MORTALITY OF WHITE-TAILED DEER FAWNS IN THE WICHITA MOUNTAINS, COMANCHE COUNTY, OKLAHOMA

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PREFACE

The purpose of this study is to determine the extent and causes of mortality among white-tailed deer fawns in the Wichita Mountains, Oklahoma. Radio-telemetry was used to relocate young fawns and detect mortalities. Home ranges, movements, and daytime bedsites of fawns are evaluated. Interspecific behavior among predators and white-tailed deer are also evaluated.

Financial assistance for the study was provided by the Oklahoma Department of Wildlife Conservation, Oklahoma State University School of Biological Sciences, Oklahoma State University Environmental Institute, and Fort Sill Military Reservation of the U. S. Department of the Army.

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A special acknoledgement is extended to O. B. Hamblin, Oklahoma Department of Wildlife Conservation, for his dedicated help in creating and conducting the study.

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CHAPTER I

INTRODUCTION

This dissertation was prepared using six manuscripts written in formats which would facilitate immediate submission to national scientific journals for publication. These manuscripts are presented as chapters in the dissertation and each is complete in itself without additional supporting materials. The manuscript entitled "Mortality of White-tailed Deer Fawns in the Wichita Mountains, Oklahoma" (Chapter II) is the principal paper of the dissertation and was written according to the style and format of the PROCEEDINGS OF THE SOUTHEASTERN ASSOCIATION OF GAME AND FISH COMMISSIONERS. The manuscript entitled "Observations of Interspecific Behavior Between Predators and White-tailed Deer in Southwestern Oklahoma" (Chapter III) was written in the note format of the JOURNAL OF MAMMALOGY. The manuscript entitled "Home Range and Movements of Young White-tailed Deer Fawns in Southwestern Oklahoma" (Chapter IV) was written according to specifications of THE JOURNAL OF WILDLIFE MANAGEMENT. The manuscript entitled "Species Composition of Vegetation Surrounding Daytime Bedsites of White-tailed Deer Fawns" (Chapter V) was written in the feature article format and style of the JOURNAL OF RANGE MANAGEMENT. The manuscript entitled "Physical Factors Associated with Daytime Bedsites of White-tailed Deer Fawns" (Chapter VI) was written in the technical note format of the JOURNAL OF RANGE MANAGEMENT. The manuscript entitled

"Ground Cover Characteristics of Daytime Bedsites of White-tailed Deer Fawns (Chapter VII) was also written in the technical note format of the JOURNAL OF RANGE MANAGEMENT.

Approval for presenting the dissertation in this manner is based upon The Graduate College's policy of accepting dissertations written in manuscript form and The Graduate College's approval of the major professor's request for a waiver of the standard format in a letter dated 29 March 1976.

CHAPTER II

MORTALITY OF WHITE-TAILED DEER FAWNS IN THE WICHITA MOUNTAINS, OKLAHOMA.

Abstract

Thirty-five white-tailed deer (*Odocoileus virginianus*) fawns 1 to 28 days of age were captured in 1974 and 1975. Survival and causes of mortality were determined by radio telemetry. Average annual mortality was 87.9 percent, based on a 63 percent mortality rate in 1974 and a 96 percent mortality rate in 1975. Predation by coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) was involved in 96.6 percent of the observed mortality. Salmonellosis was detected in three 1975 fawns at capture but clinical symptoms of the disease were not noted during the study. Coyote and bobcat predation combined to exert long-term postnatal pressure (up to 16 weeks) on the fawn segment of the deer herd. Study results suggest the experimental use of short-term seasonal predator control to allow fawn survival to increase on those portions of the county open to deer hunting, but compensatory natural mortality may offset this anticipated gain. These results also underscore the effectiveness of coyotes and bobcats as natural deer population controls on areas where hunting is not allowed.

Introduction

The Comanche County white-tailed deer range in southwestern Oklahoma is primarily confined to the Wichita Mountains complex in the northwest portion of the county (Fig. 1) and is somewhat isolated from adjacent deer ranges by agricultural lands surrounding the mountain complex. The Wichita Mountains National Wildlife Refuge (WMNWR 23,917 ha) and Fort Sill Military Reservation (FSMR 38,164 ha) contain the major part of this mountain complex and include the center of the county's deer herd.

The Wichita Mountain's herd has a history of overpopulation (Lindzey 1951) and was classified by Leopold et al. (1947) as an "incipient" irruptive area. The predicted irruption was probably delayed by extensive live-trapping from 1945 to 1965 when 4,309 deer were removed from WMNWR for transplanting purposes (Halloran 1969). Hunting on FSMR also removed a minimum of 4,650 deer during this same time period. The herd increased rapidly from 1955 to 1961, then decreased sharply from 1961 to 1965 (Steele 1969, Final P-R Job Rep., Proj. W-87-R, Okla. Dept. Wildl. Conser., Okla. City) and has apparently fluctuated little since 1965 (R. Johnson and G. Bartnicki, U. S. Fish and Wildlife Service, 1973 personal communication; O. B. Hamblin, Okla. Dept. of Wildlife Conservation, 1973 personal communication). Approximate average deer density since 1965 on the WMNWR and FSMR was estimated to be 2.8 deer/km^2 (unpublished Refuge estimates, U. S. Dept. Army 1971), although the authors believe that the portions of the Wichitas used for this study support 8 deer/km^2.

Mid-winter fawn/doe ratios declined from 1.46 fawn/doe in 1956 to 0.07 fawn/doe in 1964 (Steele 1969, Final P-R, Job Rep., Proj. W-87-R, Okla. Dept. Wildl. Conserv., Okla. City). Johnson, Bartnicki, and Hamblin (1973 personal communication) indicated that satisfactory natality was occurring but that fawns did not survive through the summer months.

Recent studies of neonatal mortality in white-tailed deer in Texas (Knowlton 1964, White 1966, Cook et al. 1971, White et al. 1972), Virginia (McGinnes and Downing 1969), and Oklahoma (Bolte et al. 1970, Logan 1972) were conducted in areas supporting relatively high deer densities. In those studies, densities ranged from 21 to 76 deer/km^2, but only Logan considered the herd he was investigating to be overpopulated (76 deer/km^2). The role of fawn mortality as a population-regulating mechanism in lower density deer herds has not been investigated directly. The present study was conducted from May 1974 to January 1976 to measure the extent and to identify the causes of fawn mortality affecting the relatively low density Wichita Mountains deer herd.

Financial assistance was provided by the Oklahoma Department of Wildlife Conservation, Oklahoma State University (OSU) School of Biological Sciences, OSU Research Foundation, and Fort Sill Military Reservation of the U. S. Department of the Army. Appreciation is extended to Roger Johnson, WMNWR, and George Johnson, FSMR, for expediting our access to the study areas. Special acknowledgement is due O. B. Hamblin, Oklahoma Department of Wildlife Conservation for his dedicated help in creating and conducting the study. Leroy Anderson, John Ault, Mack Barrington, Bill Bartush, Gene Waldrip and

David Wiseman are acknolwedged for their dedicated assistance in the field. Appreciation is expressed also to OSU students who provided a helping hand when needed.

Description Of Study Area

The study area included portions of the contiguous FSMR and WMNWR (Fig. 1), which are located in the Central Rolling Red Plains and Central Rolling Red Prairies land resource areas of Oklahoma (Gray and Galloway 1969). The topography ranges from nearly level to slopes exceeding 20 percent. Numerous outcrops of barren granitic mountain peaks, cliffs, and escarpments are evident in the central mountains area of the FSMR (Soil Conservation Service 1967) and in the more rugged portions of the WMNWR (Buck 1964). Soils are primarily derivitives of sedimentary (limestone and shale) and igneous (granite, gabbro, and rhyolite) parent materials. The climate is classified as temperate, continental, and of the dry-subhumid type. Average annual precipitation is 74.1 cm with rainfall occurring in a general spring-summer pattern (Soil Conservation Service 1967, 1970).

A wide variety of vegetation types are present on the study area and are primarily a result of variation in soil types. Open prairie comprises a majority of the area. Tall-grass species such as big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), sand bluestem (*A. halli*), switchgrass (*Panicum virgatum*) and Indiangrass (*Sorghastrum nutans*) predominate on deep soils having good soil moisture relationships. Forbs and legumes are also abundant on these deeper soils. Mid and short grasses such as blue grama (*Bouteloua gracilis*) and side-oats grama (*B. curtipendula*) are dominant on the more droughty hardland and slickspot soils. Mesquite (Prosopis juliflora) is also common on many of these droughty soils in the FSMR. Hairy grama (B. hirsuta), fall witchgrass (Leptoloma cognatum), and side-oats grama are the dominant grass species on the very shallow rocky soils (U. S. Department of Army 1971; Crockett 1964).

Wooded areas are primarily confined to stream-courses and the more sandy and gravelly soils. Typical stream-course species include elm (Ulmus americana), pecan (Carya illinoensis), hackberry (Celtis reticulata), red oaks (Quercus spp.) post oak (Q. stellata), burr oak (Q. macropcarpa), and chinquapin oak (Q. muhlenbergii). On the stony upland soils, common species include blackjack oak (Q. marilandica) (Buck 1964).

Three locations believed to be major fawning areas were selected within the general study area to be used for capturing fawns (Fig. 1). The Costain Hill area (approximately 1,550 ha) is entirely on FSMR and consists primarily of hilly, open grasslands containing numerous large boulders and occasional clumps of woody vegetation. The Wye Area (approximately 2,900 ha) is on contiguous portions of FSMR and WMNWR. Habitat types include rolling grasslands, post oak-blackjack oak woodlands, and mesquite infested grasslands. This location contains a major artillery impact area and an Air Force bombing range on FSMR. The Pinchot area (approximately 3,900 ha) is entirely in the northwestern mountainous region of WMNWR. This area has steep topography and consists of open plains intermingled with rocky hills.

The WMNWR has been protected from fire since its establishment in 1901 (Dana 1956). About one-third of the refuge is open for public use, whereas the remainder is reserved for wildlife use. FSMR is headquarters for the U. S. Army Artillery and Missile Center. It maintains six artillery impact areas, multiple firing points, observation posts, and numerous surveyed target locations throughout the reservation (Soil Conservation Service 1970). Uncontrolled range fires caused by artillery firing are common throughout the year on FSMR.

Two big game species are present on the FSMR. Population estimates in 1975 included 1,250 white-tailed deer and 100 elk (*Cervus canadensis*). Either-sex deer and elk hunting to regulate population levels are allowed on the reservation. In 1975, WMNWR supported approximately 600 buffalo (*Bison bison*) and 300 Texas longhorns (*Bos taurus*) in addition to 500 white-tailed deer and 550 elk. Eighty km of 2.4-m-high ungulate-proof fence surround the refuge. Surplus buffalo and longhorns are sold annually and surplus elk are harvested by hunters to maintain populations within carrying capacity of the range. Deer populations have not been regulated since deer trapping and transplanting ceased in 1965.

Materials and Methods

Radiotelemetry equipment was utilized to locate fawns and to aid in determining the status of their health (Cook et al. 1967). Fawn transmitters weighed approximately 110 g each and were attached to individual fawns by an expandable, elastic neck collar (Wildlife Materials, Inc., Carbondale, Illinois). AVM model LA12 portable receivers in conjunction with four-element yagi antennae (AVM Instrument Company, Champaign, Illinois) were used for monitoring. Transmitters and receivers operated at frequencies between 164.425 and 164.725 mHz.

We used various methods described by Downing and McGinnes (1969) and White et al. (1972) to capture neonatal fawns. The terrain of the study area allowed use of high vantage points (military observation towers and high mountains) from which to observe doe behavior and locate fawns. Binoculars and spotting scopes were used to observe single does until a fawn was sighted. The fawn was allowed to complete nursing and select a new bedsite. After the doe left the area, the three- to four-man capture crew proceeded to the general vicinity of the fawn. The site was then surrounded and a slow, inward-proceeding approach was made until the fawn was sighted in its bed. Normally, the fawn would be alert and watching one of the capture crew members approach. This crew member would stand quietly and hold the fawn's attention while the crew member behind the fawn approached cautiously and leaped on the fawn. Successful fawn captures were possible with this observe, surround, and leap technique following sightings of does with fawns at distances of 0.5 to 1.6 km from the observer. This technique was most effective in early mornings and late evenings.

Captured fawns were aged, measured, sexed, weighed, marked, and released at the respective capture sites. Age estimates were based on new hoof length and other physical characteristics described by Haugen and Speake (1958). Fawns were color marked with round 1.9 cm colored aluminum Perfect ear tags (Salt Lake Stamp Company, Salt Lake City, Utah) in combination with colored 2.5 x 7.5 cm strips of Saflag material (Safety Flag Company of America, Pawtuckett, Rhode Island) attached as described by Downing and McGinnes (1969). This small-sized Saflag strip was chosen because White et al. (1972:902) noted that fawns marked with 3.8 x 15 cm ear markers had mortality rates twice as great as those tagged with 3.8 cm^2 markers. Ear tags were attached to both ears at the upper edge of the ear near the head. Tag losses were nil. Each fawn also received a tattoo in the left ear. Blood samples and rectal swabs were collected from all fawns during the 1975 capture period. These samples were analyzed by personnel at the OSU College of Veterinary Medicine. The time required to process individual fawns (capture to release) ranged from 15 to 30 min. Recommendations outlined by White et al. (1972:905) for minimizing the probability of increasing fawn mortality due to handling and marking techniques (i.e. small markers, processing fawns at the capture site, etc.) were followed throughout this study.

Marked fawns were monitored by triangulation and their locations were recorded on standardized forms. During the fawn capture period (15 May to 30 June), marked fawns were located daily and observed undisturbed if possible. Following the fawn-capture period, fawn locations were triangulated twice daily until 15 August, and then monitored less frequently until the transmitter failed 12 to 14 months postcapture. If a fawn remained in the same location on any two consecutive triangulations, it was observed visually to determine its status. When a mortality occurred, a detailed inspection of the surrounding area was made to detect signs of predators or other evidence of the mortality agent. Criteria used in assigning the mortality to a certain agent (Table 1) were a combination of criteria presented by Smith (1945). Dill (1947), Cooke et al. (1971), Beale and Smith (1973), and White (1973). Special emphasis was placed on their techniques (i.e. blood around wounds, etc.) for differentiating between predator-killed carcasses and predator-scavenged carcasses.

Mortality categories corresponded to the predation-excluded and predation-involved categories of Cook et al. (1971). Fawn remains ranged from only blood and hair, with the radio-transmitter and collar, to intact carcasses. Three partial carcasses were frozen and later were transported to the OSU College of Veterinary Medicine for necropsy, whereas the two intact carcasses were immediately transported to OSU for necropsy for evidence of disease pathogens and parasites. The remaining partial carcasses which provided insufficient material for necropsy were collected and examined by the principal investigator. Predator scats were collected bimonthly along designated road systems to measure the incidence of fawn hair in scats (Salwassar 1974).

Fawn/doe counts were initiated in June each year and continued periodically until January of the following year. Observers travelled slowly by truck along designated roads and all deer sighted were classified as to sex and age whenever possible. These same routes were counted from both trucks and helicopters in 1975. FSMR provided OH-58 helicopters for use in this phase of the study. Reproductive tracts from 24 does harvested during the 1975 fall deer season on FSMR were used to obtain corpora albicantia counts (Cheatum 1949, Teer et al. 1965) for estimating the initial, postpartum rate of fawn production in spring 1975.

Results

Physical condition of all fawns at capture was judged to be excellent. Lone star tick (*Amblyomma americanum*) loads were low; an average of three ticks occurred per fawn, ranging from 0 to 17 ticks. Peak of fawning occurred around 1 June each year. Fawn drop ranged from early May to late June. Analysis of blood smears from fawns in 1975 revealed no blood parasites, although *Theileria cervi* has been detected in the adult segment of this deer herd. Rectal swab cultures were positive for *Salmonella enteriditis* var. *muenchen* in three fawns in 1975 (B-8, B-10, and B-12). Clinical symptoms of salmonellosis (Robinson et al. 1970) (i.e. emaciation, perianal hair stained yellow, distended small intestine) were not evident in any fawn or fawn carcass during this study.

Twenty-nine of the 35 fawns died during the 2-year study period (Table 2). Two of 10 fawns disappeared during the 1974 study period and their fate is unknown; therefore, subsequent calculations of mortality rates exclude these two fawns from the sample. Five of the remaining eight fawns died in 1974 (63 percent mortality rate) and 24 of 25 died in 1975 (96 percent mortality rate). The high mortality rate observed in 1975 was obviously a short term phenomena because the herd could not sustain itself with such high loss rates. The authors recognize that these mortality rates may be slightly greater than those of unmarked fawns (Cook et al. 1971:53). The effect of marking techniques and monitoring procedures is currently being studied by the Oklahoma Cooperative Wildlife Research Unit.

Probable causes of mortality were determined for each of the 29 fawn losses (Table 3). No fawn carcass examined during this study was classified as a predator-scavenged carcass. With two exceptions described later, all fawns were in good condition the last time they were observed prior to their death. The number of fawns dying in each 5-day age increment is presented in Fig. 2. Age of fawns at capture ranged from 1 to 28 days and averaged 12 days. Average age at death was 38 days within a range of 6 to 111 days. Over one-half (55.2 percent) of the observed mortality occurred during the first 30 days of life, whereas 82.7 percent occurred during the first 60 days of life (Fig. 2).

Fawn/doe ratios in 1974 (Fig. 3) were variable, but a ratio of 0.48 fawn/doe was obtained in late July at the Wye area. This ratio gradually declined to 0.25 fawn/doe in December (0.48 fawn/doe vs. 0.25 fawn/doe; $\chi^2 = 4.73$, 1 df, $0.025 < P < 0.05$). The Pinchot area ratio fluctuated but remained in a range of 0.08-0.13 fawn/doe. Small sample sizes on the Costain Hill area indicated a ratio of 0.3-0.4 fawn/doe. In 1975, counts in late July disclosed a ratio of 0.71 fawn/doe in the Pinchot area whereas the ratio at the Wye area was 0.09 fawn/doe (Fig. 4). The Wye area ratio remained at 0.09-0.11 fawn/doe, but the Pinchot area ratio declined to 0.39-0.45 fawn/doe in November and December (0.71 fawn/doe vs. 0.45 fawn/doe; $\chi^2 = 3.28$, 1 df, $0.05 < P < 0.10$). A majority of the observed mortality had occurred before meaningful fawn/doe ratios could be obtained because fawns remain secluded until 6 to 8 weeks of age and are therefore not readily visible. In general, trends in these fawn/doe ratios tend to support the extent and timing of fawn mortality rates derived from the radio-colloared fawns.

