DIET AND GENERAL AVAILABILITY OF PREY OF THE COYOTE (*CANIS LATRANS*) AT THE WICHITA MOUNTAINS NATIONAL WILDLIFE REFUGE, OKLAHOMA

By

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PREFACE

The purpose of this study was to determine the food habits of the coyotes at the Wichita Mountains National Wildlife Refuge and to contribute more knowledge of the biology of this canid. This was accomplished by field studies conducted for 13 months and by laboratory analysis of coyote scats.

The Oklahoma Cooperative Wildlife Unit and the Oklahoma State University (OSU) School of Biological Sciences furnished financial aid and equipment for this study. Dr. Glenn Todd is gratefully acknowledged for his assistance.

I express my deepest appreciation and sincerest gratitude for the advice and assistance of Dr. Bryan P. Glass, my major adviser, and to other members of my committee, Dr. James C. Lewis, Assistant Leader, Oklahoma Cooperative Wildlife Research Unit, and Dr. Rudolph J. Miller, Professor, School of Biological Sciences. Without their help and encouragement this study would not have been completed.

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I wish to thank my parents, especially my father, for kindling my interest and respect for wild things.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The coyote (*Canis latrans*) was one of the native inhabitants when Oklahoma was first settled by Europeans. The density and distribution of the coyote at that time was not documented, but apparently the species occurred throughout what is now western and central Oklahoma (Freeman 1976). As settlement of the west advanced, the coyote, as well as timber wolf (*C. lupus*) and red wolf (*C. rufus*), were considered to be in direct conflict with agriculture. Management of large carnivores has usually consisted historically in the removal of animals that jeopardize human health, safety, economic or sporting interests (Knowlton 1973).

The coyote is presently the most abundant large predator in Oklahoma and the predator about which there is much controversy. Conflict arises when the interests of farmers, ranchers, and certain government agencies (predator control programs) are in opposition to views of environmental groups which consider the coyote to have aesthetic and recreational value (McCabe and Kozicky 1972). Widespread concern for the natural environment has brought into sharp focus the conflict between the desire to allow the coyote to maintain a fairly natural population and the necessity for population control in some localities to prevent depredations (Knowlton 1973).

Knowlton (1972) stated that it is our biological knowledge of the animal that permits us to isolate, identify, and resolve the areas of conflict within species management. Ultimately knowledge of the species' biology may provide the insight that will allow biologists to alleviate hazards to other human activities and yet provide an opportunity for the coyote to live in harmony with man and his economic and recreational interests.

The discovery by Garner (1976), that 96.6 percent of the 87.9 percent mortality of white-tailed deer (*Odocoileus virginanus*) fawns observed at the Wichita Mountains National Wildlife Refuge was attributable to coyotes and bobcats, indicated a need to investigate the incidence of deer remains in the diet of the coyote. This study was undertaken on the refuge with the following specific objectives: (a) to determine the coyote's diet and detect any seasonal changes, (b) to correlate diet with the relative availability of prey species, and (c) to increase knowledge of the biology of the coyote in this particular region.

CHAPTER II

THE STUDY AREA

This study was conducted on the 23,917 ha Wichita Mountains National Wildlife Refuge (WMNWR) located in Comanche County, Oklahoma (Fig. 1). The refuge contains 12,505 ha of timber, 8,547 ha of grassland and 405 ha of marsh and water. Approximately one third of the refuge is open to public use and the remainder is reserved for wildlife. The study area is located in the central Rolling Red Plains and the Central Rolling Red Prairie land of Oklahoma (Gray and Galloway 1959). Blair and Hubbell (1938) designated the Wichita Mountains as a biotic district.

Much of the soils on uplands in Comanche County are underlain by sedimentary rocks (sandstone, shale) and were formed in material weathered from sandstone, siltstone, and clay. Igneous rock, gabbro, anorthosite, granite and rholite are also found on the rocky peaks and escarpments. Some of the upland soils were formed in material deposited by the wind but most are represented by Reddish Chestnut, Reddish Prairie, and Red-Yellow Podzolic soils. The refuge has a stony rockland-granite cobbly land association with steep granite rock outcrops and deep to very shallow soils (Soil Conservation Service 1967).

Comanche County generally slopes south and southeast with the refuge being drained by West Cache Creek. The climate is temperate continental of the dry subhumid type. Winters are mild and cold spells

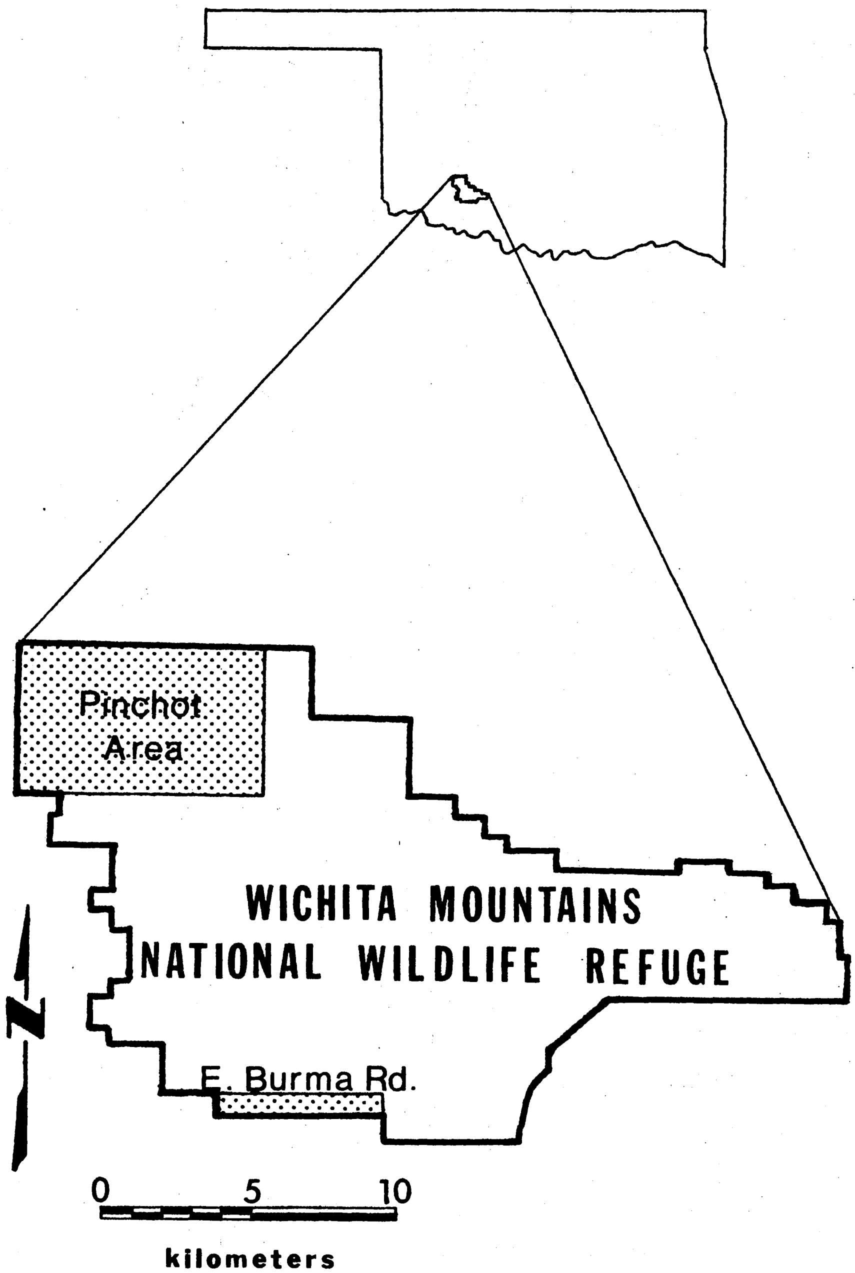

Fig. 1. The study area showing intensive sampling areas on the WMNWR, Comanche County, Oklahoma

normally last two to five days. Spring has the heaviest rainfall. Summers are long and fairly warm. The average annual precipitation ranges from about 69 to 83 cm. Average annual temperature ranges from 4.8° C in January to 29° C in August (Soil Conservation Service 1967).

The grasslands of the refuge consist of short, mixed, and tall grass prairies. The forests vary from mature blackjack (*Quercus marilandica*) post oak (*Q. stellata*) to scrub oak of the same species (Buck 1964). Dominant grasses are little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), hairy gramma (*Bouteloua hirsuta*), blue gramma (*B. gracilis*), and switch grass (*Panicum virgatum*) (Crockett 1964). The common forest association is post oak and blackjack oak. However, along stream beds, in protected valleys and on north facing slopes a more mesic forest type is encountered. Common in those areas are Shumard's oak (*Q. shumardii*), burr oak (*Q. macrocarpa*), chinquapin oak (*Q. muehlenbergii*), American elm (*Ulmus americana*), western elm (*Juglans rupestris*), chittamwood (*Bumelia lanuginosa*), sugar maple (*Acer saccharinum*), pecan (*Carya illinoensis*), hackberry (*Celtis reticulata*), and a few other species which often indicate eastern affinities (Buck 1964).

