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CAUSE-SPECIFIC MORTALITY OF WHITE-TAILED DEER AS INFLUENCED BY MILITARY TRAINING ACTIVITIES IN SOUTHWESTERN OKLAHOMA

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ABSTRACT: Radio-telemetry was used to monitor movements and mortality of 56 white-tailed deer (*Odocoileus virginianus*) in response to intensive military training activities on West Range (18,000 ha), Fort Sill Military Reservation, Oklahoma. Cause-specific mortality was determined for 22 radio-collared deer, including adults (≥2.0-yr-old), yearlings (0.6–1.9-yr-old), and fawns (≤75-day-old age group) from 1987 to 1989. Winter home ranges were largely confined to a 14,411 ha impact area centrally located on West Range. The mean annual mortality rate was 0.50 for adults and yearlings combined. Fifty percent of all adult and yearling mortality was attributed to military training activities, 28% to hunting, 16% to collisions with automobiles, and 6% to unknown causes. The mean monthly mortality rate was 0.61 for neonatal fawns and predation accounted for three of four mortalities. All captured deer in the ≥2.6-yr-old, 82% in the 1.6-yr-old, 10% in the 0.6-yr-old, and all deer in the <7-day-old age groups were seropositive for bluetongue virus (BTV). Our study strongly suggests that the consequences of military training activities should be considered in the management of white-tailed deer herds on military installations.

Key words: White-tailed deer, *Odocoileus virginianus*, mortality, movements, military training, survival, bluetongue virus, epizootic hemorrhagic disease virus, serology.

INTRODUCTION

In addition to estimates of legal harvest mortality, an understanding of other man-induced and natural mortality agents is a prerequisite to a successful white-tailed deer (*Odocoileus virginianus*) management program (Halls, 1984). Over exploitation of intensively hunted deer herds is possible when adequate survival and cause-specific mortality information is unavailable (Nelson and Mech, 1986). Several investigations in Texas (Carroll and Brown, 1977; Cook et al., 1971) and Oklahoma (Bolte et al., 1970; Bartush, 1978; Garner et al., 1976; Logan, 1973) have demonstrated the importance of fawn mortality in determining recruitment into the harvestable population. However, studies elucidating nonhunting causes of mortality among adult deer in the south-central United States are limited (Kie and White, 1985; DeYoung, 1989) and nonexistent for military training installations.

The U.S. Department of Defense manages nearly 5 million ha of land in North America for military training purposes. These training lands are subject to intensive and extensive use due to advanced mobile weapons systems operating over large areas and concentrated demands on multi-purpose training areas. Much of the land devoted to military training is also available for recreational deer hunting. Wildlife management programs on military installations with recreational hunting should consider possible alterations in animal behavioral patterns (Gese et al., 1989) or mortality rates due to training activities.

The deer herd on Fort Sill Military Reservation (FSMR) has an eruptive history and fawn mortality from predation has been implicated as a major dampening agent to herd recruitment (Steele, 1969). Despite an intensive predator control program initiated in 1977, the deer herd on FSMR appeared to be maintained below carrying capacity of the habitat even though net fawn production as measured by fawn/doe counts increased by an estimated 154% (Stout, 1982). As a result, we suspected an undetermined mortality agent was limiting the growth of the deer population on FSMR. We used radio-telemetry to determine survival and cause-specific mortality rates for fawn, yearling, and adult white-tailed deer. Because a sharp decline in the FSMR deer herd in 1979 may have been attributed to hemorrhagic disease (Pfister, 1985), we also used blood serum chemistry and serology to assess the possible influence of condition and disease factors on survival.

MATERIALS AND METHODS

Study area

Fort Sill Military Reservation, a U.S. Army field artillery and missile training center, is located in the Central Rolling Red Plains and Central Rolling Red Prairies Land Resource Areas (Gray and Galloway, 1969) of southwestern Oklahoma (34°37′ to 34°46′N, 98°17′ to 98°37′W). The area includes diverse habitats, ranging from relatively flat prairie in the east to steep granite hills in the west. Monthly mean temperatures range from 4.8 C in January to 28.7 C in August. Spring rainfall accounts for 34% of total annual precipitation (10 yr $\bar{x} = 77$ cm). Livestock grazing has been excluded for 30 yr on FSMR. Major vegetation disturbances are primarily annual prescribed burning in selected areas, wildfires resulting from military training exercises, and degradation due to the impact of artillery munitions and off-road vehicular traffic.