Analyses of predator scats (Fig. 5) indicated that they contained fawn hair most frequently in June and July, but that fawn hair occurred to some degree in predator scats from May through September. This peak incidence in June and July agrees with the chronology of fawn losses described earlier (Fig. 2).

Corpora albicantia counts from does harvested at FSMR, November through December 1975 (including the 1.5 year-old class) indicated 1.36 corpora albicantia/doe. Adult does and yearling does had 1.61 and 0.25 corpora albicantia/doe respectively. Teer et al. (1965) found that corpora albicantia rates overestimated actual ovulation rates by an average of 19 percent in Texas. Teer et al. (1965) also found that actual fertilization rates were lower than ovulation rates. Therefore, initial fawn production in the Wichita Mountains in 1975 probably was something less than 1.35 fawn/doe (perhaps 1.00-1.25 fawn/doe) but the applicability of the Texas fertilization rates to the Wichita herd is unknown.

Discussion

Predation-Excluded Deaths

Fawn B-16 was the only predation-excluded mortality during this study (Table 3). This fawn was 12 days old at capture on 24 June 1975 and was found dead on 29 June. The fawn had lost 0.6 kg of weight and was not fed upon by predators. This fawn was born late in the fawning season and the doe was not observed with the fawn after capture. Necropsy was negative for pathogenic organisms and milk was not present in the digestive tract, which suggested starvation and probable abandonment.

Predation-Involved Deaths

Predation was the immediate cause of death in 28 (96.6 percent) of the 29 mortalities (Table 2), although other factors were also involved in fawn A-7's death. This fawn was observed in a weakened state on 24 June 1974 (6 days post-capture) and was thereupon recaptured and remeasured. Skeletal growth had occurred but weight had decreased 0.9 kg. The fawn was emaciated and very weak. On 27 June a range fire swept over the Costain Hill area and burned to within 10 m of fawn A-7 where Army personnel extinguished the blaze. The fawn was observed alive at 1935. At 0915 on 28 June the fawn was found dead, an obvious coyote kill. Coyotes had been attracted to the fire and tracks were numerous along the edge of the burn. The fawn had been killed by a bite to the head, but no other wounds were found on the carcass and it had not been fed upon by coyotes. Necropsy for pathogenic organisms was negative. Abandonment was not considered a contributing agent in the death because the doe was regularly observed with the fawn from capture to death.

Four fawn carcasses (C-5, B-5, B-6, and B-13) were buried by coyotes during the 1975 study period. These carcasses consisted of the anterior half of the body or only the head and neck. The carcasses were usually covered by 1 cm of soil, but B-13 was covered by 7 cm of soil. White (1973) does not mention the caching of fawn carcasses by coyotes, but Young and Jackson (1951) mentioned the habit briefly concerning coyotes feeding on jackrabbits.

Age-specific data on fawns killed by coyotes and bobcats suggest that the two predators may exert long-term (up to 16 weeks of age) pressure on fawns at the Wichita Mountains (Fig. 6). Coyote predation usually occurred on fawns less than 8 weeks of age when they are normally associated with the more open prairie habitat (31 days average age at death). Bobcat predation usually occurred after fawns became associated with forest edge or steeper rocky slopes. Bobcats also killed more mature fawns (54 days average age at death) than very young ones. Beale and Smith (1973) and Young (1958) have also noted this ability of bobcats to subdue larger prey. These data suggest that opportunistic coyotes may actively seek the more easily captured young fawns while bobcat predation is more adventitious and is not confined to small, easily captured fawns. Observations of interspecific behavior between predators and deer support these conclusions (Garner and Morrision 1976).

The total mortality rate of 87.9 percent in this study (Table 2) is higher than the mortality rate of 72 percent reported by Cook et al. (1971); however, their study was limited to approximately 60 days postpartum, at which time field work was terminated each year. The Wichita Mountains study was not limted to this time period and additional mortalities were observed in fawns older than 60 days. If a 60-day postpartum mortality rate at the Wichita Mountains was calculated, it would be 72.7 percent, which agrees with the South Texas findings.

Management Implications

Two management tactics are suggested by our findings. First, in areas where hunting is not compatible with other uses, coyote and bobcat predation could be a very useful aid in establishing natural population control. The present management strategy on WMNWR is to establish natural regulation of deer numbers. Annual productivity rates of 0.1 to 0.4 fawn/doe are therefore not a major concern of WMNWR personnel. In view of the irruptive history of this herd, predation may now be providing the needed natural check on its size.

A second management tactic can be suggested for FSMR and surrounding private and state lands where annual deer harvests occur. Predation may be contributing to the relatively low harvest rates of deer. With a constant annual hunter pressure of 750 man-days, FSMR harvested only 10.6, 13.6 and 12.3 percent of its estimated deer herd in 1973, 1974, and 1975 either-sex hunting seasons, respectively (U.S. Department Army 1975). It should also be noted that the average mortality rate for sample fawns on FSMR was 62.5 percent (five fawns died out of eight marked) during the study, which suggests a possible compensatory relationship between herd losses by hunting and predation.

A possible conclusion based on the results of this study is that predator control on FSMR might increase fawn survival, and, thus, might increase potential harvest of deer. The same conclusion may not apply to lands in private ownership in Comanche County or other portions of Oklahoma because the fawn mortality factors may differ there. Beasom (1974a) demonstrated that intensive short-term predator removal in south Texas did significantly increase white-tailed deer populations. He also determined that this type of control was economically feasible (Beasom 1974b), but he cautioned that an increasing deer population must be closely monitored to avoid problems of overepopulation, therefore, the agency responsible for management of the deer herd being manipulated must be able to adjust deer harvest rates to avoid overepopulation problems.

The possibility of compensatory mortality factors replacing predation as the population-regulating mechanism must also be considered. Salmonella and Theileria organisms are two potentially effective mortality agents that were noted during this study, but their role in deer population regulation in the Wichitas is unclear. The nutritional status of prepartum and/or postpartum does could be predisposing young fawns to predators, while intensive interspecific competition among deer, elk, buffalo, and longhorns for various habitat requirements may also be involved in the unusually high predation. Continuing studies of fawn mortality, predation, and deer ecology in the Wichitas are being conducted to assess the potential impacts of these various factors on deer populations.

Predators are apparently able to take a significant number of healthy fawns, in this type of habitat, even when deer densities are low (8 deer/km^2). If the continuing studies of fawn mortality in the Wichitas verify these initial results, an experimental predator control program, similar to the short-term control described by Beasom (1974a), could be implemented on those portions of Comanche County open to deer hunting to determine if deer productivity and deer harvest can be increased.

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Table 1. Criteria used to determine predator species in predator-involved mortalities.

Criteria	Interpretation
1. Characteristics of wounds or death site	
A. Blood around wounds, in nostrils, ears, throat and around mouth	predator involved
B. Blood not around wounds, carcass remains show no evidence of bruises or hemorrhaging	predator scavenged
C. Blood on grass in area and/or evidence of struggle by fawn at death site	predator involved
D. Fawn observed within 48 hours prior to location of carcass and at that time appeared in good physical condition according to criteria outlined by Cook et al (1971:49)	predator involved
E. Carcass lacks signs of being bitten	predator not involved
2. Carcass Disposition	
A. Laying in open, no attempt at concealment, carcass remains not scattered	unknown predator
B. Laying in open, no attempt at concealment, remains scattered	probable coyote
C. Buried underground	probable coyote
D. Partially covered with ground litter or leaves with evident fan-like scraping pattern	bobcat

Table 1. (Continued)

Criteria	Interpretation
3. Carcass Injuries	
A. Skull punctured or crushed	coyote
B. Underside of neck bruised but without puncture wounds	probable coyote
C. Underside of neck bruised and small puncture wounds evident	bobcat
D. Narrow scratch marks on ears, neck, forelegs or back	probable bobcat
E. Broad scratch (bruises) marks on back of neck and throat	probable coyote
4. Carcass Consumption	
A. All consumed	unknown predator
B. All consumed except for bone chips, ear tags, bits of skin, etc.	unknown predator
C. All consumed except for scattered leg bones, bone fragments, etc.	probable coyote
D. Small fawns (60 days old) all viscera consumed	unknown predator
E. Large fawns (60 days old) all viscera except intestines and rumen consumed	unknown predator
F. None	unknown predator

Table 1. (Continued)

Criteria	Interpretation
5. Collar Conditions	
A. Collar expanded or unexpanded, large tooth marks on transmitter, bloody collar	probable coyote
B. Collar not expanded, no tooth marks, collar not bloody	unknown predator
6. Predator Signs in Areas	
A. Fresh coyote tracks	probable coyote
B. Fresh bobcat tracks	probable bobcat
C. Coyote fur around carcass	coyote

Table 2. Survival and causes of mortality among 35 radio-collared white-tailed deer fawns captured during 1974 and 1975 in the Wichita Mountains.

Fate Category	No. of Fawns	% of Known Fate	% of Total Dying
Survived to at least one year	4	12.1	
Fate unknown	2		
Mortalities:	29	87.9	100.0
Predation-excluded deaths:	1	3.0	3.4
Probable abandonment (starvation)	1	3.0	3.4
Predation-involved deaths:	28	84.9	96.6
Coyote	10	30.3	34.4
Bobcat	5	15.2	17.2
Coyote plus other factors	1	3.0	3.4
Coyote predation probable	9	27.3	31.0
Bobcat predation probable	1	3.0	3.4
Predator species undetermined	2	6.1	6.9

Table 3. Characteristics of fawn carcasses and criteria used to determine primary cause of mortality, Wichita Mountains, 1974 and 1975.

Fawn Number	Estimated age at capture (days)	Days surviving post capture	Predator involved in death	Estimated percent of carcass remaining	Hours since last observed in good cond.	Characteristics of kill site and carcass (Table 1)
B-13	1	14	Coyote	10	28	1A, 1D, 2C, 3A & B, 4D, 5B, 6A
B-2	3	13	Bobcat	20	27	1A, 1D, 2C & D, 3C, 4D, 5B
B-7	3	21	Coyote	0	26	1D, 4A, 5A, 6A
B-10	4	1	Coyote	0	24	1D, 2A, 4B, 5A
B-4	5	92	Coyote	0	87	2B, 3A, 4C, 5A
A-4	6	28	Bobcat	75	22	1A, 1D, 2D, 3C, 4D, 5B, 6B

Table 3. (Continued)

Fawn Number	Estimated age at capture (days)	Days surviving post capture	Predator involved in death	Estimated percent of carcass remaining	Hours since last observed in good cond.	Characteristics of kill site and carcass (Table 1)
C-2	6	53	Bobcat	30	26	1A, 1D, 2 C & D, 3 C & D, 4E, 5B
A-6[1]	7	40	Coyote	0	15	1D, 4B, 5B, 6A
B-5	8	6	Coyote	30	25	1A & D, 2C, 3B, 4 B & D
B-8	8	13	Coyote	0	16	1D, 4A, 5A
C-6	9	44	Coyote	0	32	1D, 2B, 4C, 5A, 6A
A-05[1]	10	21	Coyote	0	48	1D, 4B, 5A, 6A
C-3	10	94	Bobcat	77	33	1A, 1 C & D, 2A, 3 C & D, 4E, 5B

Table 3. (Continued)

Fawn Number	Estimated age at capture (days)	Days surviving post capture	Predator involved in death	Estimated percent of carcass remaining	Hours since last observed in good cond.	Characteristics of kill site and carcass (Table 1)
B-3	11	11	Coyote	0	25	1D, 4A, 5A
B-9[1]	11	7	Coyote	0	51	2A, 4B, 5A, 6 A & C
B-12	11	4	Coyote	0	22	1D, 2A, 4B, 5A, 6A
B-16	11	5	Abandonment	100	20[2]	1E
A-7[1]	12	10	Coyote + others	100	13[2]	1 A & D, 2A, 3A, 4F, 6A
C-5	12	9	Coyote	10	27	1A, 1D, 2C, 3A, 4D, 5A
A-01	14	68	Unk. predator	0	23	1D, 4A, 5B

Table 3. (Continued)

Fawn Number	Estimated age at capture (days)	Days surviving post capture	Predator involved in death	Estimated percent of carcass remaining	Hours since last observed in good cond.	Characteristics of kill site and carcass (Table 1)
B-1	14	23	Bobcat	85	25	1 A & D, 2D, 3D, 4D, 5B
B-6	14	2	Coyote	40	25	1 A & D, 2C, 3B, 4D, 5B, 6A
C-1	15	9	Unk. predator	0	31	1D, 4A, 5B
B-11	17	5	Coyote	0	28	1D, 4A, 5A
B-14	17	59	Coyote	50	3	1A, 1 C & D, 2A, 3 A & B, 4E, 5A, 6A
C-9	18	21	Coyote	0	25	1D, 4A, 5A
B-15[1]	19	3	Coyote	0	21	1 C & D, 4A, 5A

Table 3. (Continued)

Fawn Number	Estimated age at capture (days)	Days surviving post capture	Predator involved in death	Estimated percent of carcass remaining	Hours since last observed in good cond.	Characteristics of kill site and carcass (Table 1)
C-7	20	12	Coyote	10	49	1A, 2A, 3A, 4D, 5A
C-8	21	90	Bobcat	40	78	1A, 2A, 3C, 4E, 5B

[1]Fawns marked on Fort Sill

[2]Fawns emaciated and not in good condition

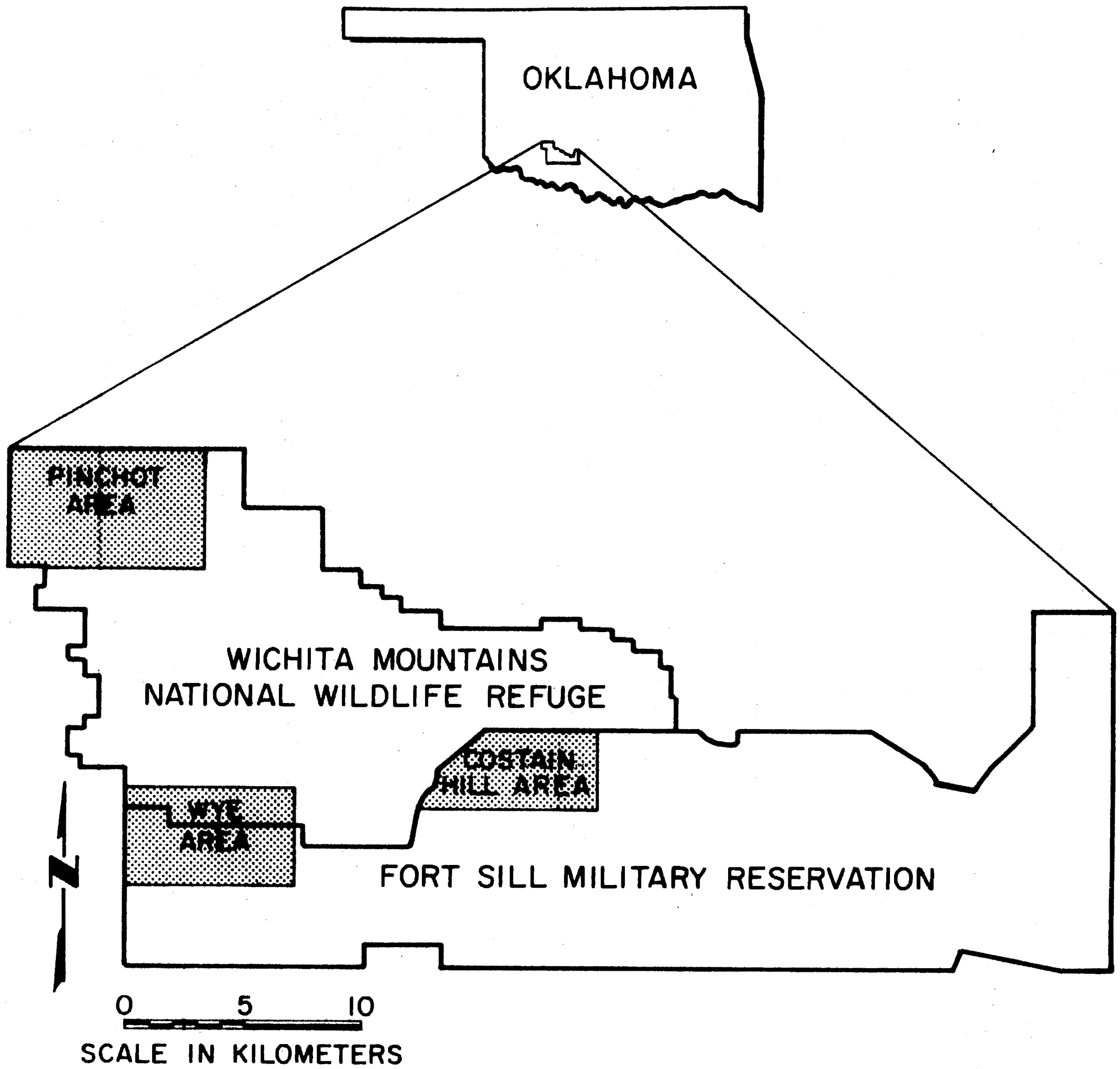

Fig. 1. Location of study area in Oklahoma and location of the three sampling areas in the Wichita Mountains, Comanche County, Oklahoma.