Fort Sill Military Reservation (FSMR) borders the refuge on the south. Grass fires caused by artillery firing are not uncommon on the firing ranges, but are not permitted to burn across onto refuge lands.

The refuge supports approximately 600 bison (*Bison bison*) and 300 longhorns (*Bos taurus*). Surplus animals are removed annually to maintain the populations within carrying capacity of the range. Refuge personnel estimate that 550 elk (*Cervus canadensis*) are on the refuge and a controlled hunt is held each year to keep their numbers within carrying capacity of the range. Approximately 500 white-tailed deer are on the refuge and at present none are harvested. Population estimates are not yet available for coyotes. Eighty km of 2.4 m high fence surround the refuge to limit immigration and emigration of the ungulates.

CHAPTER III

REVIEW OF THE LITERATURE

Food Habits

The coyote is a highly opportunistic predator able to exploit a wide variety of food sources. Coyote food habits are well documented for the western and west-central states where coyotes are most abundant. Stomach and scat analyses are the most common methods used to determine the diet.

Sperry (1941), in the most comprehensive study, reported analyses of 8,263 coyote stomachs containing by volume 33 percent rabbits, 25 percent carrion, 17 percent rodents, 20 percent livestock and poultry, and 4 percent deer. Birds, insects, fruit, and grass were also taken in smaller amounts. Sperry (1933, 1934) found that coyote stomach contents varied little from autumn to winter. Carrion was the most important food item; rabbits, rodents, sheep, and goats were other important foods. By frequency of occurrence deer were two percent of the diet in autumn and three percent in winter.

In California, Ferrel et al. (1953) determined by examination of 2,222 stomachs that coyotes consumed 96 percent animal and 4 percent vegetable food. Rodents and rabbits were found to be the most important prey species, 26.5 and 22.3 percent by volume, respectively. Mule deer (Odocoileus hemionus) constituted 13.8 percent and most were considered eaten as carrion. Dixon (1925) and Bond (1939) studying coyote stomachs in California reported similar findings.

Murie (1935) analyzed 64 coyote stomachs and 714 scat collected in Wyoming. Murie combined his stomach and scat data and determined that 70 percent of coyote feeding was beneficial to man, 18 percent neutral, and only 11.5 percent was harmful.

Analysis of 11 coyote stomachs collected from North Dakota revealed that game birds, mainly pheasant (*Phasianus colchicus*), made up 49 percent of the diet by volume; lagomorphs, 22 percent; carrion, 21 percent; rodents, 6 percent; and vegetation, 2 percent (McKean 1948). McKean felt that coyotes were moderately detrimental to the interests of sportsmen and farmers.

Fitcher et al. (1955) studying feeding patterns of coyotes in Nebraska analyzed 747 coyote stomachs. Lagomorphs made up 57 percent of the diet by volume; birds, 18 percent; livestock, 13 percent; and deer, 0.1 percent.

Gier (1968) reported analysis of 1,948 coyote stomachs collected in Kansas, during a 15 year period. The "average" winter foods of coyotes based on weight, consisted of rabbits, 54 percent; carrion, 26 percent; chicken, 7 percent; and rodents, 8 percent.

Halloran and Glass (1959) reported on 48 coyote stomachs collected by Charles Sperry at the Wichita Mountains National Wildlife Refuge from 1937 through 1940. Lagomorphs made up 19 percent of the diet by percent frequency; invertebrates, 17 percent; livestock, 12 percent; carrion, 8 percent; rodents, 8 percent; deer, 5 percent; and plant material, 13 percent.

In Missouri, 770 coyote stomachs were collected during a seven year period (Korschgen 1957). Principal foods of coyotes by volume were rabbits, 54 percent; poultry, 11 percent; livestock, 9 percent; rodents, 9 percent; other mammals, 8 percent; carrion, 6 percent; and plant material, 2 percent. A total of 326 coyote scats were also collected during the same study. Principal food items by volume were: rabbits, 64 percent; rodents, 13 percent; other mammals, 5 percent; livestock, 1 percent; and plant material, 13 percent.

Gipson (1974) analyzed 168 coyote stomachs collected in Arkansas from July 1969 through January 1974. The 10 most common food items by percent occurrence were: poultry, 34 percent; persimmons (Diospyros virginiana), 23 percent; insects, 11 percent; rodents, 9 percent; songbirds, 8 percent; cattle, 7 percent; rabbits, 7 percent; white-tailed deer, 5 percent; goats, 4 percent; and watermelons, 4 percent. Gipson stated that the coyote is highly successful in Arkansas and a factor contributing to its success appears to be the coyote's ability to utilize poultry carrion and persimmons, foods seldom found in its native western habitat.

A total of 71 coyote stomachs were collected in northwest Louisiana and analyzed using percent volume (Michaelson 1975). Principal food items were rabbits, 30 percent; armadillo (Dasypus novemcinctus), 10 percent; white-tailed deer, 1 percent; livestock, 13 percent; poultry, 12 percent; and plant material, 22 percent. Michaelson felt that the coyote's diet is at most only slightly harmful to man's interest in northwest Louisiana.

Examination of coyote stomachs show what the animal has eaten shortly before the coyote was killed and is the best method for studying food habits (other than direct observation). Gier (1968) in studying coyote food habits attempted to determine how rapidly food is digested and how long undigestible material remains in the stomach. He found that no material is passed out of the stomach in less than five hours and that no food material was left in the stomach more than 12 hours. No remnants of feathers or hair remained in the stomach after 20 hours.

Coyote food habits involving stomach analysis have shown that coyotes are only slightly detrimental to man's economic or recreational interests. Rabbits and rodents are the principal food items along with plant material and occasionally livestock or game animals.

In northeastern Washington, Ogle (1971) examined 102 coyote scats. Ogle determined that rodents made up 66 percent of the scats by frequency of occurrence; mule deer, 42 percent; insects, 26 percent; and plants, 8.3 percent. Analysis of 12 coyote stomachs supported the scat analysis findings.

Fitch and Packard (1955) collected 1,173 coyote scats from San Joaquin in California. Major food items by percent weight were: desert cottontail (*Sylvilagus audoboni*), 45 percent; ground squirrels (*Citellus beecheyi*), 31 percent; other rodents, 13 percent; reptiles, 8 percent; and birds, 1 percent. Fitch and Packard felt that predation by coyotes on rodents was not a determining factor in gound squirrel population trends of the area.

A total of 384 coyote scats were collected in northeastern California (Hawthorne 1972). Percent occurrence of principal food items were: voles (*Microtus* spp.), 40 percent; mule deer, 25 percent; and cattle, 10 percent. Hawthorne believed that the substantial quantities of deer and cattle were probably largely available to the coyote as carrion.

Murie (1945) studying coyote food habits in British Columbia collected 311 scats. The major food items by percent volume were: snowshoe rabbit (*Lepus americanus*), 70 percent; birds, 7 percent; cattle, 4 percent; mule deer, 5 percent; and field mice (*Microtus* spp.), 2 percent. In Montana during the same summer Murie collected 286 coyote scats. Principal food items by percent volume were: rodents, 40 percent; snowshoe rabbit (*L. bairdii*), 31 percent; elk and deer, 20 percent; and birds, 4 percent.

Food habits of coyotes in Yellowstone National Park were studied by Murie (1940). A total of 5,086 coyote scats were analyzed and major food items were rodents, 60 percent; lagomorphs, 4 percent; birds, 3 percent; and plant material, 2 percent.

Fitcher et al. (1955), in Nebraska, analyzed 2,500 coyote scats collected from February 1947 to March 1951. Percent occurrences of major food items were: mice, 57 percent; pocket gopher (*Geomys* spp.), 33 percent; rabbits, 23 percent; deer, 8 percent; livestock, 31 percent; birds, 34 percent; insects, 26 percent; and plant material, 39 percent.

Food habits of coyotes in northeast Kansas were determined by Fitch and Packard (1955). A total of 118 coyote scats were analyzed. Percent volumes were calculated for major food items: lagomorphs, 43 percent; cotton rats (*Sigmodon hispidus*), 22 percent; and cattle, 21 percent.

Ellis (1958) analyzed by percent volume, 726 coyote scats collected from northcentral Oklahoma. Lagomorphs and cotton rats made up 37 and 41 percent, respectively, of the coyote's diet.

Food habits of coyotes on a southwestern cattle range in Arizona were studied by Murie (1951). Murie collected a total of 3,981 coyote scats from February 1943 to July 1944. The incidence of major items by occurrence were: cattle, 16 percent; rodents and rabbits, 12 percent; birds, 2 percent; insects, 12 percent; juniper berries, 68 percent; and prickly pear, 9 percent. Murie stated that the high incidence of vegetation was due to the scarcity of rodents and rabbits in the area.