Our study was conducted on West Range (18,000 ha) of FSMR, which is used primarily for training exercises by field artillery units, including off-road vehicle maneuvers, bivouacs, and dismounted infantry activities. The impact area (14,411 ha), located in the center of West Range, is subject to year-round munitions bombardment and small arms fire. Vegetation is maintained in early successional stages as a result of direct impacts from artillery munitions and frequent wildfires. Density of the deer population on West Range was an estimated minimum of 2.50/km^2 in both 1987 and 1988 (Stout, 1989). The deer herd consisted of 0.45 bucks/doe and 0.64 fawns/doe in 1987, and 0.51 bucks/doe and 0.61 fawns/doe in 1988. An intensive predator control program was initiated in February 1977 on West Range and continued through the duration of this study. A total of 51 coyotes (*Canis latrans*) was removed from West Range in 1987 and 1988.

Radio-telemetry

Twenty-two adult (≥2.0-yr-old) and 21 yearling (0.6 to 1.9-yr-old age group) white-tailed deer were captured within the impact area of West Range in December 1987 ($n = 25$) and 1988 ($n = 18$) using helicopters and a hand-held net-gun (Coda Enterprises Incorporated, Mesa, Arizona 85203, USA). Age class of each animal was determined by tooth eruption and wear (Severinghaus, 1949). Each animal was equipped with a collar-mounted transmitter containing a mortality sensor (Advanced Telemetry Systems Incorporated, Isanti, Minnesota 55040, USA) and subsequently released at the capture site.

Nine neonatal fawns of radio-collared does and four of uncollared does were captured and fitted with radio transmitters in late spring of 1988 and 1989. Fawns (<7-day-old age group) were captured using methods described by White et al. (1972), Garner et al. (1976), and Bartush and Lewis (1978). Radio-collared does were relocated and observed daily during the fawning season in order to increase our chances of locating newborn fawns. Fawns observed nursing or following a doe were approached quickly to elicit the "drop" response (Nelson and Woolf, 1987). Age was determined by measuring new hoof growth (Haugen and Speake, 1958). The general condition of fawns was subjectively assessed based on behavior, presence or absence of a reddened umbilicus, evidence of diarrhea, and ectoparasite infestation. Fawns were marked with numbered aluminum ear tags with 2.5 × 7.5 cm strips of saflag material (Safety Flag Company of America, Pawtuckett, Rhode Island 02860, USA) attached as described by Downing and McGinnes (1969). We used AVM SMI Solar-L-Modules (AVM Instrument Company, Dublin, California 94568, USA) affixed to white, expandable elastic collars to monitor movements and survival of individual fawns. Newborn fawns were released at the exact location of capture to reduce the chances of abandonment by the doe.

Radio-telemetry equipment was used to relocate collared deer and to aid in determining survival. An AVM model LA12 portable receiver and 3-element hand-held yagi antenna (AVM Instrument Company, Dublin, California 94568, USA) were used to monitor transmitter signals. Radio-collared adults and yearlings were monitored as often as possible throughout the year, sometimes daily, but no less than twice a month. Marked does were relocated daily during the fawning season (26 May to 12 June) and observed without disturbance. Fawn locations were triangulated twice daily to 25 August, or until they moved out of range of the receiver into the impact area. All locations of radio-collared deer were recorded by grid on standardized forms.

We determined approximate size of home ranges using the minimum-area method of Mohr (1947). Home ranges were delineated into summer and winter ranges, with the beginning of the winter season defined as when > 50% of the marked animals left their summer range and ceased transient movements to winter ranges (Tierson et al., 1985).

