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REGIONAL WHITE-TAILED DEER MORTALITY DUE TO PREDATION AND NON-PREADTION EVENTS

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ABSTRACT

White-tailed deer (*Odocoileus virginianus*) fawns in the United States are vulnerable to mortality. Previous studies have found that the leading cause of mortality for fawns is predation. This study conducted a meta-analysis using previous data about fawn mortality due to predation and non-predation causes in Texas, Illinois, and Pennsylvania. A total of 121 fawn deaths were categorized into predation and non-predation events and analyzed. It was hypothesized that the mortality rates of White-Tailed Deer fawns due to predation and non-predation events does not vary between South Central, Northeastern, and Midwestern regions of the United States. To test this a 2 by 3 chi-squared test was conducted and it was concluded that there is marginal significance and a p-value of 0.051403. These findings support that there is no statistical difference between predation and non-predation fawn deaths in Texas, Pennsylvania, and Illinois despite factors such as variations in predators, deer populations, and climate. These findings have the potential to aid in the conservation and management of white-tailed deer populations in the United States. Future research could have the potential to create methods to protect fawns from predation caused mortality.

Key words: Fawn, Mortality, Odocoileus virginianus, Predation, white-tailed deer

INTRODUCTION

White-tailed deer (*Odocoileus virginianus*) are the most widespread and abundant cervid in North America. They can be found in all the conterminous United States, except for Utah. Proper deer population modeling and management planning required accurate survival and mortality rates of fawns. This is due to fawns being the most vulnerable to mortality (Rohm et al. 2007). This can be contributed to their helplessness, vulnerability, and limited mobility (Cook 1971). A previous analysis of 29 studies found that predation is the leading cause of mortality for fawns despite differences in habitat. The second leading cause of mortality was found to be natural causes and is followed by human causes (T. Gingery 2018). Predators of fawns include coyotes, bobcats, and black bears. Despite varying habitats and predators, fawns are vulnerable to predation in the United States. It is hypothesized that the mortality rates of White-Tailed Deer fawns due to predation and non-predation events does not vary between South Central, Northeastern, and Midwestern regions of the United States.

FIELD SITE

Texas

The study was completed in the central third of the 7,800-acre Welder Wildlife Refuge in south Texas during the summers of 1965 and 1966. The

refuge is located on the Coastal Bend of southern Texas where it is hot and humid. The max daily temperatures were above 80 F with 65% to 80% relative humidity. In the study site there were numerous coyotes and small numbers of bobcats. There were good range conditions and it was rich in flora. Dense stands of grass and forbs at least 2-3 ft tall covering most of the area (Cook 1971).

Pennsylvania

The study was completed in two study areas in north and central PA. The north study site was located in Susquehannock State Forest in Potter County and part of the Deep Valleys section of the Appalachian Plateaus physiographic region. Plateaus were at 800 m elevation and steep drainages were at 220 m. The site area was 88% mixture of norther hardwoods and conifer forest types, <1% agricultural land cover, and remaining area was open water, fallow ground, etc. The 2015 pre-hunt density was found to be 9.2 deer/km^2.

The south study site was located in central PA in Centre, Mifflin, and Huntingdon counties in the Ridge and Valley physiographic region. 178 km^2 of the study area was in Rothrock State Forest and 6 km^2 were in Bald Eagle State Forest. Land characteristics included long parallel ridges and valleys. The site area was 79% oak-hickory forests with an understory of ericaceous shrub species and 15% agricultural land cover. The 2015 pre-hunt densities were found to be 10.3 deer/km^2. Potential fawn predator species in both study areas included black bear (Ursus americanus), coyote (Canis latrans), red fox (Vulpes vulpes), and bobcat (Lynx rufus) (T.G. Gingery 2018).

Illinois

The study was completed in two study areas in southern Illinois. The region is characterized by hot humid summers and mild winters where mean monthly temperature's ranged from 32 C in July to -5 C in January. Both sites included moderate topography ranging from 96 m to 240 m.

The 51 km^2 Pope and Johnson counties study site was centered on the Pope-Johnson country line within the Shawnee National Forest. The site was 39% forest, 35% grassland, 17% agriculture, and 9% wetland, open water, or developed. The area was predominately mixed hardwoods with grasslands dominated by fescue (Festuca spp.) with blackberry (Rubusspp.) and goldenrod (Solidago spp.). The major crops in the site were corn and soybeans.

The Jackson country study site was 20 km^2 in area. The site was 51% forest cover, 28% grassland cover, 11% agricultural cover, 10% wetland, open water, or developed. It has the same plant species composition as the Pope and Johnson counties study site (Rohm et al.).