Meinzer et al. (1975) studying coyote food habits over a two year period in Texas, collected 514 coyote scats. They noted that honey mesquite (Prosopis glandulosa) pods, leporids, juniper (Juniperus sp.) berries, and prickly pear (Opuntia sp.) fruits collectively contributed to 69 percent of the volume of the food consumed. Analysis of 94 coyote stomachs revealed that 71 percent of the volume of food eaten was carrion, rodents, insects, leporids, and honey mesquite pods.

Michaelson (1975) analyzed 130 coyote scats collected in northwest Louisiana. Principal food items by percent volume were: lagomorphs, 43 percent; rodents, 20 percent; livestock, 13 percent; armadillo, 5 percent; white-tailed deer, 6 percent; poultry, 5 percent; and plant material, 5 percent.

In Missouri, Korschgen (1957) analyzed 326 coyote scats. Principal food items by percent volume were: lagomorphs, 64 percent; rodents, 13 percent; livestock, 1 percent; birds, 0.4 percent; and plant material, 13 percent. Korschgen felt that coyote predation may act as an additive mortality factor on the rabbit population and have a temporary effect on populations in areas of low rabbit densities.

In Michigan, Ozoga and Harger (1966) collected 92 coyote scats and analyzed them by percent frequency. White-tailed deer occurred in 91 percent of the coyote scats; rodents, 26 percent; snowshoe hare, 17 percent; and birds, 13 percent. Ozoga and Harger reported that while deer proved to be the coyotes primary winter food, most were obtained as carrion.

Coyote scat analysis is a poor method to determine food habits because only undigested remains are studied and it is hard to draw numerical relationships between what is present in the scat and its quantitative amount (Gier 1968). Danner (1976), studying coyote home ranges in Arizona, determined that coyotes usually defecate within 4.8 km of a carcass they have been feeding from. Scat analysis has one advantage over stomach analysis because scats can be collected at any time and at any place where coyotes are present.

Studies involving scat analysis are more common in the literature, one reason being that they are easier and cheaper to obtain. The studies cited have shown that coyote feeding habits have little impact on man's sporting and economic interests. However, they do reveal that in certain locations coyotes may be causing depredation problems. Generally these situations seem to be localized and of short duration.

Murie (1940), studying coyotes in Yellowstone National Park, found that the mule deer habitat was in poor condition and that many of the deer were suffering from malnutrition. Fawns were killed by coyotes, but there was no evidence that coyotes molested any adult deer (Murie 1940). In addition, Murie reported a loss of at least 29 percent of the fawns but believed the percentage to be much higher. In Texas, Knowlton (1964) determined that coyote predation accounted for 50 percent of the marked fawn mortality at the Welder Wildlife Refuge.

Horn (1941) reported that mule deer constituted a large part of the diet of coyotes in California and that the coyotes seemed to play a measurable role in controlling deer numbers. Removal of coyotes from 414 square km led to an increase in fawn survival and a decrease in rabbits and rodents. Couch (1928), Tiemeir (1955), and Robinson (1956) also expressed the view that coyotes do not control rodent populations.

In Glacier National Park, during the winter of 1934-1935, deer were weakened by hunger and severe weather conditions (Aiton 1938). Of the observed 240 deer mortalities, 25 percent were due to predation by coyotes. Skinner (1929), Howard (1937), and Rust (1946) felt that coyotes were serious predators of deer.

Skinner (1928) and Robinson (1952) believed that coyotes preyed heavily on elk calves. Murie (1940) found that elk made up 16 percent of the coyotes' winter diet, but believed that most of it was carrion. Murie felt that the actual coyote predation on the elk population was negligible.

Gipson (1974), studying food habits of coyotes in Arkansas, reported that five percent of the diet was deer. Twenty-seven percent of the deer tissue in the coyote stomachs was carrion. The highest percent of deer in the diet occurred in fall when many deer are killed illegally and left in the woods.

Hawbecker (1939) and Sperry (1939) reported that peg-leg or crippled coyotes were the most detrimental to livestock and poultry. Depredation on livestock often could be traced to old coyotes that had found domestic animals easier prey than wild species (Criddle and Criddle 1923).

There were other reports of unusual feeding habits of coyotes.

Presnall and Wood (1953) cited a case where a female and seven pups apparently fed largely upon sage grouse (Centrocercus urophasianus). Moore (1929) observed a coyote feeding on tadpoles and frogs and Grimm (1940) reported coyotes catching and feeding upon trout and crayfish.

Social Structure

Very little is known about coyote social structure. Young and Jackson (1951) reported that coyotes are either solitary or run in mated pairs. Kleiman (1967) reached the same conclusion in her research, but other researchers have drawn exactly the opposite conclusion. Murie (1940) cited two occasions when six coyotes were observed traveling together hunting elk calves. Cahalane (1947) reported three coyotes killing a yearling doe in Grand Canyon National Park. Robinson (1952) observed three coyotes killing an elk calf and cited incidents of 11 coyotes attacking an elk cow and of four coyotes attacking an elk cow and calf. Robinson and Cummings (1947) felt that they had recognized a family hunting group consisting of five adults and five pups. Ozoga and Harger (1966) believed that coyotes were only slightly gregarious during the winter months.

Davis et al. (1975), censusing coyotes in southeastern New Mexico using road counts, observed the greatest number of coyotes during winter months. The population was censused for five consecutive years and was thought to be stable during that period. It was noted that out of 254 censuses, coyotes were observed only one-third of the time and the average seen per month never exceeded two.

Ozoga and Harger (1966), tracking coyotes through the snow in northern Michigan, found that animals hunting in pairs or in larger groups normally travel parallel to one another and commonly stay within sight of each other. They also found that coyotes showed keen interest in other coyote tracks encountered during their travels and frequently followed them for considerable distances. Scott (1940) used red fox tracks as an inventory technique to determine the density of the population in rural areas and Beasom (1974) used predator track count transects to determine if coyotes resident in control areas had been removed.

The preceding data show that coyote food habits and social structure vary greatly according to geographic areas and resources available. One conclusion that can be drawn from this is that coyotes are an extremely adaptable carnivore. They will utilize almost any food source available to them and successfully establish themselves.

CHAPTER IV

METHODS AND PROCEDURE

Observations of Coyotes

Coyotes were observed with 7 x 50 mm binoculars and a 30x spotting scope. Direct observations were feasible because of the fairly open terrain and the good observation points. In Pinchot Pasture there are several mountain peaks of sufficient height to permit observation over a wide area. The observation posts were climbed before sunrise and position was taken at a favorable location downwind of the area under observation. Care was taken to make sure the observer was not conspicuous against the skyline. Similar procedures were followed in the evening.

Weather conditions during the winter made this type of observation impractical and observations were conducted from a pickup truck. Census routes varied according to prevailing weather conditions (precipitation) and access to certain areas. Selected routes were driven starting at daylight and ending at about 0930. In the evening routes were started at approximately 1430 and concluded at dark. A similar method of coyote censusing was implemented in New Mexico (Davis et al. 1975).

Observations of coyote tracks were recorded along scat routes as an index to seasonal trends in movement of coyotes. Each continuous trail of tracks was counted as one observation. Each time tracks were found an effort was made to determine the number of coyotes which might have been traveling together. Ozoga and Harger (1966) used a similar method in northern Michigan where tracking snow facilitated their study. However, tracking snow is rare in the Wichita Mountains. Ozoga and Harger (1966) found that when coyotes encountered other coyote tracks, they followed them for short distances.

Rodent Population Index

Rodent population indices were obtained by trapping. At the beginning of the study Sherman live traps were used in a mark and recapture scheme (Blair 1941). Twenty-five traps were laid out in a straight line for 300 m with 15.25 m between traps. Traps were baited with peanut butter and grain and left in the field for three consecutive nights. Thirteen rodents (including two recaptures) were captured during 625 trap nights (three percent trap success). Due to this extremely low catch rate and the amount of effort involved, the mark and recapture method was discontinued in favor of a snap trap method.

The North American Standard small mammal census (John B. Calhoun 1948, N. Amer. small mammal census: announ. of prog., Rodent Ecol. Proj., Johns Hopkins Univ. mimeo. 9pp.) was implemented for the January, March and May trapping periods using museum special snap traps. These were set along straight lines 285 m in length in three different habitat types; a wooded area, a prairie and a grazed prairie. There were 20 stations per line with three traps per station within a 1.5 m radius, making a total of 60 traps per line. Traps were baited with peanut butter and oats and left in the field for three consecutive nights. Two lines were set 12 m apart and parallel to each other in the wooded area and the prairie to give a combined sample of 360 trap nights per area. A single line was set in the grazed area for 180 trap nights. Five lines were the maximum number which could be run concurrently due to equipment and time limitations.

