Estimates of White-Tailed Deer Activity Levels in Oklahoma

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Abstract: White-tailed deer (*Odocoileus virginianus*) activity levels were estimated by track counts on 3 study sites in the Cross Timbers region of Oklahoma during 1978–79. An activity index (number of tracks/day) was developed from repetitive readings of 100 track plots (1 × 3 m) per site. Significant differences ($P < 0.05$) in monthly activity levels were found. Within-month and between-month variability was influenced by land-use patterns, ambient temperature shifts, changes in food resource availability, and deer behavior patterns. A seasonal bimodal pattern was observed, with peaks during late spring and fall–early winter, while lowered activity was observed during early spring and summer.

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Most information on seasonal activity levels for white-tailed deer has been reported for winter conditions in the northern United States. Ozoga and Verme (1970) reported that activity was high in December and January, decreased during February-March, and rebounded during spring green-up in late March. Ingestion of food resources varied directly with activity. As forage became less palatable or abundant, increased effort was required to maintain an adequate nutritional level. Moreover, increased activity entails higher energy costs, eventually outweighing caloric intake from forage. As a consequence, activity and feeding are suppressed (Moen 1976) and white-tailed deer in northern states undergo a fasting catabolism (Silver et al. 1969), often losing up to 30% of their body weight. It has also been shown that re-

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productive behavior influences female white-tailed deer activity levels (Ozoga and Verme 1975) and is suspected to affect males.

Little information on activity patterns is available for deer in the southern United States and differences in climate and associated stress periods led us to hypothesize that seasonal activity patterns were different. We monitored activity levels of white-tailed deer throughout the year in the Cross Timbers (Dyksterhuis 1948) of Oklahoma. This paper presents the pattern we observed, relates changes in activity to environmental conditions, and suggests a hypothesis to account for observed changes in activity.

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Methods

The Cross Timbers region is classified as a forest grassland, extending from Kansas through Oklahoma into Texas. Stands of post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) grow on rolling to hilly sandstone uplands (Dwyer and Santelman 1964), and are interspersed with areas of grassland and bottomland forest. Descriptions of the vegetation and its distribution are given by Rice and Penfound (1959) and Risser and Rice (1971).

Three study sites were chosen: 1 located 10 km west of Okmulgee (259 ha), the remaining 2, Hunt Creek (373 ha) and South Hiway (97 ha) were 13 km west of Stillwater.

Activity levels of white-tailed deer were estimated by track counts taken from a plot system (Ockenfels 1980) used to monitor habitat use patterns during 1978–79. One-hundred plots per site were allocated proportionally and randomly located within different cover types on 3 sites. Plots (1 × 3 m, 10-cm deep) were established with a roto-tiller and read at weekly intervals. Data collected by plot included a count of the total number of deer tracks. An activity index (number of tracks/day) was calculated by dividing the number of tracks by the interval in days since the sampling period was initiated, for each plot, then summing 100 plots/site. This resulted in a site tracks/day (TPD) value that we assumed was related to general levels of

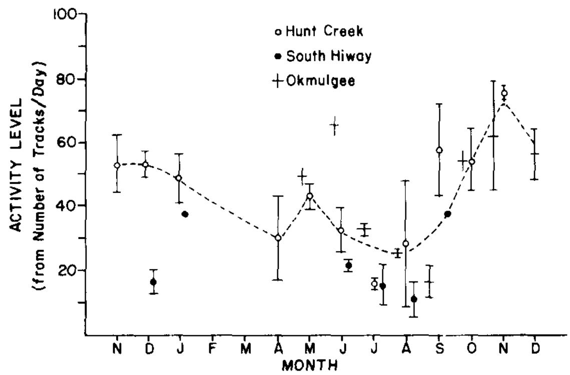

Figure 1. Activity levels ($x \pm$ SE) of white-tailed deer on selected sites within the Cross Timbers region of Oklahoma during 1978–79. Data collected for analysis were number of tracks counted/day in 100 plots/site. Dotted line is composite of 3 sites (x). December 1978 data at South Hiway were deleted from composite due to high levels of human disturbance affecting deer use of area.

deer activity. Monthly TPD means (±SE) were calculated. Bartlett's test, Analysis of Variance (ANOVA), and *t*-test were used in the analysis (Snedecor and Cochran 1967). We tested the effect of ambient temperature (mean, minimum and maximum) on general activity levels by multiple regression analysis (Statistical Analysis System, Barr and Goodnight 1972). Data from the 3 sites were combined to construct a generalized activity pattern for deer in the Cross Timbers.