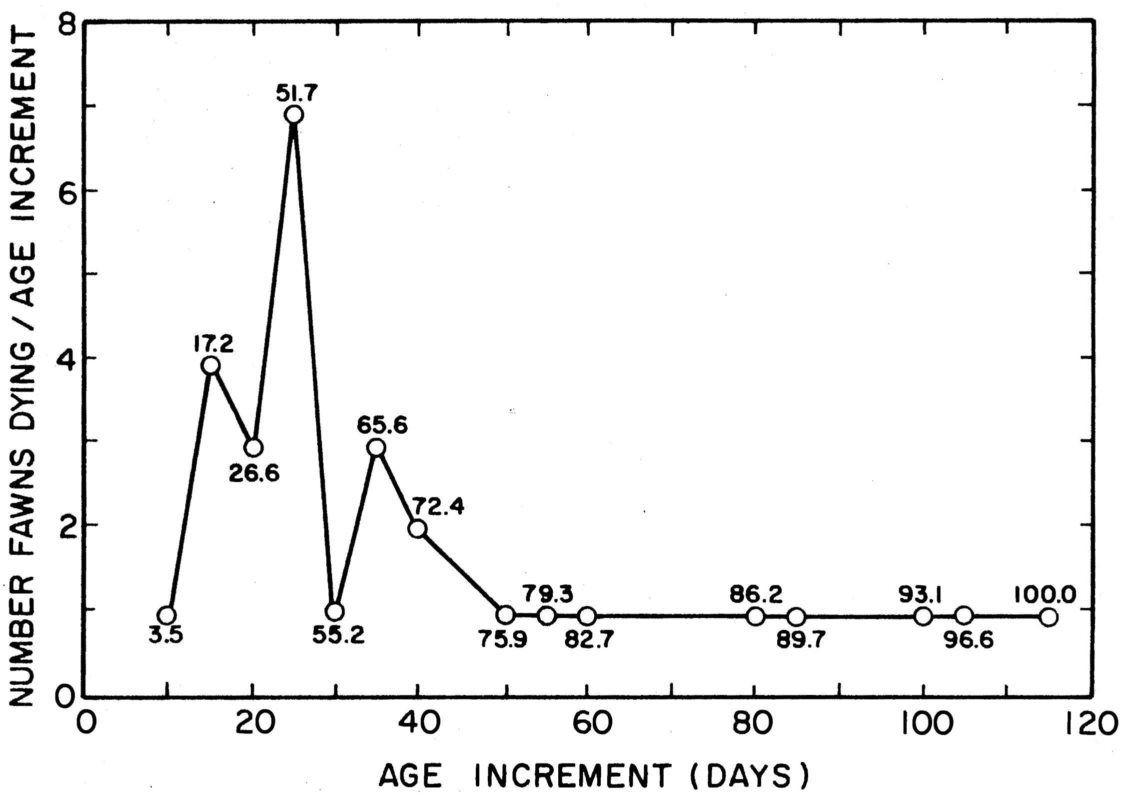

Fig. 2. Number of fawns dying within each 5 day treatment, Wichita Mountains 1974 and 1975 combined data (cummulative percent of total mortality, 1974 and 1975 combined data).

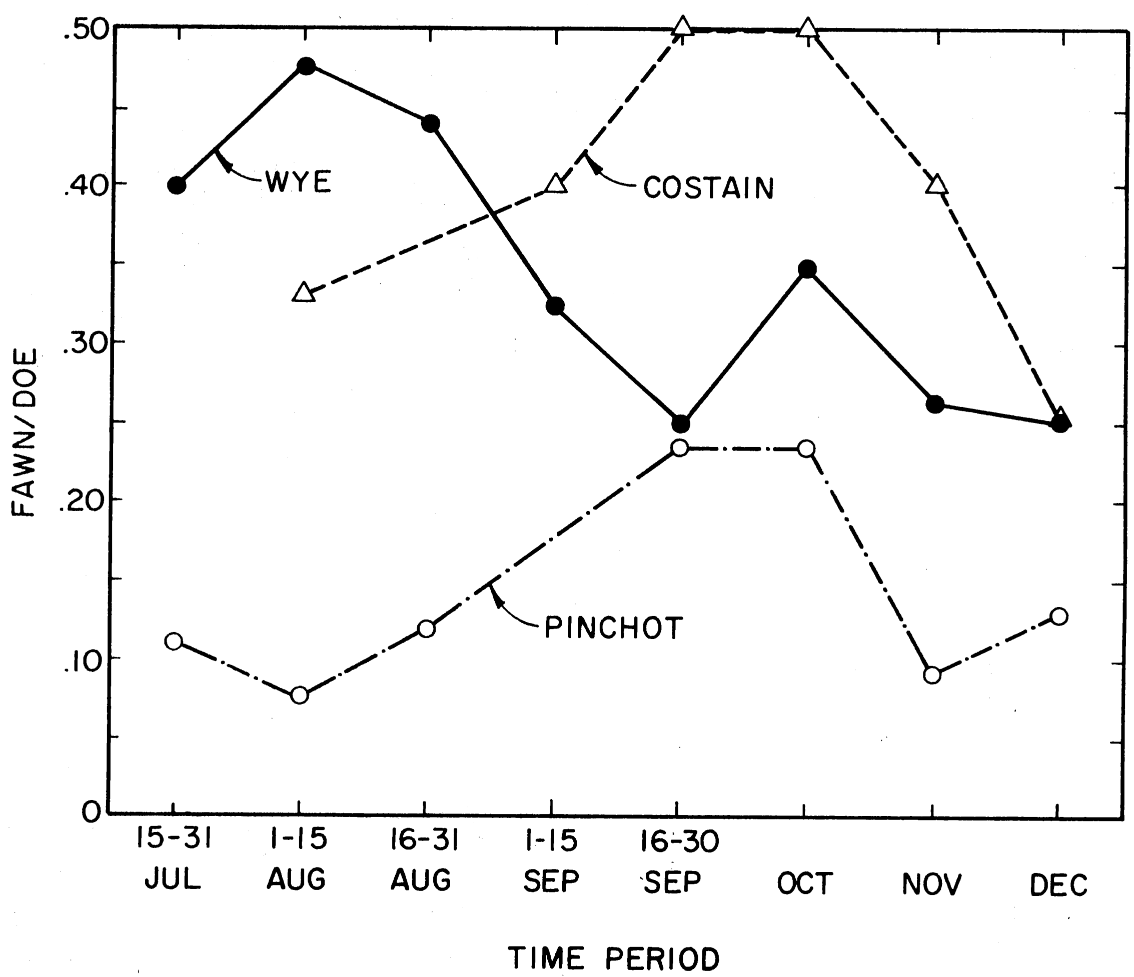

Fig. 3. Fawn/doe ratios for each study location by time period, Wichita Mountains, 1974.

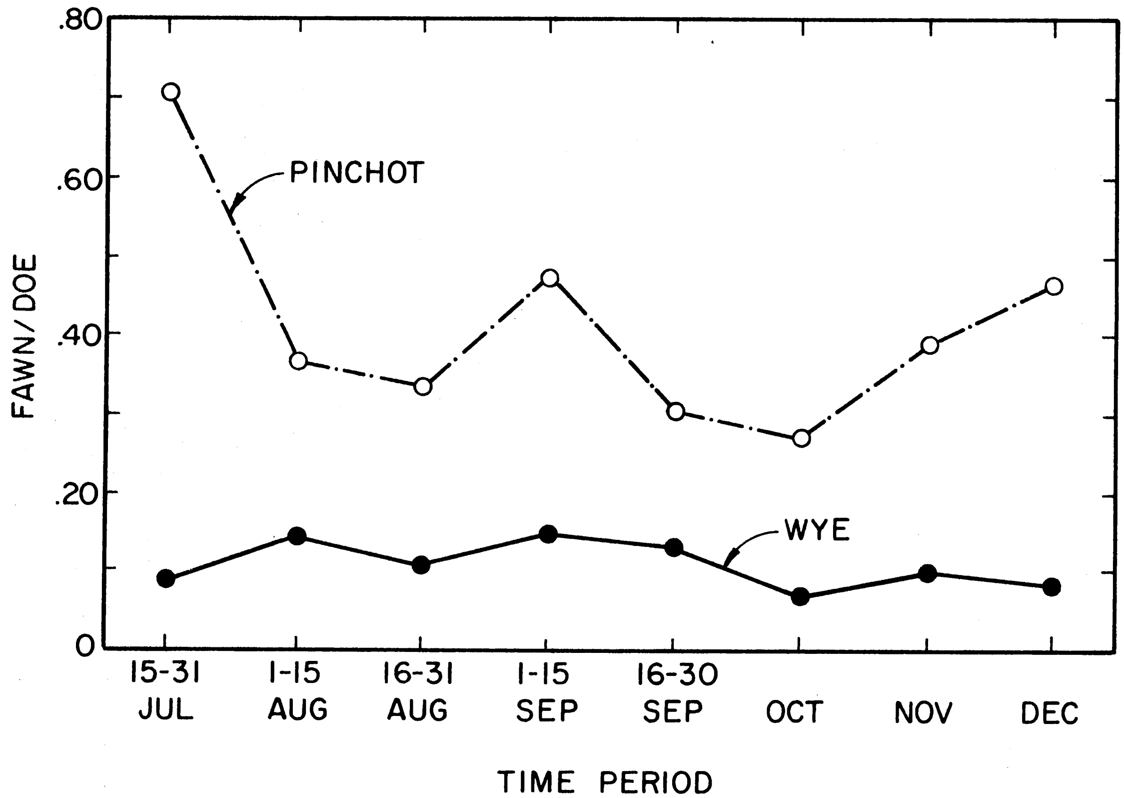

Fig. 4. Fawn/doe ratios for each study location by time period, Wichita Mountains, 1975.

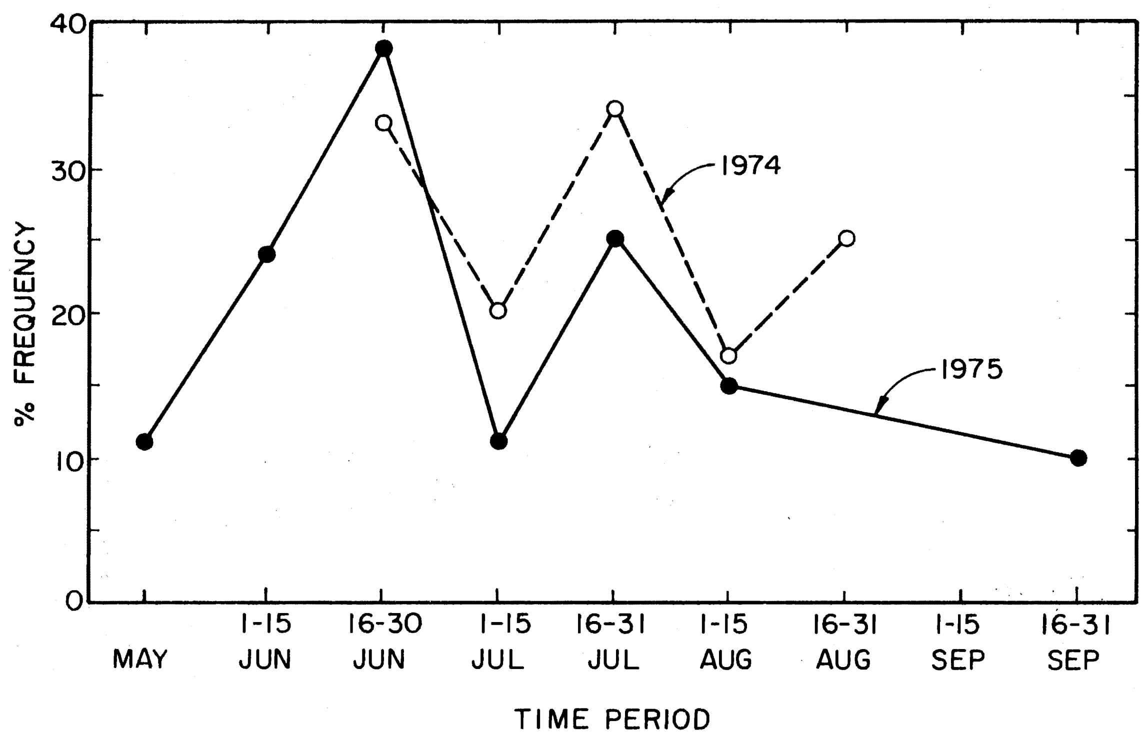

Fig. 5. Frequency of occurrence for fawn hair in predator scats by time period, Wichita Mountains, 1974 and 1975.

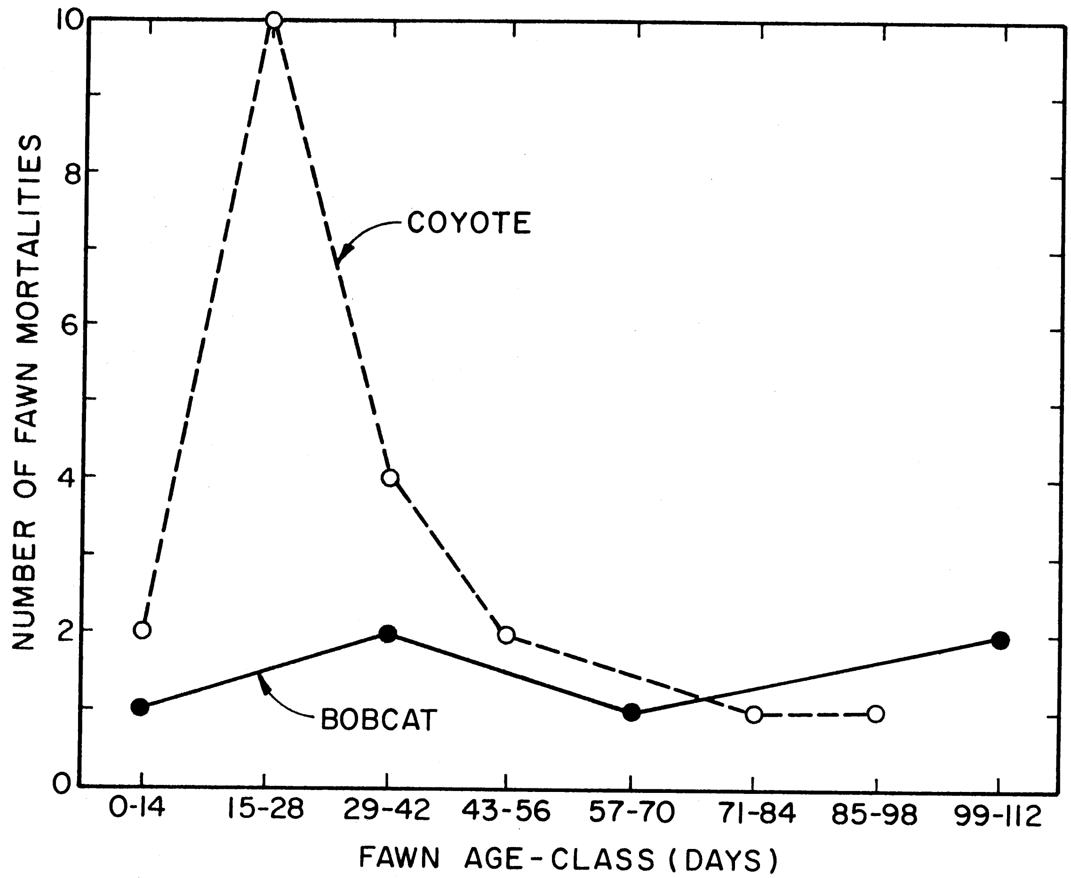

Fig. 6. Number of fawn mortalities in which coyote and bobcat predation was involved, by two weeks fawn age increments, Wichita Mountains, 1974 and 1975 combined data.

CHAPTER III

OBSERVATIONS OF INTERSPECIFIC BEHAVIOR BETWEEN PREDATORS AND WHITE-TAILED DEER IN SOUTHWESTERN OKLAHOMA

Studies of white-tailed deer (Odocoileus virginianus) ecology in south Texas revealed that coyote (Canis latrans) predation was the major mortality factor affecting neonatal fawns (Cook et al., 1971). Bobcat (Lynx rufus) predation was the most significant cause of mortality among young pronghorn antelope (Antilocapra americana) fawns as shown by a Utah study (Beale and Smith, 1973). Neither of these studies included observations on predator-prey interactions that may have contributed to the observed mortality. A recent study of mortality among white-tailed deer fawns in southwestern Oklahoma (Garner et al., 1976a) did provide numerous observations on predators and predator-prey interactions that are useful in evaluation of predation and its impact on young ungulates.

The fawn-mortality study (Garner et al., 1976a) was conducted on portions of the Wichita Mountains National Wildlife Refuge and the Fort Sill Military Reservation which are located in the Wichita Mountains area of Comanche County, Oklahoma. A total of 113 separate observations of predators and predator-prey interactions (106 involving coyotes and 7 involving bobcats) were recorded from 19 May 1974 to 1 February 1976. Prolonged observations were made from atop mountain peaks and artillery-sighting towers, with the aid of binoculars and spotting scopes. These observations were made during early morning and late evening hours in May and June while observing doe behavior for the purpose of locating young fawns for capture purposes as described by Garner et al. (1976a). Incidental observations of short duration were made from trucks and military helicopters while travelling over the study area.

The majority of all coyote observations involved single individuals, whereas pairs were more evident from spring through fall (Table 1). Groups of four coyotes were observed only during the summer period and were believed to be family groups. This seasonal distribution of group sizes does not suggest a tendency for formation of large packs by coyotes at the Wichitas, although a small increase in mean group size is evident from spring through winter. These data support the classification of coyotes as non-pack hunters that was proposed by Fox (1971: 26). All bobcat sightings involved single animals.

Coyotes were under observation for 1048 minutes (min), while bobcats were observed for 27 min. Mean duration of each observation for coyotes and bobcats was 9 min 51 seconds (sec) and 3 min 51 sec respectively. Only 38 (36 percent) of the coyote observations involved interactions with prey species (primarily white-tailed deer) and these interactions had a mean duration of 16 min 38 sec (range = 2-115 min, $S_{\bar{d}}$ = 4 min 52 sec). Prey interactions were noted in three (43 percent) of the bobcat observations and averaged 6 min 40 sec (range = 5-10 min, $S_{\bar{d}}$ = 1 min 40 sec).

