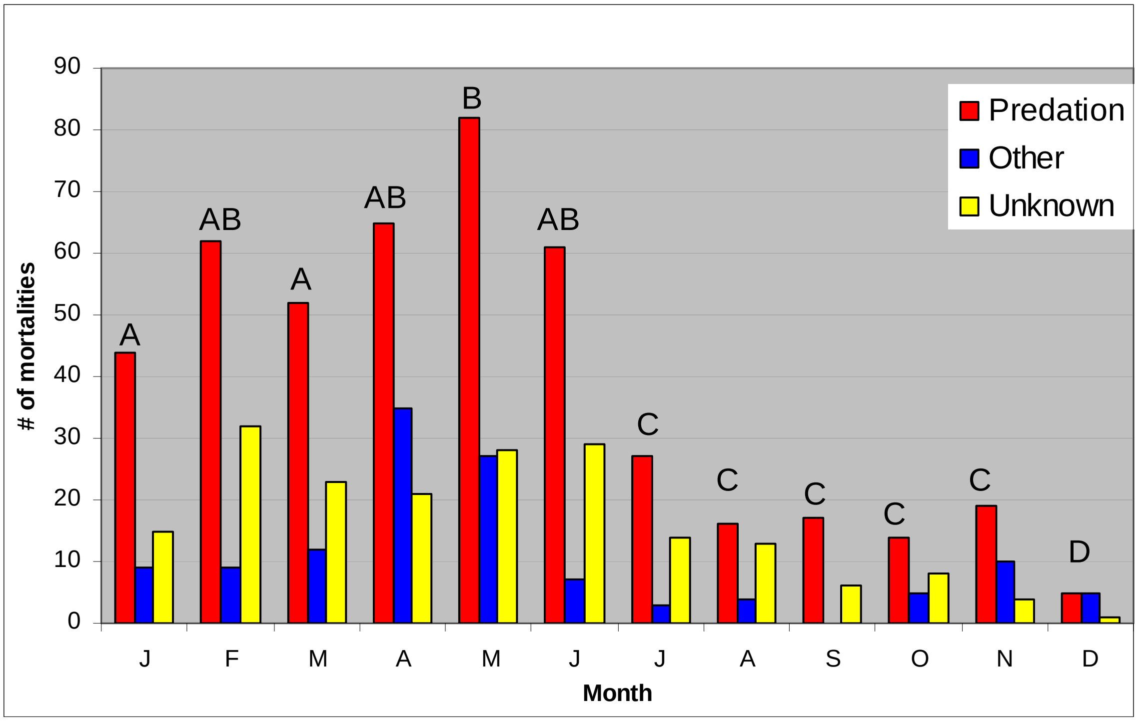

Figure 2.2. Number of Rio Grande wild turkey mortalities (age and sex classes combined) by month (January through December) attributed to predation (coyote, bobcat, great-horned owl, mountain lion, and unknown predator), other (harvested, poached, vehicular accidents, disease, and starvation), and unknown causes of mortality at 3 study sites in the Texas Panhandle and 1 in southwestern Kansas from 2000 to 2004. Number of mortalities attributed to predation were not different in months followed by the same letter were ($P > 0.05$).

The final possible cause for contradictory results is that our results do not actually contradict. It is possible that coyotes are the primary cause of mortality in adult and juvenile Rio Grande wild turkeys, but wild turkey is not a primary component of coyote diet. Average mortality rate for wild turkeys across years and study sites was about 53% (Ballard et al. 2003). We found predation as the cause of mortality in approximately ½ of all mortalities. Coyotes were determined to be the predator species responsible for turkey mortalities in approximately ½ of all predation events. We have 75 radio-transmittered turkeys per year, resulting in 36 mortalities per year, 18 mortalities in which predation would be considered the cause, and 9 in which coyotes would be found responsible. This results in 0.17 mortalities per week (9/52), or approximately 1 turkey mortality every 6 weeks.

Adult Rio Grande wild turkeys weigh from 7.7 to 9.5 kg for males and 3.6 to 5.0 kg for females. Gier (1975) and Kelly (1991) suggested that 600 grams (0.6 kg, 1.32 pounds) represented a full stomach for a coyote. Theoretically, a single turkey could represent as much as 16 days of food for a single coyote, assuming a turkey weighed the maximum of 9.5 kg, all of a turkey's weight represented food for a coyote, there were no other carnivore scavengers on the carcass, and the meat would not spoil. Realistically, an average turkey would weigh about 6 kg on average, representing about 10 maximum days of food for a coyote. While coyote predation (25% of all turkey mortalities) seems significant to turkey productivity, turkey could, at a maximum, represent only 24% (10 days out of 6 weeks) of a coyote diet.