Mortality

Cause-of-death was determined by field necropsy and detailed inspection of the surrounding area for signs of the mortality agent. Adult and yearling carcasses were usually several days to weeks old when found because of their location in the impact area which was inaccessible during daily military training exercises. Military training was considered to be the probable cause of death when craters caused by recent artillery ordinance surrounded the immediate vicinity (<20 m) of a carcass or its remains. Often several carcasses (collared and uncollared) were observed around a recent crater and characteristic lesions included evidence of hemorrhaging on hides, a variety of fractures, and shrapnel tracts. Bullet holes were observed in deer carcasses located on machine gun ranges. Mortality attributed to military training included artillery and machine gun munitions in the impact area; hunting mortality included legal hunting, poaching, and wounding loss. We differentiated between predator-killed carcasses and predator-scavenged carcasses using criteria of Smith (1945), Cook et al. (1971), White (1973), and Garner (1976). One intact and one partially consumed fawn carcass were stored on wet ice and shipped to Oklahoma State University College of Veterinary Medicine for necropsy.

Clinical evaluations

Samples of blood and feces for chemical analyses were obtained from radio-collared deer at the time of capture to assess general condition and nutritional status (Dinkines, 1990). Blood samples were obtained from the jugular vein, sera removed by centrifugation, and sera submitted to the Fort Sill Medical Diagnostic Laboratory for biochemical analyses using an Ektachem-700 Analyzer (Eastman Kodak Company, Rochester, New York 27705, USA) and procedures specified by the manufacturer. Constituents analyzed in sera included urea nitrogen, creatinine, glucose, uric acid, sodium, chloride, phosphorus, calcium, total protein, albumin, aspartate aminotransferase, alanine aminotransferase, gamma-glutamyl transferase, creatine phosphokinase, and lactate dehydrogenase. Fecal samples were analyzed for nitrogen concentration as an index of diet quality (Dinkines, 1990).

The passive transfer of colostral immunoglobulins to fawns was indirectly assessed by measuring concentrations of serum proteins. Total serum protein, albumin, gamma globulin, alpha globulin, and beta globulin concentrations were determined using Helena zip-zone electrophoresis on Titan III cellulose acetate plates following procedures of the manufacturer (Helena Laboratories, Beaumont, Texas 77704, USA).

Serum samples were tested for antibodies to bluetongue virus (BTV) by personnel of the Department of Veterinary Clinical Pathology, Stillwater, Oklahoma, using the immunodiffusion test (IDT) for group-specific antibodies described by Fulton et al. (1989). Sera positive by IDT were further tested for serotype-specific antibodies against five BTV serotypes (2, 10, 11, 13, and 17) and two epizootic hemorrhagic disease virus (EHDV) serotypes (1 and 2) using a microtitration virus-neutralization test (VNT) in 96-well cell cultures following modified procedures of Fulton et al. (1989) using Madin-Darby bovine kidney cells for cell cultures. An antibody titer >1:40 was considered to be a positive result.

Sterile cotton rectal swabs and fecal smears were obtained from each newborn fawn at the time of capture for *Salmonella* culture. Fecal samples and swabs were directly inoculated in culture media and placed in enrichment broth for reinoculation following procedures of Carter (1986). Isolates were serotyped by the National Veterinary Services Laboratory (Animal and Plant Health Inspection Service, USDA, Ames, Iowa 50010, USA).

Data analysis

Physiologic and dietary variables were tested for differences between deer that died and those that survived using one-way analysis of variance. Protected multiple comparisons (LSD) were used when significant differences ($P < 0.05$) were present. The Statistical Analysis System (SAS) was used for all data analyses (SAS Institute Incorporated, 1982).