METHODS AND MATERIALS

Texas

Fawns 1 to 12 days old were captured on foot. Estimated age, condition of navel and hooves, agility, general appearance, and size were assessed. Fawns were marked with ear tags for individual recognition. Standard measurements, rectal body temp, weight, sex, age, general health, and bedding site were recorded. Fawns were fitted with radio-transmitting collars that were constructed by University of Wisconsin Instrumentation System Center. Fawns were then returned to their capture site.

Fawns were relocated 4 to 5 times a week, or more, for the first month. Then every second or third day until the end of study. 2-man crew searched for dead fawns in early morning to locate them before vultures found them. Meaningful necropsies were made before exposed to high temperatures. Crews drove around in a pickup truck with portable transistorized crystal-controlled Johnson Messenger III receiver and long-range antenna. They drove along trails and roads 200 yards of previous location of fawn. When strong signal was detected the portable receiver and directional antenna were used. If a weak signal was detected crews drove in grid pattern until a strong signal was found.

When a fawn was found binoculars were used to assess its condition. When a fawn was found dead, photos were taken and carcass conditions and circumstances were recorded. Death was placed in predation excluded category if lack signs of being bitten, chewed, or disturbed by predators. If those signs were present, death was placed in predation category. To be determined predation, fawn had to be assessed within 48 hours of death and evidence that the fawn was killed by predator rather than been scavenged after death had to be present. Carcasses with blood in wounds, frothy blood in the nares and

trachea, or bruises surrounding tooth marks were assigned the death due to predation. Death was determined to be caused by coyote if remains were scattered about with no attempt to conceal them. Death was determined to be caused bobcat if remains were scraped under a scrub and covered with grass, leaves, and small sticks. If enough of the carcass remained taken to laboratory for necropsy. Surviving fawns with transmitters were collected at the end of study (Cook 1971).

Pennsylvania

To help fawn captures, adult female deer where captured using rocket nets and single-gate clover traps from January to April 2015-2016. Vaginal implant transmitters (VIT) were inserted under protocol approved by The Pennsylvania State University Institutional and Animal Care and Use Committee (Protocol No. 47054). Females were fitted with global positioning system satellite radio collar linked to the VIT. When the VIT was expelled change in temperature signaled the GPS collar to transmit a message that a potential birth had occurred. At least 6 hours were waited after expulsion notification before search started to ensure the formation of a social bond between mother and fawn. Additional search conducted 8-48 hours after initial search if no fawn was found.

When fawns were captured a numbered, plastic tag was placed in each ear and it was imprinted with a toll-free telephone number to collect $100 reward if found. Fawns were fitted with expandable very high frequency radio collars. Fawn collar transmitters remaining motionless for 4 hours transmitted a signal indicating that a possible mortality occurred. Survival of radio collared fawns was monitored by ground-based telemetry twice daily from capture until mid-august. Survival was then monitored 1 to 7 times weekly from mid-august through early December and 1 to 3 times weekly until mortality, collar failure, or end of study.

Fawn mortality was investigated within 24 hours of signal detection. Noted vegetation disturbances, carcass condition, presence of predator scat or prints, and published descriptions of predator-specific kill characteristics were used to identify the likely predator species. The cause of mortality was identified by information obtained from the mortality site, carcasses, and DNA evidence. Carcasses were collected for necropsy at the Pennsylvania State University Animal Diagnostic Laboratory and DNA swabs were submitted to East Stroudsburg University Northeast Wildlife DNA Laboratory for more conclusive predator identification. Causes of death were classified as predation, human-caused, natural (excluding predation), and unknown (T.G. Gingery 2018).

Illinois

Fawns were captured from May to June 2002-2004 by using methods approved by the Institutional Animal Care and Use Committee at Southern Illinois University Carbondale. Fawns were captured by conducting foot searches, searching for females displaying postpartum behavior, and monitoring radio collared females. Two crews of 4 to 5 people located fawns on foot, searching within 50 m of edges of early to mid-successional fields, pastured, small woodlots, and other suitable fawn rearing areas. When observing females with postpartum behavior crews searched area for fawns. Monitored females radio collared as part of a concurrent study during April until the onset of parturition. When parturition occurred, fawns were located by homing to the female and searching the area. When fawns were located, they were captured by hand or with assistance of a long-handled net and immediately blind folded.

The age of newborn fawns was determined by the appearance of hooves, umbilicus, and behavior. The age of older fawns was found by measuring new hoof growth with dial calipers and estimating age using a model developed by Sams et al. Each fawn was marked with numbered plastic tabs and each fawn was fitted with a 70 g very high frequency radio collar equipped with mortality sensor. Captured fawns were fitted with elastic collar that contained folds stitched together by cotton thread with a transmitter. The collar was designed to detach within 1 year due to deterioration of cotton stitches and force exerted by the growing neck of fawns.