Data recorded for each catch included species, sex, reproductive condition, and standard body measurements. Habitat descriptions were recorded for each trap line.

Lagomorph Census

Indices to lagomorph, blacktail jackrabbit (*Lepus californicus*) and eastern cottontail (*Sylvilagus floridanus*), populations were determined by road counts. The routes utilized for the counts were the same roads which were driven to and from observation points from which coyote activity was monitored visually and changed as observation points varied. Each census was run approximately 30 minutes before sunrise and 30 minutes before sunset to coincide with the most active period for lagomorphs (Lord 1959, Newman 1959, Lord 1961). Routes were driven with a pickup truck at a speed of approximately 32 km per hour with headlights on full bright. Information recorded was beginning and ending mileage along with the number of lagomorphs seen. Censuses were usually conducted five times per month whenever field work was in progress.

Armadillo Census

Indices to armadillo populations were obtained by walking transects 285 m in length. Armadillo sign (digging, tracks, burrows) was recorded as present or absent at 15 m intervals in a 1.5 m radius around each station (Dice 1938, 1941). Twenty stations were on each line. Transects were laid out in the same areas where rodent trap lines were set with two transects in prairie, two in woodlands and one in a grazed prairie. These transects were traversed in April and May of 1976.

Food Habits

Two collection routes were chosen on the study area on the basis of (a) coyote activity in the area and (b) characteristics of the areas they represented. The Pinchot Pasture route, predominantly grassland, was 5.9 km in length and the East Burma Road route, predominantly woodlands, extended 5.1 km. Coyote scats were then collected biweekly for 13 months, thus the maximum age of any scat was only two weeks. Scats of doubtful origin were discarded. Each individual scat was collected, put in a labeled bag and later autoclaved. They were stored at -37° to -42° C until analysis was begun.

Food items in the scats were separated (Korschgen 1969) and identified using a reference collection of hair from specimens in the Oklahoma State University Museum. Teeth and patches of fur (Mayer 1952, Stains 1958) were used to identify the mammalian food items with the aid of a dissecting scope. When present, claws, hooves, epidermal scales, etc. were also used to identify food items. Fawn hair was positively identified by cuticular scale pattern using a light microscope (Hausman 1920, Hardy and Plitt 1940, Williamson 1951). One drawback of using scats is that prey eaten as carrion cannot be positively determined as such. Avian remains were generally identified by beaks, feet, and on rare occasions feathers. Usually there was not enough material to enable identification to species.

Insect parts were saved and identification was later verified by Dr. W. A. Drew, Department of Entomology, Oklahoma State University. Unknown vegetable matter was identified by Drs. J. K. McPherson and Ronald Tyrl, School of Biological Sciences, Oklahoma State University. Dr. Bryan P. Glass, Oklahoma State University Museum, verified mammal remains. The sources for nomenclature of plant and animal life listed in this report are Hall and Kelson (1959) for mammals, Borror and DeLong (1954) for insects, Robbins et al. (1966) for birds, and Waterfall (1969) for plants.

After each individual food item was identified it was sorted into a separate pile, and its volume, visually estimated to the nearest five percent of the total. Individual food items were then weighed to the nearest 0.1 g on an Ohaus pan balance. The volume of each food item was determined by measuring water displacement in a graduated cylinder. A surfactant was added to increase the wetability of the items. The samples were then dried, refrozen, and saved for future reference.

Collections were grouped by season, from spring 1975 through spring 1976. Divisions between seasons were adopted arbitrarily, with each biweekly collection assigned to an appropriate season. Dates for seasons were spring 1975 (19 May 1975 to 6 June 1975), summer (23 June to 6 September 1975), fall (20 September to 29 November 1975), winter (13 December 1975 to 27 February 1976), spring 1976 (7 March to 25 May 1976).

The quantitative data (volume percent and percent frequency of occurrence) were recorded on computer cards. The cards were then run through a combination Fortran and SAS program to obtain desired tabulations and Chi squares on selected food items.

CHAPTER V

RESULTS AND DISCUSSION

Observations of Coyotes

Two hundred and fifty hours were spent watching for coyotes. A total of 40 coyotes were seen on 20 occasions for approximately one sighting per six hours of observing (Table 1). Coyotes were observed more frequently in the evening than in the morning and more coyotes were observed in the summer than in any other season (Table 1). The July figure is biased upward because denning areas were located near the observation sites and pups were seen repeatedly. The December count is probably low because of inadequate time spent observing (Table 1).

In the present study driving the census route proved unsatisfactory due to the limited number of times the census routes could be driven. Only two weekends per month (eight routes per month) could be devoted to the census. Large amounts of precipitation during the study made the unimproved roads

Observed seasonal changes probably indicate both behavioral changes and seasonal differences in habitat. One would expect to see more coyotes in the fall when naive young pups are out of the den and ranging with the adults (Gier 1968). High numbers observed in the winter could be due to increased mobility of the young coyotes and the need for coyotes to range farther for prey which probably was becoming less available

Table 1. Total number of coyotes per month showing group size and number of coyotes observed per hour, WMNWR, May 1975-May 1976

Month	Hours observed	No. coyotes seen	Size of group	Coyotes observed per hour
May	12	0	----	----
June	50	3	All singles	0.06
		1[i]	Single	
July	34	3	3 together	0.50
		5 (2 adults, 3 pups)	Family group #1	
		3 (1 adult, 2 pups)	Family group #1	
		6 (2 adults, 4 pups)	Family group #2	
August	25	2	Singles	0.08
September	15	2	Singles	0.13
		1[i]	Single	
October	13	3	3 together	
		1	Single	
		1[i]	Single	
November	15	1	Single	0.07
December	5	0	----	----
January	22	4	4 together	0.23
		1	Single	
		1[i]	Single	
February	16	1	Single	0.06
		3[i]	3 together	
		1[i]	Single	
		2[i]	Pair	

Table 1 (Continued)

Month	Hours observed	No. coyotes seen	Size of group	Coyotes observed per hour
March	14	1	Single	0.07
April	11	2	Pair	0.18
		1[i]	Single	
May	20	2	Pair	0.10
Total	250	51		$\bar{x}$ = 0.16

[i]Incidental sightings of coyotes not seen during observation periods.

(Davis et al. 1975). Also the lack of leafy vegetation could have made the coyotes easier to observe in winter. The low number seen in spring and early summer probably is due to the more secretive nature of the denning adult coyotes with young pups (Young and Jackson 1951). Also, the prairie grasses were of sufficient height to hide coyotes and make observations difficult.

Two denning areas were located in Pinchot Pasture in areas where numerous cracks, crevices, and rocky overhangs could have served as den sites. Adults and pups were observed simultaneously at each den area. One den area had at least three pups and the other den had at least four. Age of the pups at each den was estimated to be approximately three and one-half to four months when they were seen in late July. Observations of single coyotes were more common than were sightings of groups (Table 1). Sightings of groups of coyotes were more common during July and these were known to be family groups traveling together. Observations of only two groups on October 3 and January 4, are insufficient to determine if coyotes group together regularly during the fall and winter months. February, the coyotes breeding season (Gier 1968), had two observations of pairs. Both were believed to be breeding pairs because of their behavior. Coyotes were rarely seen in the spring months but they have a 60 day gestation period (Hamlett 1938, Gier 1968, Gipson 1975) and April and May are the months when the females would be denning and whelping. In New Mexico (Davis et al. 1975), the lowest number of coyotes were also seen in spring and in some spring months none were observed.

Track counts were made on the refuge to determine when the coyotes traveled the most (Table 2); they were most active from October through May. This could be due to increased mobility of young coyotes; the need for coyotes to range farther for food; and increased movement of adults during the breeding season.

The December count was low due to inadequate time spent searching for tracks. Coyotes begin breeding in February and March and a high activity index would be expected at this time (Gier 1968). Pups are born in April and May. After pups are whelped the adult coyotes may stay closer to the den during the time the pups are dependent. Analysis of the track count data seems to indicate reduced activity during the early denning season. During the summer, lack of precipitation and a more intensive use of roads by other researchers on the refuge, may have destroyed or obscured some tracks.

Table 2. Monthly distribution of coyote tracks per km at the WMNWR, May 1975-May 1976

Month	No. tracks	km surveyed	Tracks/km
May	2	22	0.09
June	3	22	0.14
July	4	22	0.18
August	13	22	0.59
September	10	22	0.46
October	16	22	0.73
November	19	22	0.86
December	6	11	0.54
January	19	22	0.86
February	15	22	0.68
March	6	22	0.27
April	18	22	0.82
May	15	22	0.68

Rodent Population Index

A total of 2,700 trap nights was compiled during the study and 92 rodents were trapped (Table 3), constituting three percent trap success. All three trapping periods, January, March, and May, had approximately the same trap success, three percent in both March and May periods and four percent in January (Table 3). The grazed prairie yielded the highest catch in all three trapping periods.

