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STUDY OF WHITE-TAILED DEER FAWN MORTALITY ON COOKSON HILLS DEER REFUGE EASTERN OKLAHOMA[1]

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Thirty-three white-tailed deer (*Odocoileus virginianus*) fawns 5 to 27 days of age were captured in 1970 through 1972. Movements were monitored during June and July to determine their survival and causes of mortality. Three hundred and thirty-one radio locations were plotted for the 22 fawns monitored. Mortality rates in 1970, 1971 and 1972 were 18, 64 and 45 percent respectively. Eighty-three percent of fawn mortality occurred during the first month of age. Blood loss and gross infection resulting from the feeding of lone star ticks (*Amblyomma americanum*) were associated with the causes of 71 percent of fawn mortality where causes were determined. The decrease in fawn mortality in 1972 followed high mast production in the Fall of 1971. Corresponding to this decreased mortality was an increase in production of both total fawns and twin fawns in 1972 as compared to 1971. Significant correlations were determined between general health of fawns, magnitude of movements, tick loads and survival. Mean tick loads at capture were 57.9 adult ticks for surviving fawns compared to 119.8 for those that died. Fawns that died exhibited more sedentary movements several days prior to death. Area of activity of surviving fawns was 5.5 acres while area of those dying averaged 1.7 acres.

INTRODUCTION

Low productivity and high postnatal fawn mortality has been acknowledged by most big game managers as natural population regulating mechanisms. Studies have repeatedly demonstrated that these factors are responses of populations that are in excess of the carrying capacity of their habitat and they often preclude drastic herd reductions (Allen 1968, Cheatum and Severinghaus 1950, Dahlberg and Guettinger 1956, Dechert 1967, Goodrum 1962, Lewis and Safley 1966, Marbuger and Thomas 1965, Severinghaus 1951, Severinghaus and

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Cheatum 1956, Steel 1969, Taylor and Hahn 1947, Teer *et al.* 1965). Some of these studies measured only gross productivity, but others compared gross productivity in the fall with potential productivity, determined from ovary examinations during the previous winter, and found that either intrauterine or postnatal fawn mortality had taken place.

Verme (1962, 1963, 1965, 1967, 1969) further demonstrated that under penned conditions maintenance of a doe's body took precedence over nourishment of her fetus. Does fed low energy rations conceived, but lost 93 percent of their fawns within 48 hr. postpartum. Fawns born of malnourished does were small and emaciated and were stillborn or starved because they were too small or weak to nurse or because of delayed lactation. Intrauterine losses were minimal.

Other factors may be associated with fawn mortality under field conditions. Predation by coyotes and bobcats have been reported as contributing to high fawn mortality in South Texas (Cook *et al.* 1971, Knowlton 1964, and White 1966). Total mortality was reported to be as high as 72 percent with predation associated with 82 percent of the deaths. The authors concluded that the mortality was an important factor which stabilized the densely populated deer herd with its food source. Bolte *et al.* (1970) reported a 57 percent mortality of white-tailed deer fawns in 1969 on the Cookson Hills Refuge in Eastern Oklahoma. They concluded that the cause of death was the result of high infestations of lone star ticks and suggested that other factors such as malnutrition were not involved.

The suggestion that malnutrition did not contribute to the fawn mortality seemed questionable, however. The population was calculated at 1 deer/3.3 acres on the refuge in January of 1969 (Raw data from departmental files) and I observed browse lines and severe hedging of winged elm (*Ulmus alata*), greenbriar (*Smilax bononox*), and wild grape (*Vitis sp.*) during this period.

It was the objective of this study to further investigate the magnitude and causes of fawn mortality and to determine the relationship between fawn mortality and deer population density on the Cookson Hills Refuge in Eastern Oklahoma.

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STUDY AREA

The study area was a portion of the Cookson Hills Refuge located in the mountainous oak-hickory region of east central Oklahoma. The refuge has been owned and managed for white-tailed deer production by the Department since the late 1940's. Controlled buck-only hunts have been held on the refuge since 1965. The highest deer kill for the refuge was in 1971 when archers and gun hunters harvested a total of 82 bucks. Fifty-six American Elk (*Cervus canadensis*) were released on Cookson Refuge during the 2 years following the 1968 hunting season. So, deer hunts were not held on the refuge again until the Fall of 1971 (Curtis 1971). In addition to a dense deer population, Hair (1968), Hair and Howell (1970), and Howell and Hair (1969) have indicated that the Cookson refuge also supports an extremely dense lone star tick population. The refuge has also served as a study area for numerous entomological studies associated with tick ecology.