Fawns monitored for survival monitored using standard ground-based radio telemetry daily from capture until August 15th and then ≥3 times per week until recruitment (October 1st). When mortality signal detected, the collar was immediately located, and cause of mortality was determined. Causes of mortality assessed by site and carcass evidence and classified into human-induced, natural, and unknown categories. Human-induced included mortality due to farming equipment,

vehicles, and fence entanglement. Natural included disease, abandonment, and predation. Predator-related mortalities were determined based on a key modified from Vreeland. Predation mortalities were distinguished from mortalities from scavenging by the presence of blood at the site and evidence of trauma, hemorrhaging, and bruising on the carcass. If the cause of mortality could not be determined in the field the carcass was taken to the laboratory and necropsied according to Woolf (Rohm et al. 2007).

Chi-Squared Test

The mortality data from Texas, Pennsylvania, an Illinois was categorized into predation and non-predation related. Predation related events were determined to be causes by the following predators; black bear (Ursus americanus), coyote (Canis latrans), bobcat (Lynx rufus), or unknown. Non-predation related mortality was considered to be due to humans and natural causes such as starvation, abandonment, and accidents. After the data was categorized a 2 by 3 chi-squared test was used to find χ^2 and the p-value ($P<0.10$).

RESULTS

Table 1. Number of deaths per state and cause of mortality

	Texas	Pennsylvania	Illinois
Predation	48	27	41
Non-Predation	10	14	23

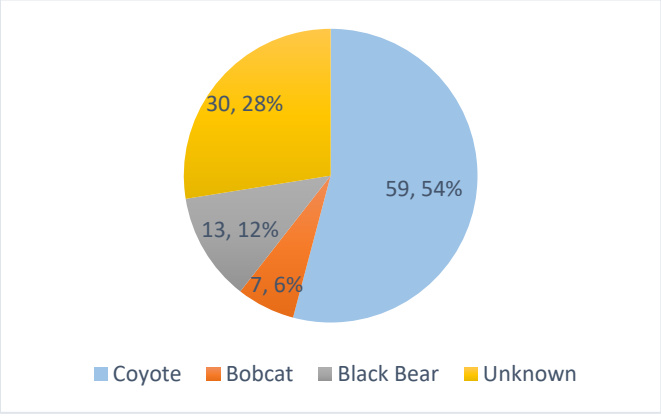

Figure 1. Pie chart representation of predation types that account for white-tailed deer fawn mortality. Total of 121 fawn deaths represented from Texas, Pennsylvania, and Illinois.

	Texas	Pennsylvania	Illinois
Coyote	29	7	23
Bobcat	2	2	3
Black Bear	0	13	0
Unknown	13	5	12
Total	44	27	38

Table 2. Summary of white-tailed deer fawn mortality by predation type for study states

Table 3. Results of 2 by 3 χ^2 test for cause of mortality by state. The χ^2 and p-value are reported.

χ2 = 5.9361; P = 0.051403	**Texas**	**Pennsylvania**	**Illinois**
Predation	48	27	41
Non-Predation	10	14	23

The chi-squared test produced a p-value of 0.51403, which is statically significant when $P<0.10$.

DISCUSSION

When comparing predation and non-predation related deaths between Texas, Pennsylvania, and Illinois there was found to be marginal significance. This suggests there is evidence against

the null hypothesis, which is the frequency of all deaths that is due to predation varies between states. The p-value was found to be 0.051403, which would not be considered significant when $P<0.05$ since it is slightly higher. When using $P<0.10$ it was found that there is marginal significance, which indicates there is not a difference between predation and non-predation related mortality in South Central, Northeastern, and Midwestern regions of the United States.

Previous studies have shown that habitat plays an important role in fawn survival since it effects predator distribution and density (Rohm et al. 2007). It has also been found that fawn survival rates increase as agricultural land cover increases (T. G. Gingery 2018). However, this meta-analysis does not take into account differences between relative abundance of white-tailed deer, predator populations, habitat, human disturbances and proximity, and climate in Texas, Pennsylvania, and Illinois. This suggests that the vulnerability of fawns to predation is high despite the influence these factors can have. Not account for these factors could also contribute to only a marginal significance being found in this study.

Table 2 shows that predation due to coyotes, bobcats, and black bears differed between the study states. Fawn mortality due to black bears only occurred in Pennsylvania and was the leading cause of predation death for the state. Coyotes were the leading cause of predation death for both Texas and Illinois. Figure 1 shows that 54% of all deaths due to predation in the study were due to coyotes. The next leading cause of mortality for all states was unknown predation. These findings suggest that despite varying predator population species and fawn mortalities within the study sites, there is no statistical differences between death due predation or non-predation causes. These findings could be used in future conservation efforts to protect white-tailed deer fawn. The data suggests that despite what region the fawns live in they are vulnerable to predation. This could be contributed to their helplessness, vulnerability, and limited mobility (Cook 1971). Further search could examine how fawns could be protected from predation within their specific habitat. Such studies could help ensure the survival, success, and management of white-tailed deer populations across the United States.

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