Predators in an area under observation were usually detected by observing deer behavior. Bedded deer would rise and stare in the direction of a nearby predator, whereas feeding deer would stop their activity and stare in one direction for one to five min. A staring deer would have the neck extended upward and the ears oriented forward. No signs of other alarm behavior (i.e. stamping, snorting or whistling) as described by Thomas et al. (1965) were evident in this stare response to nearby predators. When the stare response was seen, the observer scanned the area in the direction of these stares and usually located the predator.

Reactions of deer to nearby predators appeared to be dependent upon sex of the deer and its reproductive state (Table 2). Although adult buck/coyote interactions were observed only three times, bucks did not show any signs of aggression towards coyotes. Four adult bucks fled when a coyote approached to within 30 m of them on 4 June 1974 at 0840 hr. These bucks exhibited the alarm behavior of flagging (waving the erected tail from side to side) as described by Thomas et al. (1965). At the same time a nearby doe, also 30 m from the coyote, stood and watched the coyote pass within 20 m of her. A group of five deer (four does and one buck) lying in open prairie on 11 August 1974 jumped to their feet to watch a coyote pass 30 m west of them. When the coyote went over a hill, the group rebedded. On 13 March 1975, two coyotes approached a herd of seven deer (three bucks and four does). The entire group flagged and moved rapidly 100 m west. They stopped, turned, and watched the coyotes pass 90 m east of them.

Three observations were made in June of deer (primarily does) responding to nearby coyote vocalizations (Table 2). On two occasions in 1974, the deer were feeding in open prairie and stopped feeding to stare in the direction of the howling. When the howling stopped, the deer resumed normal feeding activities. A doe ran south from a wooded area into open prairie when coyotes began howling north of her on 24 June 1975 at 0837 hr. She stopped and began feeding when she was 50 m from the woods edge. The howling stopped and she continued normal feeding activities.

Does whose physical appearance (distended abdomen and udder) indicated that they were nearing parturition, watched coyotes for longer periods than did nonpregnant does. On two occasions a doe even followed coyotes up ridges apparently to continue watching them. When the coyotes disappeared into wooded areas, the doe returned to normal feeding activities. Two does were observed running from a coyote at 1930 hr on 25 May 1975. One doe (obviously pregnant) stopped and watched the coyote approach. She circled the coyote and watched it pass by, then proceeded to a small mesquite (*Prosopis juliflora*) thicket and bedded. The other doe, which did not appear to be pregnant, ran 1000 m to the east and disappeared into a small draw.

Does which appeared to have fawned (enlarged udder and no abdominal enlargement) were likely to attack coyotes in their immediate vicinity. This phenomenon was observed on 14 separate occasions and involved 17 does (Table 2). A doe with an enlarged udder in open prairie was under observation on 13 June 1975. At 0710 hr two coyotes appeared north of the doe. She circled the coyotes and they continued past her heading southwest. The doe watched the coyotes disappear into a small creek and then she bedded. At 0800 hr the doe was up feeding again and at 0815 hr a coyote approached her from the northeast. She charged the coyote and it ran from her but turned and tried to charge the doe. She struck the coyote on the forehead with a forefoot and it turned and ran again. She chased the coyote in a tight circle and the coyote tried to charge her several times. Robinson and Cummings (1947) also noted coyotes avoiding attacking deer by running in small circles. Each time the coyote tried to charge the doe it was struck on the head or front part of the body by the doe. Finally the coyote ran east and was joined by another coyote. The doe stopped her pursuit and stood and watched as the two coyotes left the area heading south. The doe then moved back west to her original location and bedded in open prairie. Throughout the entire chase and strike sequence, the doe's ears were oriented forward and not laid back along the neck as described for white-tailed deer during displays of intra-specific aggression (Thomas et al., 1965; Ozoga, 1972). On another occasion, two does and a fawn were observed feeding in open prairie at 0743 hr on 10 July 1974. A coyote approached the group from the south and the deer flagged and ran 50 m up a small draw. They stopped and turned to watch the coyote approach. One doe flushed and ran over a hill to the north while the other doe charged the coyote. The coyote ran in small circles to avoid the doe and escaped over a hill to the east. The fawn which had stood and watched the entire chase sequence, rejoined the doe and watched the coyote leave the area. They continued feeding for five min then entered a wooded area north of their original location. Similar observations of doe aggression towards coyotes were recorded during the 1974 and 1975 fawn capture periods.

During six of the 14 observed attacks against coyotes, the doe was obviously defending a small area against the intruding coyotes (Table 2). She would persistently drive the coyote from the area, then return to the area and await its next move.

A single doe was under observation from 0805 to 1113 hr on 19 May 1974. During this period, she attacked different coyotes which were in her vicinity on two occasions. At 0805 hr she attacked a coyote that approached a small clump of mesquite. This coyote was chased 0.5 km to the east. The doe returned to the mesquite, then moved 100 m east to a small pond. She was again observed at 1045 hr staring into a clump of buttonbush (Cephalanthus occidentalis) at the west end of the small pond. She repeatedly charged through the clump of brush until 1055 hr when a coyote flushed from the clump. The coyote attempted to charge the doe, but she struck it with a forefoot. The coyote then fled east into another draw with the doe in close pursuit. The doe returned to the area of the pond at 1113 hr and displayed the wandering and circling search behavior described by White et al. (1972). From 0745 to 0950 hr on 20 May 1974, two does cooperated in defending against a coyote a clump of buttonbush along a small creek in open prairie. The coyote attempted to hide in the brush but the does sporadically charged through the clump in an obvious attempt to drive the coyote out. At 0930 hr, a coyote flushed from the brush and ran 1 km east with one of the does in close pursuit. This doe returned to the buttonbush area at 0938 hr and was joined by a small fawn. She took the fawn 0.5 km south to a buttonbush thicket around a small pond and both deer bedded there. After the coyote flushed, the other doe moved 300 m north and bedded along the creek. The other observations of does defending an area were similar to these examples.

Interactions between deer and bobcats were observed twice. On 11 June 1975 at 0815 hr, a bedded doe was under observation when she leaped to her feet and stared south. A bobcat was moving west across the hill 30 m south of the doe and was unaware of the doe's presence. The doe watched the bobcat proceed up the hill and she moved cautiously behind it to watch it go over the hill. After the bobcat disappeared into a wooded creek, the doe turned and ran to dense tree cover 100 m southeast of her original bedsite. During this encounter and subsequent retreat, the doe did not exhibit typical alarm behavior of stamping or flagging. Distance of observation was too great to detect the other alarm responses of snorting or whistling described by Thomas et al. (1965). The significance of this lack of alarm behavior is unclear, but may have been an effort on the deer's part to avoid detection by the bobcat. Another doe was observed pursuing a bobcat across an open prairie flat between two rocky hills at 2055 hr on 13 June 1975. The bobcat ran 300 m north to large boulders at the base of a rocky mountain with the doe approximately 10 m behind the bobcat. The doe pursued the bobcat among these boulders than turned back when the bobcat disappeared. The doe then returned to the wooded area from which she and the bobcat had originated. Young (1958:41) reported that does with fawns were known to chase bobcats. He reported two observations of bobcats being chased by does.

Another aspect of doe aggression with respect to defense of their fawns was their behavioral responses when a fawn was captured. On three occasions in 1974, does charged the capture crew when the fawn bleated. These does charged with the ears forward as they did when pursuing coyotes, but when they saw the men they fled the area. Does charged the capture crew on seven occasions when their fawn was captured during 1975. In one instance four does charged the crew. Of special note was the behavior of one doe when her fawn was captured.

The fawn was flushed from the bedsite by the capture crew and was being pursued through a wooded area by the crew and a dog trained to capture fawns. The dog was closing in on the bleating fawn when the doe appeared and charged the dog. A crew member was directly behind the dog and chased the doe away from the dog and the fawn was successfully captured. Another doe with a fawn near a small creek was observed by a crew member in late June 1975. He leaped from the truck and the pair of deer flushed and ran west. The capture dog overtook the fawn in the creek and knocked it down. As the dog was turning to return to the fawn, the doe charged out of some nearby trees and ran over the dog. The startled dog began running toward the crewman, but returned to chase the fawn at the crewman's urging. This fawn successfully evaded capture due to the efforts of the doe. Such defensive behavior on the doe's part would have definite survival value for her fawn(s).

Coyote hunting behavior was observed on three occasions. Two does were feeding near a small creek in open prairie at 2015 hr on 5 June 1975 when a coyote chased them west to a wooded area. The coyote stopped the chase at the edge of the woods and returned to the doe's initial location. The coyote then searched this area (about 2 ha) for 5 min before moving west into the wooded area. On 12 June 1975, a doe with an enlarged udder appeared to be very alert and stood intently watching the prairie north of her. At 0855 hr two coyotes appeared at a small pond 200 m northwest of the doe. The doe flushed and ran east 200 m when the coyotes were within 100 m of her. She stood again and watched the two coyotes approach her initial position, separate, and search the area intently for 5 min. After this unproductive search the coyotes continued toward the doe. She flushed again and ran southeast and stopped again. The coyotes passed with 100 m of the doe and went up a large draw. The doe returned to her original position and paced over the area in a searching pattern for 5 min, then bedded in tall grass. At 0745 hr on 15 June 1975 a single doe was observed attacking two coyotes near a food plot along a wooded stream. The doe repeatedly charged and struck at the coyotes, but they continued searching 3 ha of prairie lying between the food plot and the wooded creek. At 0751 hr the coyotes abandoned their search and entered the woods along the stream with the doe in close pursuit.

Observations of actual predator kills of young fawns were observed once during this study. While locating instrumented fawns on 27 June 1975, two crew members saw a doe with a large fawn moving east up onto a saddle between two rocky hills. At approximately 1330 hr, the doe and fawn were approaching the summit of the saddle when a large bobcat came racing out of a tree clump 50 m south of the pair. The doe stood still while the fawn ran southeast up the hill. The bobcat and fawn collided with much bleating and growling behind a large cedar. The doe ran east over the saddle after the fawn was caught. Two observers rushed to the area of the attack and heard several weak bleats from the fawn as they approached the cedar. Upon their arrival at the site, no evidence of the fawn's fate could be found; both it and the bobcat were gone.

Single coyotes were observed consuming fawns on two occasions in 1975. On 5 June a coyote was observed eating a fawn at 0647 hr in open prairie. A doe was in the immediate vicinity circling the coyote as it ate. At 0726 hr the coyote departed and moved northeast with a large piece of meat in its mouth. The doe remained in the area and appeared to be searching. At 0845 hr on 6 June, a coyote passed by an observer with a large piece of fawn carcass in its mouth. The coyote continued west into the woods at the base of a rocky hill.

The predator-prey complex at the Wichita Mountains includes extensive exploitation of young white-tailed deer fawns by coyotes and bobcats (Garner et al., 1976a). Coyotes do not form large packs to accomplish this exploitation, but evidently have developed efficient hunting techniques for locating and capturing young fawns. One hunting method used appears to be the regular inspection of single does and a thorough search for fawns in their immediate vicinity. Data on doe/coyote interactions during May, June and July (the fawn-rearing season at the Wichita Mountains) indicate that a majority of these interactions involve single does (Table 3). A similar technique (observing single does) was recommended by Downing and McGinnes (1969) and White et al. (1972) for use by wildlife ecologists in capturing fawns to mark them. The open prairie habitat in the Wichita Mountains and the tendency for young fawns to bed in these open habitat types (Garner et al., 1976b) would be advantageous to coyotes using the above type of hunting strategy. Bobcat predation on young fawns at the Wichitas is not as extensive as coyote predation (Garner et al., 1976a). Bobcats appear to rely more on stealth and speed in capturing fawns and their predation effectiveness increases when older fawn begin to frequent the more rocky and wooded habitats (Garner et al., 1976b). Adult does exhibit defense behavior against both coyotes and bobcats that has definite survival value for their fawns, although fawn survival was quite low in the Wichita mortality study (Garner et al., 1976a).

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Table 1. Seasonal group size of 152 coyotes observed from 1974 to 1976 in the Wichita Mountains, Oklahoma.

Season	Number of Groups Observed	Mean # Coyotes /Group	Proportion (%) of Sightings in each Coyote Group Size			
			1	2	3	4
Spring (April, May, June)	59	1.4	67.8	28.8	3.4	0.0
Summer (July, Aug., Sept.)	26	1.5	69.2	19.2	3.9	7.7
Fall (Oct., Nov., Dec.)	10	1.5	60.0	30.0	10.0	0.0
Winter (Jan., Feb., March)	11	1.6	63.6	9.1	27.3	0.0

Table 2. Responses of individual white-tailed deer in various classes to nearby coyotes, Wichita Mountains, 1974-1976.

Type of Deer Responses	Class of Deer			
	Bucks	Non-Pregnant Does	Pregnant Does	Does Which Had Fawned
Respond to howling	1	1	4	
Stare only	1	9	3	4
Stare and follow			2	1
Flag and flee without pursuit	6	6		
Flag and flee when pursued		2		
Attach (charge, chase in circle and/or strike)			1	9
Defend area against attack			1	6

Table 3. Monthly distribution (%) for number of does involved in doe/coyote interactions, Wichita Mountains, 1974-1975.

	Number of	Number of Does in Coyote/Doe Interaction	
Month	Interactions	1	2
May	12	83.3	16.7
June	11	90.9	9.1
July	2	100	

CHAPTER IV

HOME RANGE AND MOVEMENTS OF YOUNG WHITE-TAILED DEER FAWNS IN SOUTHWESTERN OKLAHOMA

Abstract

Average home range sizes for 10 white-tailed deer (Odocoileus virginianus) fawus indicate an increase from 3.3 ha at 1 week of age to 52.0 ha at 12 weeks of age. Increasing home range size results from increasing movements as fawns grow older. Partial cause for large home ranges of fawns in the Wichita Mountains is believed to be the open prairie habitat, but other ecological and behavioral factors may also influence home range size.

Introduction

Home range and movements of white-tailed deer have been the subject of much research. Earlier studies relied on occasional resightings of marked deer for obtaining locations used in calculating estimates of home-range size and movements (Hahn and Taylor 1950, Thomas et al. 1964, Michael 1965, Alexander 1968). Movement data became more readily obtainable with the advent of reliable radio-telemetry equipment (Cochran and Lord 1963, Tester et al. 1964). A majority of the subsequent studies have dealt with home ranges and movements of adult and yearling deer, but only a few studies have been concerned with fawns. Radio-telemetry has proven to be an individual asset for studying fawn ecology during the first months of life because transmitters reveal the location of a hidden animal (Cook et al. 1967 and 1971) when fawns employ cryptic behavior for long periods (Jackson et al. 1972).

Despite the availability of dependable equipment, few reports of telemetrically determined fawn home ranges and movements occur in the literature. Kjos and Montgomery (1969) reported on size of home ranges for a wild and a tame fawn in Illinois. Byford (1970) compared home range sizes of two fawns and of adult deer in Alabama. Responses of young fawns to high water levels were reported by Samuel and Glazener (1970). Logan (1972) described fawn home range size in a fawn mortality study in eastern Oklahoma.

A recent study of fawn mortality in southwestern Oklahoma (Garner et al. 1976) provided numerous radio-locations of young fawns. Preliminary calculations indicated much larger home ranges than had previously been reported in the literature. This paper presents home ranges and movements of 10 fawns monitored from June through August 1975 (until 3 months of age) in the Wichita Mountains, Oklahoma.

Financial support was provided by the Oklahoma Department of Wildlife Conservation; School of Biological Sciences, Oklahoma State University (OSU); OSU Environmental Institute; and Fort Sill Military Reservation, U. S. Department of the Army. Roger Johnson (Wichita Mountains National Wildlife Refuge) and George Johnson (Fort Sill Military Reservation) provided access to the study areas. Leroy Anderson, John Ault, Mack Barrington, Bill Bartush, Gene Waldrip, and David Wiseman provided dedicated assistance in the field. The manu-

script was submitted in partial fulfillment of requirements for the degree of Doctor of Philosophy in Wildlife Ecology at Oklahoma State University.

Study Area and Methods

The study area includes portions of the contiguous Wichita Mountains National Wildlife Refuge and Fort Sill Military Reservation in northwestern Comanche County; it has been described in detail by Buck (1964), Crockett (1964) and Garner et al. (1976). Two locations, Wye area and Pinchot area (Garner et al. 1976), within the mountain complex, were used as fawn capture areas in May and June 1975. Twenty-five fawns were captured, measured, weighed, sexed, instrumented, and released at the capture site as described by Garner et al. (1976). Each fawn was monitored and observed daily until 1 July; after this date multiple daily locations were recorded for each surviving fawn. Daytime movements were obtained at this time by monitoring each fawn at 3 hr intervals (five observations per day) between 0600 hr and 2100 hr on three alternating days per week. Preliminary observations indicated triangulation errors of 400 m were not uncommon if normal triangulation procedures were followed. Consequently fawn locations were obtained by radio triangulating the fawn at 90 to 180 m distances to avoid the inherent error associated with longer-distance triangulations (Heezen and Tester 1967) and because the high frequency transmitter signals (164 mHz) used in the study were subject to severe bounce and deflection in the rocky terrain of the Wichita Mountains. Periodic checks indicated that triangulations were accurate to within 10 m of the fawn's actual location.

Fawn locations were recorded on field forms with an accompanying hand-drawn map. Locations were transferred from the field map to overlays on large-scale aerial photographs. All movement distances and home-range calculations were obtained by using these overlays. Home ranges were constructed for each fawn at weekly age intervals using the minimum-home-range modification (Marchinton and Jeter 1966) of the modified-minimum-area method described by Harvey and Barbour (1965). A compensating polar planimeter was used to determine home-range size.

Results and Discussion

Ten fawns survived for adequate lengths of time to provide sufficient data for calculations of home range and movements in 1975. The remaining 15 fawns died before enough locations could be obtained for determining home ranges.

Home Range

Weekly home ranges for the 10 fawns are presented in Table 1. Total home range for each fawn is depicted in Figures 1-5. Average home-range size increased steadily with increasing age (Table 1). The mean 8-weeks home range size of 37.3 ha is much larger than corresponding home-range size averages (2.2 ha) of surviving fawns in eastern Oklahoma (Logan 1972). The 6-weeks average size (27.3 ha) is also much larger than home-range size of a wild fawn (1.0 ha) observed in Illinois (Kjos and Montgomery 1969). In fact, the average 1-week home-range size at the Wichita Mountains (3.3 ha) is larger than either the 6- or 8-week home ranges in these two studies. Reasons for this much larger home-range size at the Wichita Mountains may be partially explained by the more open terrain, but this fact alone seems insufficient to explain such large differences. More research on fawn ecology at the Wichita Mountains is needed before causes for the larger fawn home range size can be clarified. High fawn-mortality rates reported by Garner et al. (1976) may somehow be related to these large home ranges, but the nature of this relationship is unclear.