MATERIALS AND METHODS

Radio transmitters, fashioned after that described by Cochran and Hagen (1963), were constructed for the instrumentation of sample fawns. The power pack consisted of two Mallory Mercury 1.4-volt batteries (2M12T2 or RM12T2) connected in parallel to produce 2.8 volts. The transmitters were potted in Plas-T-Pair (The Rawn Company, Inc., Spooner, Wisconsin). The batteries were taped one on each side of the transmitter, and the contacts were soldered, sealed with liquid tape, and potted in Silicone Rubber (General Electric, Silicone Products Div., Waterford, N. Y.). The transmitting antenna was a 3.8-inch-diam loop made of a .75-inch copper strip. The transmitting unit was constructed as a collar to fit over the fawn's head and hang around its neck. Surgical tubing was taped on the inside of each antenna so that the collar would fit snugly around the neck of any size fawn. The unit weighed approximately 6 oz. Transmitting frequencies were between 26.965 MH^2 and 27.105 MH^2.

A Johnson Messenger III and a Cobra CAM 88 transceiver were used for receiving. Both transceivers were equipped with beat-frequency oscillators.

A hand-held, loop, receiving antenna was used to determine at least two azimuths to an instrumented fawn. Triangulation was used to calculate the location of the fawn, and the location was recorded.

Thirty-three fawns, 11 each summer, were captured by methods described by Bolte *et al.* (1970) or by Downing *et al.* (1969). One of the fawns died during handling and another was near death when captured, so transmitters were attached only to the other 31 fawns.

Each fawn was aged, sexed, weighed and measured. The number of adult and nymphal lone star ticks were counted on the ears, around the eyes, and under the chin. Characteristics of general health and any abnormalities were described. The age of each fawn was determined by hoof characteristics (Haugen and Speake 1958), weight, and size. Each fawn was released at the capture site after being fitted with a transmitter. No doe was seen to reject its fawn. In most instances, fawns were not disturbed when subsequent locations were monitored unless close observation or recapture was necessary.

Each fawn was observed closely at least once each week. If fawns were in extremely poor health, they were observed more often. I attempted to recapture each fawn at least once for remeasurement to determine its growth rate and to determine any changes in tick infestation. Many of the healthy fawns were not recaptured.

Survival of sample fawns was learned by monitoring them until either they died or were known to be in good health and would not die in the near future, barring an accident. Unhealthy fawns that eventually died were sedentary, weak, and emaciated in comparison to healthy fawns that were mobile and became elusive when approached. If the transmitter ceased operating on a fawn before terminal observations were made, the fawn's survival was judged by its general appearance of health, behavior, and tick load.

Records were also made of all fawns observed on the study area during the capture period (Usually the second and third week of June). Based on the criteria established for instrumented fawns, their survival was predicted. These included fawns observed and not captured, captured fawns, and fawns found dead in the field. These data provided a survival index of a larger sample size to compare with data from instrumented fawns.

Area of movement was determined by plotting radio-monitored locations of each fawn on separate maps and drawing connecting lines between the outermost locations. A planimeter was used to circumscribe the area and calculate the total area in acres traveled by each fawn. Occasionally an extraneous location was monitored for a fawn. These showed up as a single location well out of the area of other locations, and were often the result of a fawn attempting to escape close observation or recapture. These locations were not considered normal, and were not included in the calculated acreage of movement. This type of location was observed for only three fawns, and did not exceed more than two locations for either.

Fawn number 1A-72 was located in an area that had to be entered by foot because it was a considerable distance from the nearest road. The fawn often moved from the observer and although the fawn was in poor health, it moved over a greater area than did any healthy fawns. This fawn's movements were not considered normal, and were not included in the calculation of average acreage of movement.

Fawn Number 1A-71 was a healthy fawn killed accidentally by a hay mower. This fawn's movements and measurements were included in the surviving fawn classification.