Results

Thirty-three readings (3,300 plots) were conducted at Hunt Creek, representing 50% of the total effort. Okmulgee received 17 readings, South Hiway 16. Eleven, 8, and 6 mean TPD values were calculated at Hunt Creek, Okmulgee, and South Hiway, respectively. A generalized pattern for 13 months, November 1978 to December 1979, was constructed (Fig. 1).

We analyzed the Hunt Creek data for differences between monthly activity levels. Bartlett's test indicated variances were similar ($0.10 > P > 0.05$), so ANOVA was used to test for monthly differences ($0.025 > P > 0.01$) in mean activity levels. Since we were interested in winter-summer relationships, a *t*-test was used to compare December–January (51.1 TPD, SD = 11.7) and July–August (22.1 TPD, SD = 22.2) data. Deer were 132% more active ($0.01 > P > 0.005$) in early winter than summer. With the exception of the last week in August, all July–August values were less than 18 TPD, and averaged 13.1 (SD = 4.4).

Table 1. Effect of Forestry Practices on White-Tailed Deer Activity Levels (Number of Tracks Counted/Day in 100 Plots) on the South Hiway Site, Oklahoma, during December 1978

Date	Interval Length[a]	Frequency[b]	Activity Index
December 5	8	21	26.6
December 18	6	12	19.3
December 22	9	12	12.3
December 29[c]	8	8	8.5
January 4	4	12	37.5

[a] Maximum number of days between readings.
[b] Number of plots with deer tracks during the interval.
[c] Forestry practices ended for winter, due to inclement weather, during this period.

During December 1978 intensive forestry practices on the South Hiway site altered overall deer use (Table 1). Upland forests were cleared in pasture areas, suppressing deer use 68% (26.6 TPD to 8.5). Additionally, a threefold (2.8×) decrease in TPD (77.9 to 27.6) during the November 17–25 deer hunt was noted on the Okmulgee site (Table 2). A 509% increase in the use of the brush-savanna cover type (Ockenfels 1980) occurred concurrently with decreased activity. Percentage use of this cover type was 3.5 during the pre-hunt sample period (November 15), 21.3 during the hunt (November 28), and 3.8 for the post-hunt sample (December 5). The post-hunt usage represents a decrease to within 8% of the pre-hunt sample.

Based on previous work (Short and Newsom 1969, Ozoga and Verme 1970, Church 1971, and Moen 1976), we tested our data for the relationship between ambient temperature and activity levels. A parabolic model (independent variable squared for X_2 term) was predicted a priori, with reduced

Table 2. Effect of Gun Hunting Season on White-Tailed Deer Activity Levels (Number of Tracks Counted/Day in 100 Plots) on the Okmulgee Site, Oklahoma, during November 1979

Date	Interval Length[a]	Frequency[b]	Activity Index
October 24	4	34	54.3
November 5	6	45	80.3
November 15	7	54	77.9
November 28[c]	8	32	27.6
December 5	7	34	41.1
December 12	7	31	64.4
December 17	5	25	64.0

[a] Maximum number of days between readings.
[b] Number of plots with deer tracks during the interval.
[c] Gun hunting season on area from 17 – 25 November. Period is 8 days preceding 28 November, inclusive (21 – 28).

activity (tracks) at low and high ambient temperatures, and high activity at moderate temperatures. Figure 2 illustrates the relationship between average maximum temperature during a sampling period and number of tracks/day, for 33 sampling periods on Hunt Creek. Coefficients of determination of 0.29 ($P = 0.0056$) for mean minimum and 0.25 ($P = 0.0145$) for mean maximum temperature were found. For mean minimum, Y or number of tracks/day = 44.58 + 0.083(mean in C) − 0.0157(mean^2 in C).