In addition, we expected more than 1 coyote to be present at each study site, thus lowering the maximum contribution turkey plays in a single coyote's diet. In south

Texas, average coyote home ranges were found to be between 5.2 – 7.8 km^2 (Andelt 1985, Bradley and Fagre 1988, Windberg and Knowlton 1988). Our study sites averaged approximately 1036 km^2. Assuming each potential maximum home range (8 km^2) was occupied by a single coyote, each study site could have as many as 130 coyotes. Thus the maximum 24% of coyote diet from turkey at each study site represented 0.18% of each individual coyote's diet at each study site. Our scat collections occurred on a 3-day period every 4 months at each study site. We could, by random chance alone, never find scats with turkey, although the coyotes were consuming turkey.

Management Implications

Though the role of the coyote in Rio Grande wild turkey population dynamics is still largely unknown, it appears certain that coyotes do not consume turkeys on a regular basis as part of their diet in the Texas Panhandle or Southwestern Kansas. Coyote diet in this area, dependent on season, is dominated by small and medium mammal species, especially Eastern cottontail, deer and white-footed mouse, and hispid cotton rat. Coyote diet in this area is consistent with that of an opportunistic, generalist predator.

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APPENDIX: SUMMARY OF COYOTE DIET STUDIES BY SCAT ANALYSIS IN NORTH AMERICA, 1955-2005, ORGANIZED BY DATE

			Total (scats)	Small mammals	Medium mammals	Large mammals	Vegetation	Other[a]
Author	Date	State	*n*	POS[b] (%)	POS (%)	POS (%)	POS (%)	POS (%)
Houchin (this study)	2005	TX and KS	373	40.1	15.3	7.7	23.2	12.79
Carrera	2004	AR	677	29.3[c]		48.8	9.6	12.3
Snyder	2003	NE	97	14.2	32.6	3.7	42.9	7.05
Arjo et al.	2002	MT	279	33	12	47	2	6
Cypher et al.	1993	IL	496	29.7	17.9	16.4	6.4	29.54
Reichel	1991	MT	940	54.1	1.5	18.3	5.6	20.54
Windberg and Mitchell	1990	TX	150	14	65.2	14.15	1.35	4.5
Hoerath	1990	AL	292	42.1	19.8	26.9	10.5	2.9
Toweill and Anthony	1988	OR	844	42.5	11.9	12.9	25.2	7.5
Blanton	1988	MS, AL, TN, KY	523	12.5	17.2	16.4	22.9	27.2
Drew	1988	TX	1052	30.78	36.21	28.31	1.23	2.31
Andelt et al.	1987	TX	6354			64[d]	20	16
Ortega	1987	AR	759	19.2	36	5.1	24.4	15.3
Major and Sherburne	1987	ME	531	6.6	45.4	32.1	9.1	6.85
MacCracken	1984	SD	208	19.4	23.2	52.4	1.5	4.4
Bower et al.	1983	CA	223	35.3	16.3	6.1	23.4	16
MacCracken and Hansen	1982	ID	550	32.2	57.2	6	1.75	3

APPENDIX Continued

			Total (scats)	Small mammals	Medium mammals	Large mammals	Vegetation	Other[a]
MacCracken	1981 (site 1)	CO	44	24.5	54.7	17.1	1.3	1.5
"	1981 (site 2)	CO	42	5.4	73.1	19.3	1	1.2
"	1981 (site 3)	CO	48	22.6	56.7	14.4	2.5	3
Leopold and Krausman	1980-1981	TX	410	19.1	41.7	3.5	0	35.7
Litvaitis and Shaw	1980	OK	361	30.6	11.6	15	18.5	24.27
Johnson and Hansen	1979	ID	832	33.1	51.6	4.1	5.2	6.1
Hall	1979	LA	1113	52.4	44	28.4	0.2	0.1
Johnson and Hansen	1977	AR	224	14	41	0	12.8	32.2
Meinser et al.	1975	TX	514	24.5	10.8	6	48.5	10.2
Michaelson	1975	LA	130	7.5	43.2	14.2	22.1	12.4
Leopold and Krausman	1972-1974	TX	245	17.48	34.78	16.04	0	31.71
Hawthorne	1972	CA	384	53	6.5	35.5	2.5	2.2
Fitcher et al.	1955	NE	2500	46.1[c]		12.6	15.2	25.93

[a] Other category includes insects, birds, and other miscellaneous food items
[b] Percent of scats
[c] Author pooled medium and small sized mammals into one category
[d] Author pooled all mammals into one category

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