Two sets of twins were marked in the sample of 10 fawns (B4 and B8; B7 and B14). Unfortunately B7 and B8 succumbed to predation at three and four weeks of age respectively. Figure 6 compares concurrent home ranges of each set of twins at the time of death. Although large areas of home range overlap for both sets of twins (especially B4 and B8), neither set of twins was located together. Fawns B4 and B8 were never concurrently located closer than 45 m, whereas B7 and B14 were never closer than 110 m. These data indicate that twin fawns at the Wichitas do not bed together until at least four weeks of age.

Movements

Distances between successive daily locations during a fawn's first month of life were examined to determine if home-range expansion may be related to increasing distances between daily locations (Table 2). Although there is considerable variation among an individual fawn's weekly average of daily movements, overall mean daily movements do indicate increasing daily movement distances with increasing fawn age. The magnitude of this increase also appears to increase with time. A minimum daily movement of 12 m was recorded at five days of age for fawn B4, whereas the maximum daily movement of 953 m was recorded at 25 days of age for fawn C8. These data suggest that increasing home range size is directly related to increasing daily movements.

Weekly average daytime movements (five locations per day) for fawns between the ages of 4 and 11 weeks do not indicate that distances of daytime movements increases with age (Table 3). Minimum daytime movement was zero and the maximum daily movement was 1,208 m. Individual fawns were quite variable in their daily movements. Some fawns would change locations in each of the five daily monitorings. The same fawn might move extensively on one day, and then remain in one location on other day. The majority of the daytime movements were less than 750 m, with the longer distance movements being less frequest (Table 4).

Conclusions

Home ranges of young fawns at the Wichita Mountains were much larger than home ranges reported in other studies. The open prairie habitat in the Wichita Mountains is believed to contribute to this larger home range, but other unknown factors are probably also involved. Relationships between high fawn-mortality rates due to predation and large home range sites are unclear, but may involve either predator harassment or a predator avoidance mechanism by the fawns. Development of a fawn's home range appears to be a function of increasing movements by the growing fawn. Home ranges increased steadily as the fawns grew older. Daytime movements of fawns did not appear to be related to home range size and is quite variable among fawns and sampling days.

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Table 1. Home range size (ha) weekly age intervals for fawns in the Wichita Mountains, Comanche County, Oklahoma, 1975.

Age Interval	Fawn Number and Sex										Mean
	B-2 F	B-4 F	B-7 F	B-8 F	B-14 F	C-2 M	C-3 F	C-4 F	C-6 F	C-8 F	
1 week	5.3 (5)[1]	I[2]	2.2 (6)	I	I	2.3 (3)	I	I	I	I	3.3
2 weeks	7.4 (12)	3.5 (12)	5.4 (13)	4.7 (7)	I	3.2 (10)	1.6 (6)	I	8.4 (6)	I	4.9
3 weeks	9.4 (14)	12.2 (19)	13.8 (21)	20.6 (14)	10.4 (7)	5.1 (17)	3.7 (13)	3.8 (11)	23.6 (13)	I	11.8
4 weeks	Dead	20.3 (26)	19.4 (24)	Dead	20.9 (14)	7.7 (33)	8.4 (20)	8.2 (18)	30.3 (22)	23.8 (10)	17.4
5 weeks		20.9 (33)	Dead		26.9 (30)	8.7 (49)	13.5 (41)	26.0 (30)	37.1 (41)	34.0 (32)	23.9
6 weeks		24.1 (55)			31.2 (46)	12.2 (69)	20.9 (55)	28.3 (52)	39.4 (57)	34.9 (48)	27.3
7 weeks		24.9 (70)			57.9 (67)	15.9 (90)	32.7 (76)	32.5 (65)	42.1 (81)	39.5 (69)	35.1
8 weeks		26.9 (91)			59.1 (89)	16.4 (110)	32.7 (96)	43.2 (85)	Dead	45.2 (89)	37.3

Table 1. (Continued)

Age Interval	Fawn Number and Sex: B-2 F	B-4 F	B-7 F	B-8 F	B-14 F	C-2 M	C-3 F	C-4 F	C-6 F	C-8 F	Mean
9 weeks		31.8 (112)			62.8 (105)	18.9 (116)	34.4 (117)	46.1 (106)		49.9 (110)	40.7
10 weeks		32.7 (128)			77.5 (124)	Dead	46.8 (135)	59.8 (123)		50.0 (123)	53.4
11 weeks		35.6 (147)			77.5 (132)		51.6 (140)	65.0 (129)		50.7 (130)	56.1
12 weeks		35.6 (151)			Dead		51.6 (143)	65.0 (132)		55.8 (133)	52.0

[1]Number of fawn locations used in each calculation of home range is shown in parentheses.

[2]Insufficient data or fawn not captured at this age.

Table 2. Weekly mean daily movements (m) for 10 fawns during the first month of life at the Wichita Mountains, 1975.

Fawn Number	Age Interval			
	1 week	2 weeks	3 weeks	4 weeks
B-2	260	148	Dead	
B-4	49	189	347	415
B-7	153	131	338	250
B-8	I[1]	225	415	Dead
B-14	I	I	475	346
C-2	151	77	195	229
C-3	I	135	115	241
C-4	I	235	131	245
C-6	I	331	262	458
C-8	I	I	I	539
Mean	153	184	285	340

[1]Insufficient data or fawn not captured at this age interval.

Table 3. Weekly average for daytime movements (0900-2100 hrs) of 4 to 11-week-old fawns at Wichita Mountains, 1975.

Time Interval	Average Distance of Daytime Movement (m)
4 weeks	315
5 weeks	446
6 weeks	425
7 weeks	347
8 weeks	361
9 weeks	458
10 weeks	508
11 weeks	258

Table 4. Distribution (%) of daytime fawn movements by distance intervals at Wichita Mountains, 1975.

Distance Interval (m)	% of Daytime Fawn Movements In Distance Interval
0-150	13.3
150-300	30.1
300-450	20.5
450-600	18.1
600-750	10.8
750-900	1.2
900-1050	3.6
1050-1200	2.4

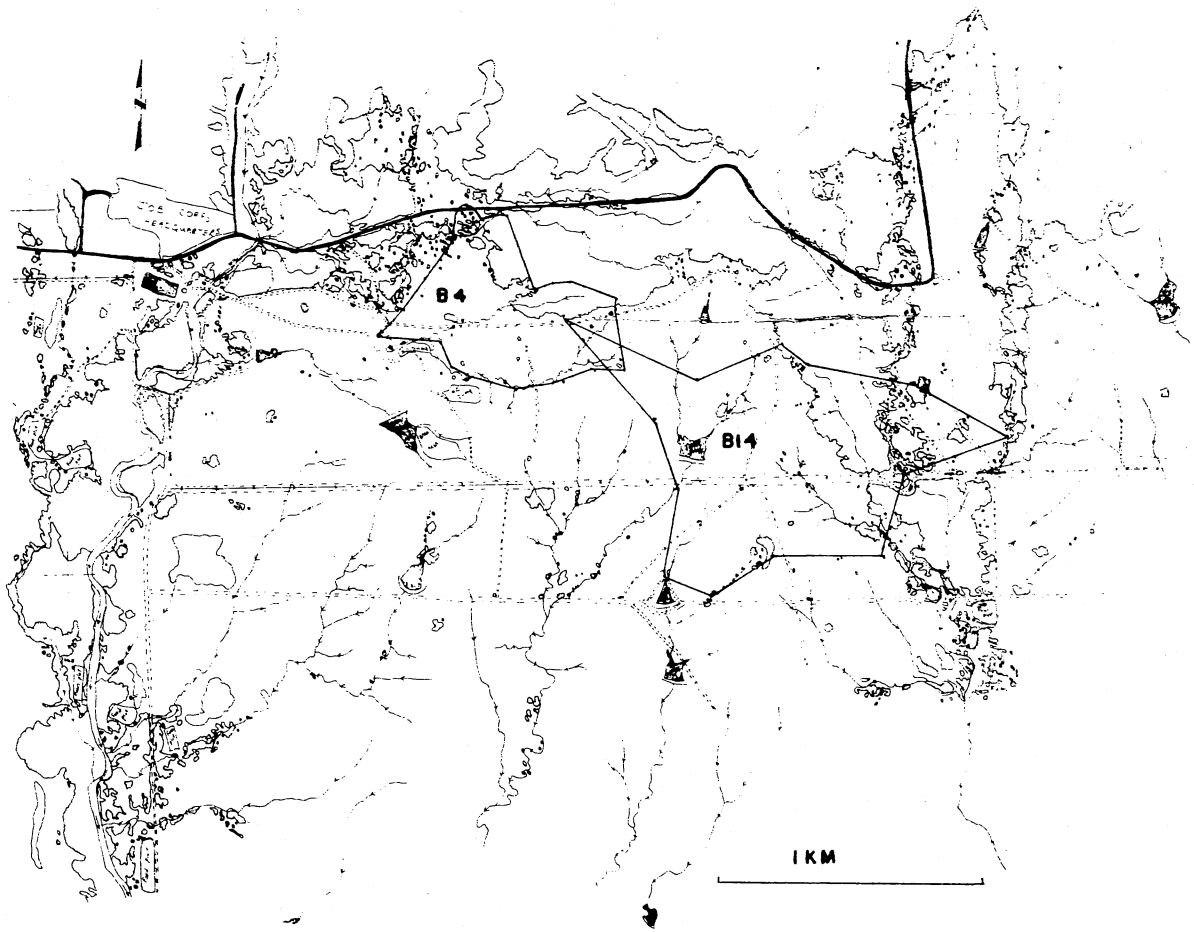

Fig. 1. Home ranges of fawns B4 and B14 at the Wye area of Fort Sill and the Wichita Mountains National Wildlife Refuge at Wichita Mountains, Comanche County, Oklahoma, summer 1975.

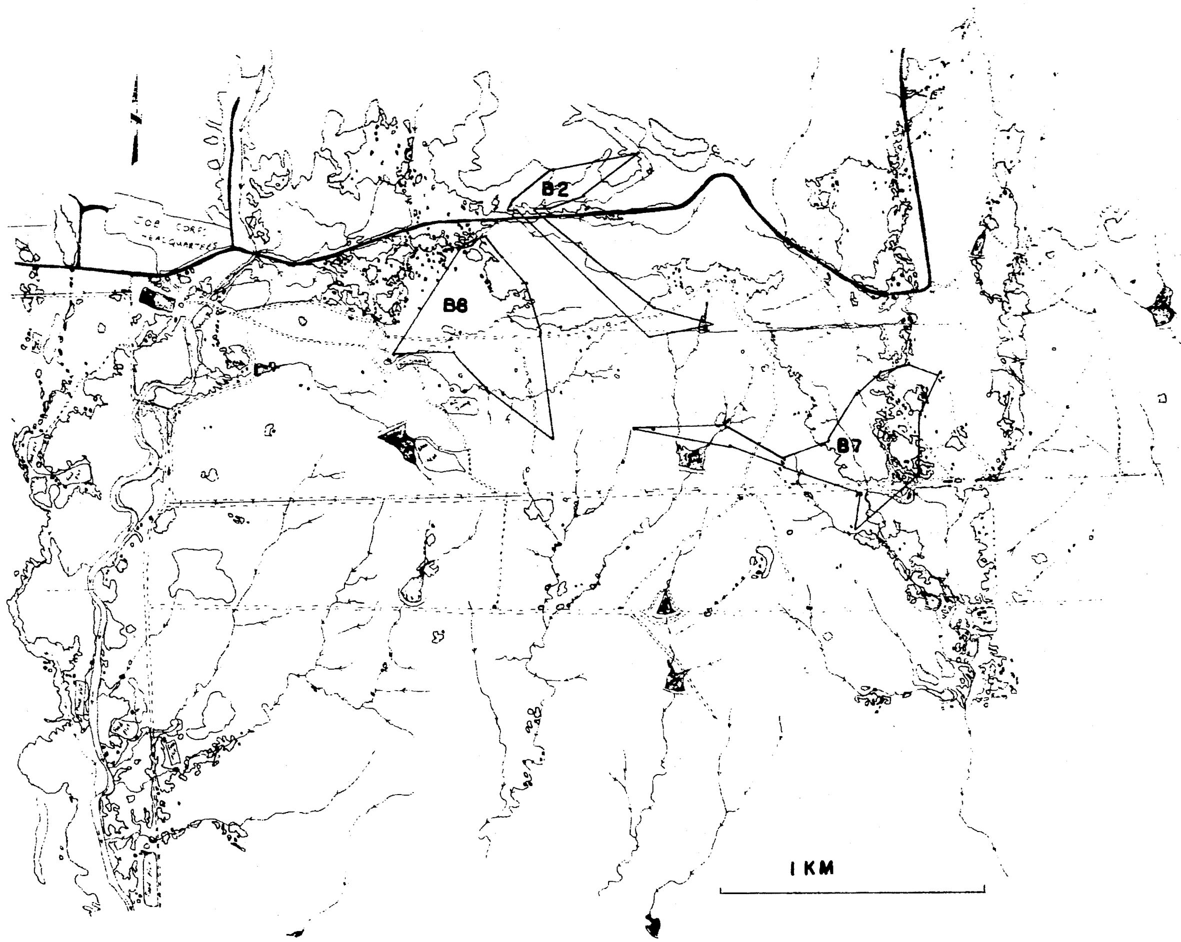

Fig. 2. Home ranges of fawns B2, B7, and B8 at the Wye area of Fort Sill and the Wichita Mountains National Wildlife Refuge, Comanche County, Oklahoma, summer 1975.

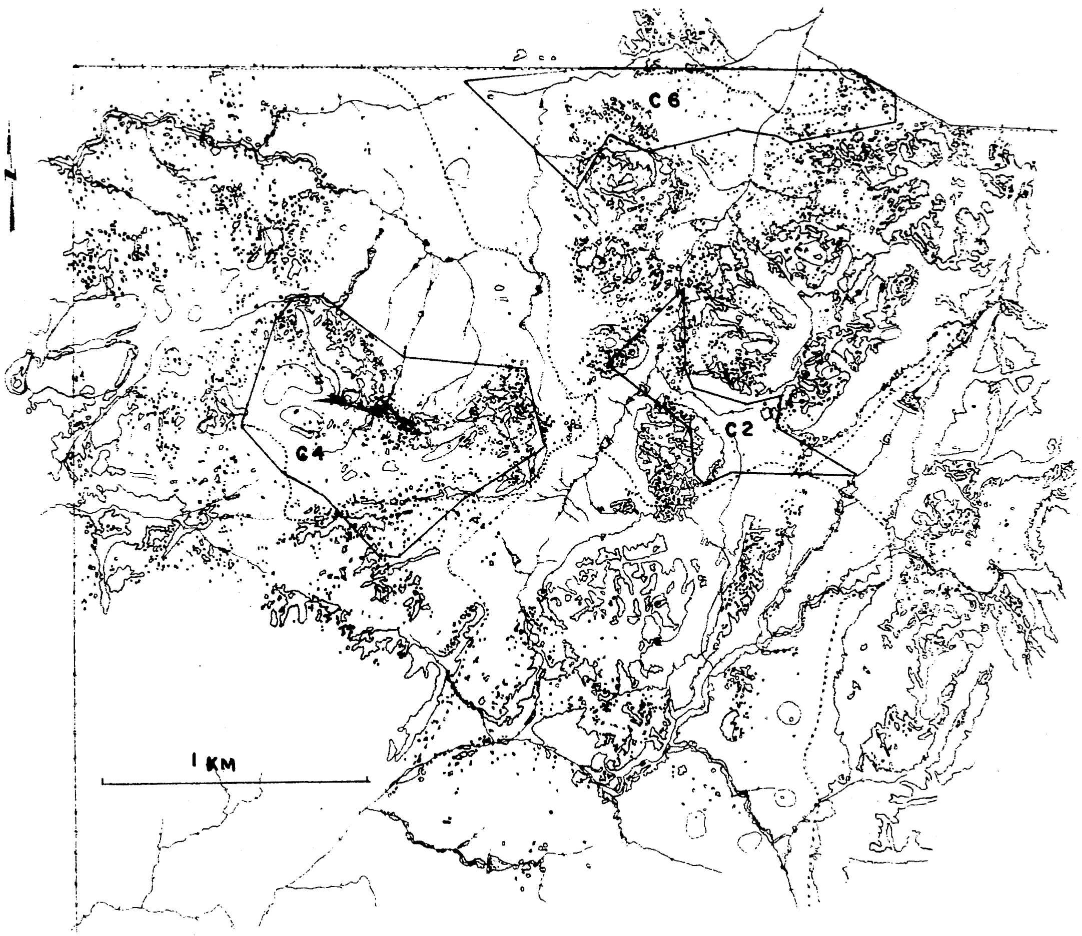

Fig. 3. Home ranges of fawns C2, C4, and C6 in the Pinchot area of the Wichita Mountains National Wildlife Refuge, Comanche County, Oklahoma, summer 1975.