Annual survival and cause-specific mortality rates were calculated using the microcomputer program MICROMORT (Heisey and Fuller, 1985). Annual and seasonal (September to February, March to August) survival and mortality rates were determined for two age groups (0.6–1.9- and ≥2.0-yr-old). Monthly survival and mortality rates were determined for fawns (≤75-day-old group; all ages and sexes combined). Selected survival and mortality rates were tested for differences by Z-tests (Heisey, 1985). For annual rates, we compared survival and mortality rates between 0.6–1.9- and ≥2.0-yr-old

TABLE 1. Causes of death among radio-collared white-tailed deer on West Range of Fort Sill Military Reservation, Oklahoma, from 1987 to 1989. Deer numbers ≤25 were captured in 1987 and those ≥26 were captured in 1988.

Deer number	Sex	Age at capture (months)	Age at death (months)	Cause of death
2	F	6	30	Artillery ordinance
4	F	18	36	Artillery ordinance
5	F	30	40	Wounding loss
6	M	6	17	Poacher
8	M	6	13	Machine gun fire
13	M	6	17	Hunter
14	M	6	30	Artillery ordinance
17	F	6	15	Deer-vehicle collision
19	F	18	20	Artillery ordinance
20	F	30	40	Deer-vehicle collision
21	F	30	41	Wounding loss
22	F	30	40	Hunter
23	F	18	29	Unknown
24	F	18	39	Machine gun fire
32	F	54	60	Deer-vehicle collision
36	F	18	20	Artillery ordinance
38	F	42	43	Artillery ordinance
40	F	42	53	Artillery ordinance
88[a]	M	5	17	Bobcat predation
93[a]	F	4	6	Starvation
97[a]	M	5	16	Probable coyote predation
99[a]	F	4	17	Coyote predation

[a] Age at capture and death expressed in days.

age groups. Seasonal (September to February vs. March to August) differences in survival and mortality rates were tested with both age groups combined (yearlings and adults). Differences in mortality and survival rates were considered significant at $P < 0.10$; all other comparisons were considered significant at $P < 0.05$ level.

RESULTS

Seasonal home ranges

Thirty-nine female and four male white-tailed deer (≥6-mo-old age group) were radio-collared and collectively relocated on 3,540 occasions from December 1987 to December 1989. Radio-collared deer maintained winter home ranges within the artillery impact area of West Range, but most adult does shifted their home ranges to areas outside of the impact area in the spring where they remained until fall.

Mortality rates

Twenty-two of 56 radio-collared deer died from various causes during the 2-yr study (Table 1). Thirty-nine percent of all adult and yearling mortalities were attributed to artillery munitions, 16% to collisions with automobiles, 11% to machine gun munitions, 11% to legal hunting, 11% to wounding loss, 6% to poachers, and 6% to unknown causes. The annual mortality rate for deer pooled across ages (adults and yearlings), sexes, and causes was 0.50 (95% CI = 0.37–0.69). Survival rates did not differ ($P = 0.69$) between adult and yearling age classes and mortality rates of both age classes were similar for military training (0.25, $P = 0.85$), hunting (0.14, $P = 0.65$), and collisions with automobiles (0.08, $P = 0.92$).

Eight male and five female fawns ranging in age from 3 to 5 days ($\bar{x} = 4.30 \pm 0.23$ (SE) days) were captured and radio-collared; physical condition of all captured fawns was judged to be excellent. Fawns were relocated on 1,560 occasions throughout summer in 1988 and 1989, yielding 674 deer days of observation and 4 mortalities (Table 1). Monthly mortality rate of fawns pooled across ages, sexes, and causes was 0.61 (95% CI = 0.02–0.85). Mortality attributed to predation (three of four) by coyotes and bobcats (*Lynx rufus*) was more common than nonpredator causes (one of four).

Seasonal survival rate of adults and yearlings combined was significantly higher ($P < 0.01$) during March-August (0.86, 95% CI = 0.74–0.99) than September–February (0.58, 95% CI = 0.43–0.77). Mortality rates due to military training (0.18 and 0.10) and collisions with automobiles (0.06 and 0.04) were similar ($P = 0.36$) for September to February and March to August seasons, respectively. Hunting mortality rates were significantly lower ($P < 0.05$) than all nonhunting mortality rates combined. Seasonal survival rate of adults from

September to February (0.58) was significantly lower ($P < 0.01$) than from March to August (0.90). Seasonal survival rates of yearlings for September to February (0.57) and March to August (0.78) were similar ($P = 0.32$). There were no differences in mortality rates between adult and yearling age groups within a season due to military training ($P = 0.24$), hunting ($P = 0.57$), or collisions with automobiles ($P = 0.31$).