Table 3. Rodent trapping results and percent trap success for three sampling periods in three habitats, WMNWR, 1976

Sampling date and habitat	Trap night 1	Trap night 2	Trap night 3	Percent trap success
January 4-7:				4
Prairie	----	3 cotton rats 3 deer mice 1 least shrew 1 house mouse	5 cotton rats 3 deer mice 2 least shrews	
Woodland	----	2 deer mice	2 deer mice	
Grazed prairie	2 cotton rats 5 deer mice 1 s. t. shrew	5 cotton rats 2 deer mice	1 cotton rat 1 deer mouse	
March 6-9:				3
Prairie	1 deer mouse 1 least shrew	2 deer mice 1 least shrew 2 harvest mice 1 s. t. shrew	1 deer mouse 2 harvest mice	
Woodland	----	3 deer mice	----	
Grazed prairie	3 deer mice	7 deer mice	1 deer mouse	

Table 3 (Continued)

Sampling date and habitat	Trap night 1	Trap night 2	Trap night 3	Percent trap success
May 4-7:				3
Prairie	1 harvest mouse	9 harvest mice	3 harvest mice	
Woodland	1 deer mouse	5 deer mice	2 deer mice	
Grazed prairie	4 harvest mice	----	3 harvest mice	
Total percent trap success				3

Mice of the genus _Peromyscus_ were the most frequently taken rodents with 34 deer mice (_P. maniculatus_), 5 white-footed mice (_P. leucopus_), and 5 brush mice (_P. attwateri_) caught. Harvest mice (_Reithrodontomys_ spp.) followed in frequency with 24 being captured, mostly in May. Cotton rats appeared only in the January sample (16). Five least shrews (_Cryptotis parva_), two short-tailed shrews (_Blarina brevicauda_), and one house mouse (_Mus musculus_) were also caught.

Ozoga and Harger (1966) deduced that shrews are unpalatable to coyotes. Gier (1968) found that coyotes tended to avoid shrews and that house mice were not in the regular diet of coyotes. He also found that coyotes utilized voles, but he could not catch voles in traps set especially for them. The subterranean pine vole (_Microtus pinetorum_) is usually common on the refuge (Glass and Halloran 1961) but none were caught during the entire trapping period. Cotton rats, harvest mice and deer mice were taken regularly in small amounts. Gier (1968) found that woodrats (_Neotoma floridana_) were not readily available to coyotes even though he caught them in his traps. During this study two traps were lost in the course of trapping and by the presence of woodrat nests, they were presumed to have been removed by woodrats.

Cotton rats were caught only during the January sampling period. Numbers of deer mice seemed to remain constant in the January and March sampling periods but diminished in the May sample. Harvest mice appeared in low numbers in the March sample but were very high in the May period while deer mice declined during May.

Gier (1968) found that trends in rodent populations closely paralleled the presence of rodents in coyote stomachs. Fitchter et al. (1955) found that mouse remains in scats showed a winter-spring high followed by a summer-fall depression. They stated that availability of a prey species to a predator is largely a function of its numbers per unit area, its habits, and certain factors of the habitat, all operating in a complex pattern of interrelationships that varies from locality to locality and from time to time. As a general rule, a greater number of prey species probably results in increased availability to the predator, whether absolute or in relation to factors of security in the habitat.

Lagomorph Census

Cottontails were more abundant during the entire study than were jackrabbits (only one seen, on 4 June 1975). This was probably because the vegetation of the nonwooded area is mostly dense and grassy. Jackrabbits prefer open habitat while cottontails prefer dense cover (Vaughn 1972). Overgrazing of the grasslands is not permitted and fires are controlled.

An average of one lagomorph per 18 km was tallied during the study (Table 4). The seasonal averages were: summer, one per 30.5 km; fall, one per 23.1 km; winter, one per 13.1 km; and spring, one per 34.4 km. The highest numbers of rabbits seen per km was in December (Table 4). The unexpectedly high December count may have been due to unseasonably mild humid weather at the time of the census. Breeding of cottontails occurs in February and March with the young being born in April and May. Two litters per year are common with breeding being curtailed in September (Bigham 1965).

Table 4. Monthly results of lagomorph census at the WMNWR, May 1975-May 1976

Month	Distance driven (km)	Rabbits seen	$\bar{x}$ km driven per month per lagomorph
May	49.2	2	24.6
June	144.1	10	14.4
July	67.3	3	22.5
August	38.2	3	12.7
September	40.7	5	8.2
October	64.8	1	64.8
November	56.5	1	56.5
December	45.7	10	4.6
January	92.0	1	92.0
February	32.0	2	16.0
March	46.0	0	----
April	18.7	2	9.4
May	38.5	1	38.5
Total	733.7	41	$\bar{x}$ = 18.0

Armadillo Census

Armadillo sign was most numerous on the grazed prairie (Table 5). Transects in woodland had the second highest incidence of armadillo sign and the prairie grasslands showed the least. While there are no data to relate sign to actual number of armadillos, it is obvious that the species is a common component of the local fauna.

Table 5. Relative abundance of armadillo sign at the WMNWR, April 3, and May 4, 1976

Transect	Number of sign per transect April 3, 1976	May 4, 1976	Sign per station
Grazed prairie (20 stations)	5	10	0.75
Prairie (40 stations)	6	0	0.15
Woodlands (40 stations)	12	9	0.53

Young armadillos are born in March and April. Breeding occurs in July but implantation does not occur until November (Kalmbach 1943). The young armadillos probably were not out of the next in April, but they may have been out foraging when the second transect was conducted in May.

Food Habits

A total of 671 scats were analyzed. The scats consisted mainly of plant material, rodents, insects, lagomorphs, birds, deer, armadillo and elk (Table 6). Plant material was the most frequently occurring food item found in the scats (77 percent). However, according to the weight and volume measurements, plant material was of little importance. Rodents were the second most frequent food item encountered (45 percent) and quantitatively were the most important. Insects occurred in 24 percent of the scats and were the third most important food item. However, by volume, insects ranked ninth in relative importance. By frequency

Table 6. Percent frequency of occurrence and percent volume of food items identified from 671 coyote scats collected from the WMNWR, May 1975-May 1976

Food item	Percent frequency of occurrence	Percent volume
Plant Material	77.0	6.0
Grass	65.0	2.0
Leaves	15.0	0.2
Vegetation--other	8.0	tr
Plums	5.0	1.0
Fruits--other	4.0	1.0
Mesquite beans	4.0	1.0
Prickly pear	3.0	0.2
Persimmon fruits	3.0	0.1
Juniper berries	2.0	1.0
Wheat	0.3	tr
Twigs	0.3	tr
Acorns	0.2	tr
Rodents	45.0	28.0
Cotton rat	27.0	15.0
Woodrat	8.0	7.0
Deer mice--all spp.	6.4	0.7
Pine vole	6.0	1.0
Harvest mice	4.0	0.3
Fox squirrel	4.0	3.0
Rodent--unidentified	1.0	tr
Hispid-pocket mice	1.0	tr
Short-tailed shrew	0.3	tr
Least shrew	0.2	tr
Thirteen-lined ground squirrel	0.2	tr
House mouse	0.2	tr
Insects	24.0	3.0
Grasshoppers	18.0	3.0
Insects--other	4.0	0.1
Beetles	4.0	tr
Dragon flies	2.0	0.1
Bot fly larva	0.3	tr
Ticks	0.2	tr
Cattle	19.0	14.0
Lagomorphs	16.0	11.0
Cottontail	12.0	10.0
Lagomorph--unidentified	3.0	1.0
Jackrabbit	1.0	0.4

Table 6 (Continued)

Food item	Percent frequency of occurrence	Percent volume
Avian	14.0	2.0
Birds	14.0	2.0
Egg shells	1.0	tr
Deer	14.0	13.0
Adults	8.0	9.0
Fawns	6.0	4.0
Armadillo	12.0	6.0
Elk	9.0	8.0
Adults	8.0	8.0
Calves	0.2	tr
Reptile	2.0	0.5
Snake	1.0	0.4
Lizard	0.3	tr
Reptile--unidentified	0.2	0.2
Reptile eggs	0.2	tr
Skunk	1.0	1.0
Raccoon	1.0	0.3
Bison	1.0	0.3
Miscellaneous	16.0	7.0
Animal protein--unidentified	9.0	6.0
Mammal hair--unidentified	4.0	0.3
Bones--unidentified	2.0	0.2
Refuse	1.0	0.3
Rocks	1.0	tr

of occurrence the fourth most important food item was cattle. Cattle occurred in 19 percent of the scats and by volume, were third in relative importance. Birds appeared in 14 percent of the scats, ranking sixth by frequency, but were of little importance by volume. Deer were the seventh most important food item occurring in 14 percent of the scats; by volume deer were the third most important food item in the diet. Armadillo, found in 12 percent of the scats, ranked seventh and eighth respectively by frequency of occurrence and quantity. Elk occurred in 9 percent of the scats and by volume ranked sixth. Other minor items such as unidentified mammal hair, reptiles, skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), and bison ranked lower. Unidentifiable animal protein, rocks, refuse, and unidentifiable bones were lumped under the category of miscellaneous, which together occurred in 16 percent of the scats.