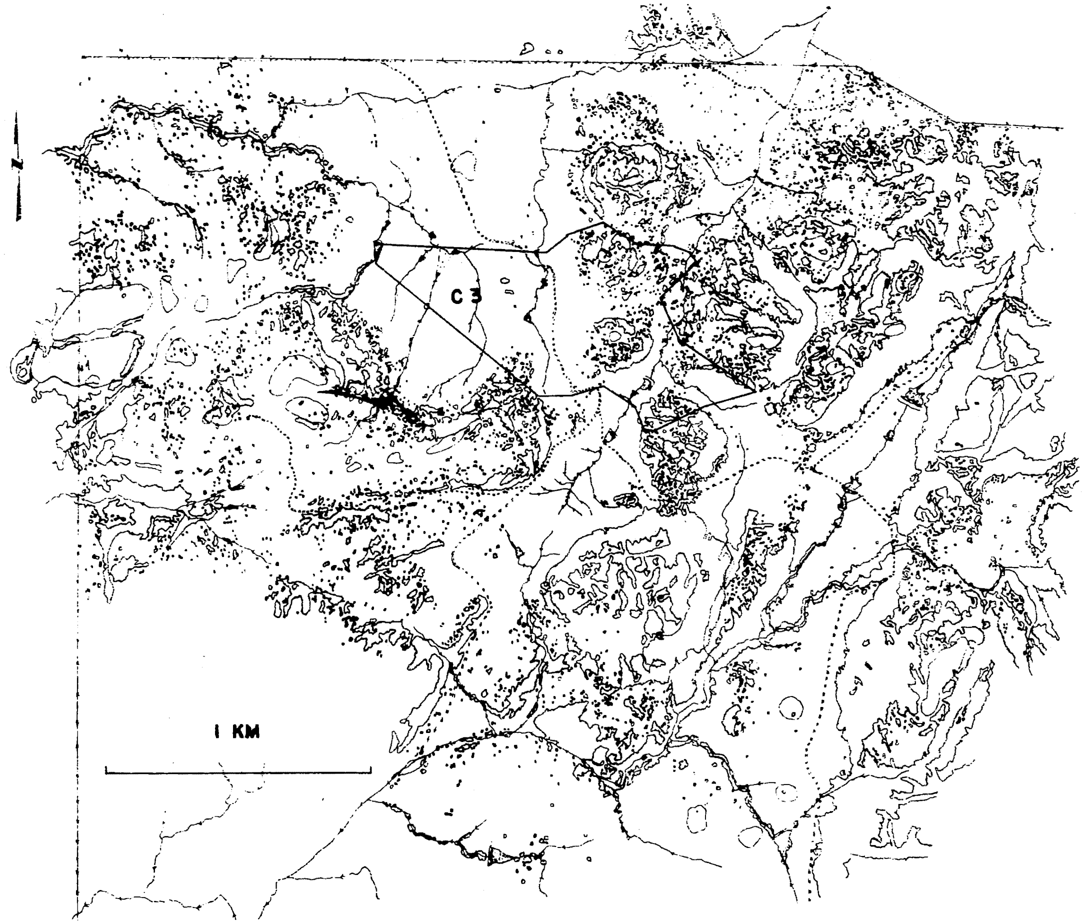

Fig. 4. Home range of fawn C3 at the Pinchot area of the Wichita Mountains National Wildlife Refuge, Comanche County, Oklahoma, summer 1975.

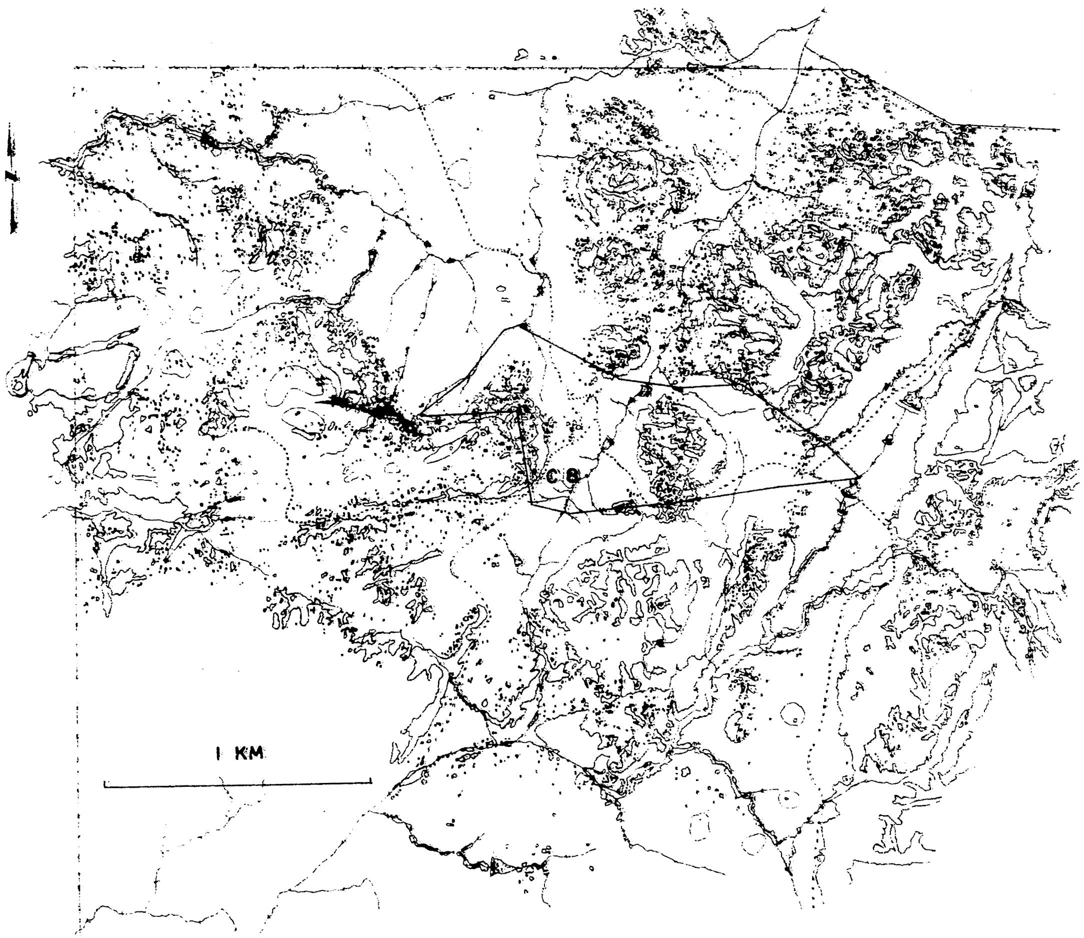

Fig. 5. Home range of fawn C8 at the Pinchot area of the Wichita Mountains National Wildlife Refuge, Comanche County, Oklahoma, summer 1975.

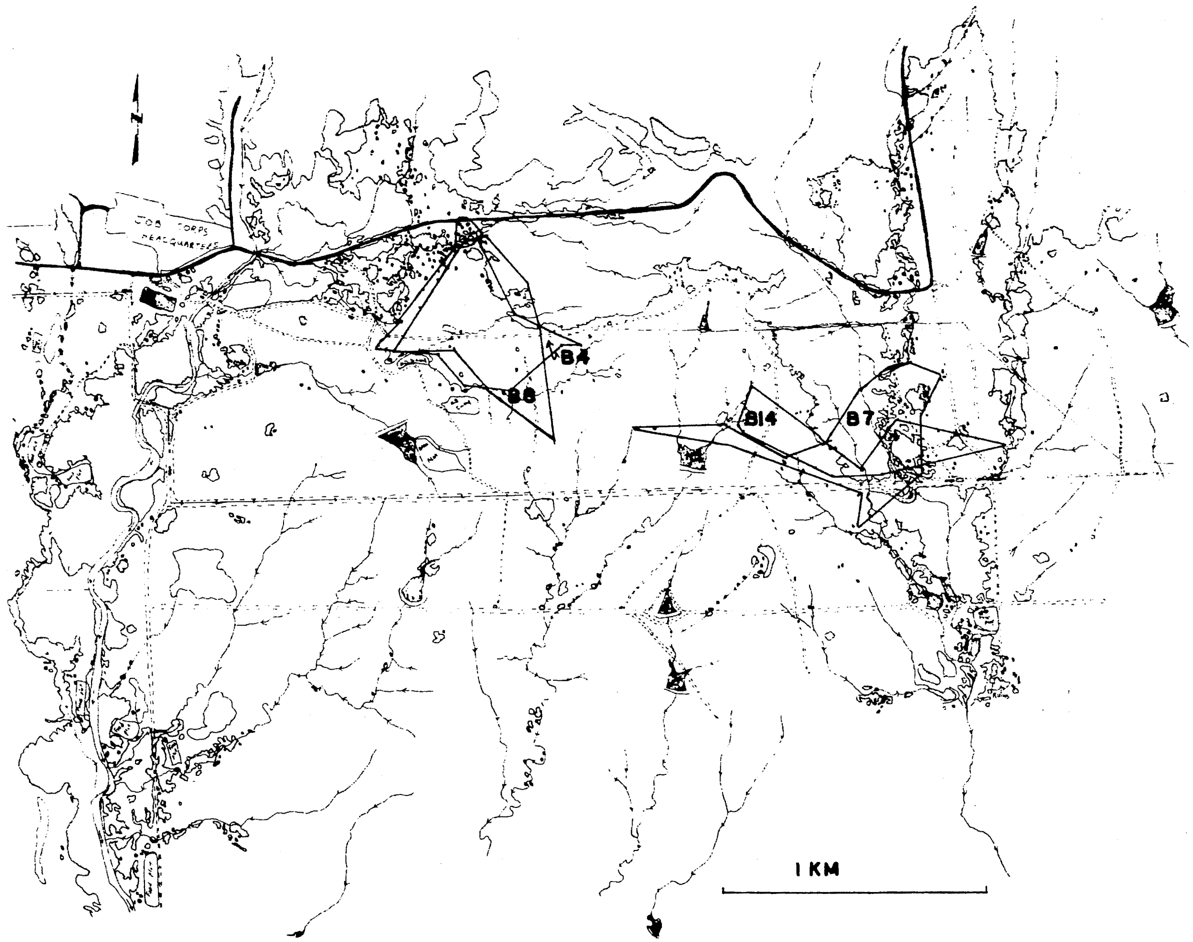

Fig. 6. Concurrent home ranges of two sets of twins (B4 and B8, B7 and B14), at the Wye area of Fort Sill and the Wichita Mountains National Wildlife Refuge, Comanche County, Oklahoma, summer 1975.

CHAPTER V

SPECIES COMPOSITION OF VEGETATION SURROUNDING DAYTIME BEDSITES OF WHITE-TAILED DEER FAWNS

Highlight

Midsummer daytime bedsites of white-tailed deer (Odocoileus virginianus) fawns in southwestern Oklahoma were analyzed to determine the percent composition of the surrounding vegetation. Fawns used five different range sites for daytime bedsites. The bedsites located in the boulder ridge, hilly stony, and hardland range sites were in good to excellent range condition, whereas the bedsites located on the hilly stony savannah and boulder ridge savannah range sites varied from poor to excellent in range-condition class. Range-condition class appears to be a valid index to the suitability of range sites (especially the open prairie sites) for use by deer as fawn-rearing areas in the Wichita Mountains, Oklahoma.

Introduction

The literature is replete with descriptions and appraisals of various aspects of white-tailed deer (deer) habitat. One component of deer habitat that is notable for its lack of detailed descriptions is fawn-rearing habitat. Severinghaus and Cheatum (1956) mentioned briefly the fawn-rearing-habitat component of deer summer range, but did not provide detailed descriptions. Because young deer fawns exhibit cryptic behavior patterns during the first months of life (Jackson et al., 1972), study of this early stage of life has been difficult. Kjos and Montgomery (1969) used radiotelemetry equipment to repeatedly relocate two fawns in Illinois for the purpose of collecting data on daytime bedsites. Their subsequent descriptions of bedsites were qualitative and did not include data on species composition of vegetation surrounding the bedsites.

A recent telemetry-aided study of fawn mortality in Oklahoma (Garner et al., 1976) provided an opportunity to collect species-composition data on vegetation surrounding midsummer daytime bedsites of young fawns. This paper reports on the percent composition of vegetation surrounding those bedsites and compares differences in percent composition of bedsites located on different range sites (Soil Conservation Service, 1967). These data provide baseline information on fawn-rearing habitat in southwestern Oklahoma and should be useful in further evaluations of habitat quality for deer in the Wichita Mountains, Oklahoma.

Study Area and Methods

This study area is located in the Wichita Mountains complex of northwestern Comanche County, Oklahoma and has been described by Buck (1964), Crockett (1964) and Garner et al. (1976). The Soil Conservation Service (1967) has recognized and described 19 range sites in the county, but only eight range sites (loamy prairie, hardland, slickspots, loamy bottomland, boulder ridge, boulder ridge savannah, hilly stony, and hilly stony savannah) are located within the confines of the Pinchot and Wye study areas delineated by Garner et al. (1976). Table 1 lists the soil series and their classifications (Soil Conservation Service, 1967; Bartelli and Coover, 1973) for each of the eight range sites.

Young fawns were captured, fitted with radiotransmitters, and released at their capture sites (Garner et al., 1976) in May and June, 1975. Daytime bedsites of marked fawns were located by triangulating each fawn and then cautiously approaching the fawn until it was observed in its bed. The fawn was flushed from the bedsite and the vegetation was analyzed.

Each bedsite location was recorded on field forms and plotted onto aerial photographs. The range site for each bedsite was then determined by comparing this photo-map plot to the published soil-survey photomaps (Soil Conservation Service, 1967).

At each bedsite, two 20-m bisecting lines were established, with one line along the axis of the slope (up slope line) and the other line (cross slope line) perpendicular to the first. The bedsite was located at the midpoint of each line (the bisection point) in the manner described by Reichelt (1973). A sharpened surveyor's pin was lowered verticially to ground level at 2-dm intervals along each line and the plant nearest to the pin at ground level was recorded at each point (200 total points per bedsite).

Range condition classes on each bedsite were determined by calculating the percent species composition of vegetation. The percentages of climax vegetation present on each bedsite were tabulated with respect to range site and the percent range condition class (Dyksterhuis, 1949) was calculated.

Statistical analyses of species-composition data by one-way classification analysis of variance and linear correlation analysis (Steel and Torrie, 1960) were accomplished by using the statistical analysis system (SAS) computer programs described by Service (1972). To facilitate these analyses and avoid the bias of missing observations, computations were based on 12 species which occurred on the majority of bedsites. The twelve species used for statistical analyses include: western ragweed (*Ambrosia psilostachya*), big bluestem (*Andropogon gerardi*), heath aster (*Aster ericoides*), sideoats grama (*Bouteloua curtipendula*), sedges (*Carex* spp.), spike rushes (*Eleocharis* spp.), fall witchgrass (*Leptoloma cognatum*), Scribner's panicum (*Panicum oligosanthes* var. *scribnerianum*), switchgrass (*Panicum virgatum*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and tall dropseed (*Sporobolus asper*). In addition to these species, four groups of species (tall, short, forbs, all-12) were also used in the analysis. The tall group included big bluestem, switchgrass, little bluestem, Indiangrass and tall dropseed, whereas the short group included sideoats grama, sedges, spike rushes, fall witchgrass and Scribner's panicum. The forbs group included western ragweed and heath aster; the all-12 group included all 12 species.

Each species/group (species or group of species) was tested by analysis of variance for differences between lines (up slopes and cross slope) within bedsites, and differences between bedsites. Data from the two lines were then pooled within each bedsite for each species/group and tested for differences between range sites. Least significant differences (LSD) values were used to determine which species/group means were contributing to the significant differences observed in the analysis of variance. Linear correlation analysis was used to determine significant relationships between species/groups.

Results and Discussion

Twenty-eight daytime bedsites were sampled from 30 June to 18 August, 1975 (Table 2). These bedsites were located on five of the eight range sites within the study areas. Table 3 presents average percent composition of the more common species for each range site. Some degree of selection for certain range sites was evident when 295 nonmoving daytime fawn locations (fawn not moving when triangulated and assumed bedded or fawn observed bedded) during the same time period for these five fawns were compared to range site percentages available on the study area (Table 4). Loamy bottomland and slickspots range sites appeared to be avoided while loamy prairie, hardland and boulder ridge range sites were used to a low degree in proportion to their availability. Hilly stony, hilly stony savannah, and boulder ridge savannah were used to a high degree in proportion to their availibility. The sampled bedsites also indicated a preference for range sites in the good and excellent range-condition classes (Table 2). Only three bedsites were located on poor or fair condition range sites, and these bedsites were confined to the two savannah range sites where woody cover might offset any negative aspects of low range-condition classes.

Analysis of variance of the major 16 species/groups (a total of 86 species occurred on the sampled bedsites) for variation between lines within bedsites revealed no significant differences at the 0.05 or lower significance levels. Heath aster, tall dropseed, and fall witchgrass were the only species to approach significance, having observed significance levels of 0.0866, 0.0904, and 0.1463 respectively. Observed significance levels for the remaining species group ranged between 0.51 and 0.73. Therefore, subsequent statistical analyses used pooled percent-composition data for the two lines at each bedsite.

Table 5 presents the observed significance levels for each species/group in the analysis of variance for differences between individual bedsites and the five range sites. Heath aster, fall witchgrass, and Indiangrass were not significantly different ($\hat{\alpha} > 0.05$) between bedsites, whereas the remaining species/groups did exhibit significant differences in percent composition between bedsites. When species/group percent compositions were classified by range sites, only nine were judged different. The level of significance was lowered to 0.10 in the range-site analysis of variance to allow for more species/group variation within range sites. These nine species/group means were examined to detect significant differences between range site means for each species/group (Table 6).

Linear correlation analysis of the 16 species/group revealed many significant correlations. Most of these correlations were concerned with verifying the classification of each species in its appropriate group, but several meaningful relationships between species in different groups were also evident. Sedges were negatively correlated with the tall group (c.c. = -0.5672, $\hat{\alpha} \doteq 0.0001$) and big bluestem (c.c. = -0.3525, $\hat{\alpha} = 0.0077$). Spike rushes were negatively correlated with the more xeric little bluestem (c.c. = -0.4816, $\hat{\alpha} = 0.0004$), but was positively correlated with the more mesic switchgrass (c.c. = 0.5476,

$\hat{\alpha}$ = 0.0001). These species (sedges, spike rushes and switchgrass) are normally associated with more moist soils in the Wichita Mountains.