Discussion

The combined data means (Fig. 1) indicated that activity levels in the Cross Timbers region were essentially bimodal, with peaks in tracks counted during spring and fall–early winter. Lowered activity was observed during early spring and summer. Within-month and between-month varaibility appeared to be influenced by land-use patterns and ambient temperature shifts, as well as changes in availability of food resources, which was untested. These factors, plus deer behavior itself, appear to be the driving force behind the yearly cycle.

Effects of land-use patterns on activity levels were short-term. The 68% reduction in activity at South Hiway associated with the clearing of upland forests (Table 1) was followed by a sharp increase in January to 37.5 TPD, 341% above the last reading in December, and coincided with an increase of available forage in the form of fallen mast and foliage (Ockenfels 1980). Although hunting decreased levels at Okmulgee in November 1979 (Table 2), within 2 weeks post-hunt levels were near the pre-hunt values, suggesting that hunting modified activity only temporarily. Thus, land-use patterns changed the behavior patterns of white-tailed deer, by reducing either use of land or movement patterns.

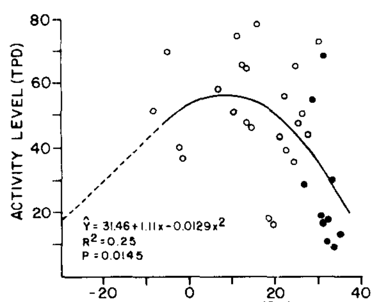

Figure 2. Effect of mean maximum ambient temperature (C) on activity levels (number of tracks counted/day in 100 plots) of white-tailed deer on the Hunt Creek site during 1978–79. Dotted line is prediction based on data of Ozoga and Verme (1970) and Moen (1976). Solid dots are summer readings (15 June–31 August).

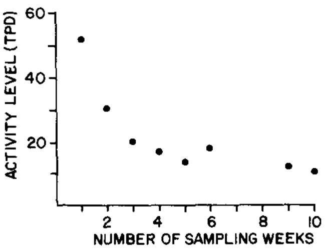

Figure 3. Summer pattern of white-tailed deer activity levels (number of tracks counted/day in 100 plots) on Hunt Creek during 1979. X-axis values are number of weekly sampling periods since start of summer (15 June).

Ambient temperatures were important ($P = 0.0056$, $P = 0.0145$ for mean minimum and maximum) in determining levels of activity in white-tailed deer. However, high variability in activity during moderate temperatures suggested that deer were not stressed and seemed unaffected by −10 to 30 C temperatures. Temperature extremes did influence behavior. Summer readings shown as solid dots in Figure 2 are clustered, suggesting that prolonged high temperatures did reduce activity. As summer progressed, the index tended to drop (Fig. 3). Data were not collected during mid-August (weeks 7–8) due to inclement weather. We are unable to explain 2 high readings. The high points (51.8, 66.6) were the starting and ending periods of summer (weeks 1, 11). For the 11th week the value jumped up and stayed high throughout the fall. Food resources are suspected for week 11, while fawning activity may have caused the high level of week 1.

The relationship between activity and lower temperature (< −10 C) is unclear in Oklahoma due to relatively mild winters. Temperatures seldom drop below −10 C. However, the patterns of winter movements of telemetered deer (Ockenfels 1980) and available readings showed a similarity to those reported by Ozoga and Verme (1970) and Moen (1976). The winter of 1978–79 was the most severe in the last 21 years, thus, a "normal" winter for the region may not suppress activity levels as much as in northern states. Winters are normally short in duration, with intermittent or no snow cover. We suspect that winter activity levels in Oklahoma are higher than those reported in northern states. Inclement weather prevented us from collecting track data during February–March, therefore, we are unsure of the winter levels.