Plant Material

Grass was present in 433 scats, but was probably eaten incidental to other food items, judging from the relatively small amounts, and may have been accidentally ingested while capturing and eating prey. Based on appearance and quantitative amounts, grass was eaten deliberately on only 16 occasions. Leaves occurred in 102 scats but quantitatively in very small amounts, and were probably also ingested accidentally. There was no seasonal shift in utilization of grass and leaves. Plums (*Prunus* sp.) occurred in five percent of the scats. Usually only the seeds were encountered, but some fruit skins were also found. The highest frequency occurred in summer when plums are readily available. Mesquite beans occurred only in summer and fall. The fruit of prickly pear cactus (*Opuntia* sp.) occurred in three percent of the scats with the highest utilization during fall. Persimmon fruits were found primarily in fall. Juniper berries (*Juniperus* sp.) had the highest utilization in fall and winter. Wheat kernels (*Triticum aestivum*), acorns (_Quercus_ sp.), and twigs were also found. Some of these may have been in the cheek pouches of rodents. Unidentified fruits occurred in four percent of the scats and the category "other vegetation", including forbs and unidentified plants, occurred in eight percent.

Rodents

Quantitatively rodents were the most important food item, composing 29 percent of the diet. Cotton rats made up 15 percent of the diet. Seasonally, cotton rats were the most abundant in the diet in spring and winter. Wood rats made up seven percent, by percent occurrence, and seasonally there was no difference in the occurrence. Pine voles occurred in six percent of the scats with spring 1976 having the highest incidence. Fox squirrel (_Sciurus niger_) occurred in four percent of the scats with no seasonal differences being apparent. Deer mice (_Peromyscus_ spp.) occurred in six percent of the scats with the highest frequency occurring in spring of 1976. Minor occurrences of other small mammals included hispid pocket mice (_Perognathus hispidus_), shorttailed shrew, least shrew, thirteen-lined ground squirrel (_Citellus tridecemlineatus_), and a house mouse.

Insects

By frequency of occurrence, the class Insecta ranked third in relative importance but quantitatively they were of little importance. Grasshoppers, order Orthoptera, occurred in 18 percent of the scats. The highest frequencies occurred in summer and fall which corresponds with seasonal availability. A few were eaten in winter and spring. The second largest group of insects were in the "other" or "unknown" category, occurring in only four percent of the scats. Most insects were extremely fragmented and only pieces of legs and wings were found. Beetles, order Coleoptera, occurred in four percent of the scats and also ranked low quantitatively. They occurred mostly in spring and summer. Dragonflies, order Odonata, occurred in two percent of the scats collected during summer and fall, and quantitatively they also were of little importance.

Cattle

Cattle hair was encountered in 19 percent of the scats. Quantitatively cattle ranked second in relative importance. The highest frequency occurred during spring of 1976 when the longhorns were dropping their calves. The hair may have been from calves, but there is no method of distinguishing calves from adults by the hair. Coyotes may kill or scavenge a large animal that would provide it with more than one meal and return to it repeatedly. When larger prey animals are eaten the same animal will furnish material for a considerable number of scats (Murie 1946).

Lagomorphs

Cottontails were the most important lagomorph, occurring in 12 percent of the scats. Jackrabbits were encountered only four times. The refuge is in an advance stage of succession which favors cottontails. Quantitatively, cottontails were the third most important item and did not seem to show seasonal variation.

Birds

Bird remains, including feathers, feet, and beaks, were found in 14 percent of the scats; egg shells were present in four scats. Birds ranked sixth in relative importance by frequency but much lower quantitatively. The gastrointestinal tract of the coyote seems very destructive to feathers and bird bones. Only 15 samples were identifiable, the relatively high frequency of undetermined bird remains is regrettable, but was unavoidable due to the technical limitation of using scats. The highest frequency of avian remains in scats occurred during winter. Egg shell fragments were found in spring samples and probably were from eggs of ground nesting birds. Bobwhite (*Colinus virginianus*) occurred in five samples with four of them occurring in winter samples. Meadowlark (*Sturnella* sp.) remains were found in three spring samples. Meadowlarks are ground nesters and may have been preyed upon while nesting. Meadowlarks are commonly found in coyote diets (Ferrel et al. 1953, Tiemeier 1955, Korschgen 1957). Four birds were identified to the family Fringillidae and one to the order Passeriformes. One lark sparrow (*Chondestes grammacus*) and one burrowing owl (*Speotyto cunicularia*) were also present.

Deer

While it is well documented that coyotes prey on deer (Ogle 1971, Hawthorne 1972), Halloran and Glass (1959) reported that Sperry found deer remains in only five percent (by frequency) of 48 coyote stomachs collected at the WMNWR from 1937 through 1940. In this study deer were found in 14 percent of the scats and were ranked seventh by frequency of occurrence, but quantitatively ranked third in relative importance. Adult deer hair occurred with greatest frequency during the fall and winter. Fawn hair occurred during late spring, summer and early fall with most appearing in scats collected during June. Garner (1976) found that coyotes may prey on fawns for up to 16 weeks following the fawn's birth. Fawns occurred in six percent of the scats, but they lose their juvenile pelage during fall and then would be undistinguishable from adult deer. Adult deer hair was found in eight percent of all scats but, as noted, this may have included hair from molted juveniles.

Predation on fawns by coyotes is well documented in the literature (Knowlton 1964, Cook et al. 1971, White et al. 1972). The months of June and July in this study, had the highest incidence of fawn hair, which agrees with the chronology of fawn mortality which Garner (1976) found at the WMNWR and FSMR.

Armadillo

Armadillos occurred in 12 percent of the scats which placed them eighth in relative importance; quantitatively they ranked seventh. Generally only small dermal bones were encountered. Scats collected during the summer and fall had the highest frequency of armadillo remains. This is the time when young armadillos would be more vulnerable to predation. Armadillos have been expanding their range northward (Kalmbach 1943) and probably their numbers have not been at the present level for more than 30 to 40 years at most (Blair 1939).

Miscellaneous

Items in the miscellaneous category included unidentifiable animal protein, rocks, refuse, and unidentifiable bones. Meat and bone fragments were described as unidentifiable animal protein when they occurred without other recognizable vertebrate parts. Refuse included cardboard, paper towels, plastic, tinfoil, rubber, bologna skins, and cigarette packages. Most refuse was encountered in the winter and occurred in scats collected from Burma Road in an area with frequent public use.

Elk

Elk occurred in nine percent of the coyote scats which placed them tenth in relative importance by frequency of occurrence and quantitatively they were ranked fifth. The highest frequency of elk hair occurred in winter. There is a controlled elk hunt on the refuge in December and much of the elk eaten may have been viscera and other remains, including legs of field dressed animals, or carrion from crippled animals that later died. Elk calf hair was encountered in only one scat.

Other Mammals

Unidentified mammal hair was observed in four percent of the scats and most is believed to be of rodent origin due to its length and texture. Rodent hair was described as "unidentifiable rodent" if rodent teeth or bones were found with the hair, otherwise it was identified as "unidentified mammal" hair. Skunk was found in five scats, raccoon in three, and bison in three. Raccoon was only found in summer.

Reptiles

Reptiles were found in two percent of the scats and were quantitatively of little importance. Snake remains were found in seven scats and collared lizards (Crotaphytus collaris) were identified in two. Remains of two unidentified reptiles and one reptile egg were found. Reptile remains were only recovered in spring and summer, corresponding with the phenology of reptilian activity.

Seasonal Trends

Figs. 2 and 3 show seasonal trends of major food items by percent volume and percent frequency of occurrence appearing in the coyotes' diet. During spring, rodents, and cattle had the highest utilization but declined markedly during the summer and fall. Longhorns on the refuge calve during March and April and calves are susceptible to predation at this time. It is also possible that calves which were stillborn or died shortly after birth were scavenaged. Winter and spring is also the time of year when carcasses of range cattle would be most available due to mortality caused by cold weather, calving, and food shortages.

Rodent populations would theoretically be increasing in numbers during the spring and most available as a food source during summer. However, the decline during summer (Figs. 2 and 3) may be due to fawns becoming more readily available. Fawns would provide more biomass per capture effort than rodents. Also, rabbits and armadillo would become more available (young of the year) during the summer and would also provide more biomass per capture effort than rodents.