Bedsites located on the two savannah range sites had higher total percentages for woody vegetation than did the three open range sites (Table 7). Oaks (Quercus spp.), cedar and skunkbrush (Rhus aromatica) were the major woody species of the boulder ridge range savannah site, whereas a wider variety of species composed the woody vegetation on the hilly stony savannah range site (Table 3). Grasses and grass-likes were the most abundant plant forms around all bedsites, but those bedsites located on the two savannah range sites had lower total percentages for grasses and grass-likes than the more open range sites (Table 7). These lower percentages were a result of both fewer species and fewer individuals of those grass and grass-like species that did occur on the savannahs (Table 3). The species mixture of grasses and grass-likes on boulder ridge and hilly stony savannahs were similar, whereas bedsites on the hardland range site had less big bluestem and switchgrass (Table 3). The hardland bedsites had more silver bluestem (Bothriochloa saccharoides), sedges, and tall dropseed than those bedsites located on boulder ridge and hilly stony range sites (Table 3). The high forb percentage on the hardland range site (Table 7) resulted from higher percentages for western ragweed and heath aster than on the other range site (Table 3).

The white-tailed deer on the Wichita Mountains are descendents of native herd remnants (Lindzey, 1951) and have apparently become well adapted to the prairie-woodland type of habitat. The open prairies and wooded areas are important to fawns as locations for daytime bedsites. This paper has described the percent composition of the vegetation surrounding those bedsites and has examined differences in percent composition as it relates to the different range sites in the study area.

The range manager's concept of the range site appears to have merit for use in fawn-rearing habitat appraisal for white-tailed deer. This study suggests that range condition classes in the Wichita Mountains may be important in determining the suitability of a range site for fawn-rearing habitat. Open-prairie range sites that are in poor or fair condition appear to be avoided by fawns for use as bedsites, while poor and fair condition savannah range sites may occasionally be used by fawns. The management strategy for rangelands in the Wichita's should provide for retention and development of good and excellent range condition classes on the various range sites for continued use as fawn-rearing habitat.

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Table 1. Range sites and their associated soil series and respective classifications within the study area, Wichita Mountains, Comanche County, Oklahoma.

Range Site	Soil Series	Soil Series Classifications (Subgroup, Great Group, Suborder, Order)
Loamy Prairie	Lawton	Udic Argiustolls
	Vernon	Typic Ustochrepts
Hardland	Foard	Typic Natrustolls
	Tillman	Typic Paleustolls
Slickspots	Hinkle	Mollic Natrustalfs
Loamy Bottomland	Claremont	Typic Ustifluvents
	Mangum	Vertic Ustifluvents
	Port	Cumulic Haplustolls
Boulder Ridge	Brico	Udic Argiustolls
Boulder Ridge Savannah	Brico	Udic Argiustolls
Hilly Stony	Brico	Udic Arguistolls
Hilly Stony Savannah	Brico	Udic Argiustolls

Table 2. Daytime fawn bedsites sampled during 1975 in the Wichita Mountains, Comanche County, Oklahoma.

Fawn Number and Sex	Time of Sample	Date of Sample	Fawn Age at Sample Time (Days)	Range Site	% Range Condition
B-4	0935	22 July	59	Boulder Ridge Savannah	60.0
Female	1039	5 August	73	Boulder Ridge	81.0
	1635	7 August	75	Boulder Ridge	64.0
	1003	12 August	80	Boulder Ridge Savannah	20.0
	1325	15 August	83	Boulder Ridge	57.0
	1035	18 August	86	Boulder Ridge	87.5
B-14	0848	29 July	60	Boulder Ridge	76.0
Female	0807	5 August	67	Boulder Ridge	71.0
	1455	7 August	69	Boulder Ridge	80.0
	0830	12 Sugust	74	Boulder Ridge	65.6
C-3	0940	31 July	61	Hilly Stony	81.5
Female	1822	5 August	66	Hardland	75.5
	0950	7 August	68	Hilly Stony	54.5
	0830	11 August	72	Hilly Stony	78.0
	1604	12 August	73	Hilly Stony	88.0
	1600	14 August	75	Hilly Stony	73.5
C-4	0840	2 August	63	Hilly Stony	81.5
Female	1715	6 August	67	Hilly Stony	74.0
	1444	10 August	71	Hilly Stony Savannah	32.0

Table 2. (Continued)

Fawn Number and Sex	Time of Sample	Date of Sample	Fawn Age at Sample Time (Days)	Range Site	% Range Condition
	1750	12 August	73	Hilly Stony	87.5
	1100	14 August	75	Hilly Stony Savannah	79.5
	0847	15 August	76	Hilly Stony Savannah	54.5
C-8	1100	30 June	29	Hilly Stony	72.5
Female	1800	22 July	51	Hilly Stony	62.0
	0755	7 August	67	Hilly Stony	76.0
	1003	11 August	71	Hilly Stony	72.5
	1443	12 August	72	Hilly Stony Savannah	20.5
	1240	18 August	78	Hardland	76.5

Table 3. Average percent composition of the more common species on five range sites in the Wichita Mountains, Oklahoma, 1975.

Species	Hardland	Boulder Ridge	Boulder Ridge Savannah	Hilly Stony	Hilly Stony Savannah
	Percent (%) Composition by Range Site				
Grasses and grass-likes:					
Andropogon gerardi	14.0	22.1	0.8	33.4	19.3
Bouteloua curtipendula	0.75	4.1	0.8	1.8	0.5
Boulteloua gracilis	1.3	2.1		1.4	2.0
Bouteloua hirsuta	1.5	1.6	0.8	0.4	
Bothriochloa saccharoides	4.8			0.1	
Buchloe dactyloides	0.5	0.1			0.1
Carex sp.	2.5	0.7	3.0	0.9	9.4
Cyperus sp.	4.5	0.1		0.3	0.4
Elymus canadensis		0.1		0.7	2.3
Eleocharis sp.	0.5	4.7		9.6	2.0
Leptoloma cognatum	1.0	3.4		1.4	0.3
Panicum oligosanthes var. *scribnerianum*	5.8	7.9		2.1	1.8
Panicum virgatum	2.0	10.4		10.5	0.1
Schizachyrium scoparium	17.0	15.7	14.5	14.9	14.5
Sorghastrum nutans	5.8	6.1		2.8	2.6
Sporobolus asper	19.3	5.6	14.0	5.1	1.3
Sporobolus cryptandrus		0.1	15.6	0.2	
Tridens flavens		1.1		0.1	2.0

Table 3. (Continued)

	Percent (%) Composition by Range Site				
Species	Hardland	Boulder Ridge	Boulder Ridge Savannah	Hilly Stony	Hilly Stony Savannah
Forbs:					
<u>Achillea</u> sp.	1.3	1.1		0.3	
<u>Ambrosia psilsostachya</u>	7.8	4.4	0.5	6.4	5.4
<u>Artimisia ludoviciana</u>	1.5	0.1	1.5	0.2	
<u>Aster erocoides</u>	3.5	0.4		1.0	0.3
<u>Erigeron canadensis</u>		0.7	0.8	0.1	0.3
<u>Gutierrezia dracunculoides</u>				0.1	0.1
<u>Oxalis stricta</u>	0.3	0.3		0.6	0.4
<u>Psoralea tenuiflora</u>	0.8			0.5	0.1
<u>Solidago</u> sp.		0.1	2.3	0.2	
<u>Veronia baldwinii</u>	0.3	0.1		0.3	0.1
Woody Vegetation:					
<u>Acer saccharum</u>					5.9
<u>Celtis</u> sp.				0.1	0.6
<u>Juglans nigra</u>				0.1	3.4
<u>Juniperus virginianus</u>		0.3	1.3	0.1	0.6
<u>Parthenocissus quinquefolia</u>			0.1	0.3	0.7
<u>Quercus marilandica</u>			1.3		1.1
<u>Quercus stellata</u>		0.2	3.0		1.6
<u>Rhus aromatica</u>			29.5		
<u>Rhus radicans</u>				0.5	7.8

Table 3. (Continued)

	Percent (%) Composition by Range Site				
Species	Hardland	Boulder Ridge	Boulder Ridge Savannah	Hilly Stony	Hilly Stony Savannah
Rubus sp.				0.2	3.3
Symphoricarpos orbiculatus		0.3		0.2	
Ulmus americana				0.4	1.4
Yucca glauca		0.5			

Table 4. Utilization of range sites as fawn bedsites in relation to their availability on the study area.

Range Site	Percent Occurrence Range Site Available on Study Area	Proportion of 295 Locations of Nonmoving Fawns Within Each Range Site (percent occurrence)
Loamy Bottomland	3.50	0.00
Loamy Prairie	6.26	2.71
Slickspots	0.38	0.00
Hardland	6.85	5.76
Hilly Stony	29.62	36.95
Hilly Stony Savannah	19.85	21.02
Boulder Ridge	25.28	22.37
Boulder Ridge Savannah	8.26	11.19

Table 5. Observed significance levels from analysis of variance of species/group difference between bedsites and range sites.

	Observed Significance Level for Analysis of Variance	
Species/Group	Species/Group Between Bedsite[1]	Species/Group Between Range Site[2]
Western ragweed	0.0001	0.3989
Big bluestem	0.0001	0.0160
Heath aster	0.0744	0.0125
Sideoats grama	0.0018	0.0578
Sedges	0.0001	0.2125
Spike rushes	0.0002	0.2744
Fall witchgrass	0.0969	0.1304
Scribner's panicum	0.0001	0.0134
Switchgrass	0.0001	0.0786
Little bluestem	0.0003	0.9966
Indiangrass	0.0830	0.9966
Tall dropseed	0.0121	0.0053
Tall group	0.0001	0.0061
Short group	0.0001	0.5539
Forbs group	0.0002	0.2107
All 12 group	0.0001	0.0001

[1]n = 28

[2]n = 5

Table 6. Species/group mean percent composition for each range site, Wichita Mountains, 1976.

Species/Group	Least Significant Difference[2]	Hardland	Boulder Ridge	Boulder Ridge Savannah	Hilly Stony	Hilly Stony Savannah
Western ragweed		7.74	4.38	0.50	6.42	5.37
Big bluestem	15.14	14.00ab[3]	22.13	0.75a	33.38c	19.25bc
Heath aster[1]	1.25	3.50	1.44b	0.00a	1.04ab	0.25ab
Sideoats grama[1]	2.63	0.75a	4.13b	0.75a	1.75ab	0.50a
Sedges		2.50	0.69	3.00	0.88	9.38
Spike rushes		0.50	4.69	0.00	9.63	2.00
Fall witchgrass		1.00	3.44	0.00	1.42	0.25
Scribner's panicum[1]	4.44	5.75bc	7.88c	0.00a	2.13ab	1.75ab
Switchgrass[1]	9.15	2.00ab	10.38b	0.00a	10.50b	0.13a
Little bluestem		17.00	15.69	14.50	14.88	14.50
Indiangrass[1]	2.58	5.75c	6.13c	0.00a	2.75b	2.63b
Tall dropseed[1]	6.45	19.25b	5.56a	14.00a	5.13a	1.25a
Tall[1]	17.70	58.00b	59.88b	29.25a	66.63b	37.73a
Short		10.50	20.81	3.75	15.79	13.88
Forbs		11.25	5.81	0.50	7.46	5.63
All 12[1]	12.36	79.75	86.50c	33.50a	89.88	57.25b

[1]Species/group mean judged significantly different (0.10) by analysis of variance.

[2] = 0.05

[3]Means in each row followed by the same letter are not different at the 0.05 level of significance.

Table 7. Composition (%) of three major plant forms for each range site as determined from the average percent composition of the more common species, Wichita Mountains, 1975.

Major Plant Form	Hardland	Boulder Ridge	Boulder Ridge Savannah	Hilly Stony	Stony Hilly Savannah
Grasses and Grass-likes	81.3	85.9	49.5	85.7	58.6
Forbs	15.5	7.2	5.1	9.7	6.7
Woody Vegetation	0.0	1.3	35.2	1.9	26.4

CHAPTER VI

PHYSICAL FACTORS ASSOCIATED WITH DAYTIME BEDSITES OF WHITE-TAILED DEER FAWNS

Highlight

Physical factors associated with daytime fawn bedsites are described. Fawns used bedsites having cooler bed temperatures than the surrounding environment. Northeast and southeast aspects were cooler, steeper, and more rocky than their counterparts. Fawns also bedded on steeper slopes after a heavy rainfall had occurred in the previous 24-hr period.

Introduction

Fawn-rearing habitat of white-tailed deer (*Odocoileus virginianus*) has recently been the subject of two research efforts. Kjos and Montgomery (1960) reported on the relationship of several physical factors associated with daytime bedsites in Illinois. Garner et al. (1976b) described percent composition of vegetation surrounding daytime bedsites of fawns in Oklahoma. The present paper is a further analysis of the Oklahoma bedsite data and is concerned with describing the physical factors associated with daytime fawn bedsites. Statistical analyses are used to examine these physical factors for interrelationships that might prove useful in future deer habitat management planning.

Study Area and Methods

The study area is located in the Wichita Mountains, Comanche County, Oklahoma. It has been described by Buck (1964), Crockett (1964), and Garner et al. (1976a). Daytime fawn bedsites were located, then two 20-m intersecting lines were established through each bedsite as described by Garner et al. (1976b). A sharpened surveyor's pin was lowered to ground level at 2-dm intervals along each line (200 total points per bedsite) and the major ground feature at each point of contact was recorded as to rock, litter, bare ground, or basal vegetation.

Physical factors recorded at each bedsite included ambient air temperature, ground-level temperatures in the bed and in the open (direct sunlight) near the bed, and soil temperatures at 2-cm and 4-cm depths in the bed. A five minute delay was necessary before these temperature readings were recorded to allow for dissipation of any fawn body heat that may have been transferred to the bed. Weather conditions recorded at the time the fawn was flushed from the bedsite included percent cloud cover (ocular estimate to nearest 10 percent), wind direction, wind speed, and amount of precipitation in the previous 24 hours. Percent slope (up slope line) for each bedsite was measured with an Abney level, and the slope aspect was also recorded. The absence or presence of overhead woody cover at each bedsite was noted, and the distances and directions to the nearest woody plant and nearest woody clump larger than 0.1 hectare were measured. Major species of overhead woody cover, nearest woody plant, and nearest woody clump were also recorded. Woody clump size was calculated by locating the woody clump on aerial photographs and using a compensating polar planimeter to measure the clump area.

Statistical analyses for interrelationships among selected physical factors used the maximum R^2 Improvement Technique (Service, 1972) of the stepwise regression procedure (Draper and Smith, 1966). The following 23 physical factors were examined in the analyses: air temperature, bed temperature, 2-cm depth soil temperature, 4-cm depth soil temperature, time, $time^2$, time + $time^2$, slope, aspect, precipitation, percent cloud cover, wind direction, wind speed, direction to the nearest woody plant, distance to the nearest woody plant, direction to the nearest woody clump, distance to the nearest woody clump, woody-clump size, percent litter, percent rock, percent bare ground, percent vegetation, and moisture-efficiency index (MEI). The MEI (Powell, 1968) for each bedsite was calculated by using the appropriate formula from the following set of three formulas:

If aspect $\leq 135^o$, then;

$$MEI = \text{sine} \left[\frac{135\text{-aspect}}{57.3} + 1\right] \text{ X slope}$$

If aspect $> 135^o$ and $\leq 315^o$, then;

$$MEI = -1 \text{ X sine} \left[\frac{(\text{aspect}-135)}{57.3} + 1\right] \text{ X slope}$$

If aspect $\leq 360^o$ and $> 315^o$, then;

$$MEI = \text{sine} \left[\frac{\text{aspect}-315}{57.3} + 1\right] \text{ X slope}$$

Linear correlation (Pearson's product-moment correlation) analysis (Steel and Torrie, 1960) and Spearman rank-correlation analysis (Conover, 1971) were used to determine significant relationships between the 23 variables. Statistical analyses used the corresponding statistical analysis systems computer program (SAS) described by Service (1972).

Results and Discussion

Twenty-eight daytime bedsites located on five range sites (Garner et al., 1976b) were sampled between 30 June and 18 August, 1975. Average values for 21 variables on each range site are presented in Table 1. Fawns selected bedsites that averaged 5.4° C and 1.6° C lower than the corresponding open air and ambient air temperatures. Correlation analysis verified the relationship between open-air temperatures and bed temperatures (correlation coefficient (c.c.) = 0.67, observed significant level ($\hat{\alpha}$) = 0.0002). Kjos and Montgomery (1969) also noted this selection for cooler bedsites. Overhead woody cover occurred at six bedsites (21.4 percent), which is lower than the overhead-woody-cover incidence of 58.9 percent on fawn bedsites in Illinois (Kjos and Montgomery, 1969).

Stepwise regression analysis with bed temperature (B) as the dependent variable produced the following highly significant (R^2 = 0.65, $\hat{\alpha}$ = 0.0001) regression equation:

$$B = 1.4637 + 0.4044\ AT + 0.0135A + 0.5183\ S2$$

Air temperature (AT), aspect (A), and 2-cm soil temperature (S2) are the independent variables in the equation. Linear correlation coefficients for bed temperature and the three independent variables were 0.60 (AT, $\hat{\alpha}$ = 0.0001), 0.43 (AS, $\hat{\alpha}$ = 0.0222), and 0.50 (S2, $\hat{\alpha}$ = 0.0007). The air temperature and 2-cm soil temperature correlations with bed temperature were as expected, whereas the correlation between aspect and bed temperature suggested that as bed temperature increases there is a corresponding tendency for the aspect to rotate in a clockwise fashion from a northeasterly direction to a northwesterly direction. Bedsites on northeasterly and southeasterly aspects would therefore tend to be cooler than bedsites on southwesterly and northwesterly aspects.

With aspect (A) as the dependent variable, stepwise regression produced the following highly significant ($R^2 = 0.82$, $\hat{\alpha} = 0.0001$) regression equation:

$$A = -383.9710 + 0.6595\ DNC + 7.8141\ B + 0.6948\ WD + 1.9373\ L + 4.4379\ WS + 19.6442\ P$$

Independent variables are distance to nearest woody clump (DNC), bedsite temperature (B), wind direction (WD), litter (L), wind speed (WS), and precipitation (P). Linear correlation of aspect and distance to the nearest woody clump indicated a significant correlation (c.c. = 0.54 $\hat{\alpha}$ = 0.0036) which is the same type of relationship as described earlier for bed temperature and aspect. The remaining variables in the model (WD, L, WS, and P) did not demonstrate significant correlations (Pearson's product-moment correlation or Spearman's rho). Aspect was negatively correlated with percent slope and percent rock (c.c. = -0.43, $\hat{\alpha}$ = 0.0218; and c.c. = -0.41, $\hat{\alpha}$ = 0.0267 respectively) which indicates that sample bedsites occurred on steeper, more rocky slopes having northeasterly to southeasterly aspects.