In the Cross Timbers region, activity levels were lowest during July–August (Fig. 1). Movement patterns associated with fawning have finished, while disruptions due to rutting behavior have not commenced. Short and Newsom (1969) and Church (1971) noted that heat stress and related physiological problems associated with the stress arise if ambient temperatures exceed 30 C, with concurrent reductions in activity and food intake. Temperatures were commonly in the 30–35 C range during June–August in Oklahoma and fewer tracks/day were counted. During this period deer used riparian areas much greater than one would expect, based on percentage of area available (Ockenfels 1980). Riparian areas in the southern United States are cooler than surrounding habitats during summer months. White-tailed deer in the Cross Timbers apparently use this habitat component to reduce the possibility of heat-induced stress.

Decreases in food consumption during midsummer as temperatures in excess of 27 C became more frequent and longer in duration were noted by Short and Newsom (1969). They concluded that the decline in food consumption was voluntary and created dietary deficiencies. Verme and Ullrey (1972) reported that during prolonged periods of hot weather, digestibility of deer forage decreased, due to lignification of plant cell walls. In south Texas, Verner et al. (1977) found crude protein, dry matter digestibility, and phosphorus levels in deer forage were lowest during the summer months, and concluded deer were under nutritional stress. During this period, does are lactating and catabolizing body fat to compensate for reductions in food intake, whereas bucks are in a period of maximum antler development and need high levels of energy. It is likely that heat stress and food availability reductions, due to maturation, change the movement patterns, thus, activity levels, of deer during summer months.

The sharp increase in activity during September and early October apparently was a response to the onset of acorn drop, as deer searched for ripened mast. Habitat use patterns changed considerably at this time (Ockenfels 1980). Use of upland forest increased 386% from August to October on Hunt Creek, with a similar increase for Okmulgee from September to November (Fig. 1). Rutting behavior occurs during this period (Halls 1978) and activity levels increased concurrently. Field observations of marked and unmarked deer on Hunt Creek suggested food availability was the predominant reason for the initial increase during early fall, as rutting behavior was not noted until October. Peak activity was noted in late fall-early winter, as the acorns and rutting behavior peaked. Although we could not account for amount of variability due to either factor, both likely influenced activity considerably.

The cycle of activity at Okmulgee was delayed 10–14 days compared to Hunt Creek and South Hiway (Fig. 1). Differences in population density, age distribution, or sex ratio may be involved. McCullough (1979) showed that population characteristics influenced reproductive performance of white-tailed deer. Populations with age structures skewed toward younger animals tended to breed and fawn later. Peaks in tracks/day coincided with rutting and fawning periods on the 3 sites, thus behavioral changes would influence our index. Likewise, populations at higher densities showed later fawning dates. Verme (1965) found that well-fed female white-tailed deer bred 12 days earlier than poorly-fed ones. Population surveys and vegetation analyses on the sites would be necessary to test for probable influences. Stout (1973) concluded that notheastern Oklahoma (Okmulgee) habitat was substandard, due to range deterioration through high deer densities. He further concluded that different age structures and physical conditions of populations were present, between northeastern areas and the remainder of the state. It seems likely that the observed delay in activity was real and vegetational changes due to different deer densities played a part in determining this difference.

Seasonal rhythms, both in terms of physical activity and physiological characteristics and function, are adaptations for energy conservation (Moen 1978, Mautz 1978). Deer in northern areas limit activities to reduce heat losses during harsh winter conditions when the cost/benefit ratio of energy balance is large. In most cases, voluntary reduction of feeding is a response to lower food quality (Moen 1976). This pattern appears modified in southern deer living under conditions of mild winters and hot prolonged summers. Activity was reduced during periods of high ambient temperatures and decreased food quality, likely in response to heat-induced stress, rather than the conservation of heat. Therefore, different management strategies are necessary to maintain healthy deer populations in southern habitats. Whereas habitat management has been concentrated on winter ranges in the North, deer managers should consider management of late summer ranges in the South. In addition, research is needed to separate the effects of heat-induced stress and low quality forage on activity levels for deer in the southern states. Management could differ significantly depending upon the results.

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