In fall there was a slight increase in utilization of rodents and cattle while utilization of deer, rabbits, and armadillo remained relatively constant. Availability of insects and plant material would be highest during the summer and start declining during the fall

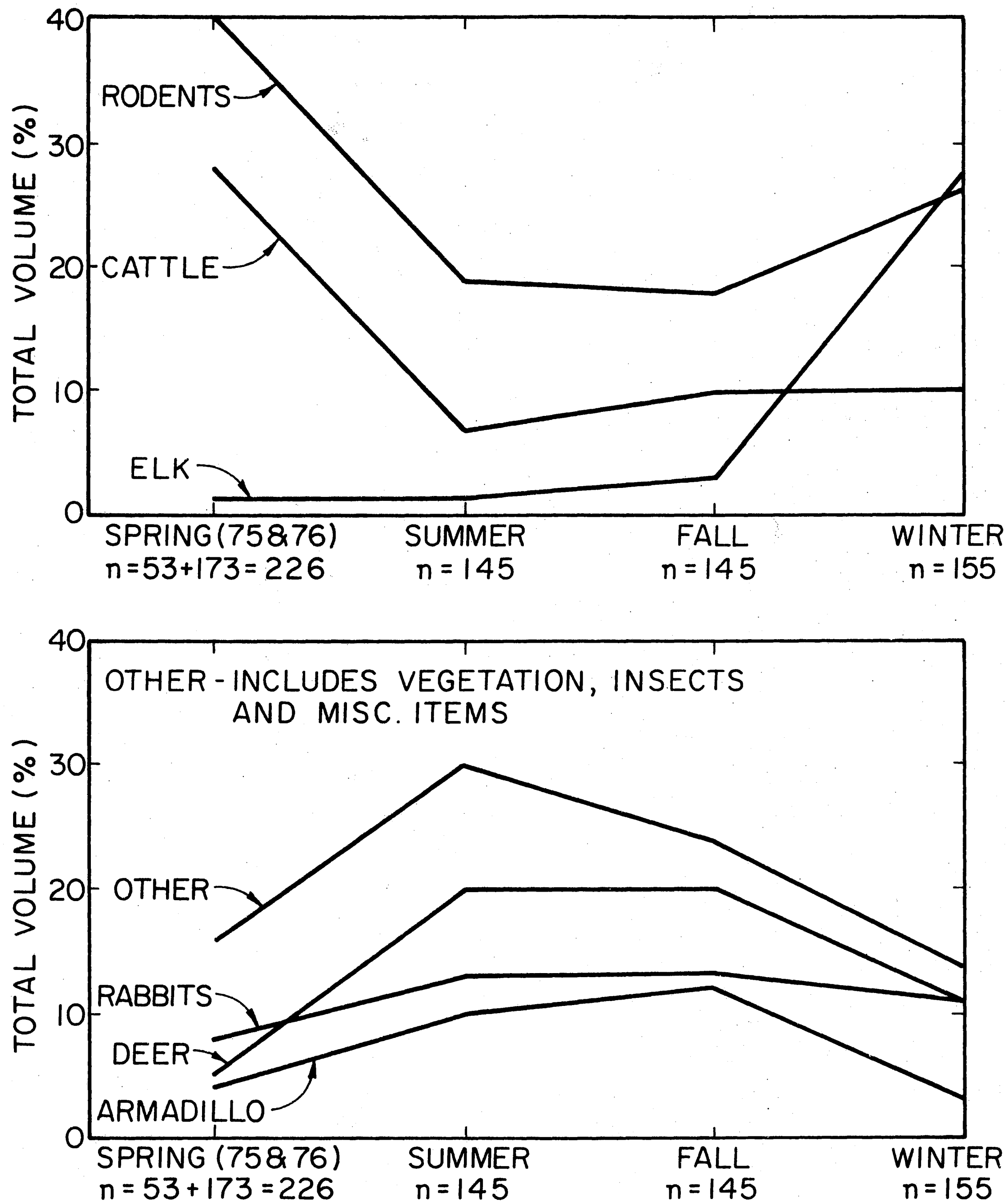

Fig. 2. Seasonal trends of major food items in volume percent, of coyote scats, WMNWR, May 1975-May 1976

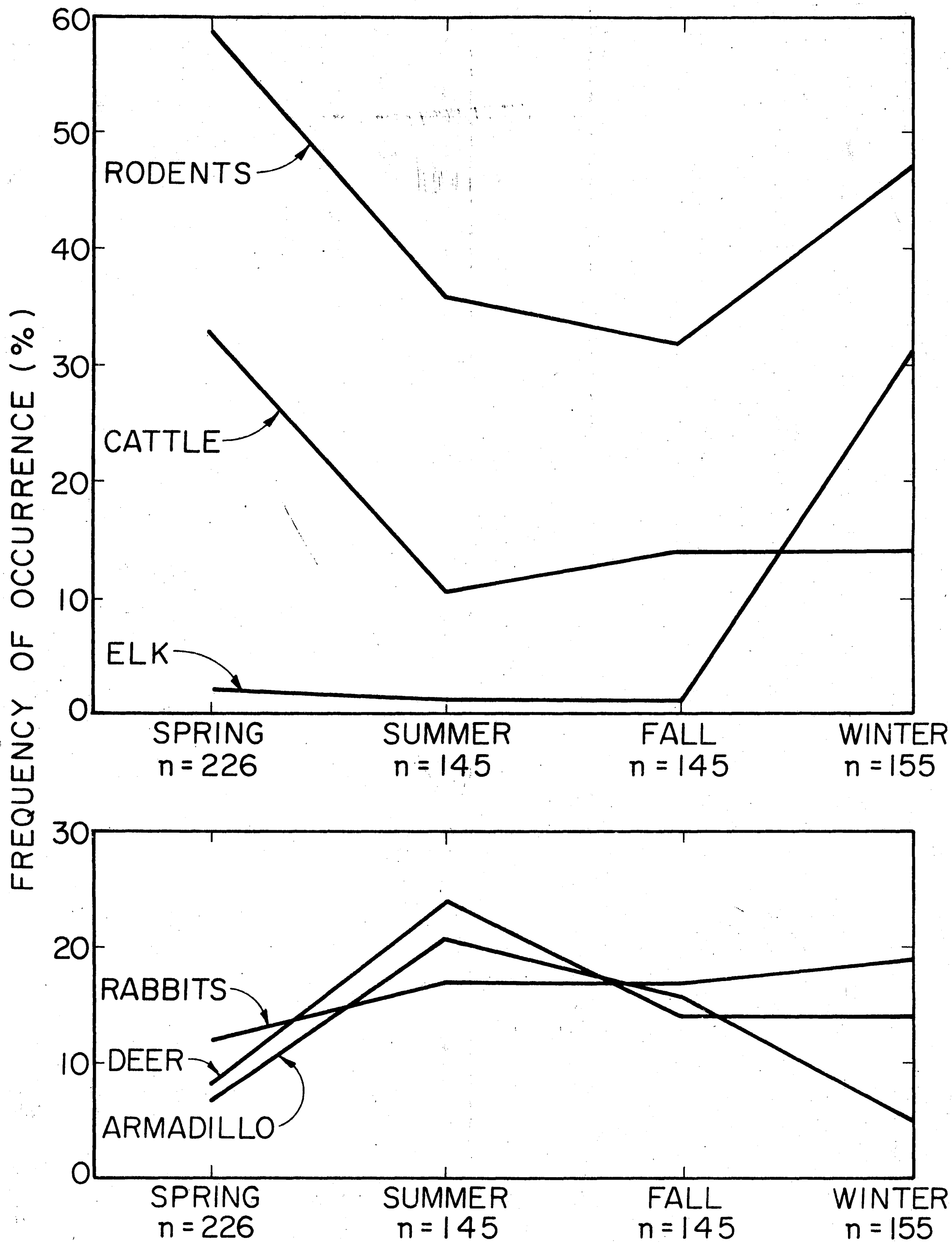

Fig. 3. Seasonal trends of major food items in percent frequency of occurrence, of coyote scats, WMNWR, May 1975-May 1976

(Fig. 2). The presence of elk hair in the diet increases during the fall and reaches its peak during the winter. This coincides with the controlled elk hunt held on the refuge in December and most is probably eaten as carrion. Elk may provide the coyote with an "easy" food source, because the presence of deer, rabbits, and armadillo decline in the diet.

A coyote feeding stragegy may be represented. Coyotes shift from rodents and cattle in the spring to more efficient (capture effort per biomass) and more available food sources (deer, rabbits, and armadillo) during the summer. Calves would not be as available to predation or scavenaging at this time and rodents might be too "expensive" in terms of the amount of capture effort involved. Utilization of deer, armadillo, and rabbits, shows a slight decline in frequency from summer to fall. The upsurge of elk hair in the scats may indicate that coyotes are switching their diet preference to a more efficient food source. Elk would not be as readily available during the spring so coyotes would switch to more available food sources (rodents, calves).