Air temperatures (AT) and percent rock (R) were the only significant independent variables in the stepwise regression, with slope (SL) as the dependent variable. The regression equation ($R^2 = 0.76$, $\hat{\alpha}$ = 0.0001) is as follows:

$$SL = 1.88 + 0.2419\ R + 0.1348\ AT$$

Percent rock increased with increasing slope (c.c. = 0.84, $\hat{\alpha}$ = 0.0001), while percent litter (c.c. = 0.46, $\hat{\alpha}$ = 0.0122), percent vegetation (c. c. = 0.37, $\hat{\alpha}$ = 0.0485), distance to nearest woody clump (c.c. = -0.4415, $\hat{\alpha}$ = 0.0177), distance to nearest woody plant (c.c. = -0.40, $\hat{\alpha}$ = 0.0336), and aspect (as previously described) decreased with increasing slope. Spearman's rho for precipitation and slope (rho = 0.36, $\hat{\alpha}$ = 0.0537) indicated that a nonlinear positive relationship also exists, which suggests that fawns may select bedsites on steeper slopes when heavy rainfall occurs in the previous 24 hours.

Stepwise regression analysis with MEI as the independent variable produced the following regression equation (R^2 = 0.70, $\hat{\alpha}$ = 0.0001):

$$\text{MEI} = -1.9382 + 1.5917\ \text{SL} + 0.0804\ \text{WPD} - 1.2174\ \text{WS} - 0.0737\ \text{WD} + 2.7215\ \text{P}$$

Percent slope and woody plant direction (WPD) had positively linear correlation with MEI (c.c. = 0.42, $\hat{\alpha}$ = 0.0258; and c.c. = 0.42, $\hat{\alpha}$ = 0.0262 respectively), whereas Spearman's rho revealed a positive non-linear relationship between MEI and precipitation (rho = 0.40, $\hat{\alpha}$ = 0.0320) and negative nonlinear relationships between MEI and percent bare ground (rho = 0.44, $\hat{\alpha}$ = 0.0173). The relationship between slope and MEI was expected due to inclusion of slope in the calculation of MEI. Reasons for the woody-plant direction and precipitation relationships to MEI are not clear. MEI and percent bare-ground correlations suggest that the southerly aspects (136°-315°), which have negative MEI values, have a higher percentage of bare ground than northeast and northwest aspects.

Soil temperatures at 2-cm depth increased as percent of bare ground increased (c.c. = 0.53, $\hat{\alpha}$ = 0.0041). Soil temperature at 2-cm depth decreased as percent litter increased (c.c. = -0.50, $\hat{\alpha}$ = 0.0065). The same relationships of percent bare ground and percent litter to 4-cm depth soil temperatures were also evident but they occurred at slightly lower significance levels. These correlations verify expected ecological relationship between soil temperature and ground cover.

These data suggest that fawns select daytime bedsites that are cooler than prevailing ambient and open ground-level temperatures. Cooler bedsites were located on northeasterly and southeasterly aspects in the Wichita Mountains; these aspects are steeper and rockier than their counterparts. Fawns also displayed a tendency to select steeper slopes for bedsites when heavy rainfall had occurred during the preceding 24-hour period.

Fawn preferences for certain levels of physical factors associated with daytime fawn bedsites indicate that habitat management planning in the Wichita Mountains should include consideration of the effects of habitat management practice upon those physical factors. For example, a prescribed burning program which included all northeast and southeast aspects might produce low-quality fawn-rearing habitat. The plan might be modified to retain these slopes for use as bedsites by fawns during the fawn-rearing period. These suggestions are tentative and will require verification by further research efforts on fawn-rearing habitat and management.

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Table 1. Means and coefficients of variation (%) for 21 physical factors associated with daytime fawn bedsites located on five range sites in the Wichita Mountains, Oklahoma, 1975.

	Mean Value and % Coefficient of Variation (c.v.) of each Variable by Range Site									
	Boulder Ridge (8)[1]		Boulder Ridge Savannah (2)		Hardland Hilly		Stony		Hilly Stony	Savannah (4)
Variable	x	%c.v.	x	%c.v.	x	%c.v.	x	%c.v.	x	%c.v.
% Cloud Cover	12.0	182.9	0.5	141.4	0.5	141.4	27.5	116.4	53.3	57.8
Wind Direction (°)	199.6	29.2	202.5	15.7	202.5	15.7	170.7	41.9	202.5	22.2
Wind Speed (Km/hr)	6.8	53.6	9.0	62.9	3.0	94.3	11.2	53.4	9.7	98.2
Precipitation (cm)	0.8	282.8	0.0	0.0	0.0	0.0	0.0	0.0	0.5	115.5
Slope (%)	6.3	31.7	9.5	22.3	5.0	56.5	8.8	37.8	13.5	50.1
Aspect (°)	223.6	41.6	175.0	28.3	338.5	7.7	189.3	53.8	143.3	84.3
Air Temperature (°C)	32.8	20.1	36.0	27.5	40.0	24.7	30.7	14.2	36.0	26.4
Bed-Temperature (°C)	27.4	14.1	27.5	7.7	35.0	32.3	27.2	14.6	26.2	16.0
2 cm Soil Temp (°C)	26.0	8.7	24.5	2.9	24.5	8.7	25.1	9.7	24.2	5.2
4 cm Soil Temp (°C)	24.8	8.8	22.0	0.0	23.5	9.0	23.5	11.5	22.5	9.3
MEI	0.7	1553.4	-13.8	19.3	6.3	29.2	- 2.1	795.4	15.0	98.0

Table 1. (Continued)

Variable	Boulder Ridge (8)[1] x	%c.v.	Boulder Ridge Savannah (2) x	%c.v.	Hardland x	%c.v.	Hilly Stony x	%c.v.	Hilly Stony Savannah (4) x	%c.v.
	Mean Value and % Coefficient of Variation (c.v.) of each Variable by Range Site									
Woody Plant Direction (°)	180.5	41.8	27.5	12.9	170.0	5.8	169.7	59.7	192.75	56.8
Woody Plant Distance (m)	8.2	144.6	0.2	47.1	14.3	138.4	8.2	95.4	1.2	91.1
Woody Clump Direction (°)	112.9	91.9	0.0	0.0	154.5	44.4	150.8	71.4	0.0	0.0
Clump Size (ha)	102.3	102.1	200.0	0.0	5.4	1.3	2.5	86.1	5.6	68.0
Litter (%)	69.8	36.1	72.0	4.9	83.0	17.0	77.3	17.8	66.4	26.2
Rock (%)	0.1	282.8	9.5	52.1	0.3	141.4	10.0	143.5	27.3	70.4
Bare Ground (%)	24.9	98.5	14.8	50.3	11.3	110.0	8.9	73.8	3.0	70.7

Table 1. (Continued)

	Mean Value and % Coefficient of Variation (c.v.) of each Variable by Range Site									
	Boulder Ridge (8)[1]		Boulder Ridge Savannah (2)		Hardland		Hilly Stony		Hilly Stony Savannah (4)	
Variable	x	%c.v.	x	%c.v.	x	%c.v.	x	%c.v.	x	%c.v.
Vegetation (%)	5.2	38.2	3.8	28.3	5.5	25.7	3.8	48.1	3.4	32.9
Time	1121.8	28.0	969.0	5.0	1531.0	26.9	1258.8	31.9	1208.5	24.0

[1]Sample size.

CHAPTER VII

GROUND COVER CHARACTERISTICS OF DAYTIME BEDSITES OF WHITE-TAILED DEER FAWNS

Highlights

Daytime fawn bedsites were found to have surrounding herbaceous vegetation that is fairly stable in average height. This vegetation provides concealment for predators that may pass nearby. When large boulders or trees surround a bedsite, they offset to a certain degree the loss of more dense herbaceous vegetation and these bedsites have a level of concealment that is comparable to bedsites in more open terrain.

Introduction

Garner et al. (1976b and 1976c) have recently described and analyzed vegetational species composition and physical factors associated with daytime bedsites for white-tailed deer (*Odocoileus virginianus*) fawns in Oklahoma. The current paper is a description and analysis of the ground cover characteristics associated with those bedsites and is intended to complete the description of bedsite attributes indicated by the previous two papers. Because reported high fawn mortality rates in the Wichita Mountains are attributed to predation (Garner et al. 1976a), ground cover characteristics of bedsites are believed to be important in general fawn ecology and survival.

Study Area and Methods

Buck (1964), Crockett (1964), and Garner et al. (1976a) have described the study area, which is located in the Wichita Mountains, Comanche County, Oklahoma. Two 20-m intersecting lines were established through each bedsite as described by Garner et al. (1975b). Percentages of bare ground, rock, litter, and vegetation were determined by lowering a sharpened surveyor's pin to ground level at 2-dm intervals along each line (200 total points per bedsite). At 1-m intervals along each line, the height and species of the tallest plant within 10 cm of the line were recorded (40 heights per bedsite). Four sets of density-pole readings (Robel et al., 1970) were taken along four directions at each bedsite; the two intersecting lines determining the directions (up slope, down slope, right slope and left slope). Each set of density-pole readings consisted of the visual obstruction on the density pole (in 0.5-dm intervals) at 1-m and 0.5-m heights at 2-m and 4-m distances from the bedsite (total of 16 readings per bedsite). The length and width of each bedsite was measured and the ground litter was collected. Standing litter and standing live vegetation were clipped at ground level and collected. Litter, standing litter, and standing vegetation were oven dried at 90° C until a constant weight was obtained.

Data were analyzed with the statistical analysis system (SAS) computer programs (Service, 1972) for stepwise regression (Draper and Smith, 1966), one-way analysis of variance, and correlation analysis (Steel and Torrie, 1960). Least significant differences (LSD) were used to locate a significant differences detected in the analysis of variance.

Results and Discussion

Twenty-eight daytime bedsites were sampled between 30 June and 18 August 1975. These bedsites were located on five range sites (Garner et al., 1976b). Average ground-cover values for each range site are presented in Table 1. Means for rock percentage were lower on hardland and boulder ridge range sites than on the other three range sites. Means for the remaining ground-cover variables were similar among range sites. Interrelationship between these ground cover variables to physical factors of bedsite has previously been reported by Garner et al. (1976b).

Analysis of variance detected significant differences between height means (Table 2) on range sites when tree heights were included in the analysis (observed significance level ($\hat{\alpha}$) = 0.0004). When tree heights were excluded from the data, analysis of variance revealed no significant difference among height means for the range sites (Table 2). Plant species that occurred on a majority of the bedsites were subjected to a similar analysis to determine if these species had different mean heights on different range sites. Western ragweed (*Ambrosia psilostachya*), big bluestem (*Andropogon gerardi*), switchgrass (*Panicum virgatum*), and Indiangrass (*Sorghastrum nutans*) did not differ in height means among range sites, while little bluestem (*Schizachyrium scoparium*) and tall dropseed (*Sporobolus asper*) did differ (Table 3) among range sites ($\hat{\alpha}$ = 0.05 and $\hat{\alpha}$ = 0.025 respectively).

Oven dry weights of ground litter, standing vegetation, standing litter plus vegetation, and total vegetation plus litter per square meter varied significantly among range sites (Table 4). Highest ground-litter means occurred on hardland and boulder ridge range sites, whereas the two savannahs had the lowest means for standing litter and vegetation.

Density-pole data were intended for use as described by Robel et al. (1970), but regressions and correlations of these data did not agree closely with results of the Kansas study. Stepwise regression (without visual obstruction readings due to boulders) indicated that the average density-pole reading at 2-m distance and 0.5-meter height (A20.5) was the only significant density-pole variable useful in constructing the following regression equations in which standing vegetation per square meter (SVM^2) and standing vegetation plus litter per square meter ($SVLM^2$) were the dependent variables;

$$SVM^2 = 36.75 + 2.2904 \text{ A20.5}$$

$$(R^2 = 0.0469, \hat{\alpha} = 0.0001)$$

$$SVLM^2 = 40.63 + 2.4429 \text{ A20.5}$$

$$(R^2 = 0.49904, \hat{\alpha} = 0.0001)$$

Corresponding correlation coefficients (c.c.) of A20.5 with standing vegetation/m^2 (c.c. = 0.70, $\hat{\alpha}$ = 0.0001) and standing litter plus vegetation (c.c. = 0.70, $\hat{\alpha}$ = 0.0001) also support these relationships. Correlation of height data with the four density-pole means indicated that the two density-pole readings at the 4-m distance (1-m and 0.5-m heights were more strongly related to the height average (c.c. = 0.7121, $\hat{\alpha}$ = 0.0001 and c.c. = 0.7197, $\hat{\alpha}$ = 0.0001 respectively) than were the two density-pole readings at the 2-m distance (1-m and 0.5-m heights) which had c.c. = 0.6767 ($\hat{\alpha}$ = 0.0002) and c.c. = 0.6617 ($\hat{\alpha}$ = 0.0003) respectively. In contrast to these results, Robel et al., (1970) found that the 4-meter distance, 1-meter height reading was the best prediction variable for weights in Kansas grasslands. Only one plot (bed) was clipped at each bedsite in the Wichita Mountains study, whereas in the Kansas study 10 plots were clipped at each sample location. Therefore, the calculated weight per m^2 at the Wichita Mountains may be biased due to small sample size. In the Kansas study, plots were clipped at 0.5-dm heights, whereas in the Wichita Mountains study beds were clipped at ground level.

A more meaningful use for the density-pole data at the Wichita Mountains may be for measurement of fawn concealment. When all density-pole readings (including obstruction due to boulders and tree trunks) were used in an analysis of variance, no significant variations in mean values (for readings at 1-m and 0.5-m heights at 4-m and 2-m distances) were detected (Table 5). These data imply that fawns select bedsites that supply a relatively uniform level of concealment, which may be useful in avoiding detection by nearby predators.

The results of the study indicate that heights of herbaceous vegetation surrounding daytime fawn bedsites are similar, even when bedsites are located in different range sites. Fawn concealment afforded by vegetation, boulders and trees is also fairly stable among the five range sites. There is a need for continued research on fawn bedsites and other aspects of fawn-rearing habitat in the Wichita Mountains. High fawn-mortality rates (due primarily to predation) may in part be attributable to some deficiency in the available habitat which predisposes fawns to predation.

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Table 1. Average ground cover characteristics (%) for fawn bedsites on each range site at the Wichita Mountains, 1975.

	Range Sites									
Ground Cover	Boulder Ridge (8)[1]		Boulder Ridge Savannah (2)[1]		Hardland (2)[1]		Hilly Stony (12)[1]		Hilly Stony Savannah (4)[1]	
Characteristics	$\bar{x}$	sd[2]	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Litter	67.75	25.18	72.00	3.54	83.00	14.14	77.29	13.75	66.38	17.40
Rock	0.13	0.35	9.50	4.95	0.25	0.35	10.08	14.47	27.25	19.17
Bare Ground	24.94	24.57	14.75	7.42	11.25	12.37	8.88	6.55	3.00	2.12
Vegetation	5.19	1.98	3.75	1.06	5.5	11.31	3.75	1.80	3.38	1.11

[1]sample size

[2]standard deviation

Table 2. Mean plant heights (dm) at bedsites on each range site, Wichita Mountains, 1975.

Range Site	Sample Size	Height Means (all species included)	Height Means (tree height excluded)
Boulder Ridge	8	12.20 a[1]	10.25
Boulder Ridge Savannah	2	24.82 c	7.60
Hardland	2	8.89 a	8.89
Hilly Stony	12	9.27 a	8.96
Hilly Stony Savannah	4	37.86 b	8.73

[1]Means followed by the same letter do not significantly differ at the 0.05 level of significance level using LSD.

Table 3. Mean heights (dm) of selected plant species at bedsites on each range site, Wichita Mountains, 1975.

Range Site	Little Bluestem	Tall Dropseed
Boulder Ridge	10.15 b[1]	9.50 d
Boulder Ridge Savannah	7.81 a	4.00 b
Hardland	9.22 ab	5.71 bc
Hilly Stony	8.04 a	6.33
Hilly Stony Savannah	7.88 a	0.00

[1]Means followed by the same letter do not significantly differ at the 0.05 level of significance using LSD.

Table 4. Mean weights (g/m^2) of litter and vegetation components of bedsites on five range sites at the Wichita Mountains, 1975.

Range Site	Ground Litter[1] (g/m^2)	Standing Litter (g/m^2)	Standing[1] Vegetation (g/m^2)	Standing Litter[1] and Vegetation (g/m^2)	Total Litter[1] plus Vegetation (g/m^2)
Boulder Ridge	195.26a[2]	6.79	150.31bc	157.10bc	352.35a
Boulder Ridge Savannah	548.57b	0.00	17.14a	17.14a	565.71a
Hardland	658.84b	22.56	224.20c	246.76c	905.60b
Hilly Stony	256.99a	20.00	212.82b	232.82c	489.82a
Hilly Stony Savannah	285.08a	2.71	103.90ab	106.90ab	391.68a

[1]Significance level ( ) for analysis of variance: ground litter = 0.0191, standing vegetation = 0.0590, standing litter plus vegetation = 0.0354, total litter and vegetation = 0.0650.

[2]Means followed by the same letter do not differ significantly at the 0.05 level of significance in analysis by LSD.

Table 5. Mean density pole readings at bedsite on five range sites in the Wichita Mountains, 1975.

Range Site	4-m distance 1-m height (dm)	4-m distance 0.5-m height (dm)	2-m distance 1-m height (dm)	2-m distance 0.5-m height (dm)
Boulder Ridge	5.57	9.58	3.67	6.22
Boulder Ridge Savannah	1.63	4.06	0.13	1.50
Hardland	6.25	7.94	4.94	7.25
Hilly Stony	5.95	9.82	4.14	69.27
Hilly Stony Savannah	7.22	8.69	4.75	5.69

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