Physiological and dietary indices

All deer grossly appeared to be in good to excellent condition at the time of capture. No differences ($P > 0.05$) were detected in any blood or fecal condition index of adult and yearling deer that died compared to those that survived during our study (Dinkines, 1990).

Results of serum protein electrophoresis provided information on the physiological status of newborn fawns. Fawns that died during our study had significantly higher ($P < 0.01$) concentrations at time of capture for serum total protein and gamma globulins (6.40 ± 0.35, 2.78 ± 0.49 g/dl) than those that survived (5.44 ± 0.11, 1.46 ± 0.15 g/dl, respectively). Serum concentrations of alkaline phosphatase also were higher ($P < 0.05$) in fawns that died ($1,545 \pm 38.20$ U/L) compared to those that survived ($1,071 \pm 108.14$ U/L). We observed no differences ($P > 0.05$) in serum concentrations of albumin, alpha globulin, beta globulin, and other biochemical constituents between fawns that survived and those that died.

Of 49 deer evaluated by the IDT, antibodies to BTV were detected in <7-day-old (seven of seven), 0.6-yr-old (one of 10), 1.6-yr-old (nine of 11), and ≥2.6-yr-old (21 of 21) age groups. Sera positive by IDT were tested for serotype-specific antibodies by VNT (Table 2). Among deer in the 1.6-yr-old age group, reactors to BTV serotypes 10 (one of nine), 11 (five of nine), 13 (nine of nine), 17 (five of nine), and EHDV serotypes 1 (nine of nine) and 2 (eight of nine) were observed. Among ≥2.6-yr-old deer, we detected reactors to BTV serotypes 10 (seven of 21), 11 (16 of 21), 13 (19 of 21), 17 (15 of 21), and EHDV serotypes 1 (17 of 21) and 2 (20 of 21). None of the radio-collared deer were seropositive for BTV-2 on the basis of VNT. Results of the VNT also revealed that fawns (<7-day-old group) captured from seropositive does were seropositive for similar BTV and EHDV serotypes (Table 3). Only one of 13 rectal swabs obtained from 13 newborn fawns was positive for *Salmonella arizona*; however, no mortalities or clinical signs of salmonellosis were detected.

DISCUSSION

Seventy-five percent of all adult and yearling mortality occurred between September and February. Lower September to February survival rates were partially attributed to hunting-related mortality which occurred from October–December. However, the lower September to February survival rate was also indicative of the deer shifting their summer home ranges to winter home ranges inside the impact area, which predisposes them to mortality factors related to military training. DeYoung (1989) reported that natural mortality of male white-tailed deer in southern Texas from December to March was twice the April to November rate. Similarly, Gavin et al. (1984) found most natural mortality occurred during November–January in white-tailed deer, possibly a result of stressors associated with the rut.

Annual and seasonal survival rates of deer on FSMR generally were similar between yearlings and adults. This is in agreement with observations of Nelson and Mech (1986) in Minnesota. McCullough (1979) found that hunting accounted for all mortality of adult males on Michigan's George Reserve. Conversely, DeYoung (1989) reported mortality due to natural causes exceeded hunting losses in south Texas. Reported annual mortality rates for adult males in southwestern Washington (0.40; Gavin et al., 1984) and northeastern Minnesota (0.53; Nelson and Mech, 1986)

TABLE 2. Virus-neutralizing antibody titers to bluetongue virus (BTV) and epizootic hemorrhagic disease virus (EHDV) serotypes in white-tailed deer positive to BTV antibodies by an immunodiffusion test. Serum samples were obtained from deer on West Range, Fort Sill Military Reservation, Oklahoma, in December 1987 and 1988. Age of deer (yr) when tested is indicated in parentheses; deer numbers ≤25 were captured in 1987 and those ≥26 were captured in 1988.