RESULTS AND DISCUSSION

Annual mortality rates measured for instrumented fawns were 18, 64, and 45 percent for 1970, 1971, and 1972 respectively (Figure 1). Seventy-one percent of the instrumented fawns died of causes associated with heavy infestations of lone star ticks (Table 1). Fourteen percent of deaths were due to accidents and 14 percent to unknown causes (Table 1). One fawn killed accidentally and another dead of an unknown cause had adult tick loads of 98 and 116 ticks respectively. Their heavy tick loads may have contributed to their deaths. Eighty-three percent of the deaths occurred at less than 30 days of age.

Heavy infestations of lone star ticks were probably a major contributing cause of death among young fawns during the study. The sequence of events associated with the feeding of large numbers of ticks was quite dramatic prior to fawn death. The lone star tick, being a parasite that requires a blood meal (Hair and Howell 1970), seeks a feeding site upon contact with its host. Although ticks attach to several areas of fawns' bodies, they usually concentrate about the ears, eyes and under the chin. One fawn was observed with 246 adult and 510 nymphal ticks attached to its head. The tick attaches to the fawn by inserting its mouthparts through the fawn's integument to begin the feeding process. Secondary infection apparently results from bacteria introduced at the site of attachment. The infected area swells and subsequently develops into an open lesion from which mucus and blood are secreted. Necrosis develops in the tissue of the ears and under the chin. The necrotic condition around the eye often results in total erosion of the eye and associated tissue, blinding the eye. Fawns with heavy tick loads often were blinded in both eyes. A totally blind fawn was naturally subject to additional complications. One such fawn, which was instrumented, received a puncture wound in the left hind leg, apparently due to the fawn's inability to recognize obstacles. The wound became grossly infected, further contributing to the fawn's dilemma. Three instrumented fawns experienced paralysis in their legs associated with advanced stages of infection. Instrumented fawns commonly moved to the most densely vegetated location within their area of movement when nearing death.

No fawn was observed during the study that did not support an infestation of ticks. The numbers of adult ticks on instrumented fawns and the survival of the fawns were significantly correlated (31 d.f., P = .05). Adult tick loads for surviving fawns and fawns that died averaged 57.9 ticks and 119.8 ticks respectively (Table 2). Barker (1970, personal communication) artificially infested penned white-tailed fawns with varying numbers of lone star ticks, and found that fawn mortality could be induced if heavy infestations were applied. The two fawns that died were treated with 100 ticks every 3 days and died after one had been treated with 500 ticks and the other 700 ticks. Fawns treated with 40 or less ticks at 3-day intervals survived. Hock and Barker (1971) reported similar findings in another study of penned fawns.

Relationship of Fawn Mortality to Deer Density

Dechert (1967) in Kentucky, Lewis and Safley (1966) in Tennessee, and Steele (1969) in Oklahoma reported decreasing productivity as deer populations exceeded carrying capacity of the range. They measured the lowest productivity during the period of population decline following the population peak.

As indicated in Figure 2, the deer population on the Cookson Refuge peaked in January 1970 at an estimated 4233 deer (1 deer/3.2 acres). The population had declined 62 percent by January 1972 to an estimated 1814 deer (1 deer/7.5 acres). These figures are based on data collected by the Hahn Transect Method (Hahn 1949) and their accuracy is uncertain for this area. The trend which the figures portray, however, should represent the dynamics of the Cookson deer herd. Production data were not collected on the refuge until August 1971 and 1972. Fawn mortality rates are available since 1968. Fawn mortality may be interpreted as an indicator of physical condition or status (Verme 1963) of the deer herd, but it is difficult to determine the affect that fawn mortality has on net productivity without some measure of gross or net production.

Fawn mortality was highest in the summer of 1971, which was the second summer following the peak in the refuge deer population. One would expect, since fawn mortality was increasing in 1968 and 1969, that fawn mortality would be as high or highest in the summer of 1970, which was the summer following the winter of peak deer density. Fawn mortality for the summer of 1970, however, was 18 percent for instrumented fawns. This was the lowest fawn mortality measured during the five-summer period.