Figs. 2 and 3 correspond closely for the presence of rodents, cattle, and elk in the diet. Variation between the graphs is apparent for rabbits, deer, and armadillo, but generally volume and frequency of occurrence trends for food items are very similar.

Coyotes seem to readily shift food sources with respect to availability and "ease" of utilization.

Differences Between Areas

Chi-square tests indicated highly significant ($p < 0.05$) differences between food items occurring in scats collected from Burma Road and Pinchot Pasture (Table 7). Fawn, elk, and cattle hair were found more frequently in scats collected from Pinchot Pasture than Burma Road. Pinchot Pasture has more grassy habitat than the Burma Road area which is more heavily wooded. Elk and cattle were observed in greater abundance in Pinchot Pasture than Burma Road. Greater observed abundance of elk and cattle may be due to higher densities of these animals in the area or that these ungulates were more readily observable (visible) in the grasslands. The significance of fawn hair in Pinchot Pasture scats may indicate a habitat perference of does for grassland or may indicate that competition for space by other ungulates (elk) forces does into the grassland where fawns are more vulnerable to predation.

Rodents, lagomorphs, birds and fruits were more prevalent in scats collected from Burma Road, perhaps because these species were more abundant in woody habitat or because alternative foods were not as available there. Burma Road borders a public use area which would account for refuse being identified in those scats.

Table 7. Significant Chi-square differences between the abundance of various food items found in coyote scats from Pinchot Pasture and Burma Road, WMNWR, May 1975-May 1976

Pinchot Pasture			Burma Road		
Species	X^2	($p < 0.05$)	Species	X^2	($p < 0.05$)
Fawn	22.21	0.0001	Rodents	7.24	0.0001
Elk	24.38	0.0001	Pine voles	12.34	0.0006
Cattle	9.66	0.0021	Squirrel	18.93	0.0001
Grass	14.56	0.0002	Lagomorphs	30.27	0.0001
			Cottontail	25.63	0.0001
			Jackrabbit	5.58	0.0173
			Persimmon	9.16	0.0002
			Juniper berries	4.08	0.0400
			Birds	27.26	0.0001
			Refuse	11.24	0.0010

CHAPTER VI

SUMMARY AND CONCLUSIONS

The principal objectives of this study were to determine coyote's diet and detect any seasonal changes, to correlate diet with the relative availability of prey species, and to increase knowledge of the biology of the coyote in this particular region.

Analysis of 671 coyote scats showed that rodents (28 percent), cattle (14 percent), deer (13 percent), lagomorphs (11 percent), elk (8 percent), and armadillo (6 percent) were the principal food items by volume. Rodents and cattle were utilized mainly during the winter and spring and elk were heavily utilized during winter. Lagomorphs, deer, and armadillo occurred more frequently in scats collected during summer and fall.

The second objective, determining availability of prey, was not fully achieved due to insufficient data. Trapping indicated that rodents were in low densities but they appeared with high and regular frequency in the coyote scats. It is apparent that rodent populations were higher than trapping results indicated. However, it is possible that coyotes were more efficient in capturing rodents than the sampling method. Lagomorph censuses indicated low population densities. Lagomorphs occurred in 16 percent of the scats. Sperry's 1937-1940 analysis of coyote stomach contents on WMNWR showed that jackrabbits and cottontails were the most important food item. Although direct comparisons between stomach and scat contents are difficult, lagomorphs presently do not seem to be as important in the diet as they were during Sperry's study. Census data indicate low lagomorph populations on the refuge; they probably were more abundant in the brushy areas which supply more cover. Other researchers (G. Waldrip, personal communication, 1977, OSU School of Biological Sciences) frequently observed cottontails on rocky mountain tops while studying elk.

Armadillos are a common component of the mammalian fauna of the refuge and occurred in 12 percent of the coyote scats.

The presence of deer and cattle hair in the diet corresponds to the time when these species would be most readily available (fawning or calving). Elk in the diet were probably eaten as carrion of hunter-killed animals.

There were insufficient observations of coyotes to determine if there was any significant seasonal change in group size of coyotes. However, more intensive sampling needs to be conducted before it can be fully ascertained whether seasonal shifts of diet affect group size of coyotes. Winter was the season of greatest coyote activity (movement) as indicated by coyote track observations.

Coyotes in the WMNWR tend to utilize more cattle, deer, and armadillo in their diet than coyotes in surrounding states (Korschgen 1957, Gier 1968, Meinzer et al. 1975, Michaelson 1975) and other areas of Oklahoma (Ellis 1958). The WMNWR is a unique area containing populations of four species of ungulates, including an unhunted white-tailed deer population. The foods available to the coyotes on the WMNWR are unique to that area and are reflected in the results of this study.

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APPENDIX

Table 8. Food items found in 671 coyote scats at the WMNWR, collected from May 1975 through May 1976, showing frequency of occurrence, total percent occurrence, total weight, total volume, and a ranking of each food item estimated by frequency (F) of occurrence, percent volume (%), weight (W) in g and volume (V) in cc.

Food item	Frequency of occurrence	Total percent occurrence	Total weight	Total volume	F	%	W	V
Grasses	433	3,705	125.4	285	1	8	13	12
Cotton rat	178	9,955	1,139.5	1,776	2	1	2	1
Cattle	128	8,860	1,525.0	1,709	3	2	1	2
Grasshoppers	122	2,430	267.1	343	4	11	11	13
Leaves	102	255	7.4	24	5	23	6	29
Birds	93	1,205	83.8	180	6	14	16	13
Cottontail	81	5,895	795.8	1,147	7	3	3	3
Armadillo	79	3,940	692.1	745	8	5	6	8
Unidentified animal protein	57	3,270	722.7	754	9	10	5	7
Elk--adult	56	4,270	753.7	1,006	10	4	4	5
Vegetation--other	56	60	3.6	7	10	8	38	35
Woodrat	53	3,850	519.5	880	11	6	8	6
Deer--adult	52	3,761	610.2	1,037	12	7	7	4

Table 8 (Continued)

Food item	Frequency of occurrence	Total percent occurrence	Total weight	Total Volume	F	%	W	V
Pine vole	43	840	74.7	133	13	15	17	14
Deer fawn	42	3,480	326.1	492	14	9	9	9
Plums	31	1,400	151.0	169	15	13	12	13
Fruit--other	29	825	84.9	97	16	16	15	18
Insects--other	28	175	9.2	13	17	31	34	33
Mammal hair--unidentified	28	345	17.2	30	17	21	27	27
Beetles	27	65	0.8	3	18	37	41	38
Harvest mice	25	220	19.4	36	19	26	26	24
Fox squirrel	25	2,010	290.1	402	19	12	10	10
Mesquite beans	25	625	51.1	97	19	19	19	18
Lagomorph--unidentified	19	700	52.3	99	20	8	18	17
Prickly pear fruit	19	245	19.6	29	20	24	25	28
Dragon flies	16	50	8.4	11	21	39	35	34
Persimmon fruits	15	805	114.1	112	22	17	14	16

Table 8 (Continued)

Food item	Frequency of occurrence	Total percent occurrence	Total weight	Total volume	F	%	W	V
Deer mice	14	220	14.5	18	23	26	32	32
Juniper berries	13	340	34.4	56	24	22	21	19
Brush mice	12	155	11.4	18	25	32	33	32
Bones--unidentified	12	150	15.8	19	25	33	30	31
White-footed mice	9	215	16.2	21	26	27	29	30
<u>Peromyscus</u> sp.	8	135	15.3	21	27	34	31	30
Refuse	8	180	19.7	40	27	30	24	23
Snakes	7	215	16.2	43	28	27	29	22
Skunk	5	360	48.4	54	29	20	20	20
Rocks	5	20	----	--	29	41	--	--
Rodents--unidentified	4	---	0.2	1	30	--	43	40
Hispid pocket mice	4	50	5.0	5	30	39	37	36
Jackrabbit	4	205	25.6	45	30	28	22	21
Egg shells--avian	4	30	2.9	4	30	40	39	37

Table 8 (Continued)

Food item	Frequency of occurrence	Total percent occurrence	Total weight	Total volume	F	%	W	V
Raccoon	3	200	21.3	33	31	29	24	25
Bison	3	240	23.9	32	32	25	23	27
Shorttailed shrew	2	15	0.5	1	32	42	42	40
Collard lizards	2	5	0.2	1	32	43	43	40
Wheat	2	---	---	--	32	--	--	--
Twigs	2	5	1.0	2	32	43	40	39
Bot fly larva	2	---	---	--	33	--	--	--
Elk calf	1	100	---	--	33	35	--	--
Least shrew	1	5	---	--	33	43	--	--
Thirteen-lined ground squirrel	1	---	---	--	33	--	--	--
House mouse	1	---	---	--	33	--	--	--
Reptiles--unidentified	1	90	17.1	18	33	36	28	32
Reptile eggs	1	---	---	--	33	--	--	--
Acorns	1	---	---	--	33	--	--	--

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