Deer number[a]	Antibody titer to BTV and EHDV serotypes						
	BTV-2	BTV-10	BTV-11	BTV-13	BTV-17	EHDV-1	EHDV-2
42 (0.6)	0	80	80	80	80	40	0
16 (1.6)	0	0	40	320	40	321	≥1,280
19 (1.6)	0	0	80	320	40	80	80
24 (1.6)	0	0	0	80	0	160	0
27 (1.6)	0	0	0	≥1,280	40	40	640
30 (1.6)	0	0	40	≥1,280	0	40	160
33 (1.6)	0	0	0	≥1,280	0	80	160
35 (1.6)	0	40	80	80	640	160	≥1,280
36 (1.6)	0	0	0	≥1,280	0	40	≥1,280
43 (1.6)	0	0	≥1,280	320	80	40	320
1 (2.6)	0	0	0	320	0	≥1,280	320
5 (2.6)	0	0	≥1,280	40	160	0	320
9 (2.6)	0	0	40	≥1,280	40	40	640
15 (2.6)	0	0	0	0	0	640	160
18 (2.6)	0	0	≥1,280	≥1,280	80	40	320
22 (2.6)	0	0	≥1,280	0	40	160	320
26 (2.6)	0	0	80	≥1,280	320	80	160
29 (2.6)	0	0	0	≥1,280	0	80	80
31 (2.6)	0	0	0	320	0	0	320
11 (3.6)	0	40	≥1,280	320	40	160	640
25 (3.6)	0	40	≥1,280	≥1,280	80	160	640
28 (3.6)	0	40	320	320	80	160	640
37 (3.6)	0	160	≥1,280	160	160	160	640
38 (3.6)	0	40	320	80	320	80	320
40 (3.6)	0	40	≥1,280	640	40	80	160
41 (3.6)	0	0	≥1,280	160	160	40	0
3 (4.6)	0	0	≥1,280	320	40	≥1,280	320
7 (4.6)	0	40	≥1,280	≥1,280	640	160	80
32 (4.6)	0	0	40	≥1,280	0	0	160
34 (4.6)	0	0	0	≥1,280	0	0	640
44 (4.6)	0	0	40	640	80	80	320

[a] Number followed by age in parentheses.

were similar to our estimate of mortality rates for adults on FSMR.

Coyote predation and parasitism are major nonhunting causes of mortality in white-tailed deer fawns. Fawn mortality in the Wichita Mountains, Oklahoma can approach 90%, with coyotes responsible for most mortality (Garner, 1976; Bartush, 1978). Tick infestations are a leading cause of fawn mortality in high density deer herds in eastern Oklahoma (Bolte et al., 1970). All mortality of radio-collared newborn fawns on FSMR occurred during the first 17 days of age. Similar observations have been reported in Oklahoma (Bartush and Lewis, 1978) and Texas (Cook et al., 1971).

Fawns may be predisposed to predators due to malnutrition, infections, or other diseases (Cook et al., 1971; Logan, 1973). Logan (1973) suggested that nutritional stress can decrease fawn vigor and increase their susceptibility to secondary infection from tick infestations in eastern Oklahoma. Failure to obtain sufficient colostral immunoglobulins has been shown to be a major mechanism of lamb (McGuire et al., 1983) and calf (McGuire et al., 1976) mor-

TABLE 3. Corresponding virus-neutralizing antibody titers in does (≥1.6-yr-old age group when sampled) and their neonatal fawns (<7-day-old age group when sampled) to bluetongue virus (BTV) and epizootic hemorrhagic disease virus (EHDV) serotypes from West Range, Fort Sill Military Reservation, Oklahoma, 1987 to 1989.