The reason for the drastic decrease in fawn mortality in the summer of 1970 can only be speculated, since productivity data are not available. No fawn under 5 days of age was captured, and the mortality period measured by this study does not include fawn mortality that occurred during the period from conception to at least 5 days postpartum. Figure 2 indicates that the Cookson deer population decreased 31 percent from January 1970 to January 1971. Theoretically, if the winter deer density decreased from January 1970 to January 1971 and if fawn mortality for fawns 5 days of age and older was lower in the summer of 1970, the total number of fawns produced to 5 days of age would have been fewer that summer. Verme (1962, 1963) demonstrated, under penned conditions, that does maintained on very low evergy diets displayed reduced ovulation rates and gave birth to fawns that, because of small size and emaciated condition, died within 48 hours postpartum. Stress resulting from competition for food should be greatest during the winter of peak population density and the response could have been mortality of fawns taking place during the period prior to fawn capture. If fawn mortality occurred prior to sampling, only the stronger fawns would be available for sampling, resulting in a lower mortality of instrumented fawns. The end result would be low productivity for the summer of 1970 and low recruitment to the 1970-71 winter population.

The mortality of instrumented fawns in the summer of 1971 was 64 percent. This was the highest mortality measured during the five summers for which data is available. A total of 21 individual fawns were observed on the refuge during the 1971 capture period. A 58 percent mortality was predicted for the observed fawn sample based on measurements, tick load, and behavioral criteria established from instrumented fawns. A doe/fawn survey was initiated in early August 1971 measuring 1 doe/.255 fawn (+.019, P = .05) in the field after the 64 percent mortality had occurred (Logan, unpublished data). Such low net productivity would be considered normal since this was during the period of population decline following the peak. Steele (1969) reported net productivity as low as 1 doe/.07 fawn during periods of population decline in Oklahoma.

A large mast crop occurred in the fall of 1971, but unfortunately, no quantitative measure of mast production was available. Personnel in the area, however, described the mast crop as "the most productive and extensive mast crop that had been observed in that portion of the state in several years."

The January 1972 population was measured at 1814 deer. This represents a 38 percent decline from 2910 deer in the previous January. These figures indicate that the decline occurring between January 1971 and 1972 must have taken place prior to mast production in the fall of 1971. The number of deer that survived as the 1971-72 winter deer population was not influenced by the additional food that was available on the refuge. The response of these deer to the additional food, however, was demonstrated the following summer by increased fawn survival and an increased number of fawns produced.

Mortality for instrumented fawns declined to 45 percent in the summer of 1972. This figure was considered to be biased upward, indicating that actual fawn mortality was lower than indicated by the instrumented sample. Only 28 percent of the attempts to capture fawns were successful this year as compared to 58 percent the previous year. The dates for fawn drop were determined by subtracting the fawn's ages from the dates they were captured. Fawn drop was earlier in 1972 (May 24 to June 6, 1970; May 24 to June 6, 1971; and May 9 to June 3, 1972). As a result, the fawns captured were either very young or older fawns in poor health and already responding to heavy infestations of ticks. This factor would tend to bias upward the mortality for sample fawns. A total of 51 individual fawns were observed on the refuge during the 1972 capture period. Mortality was predicted at 29 percent for these fawns, based on criteria already described.

The number of dead fawns observed, per 100 man hours, other than those instrumented, were 2.19 and .29 dead fawns during 1971 and 1972, respectively. This further substantiates a decrease in fawn mortality for 1972.

An increase in production was indicated by an increase in total fawns observed on the refuge during the 1972 capture period as compared to 1971. The doe/fawn survey for August 1972 yielded 1 doe/.376 fawn (+.057, P = .05) as compared to 1 doe/.255 fawn (+.019, P = .05) in 1971 (Logan, unpublished data).

The Lone Star Tick as a Source of Mortality

Bolte *et al.* (1970) concluded that fawn mortality was induced by heavy infestations of lone star ticks on the Cookson refuge independent of any factors other than the high densities of ticks. A variety of factors which may contribute to fawn mortality have been documented in the literature. Coyotes were reported responsible for fawn mortality on the Welder Refuge in Southeast Texas (Cook *et al.* 1971), internal parasites had a major influence on black-tailed deer mortality in California (Longhurst 1955) and Salmonellosis contributed to fawn mortality in moist river bottom areas of Texas (Robinson *et al.* 1970). Screw worms (*Cochliomyia americana*), stomach worms (*Haemonchus* sp.), ticks, and pneumonic lung infections were reported as causes of white-tailed deer mortality in other regions of Texas (Marbuger and Thomas 1965, Taylor and Hahn 1947, Teer *et al.* 1965) Verme (1962) described fawns born of malnourished does that were physically too small and weak to nurse. In all of the above cases, mortality was associated with competition for food, deteriorating range conditions, and/or malnutrition.

The data discussed thus far presents a typical relationship between deer density and fawn mortality on the Cookson refuge, and suggests that ticks may not be causing mortality independent of other factors.

The fact remains, however, that a significant difference (31 d.f., P = .05) was observed between adult tick loads for surviving fawns (57.90) and fawns that died (119.78) in the field (Table 2). An Analysis of Variance revealed that no significant difference (P = .01) in numbers of adult ticks on fawns (Table 2) existed between years among surviving fawns or between years among fawns that died. Yet, the rate of fawn mortality fluctuated between years. We have interpreted this to mean that factors other than ticks contributed to fawn mortality. This further suggests that an interaction exists between ticks, deer density, range carrying capacity, and the annual rate of fawn mortality on Cookson refuge.

Behavior Patterns of Fawns

The fact that deer density influences fawn survival offers no explanation why an unhealthy fawn born of a malnourished doe would receive a heavier infestation of ticks than a healthy fawn. A significant difference in (20 d.f., P = .01) movement behavior was observed between surviving and dying fawns (Table 2), suggesting that a difference in behavior patterns may influence infestation rates. Acreage of movement for surviving fawns and dying fawns averaged 5.54 acres and 1.69 acres respectively (Maps 1, 2). The unhealthy fawns that eventually died were obviously more sedentary than healthy fawns. Jackson (1972) and Haugen *et al.* (1957) reported that white-tailed fawns were normally sedentary during the first days of life, but by the second week of age activity rates began increasing rapidly, and less time was spent resting.

Wilson (1972) used CO^2 to bait lone star ticks to traps on the Cookson refuge and found that 9.6 percent of marked ticks released within 13.1 yd. of a trap were captured within 72 hr. A few ticks were attracted from as far as 25.5 yd. during the same period. Similar behavior was observed of ticks moving to an instrumented fawn which had been dead only a brief period on June 19, 1972. Ticks that were in close proximity to the fawn were observed crawling en masse from the leaf duff to the fawn's body.

These data suggest that healthy fawns may receive their infestations of ticks by different means than do unhealthy fawns. The unhealthy fawn may receive its tick infestation from ticks attracted to its body during extended sedentary periods as compared to the active fawn which would be exposed more to ticks it brushed against on vegetation. The weak fawn born of an unhealthy doe is obviously affected more adversely by the initial infestation of ticks than is a healthy fawn. Growth rates calculated for 10 instrumented fawns were .52 lb. gained/day by fawns that survived and .06 lb. gained/day by fawns that died (Table 3).

A weak fawn remains sedentary in response to the initial tick load and apparently becomes infested with additional ticks at a greater rate than the healthy fawn. Infestation rates calculated for the 10 instrumented fawns were 1.46 ticks/day for surviving fawns and 2.40 ticks/day for fawns that died (Table 3). The healthy fawn is not affected by the initial tick load as severely as a weak fawn, and becomes increasingly more active with growing strength. It seems reasonable that the difference of movement patterns between healthy and unhealthy fawns may provide a behavioral mechanism that results in greater infestation rates of ticks on the unhealthy fawns. This explanation can only be offered as a hypothesis, however, until more conclusive data are available.

CONCLUSION

The data discussed in this report present a typical correlation between deer density and fawn mortality. In general, fawn mortality increased as deer density increased, and was highest during the period of population decline. Fawn survival increased following an autumn of unusually high mast production, apparently in response to the improved nutritional conditions of the does. Similar situations have been described in many areas of the United States. The lone star tick and its voracious feeding behavior is probably not causing mortality independent of other factors. Additional factors are high population density of deer, increased competition among deer for food, and deterioration of the deer range. The lone star tick is apparently the mechanism directly responsible for losses in the annual fawn crop. The presence of an unusually high tick population in eastern Oklahoma provides an added dimension to deer management in this area. It is apparent, however, that the principle of balancing the deer herd with the carrying capacity of the range still applies. There is strong evidence that productivity of deer has been severely reduced by allowing the herd to exceed carrying capacity. In addition, it seems highly probable that if the herd is reduced to fit within carrying capacity of the range, productivity will respond and a greater percentage of fawns will survive.