Doe[a] and fawn number	Antibody titer to BTV and EHDV serotypes						
	BTV-2	BTV-10	BTV-11	BTV-13	BTV-17	EHDV-1	EHDV-2
7	0	40	≥1,280	≥1,280	640	160	80
F97	0	40	640	160	160	160	160
5	0	0	≥1,280	40	160	0	320
F96	0	0	≥1,280	0	40	0	640
25	0	40	≥1,280	≥1,280	80	160	640
F95	0	40	640	160	160	160	640
37	0	160	≥1,280	160	160	160	640
F94	0	40	160	320	80	160	640
25	0	40	≥1,280	≥1,280	80	160	640
F93	0	40	640	≥1,280	80	80	640
43	0	0	≥1,280	320	80	40	320
F92	0	40	≥1,280	≥1,280	160	40	320
44	0	0	40	640	80	80	320
F88	0	0	40	≥1,280	160	80	320

[a] Adult doe and her neonatal fawn (F prefix) are arranged consecutively. Does were blood sampled during gestation in December.

tality. Since gamma globulins and antibodies to specific BTV/EHDV serotypes were present in serum of fawns that both survived and died during our study, we concluded that the initial passive transfer of immunity from does to fawns was adequate. Reasons for elevated concentrations of gamma globulin and alkaline phosphatase in serum of fawns that died are unknown, but may be a clinical reflection of disease. Dehydration is not suspected as other blood consituents did not differ between fawns that died and survived.

Stout (1982) speculated that apparent benefits of buck only harvests and increased fawn survival through predator control on FSMR may be offset by significant mortality of younger does due to density independent diseases. Serologic surveys have become a standard method of establishing baseline data on the possible prevalence of various infectious diseases in wild animal populations (Kocan, 1983). Five serotypes of BTV (2, 10, 11, 13, and 17) and two serotypes of EHDV (1 and 2) are recognized in the United States (Barber and Jochim, 1975; Gibbs et al., 1983). To our knowledge, only BTV serotypes 11, 13, and 17 (Kocan et al., 1987) and no EHDV serotypes have been reported for white-tailed deer in Oklahoma. Our survey of deer on FSMR revealed a higher percentage (94%) of seropositive deer (≥1.6-yr-old age group) than a previously reported survey (57%; Kocan et al., 1987) of white-tailed deer in southwestern Oklahoma. The high percentage (100%) of seropositive fawns (<7-day-old age group) suggests that they received early protection against various BTV serotypes via colostrum. However, the subsequently low prevalence of seropositive (10%) deer in the 0.6-yr-old age group and high prevalence of seropositive (94%) deer in the ≥1.6-yr-old age group suggests a gradual loss of maternal antibody and evidence of subsequent exposure as yearlings to the disease agent. Potential for vector-borne transmission of viruses was probably highest from midsummer to early fall. Prevalence of antibodies to BTV and EHDV in some deer populations can approach 100% with no observable clinical disease (Trainer and Jochim, 1969; Kocan et al., 1987). Mortality due to a specific etiologic agent in free-ranging deer on FSMR has never been documented and no clinical signs of BTV/EHDV were observed in this study.

Without viral isolation, interpretation of serologic test results must be done with caution. Although VNT assays are useful for detecting serotype-specific antibody in animals, there exists the possibility of cross-reacting antibodies or heterotypic neutralizing antibodies in serum (Fulton et al., 1989). Animals exposed to different BTV serotypes may develop neutralizing antibodies to heterologous BTV without actually being exposed to them (Jeggo et al., 1983). Seropositive (by IDT) deer at FSMR had antibodies to at least one EHDV and one BTV serotype, but several had neutralizing antibody titers to all serotypes tested. High titers were evident to BTV serotypes 11 and 13 and EHDV serotypes 1 and 2 in deer. The high frequency of positive titers to BTV serotypes 11 and 13 suggests that responses to BTV-10 are the result of cross-reactions.

Data collected from our radio-telemetry suggests that military training is the unaccountable mechanism responsible for maintaining the deer density on FSMR at low levels. The high rate of mortality associated with military training, coupled with hunter-induced mortality and losses in the annual fawn crop due to predation, appears to explain the lack of significant growth in the FSMR deer herd. Our study provides evidence that nonhunting causes of mortality may be significant and should be considered in deer management programs on military installations with similar training activities.

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