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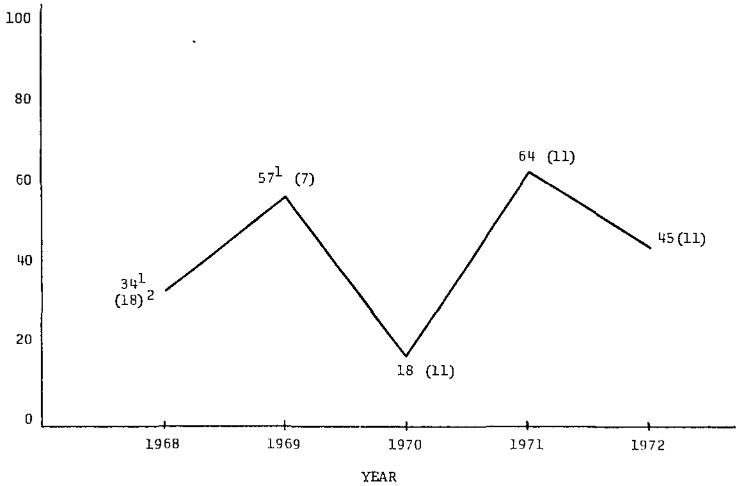


Figure 1. Annual Rate of Mortality of Instrumented Fawns, Cookson Refuge, Eastern Oklahoma, 1968-72.

[1]J. R. Bolte *et al.* 1970.
[2]Sample Size.

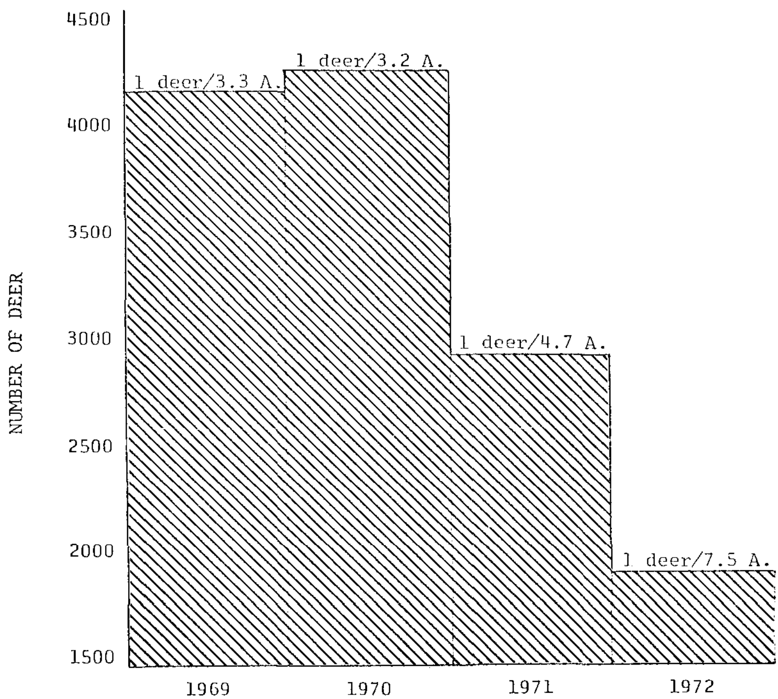


Figure 2. Deer Population Based on Hahn Census Method, Cookson Refuge, Eastern Oklahoma, 1969-72.

Table 1. Sex, Age, and Probable Cause of Mortality of Instrumented Fawns, Cookson Refuge, Eastern Oklahoma, 1970-72.

			Cause of Mortality		
Fawn No.	Age At Death (days)	Sex	Ticks	Accident	Unknown
8A-70	21	F	X		
4A-70	26	F		X[1]	
10A-71	14	M			X
10B-71	18	M	X		
9A-71	27	M	X		
3A-71	35	F	X		
5A-71	26	F	X		
1A-71	25	M		X[2]	
12A-71	Unk	M	X		
4A-72	44	M	X		
3A-72	17	F			X
9A-72	25	M	X		
10A-72	25	M	X		
1A-72	Unk	M	X		
	Under 30 Days 83%	36% F 64% M	71.4%	14.3%	14.3%

[1]Struck by automobile.
[2]Killed by hay mower.

Table 2. Average Movements and Adult Tick Loads of Instrumented Fawns by Year, Cookson Refuge, Eastern Oklahoma, 1970-72.

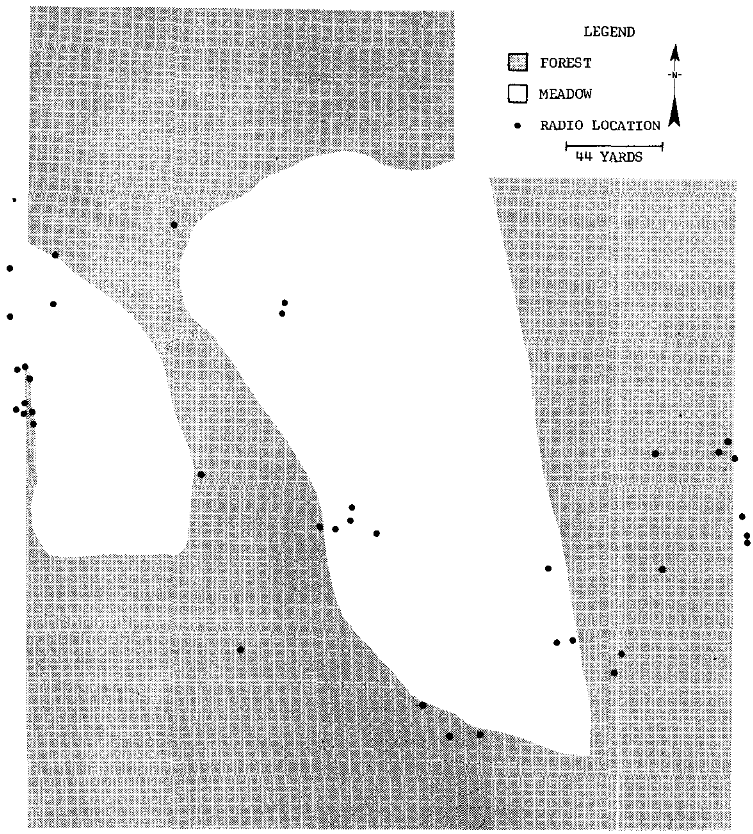
	Average For Surviving Fawns		Average For Dying Fawns	
Year	Tick Load	Movement (Acres)	Tick Load	Movement (Acres)
1970	67 (9)[1]	6.4 (4)	68 (2)	0.9 (2)
1971	40 (5)	7.8 (3)	111 (6)	2.7 (3)
1972	59 (6)	4.9 (6)	151 (5)	1.3 (4)
Ave.	57.90 (20)	5.54 (13)	119.78 (13)	1.69 (9)

[1]Sample Size.

Table 3. Growth of Fawns and Adult Tick Infestation Rates, Cookson Refuge, Eastern Oklahoma, 1970-72.

	Ave. lb. Gained/Day	Ave. Increase in Tick Infestation/Day
Surviving Fawns (4)[1]	.52	1.46
Dying Fawns (6)	.06	2.40

[1]Sample Size.



Map 1. Movements (8.4 acres) of surviving fawn 2B-72, Cookson Refuge, Eastern Oklahoma, June 6 to July 7, 1972.

Map 2. Movements (2.4 acres) of fawn 4A-72 that died, Cookson Refuge, Eastern Oklahoma, June 8 to June 28, 1972.

THE MONTHLY AVAILABILITY AND USE OF BROWSE PLANTS BY DEER ON A BOTTOMLAND HARDWOOD AREA IN TENSAS PARISH, LOUISIANA

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ABSTRACT

The monthly availability and use of browse plants for food by white-tailed deer *(Odocoileus virginianus)* was studied from February 1971 through January 1972 on Durango Hunting Club, a bottomland hardwood area in Tensas Parish, Louisiana. A modified version of the Aldous Deer Browse Survey Method was used to determine the monthly availability of all plants present and the actual use of these plants by deer. A total of 141 plant species and plant groups was