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# PREVALENCE OF CHRONIC WASTING DISEASE AND BOVINE TUBERCULOSIS IN FREE-RANGING DEER AND ELK IN SOUTH DAKOTA

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ABSTRACT: Heads of hunter-harvested deer and elk were collected throughout South Dakota (USA) and within established chronic wasting disease (CWD) surveillance areas from 1997–2002 to determine infection with CWD and bovine tuberculosis (TB). We used immunohistochemistry to detect CWD-infected individuals among 1,672 deer and elk sampled via geographically targeted surveillance. A total of 537 elk (*Cervus elaphus nelsoni*), 813 white-tailed deer (*Odocoileus virginianus*), and 322 mule deer (*O. hemionus*) was sampled for CWD. Estimated overall prevalence and associated confidence intervals (95%) in white-tailed deer was 0.001% (0–0.007%). Similarly, estimated overall prevalence in elk and mule deer was 0.0% (0–0.004%) and 0.0% (0–0.011%), respectively. A total of 401 elk, 1,638 white-tailed deer, and 207 mule deer was sampled for TB. Estimated overall prevalence of infection with TB in elk harvested in South Dakota was 0.0% (0–0.009%). Similarly, estimated overall prevalence of TB in white-tailed deer and mule deer harvested throughout South Dakota was 0.0% (0–0.002%) and 0.0% (0–0.018%), respectively.

*Key words:* Bovine tuberculosis, cervid, chronic wasting disease, elk, mule deer, prion, South Dakota, transmissible spongiform encephalopathy, white-tailed deer.

## INTRODUCTION

Infectious diseases are important factors affecting the health of cervid populations. Chronic wasting disease (CWD) is a transmissible spongiform encephalopathy that affects deer (*Odocoileus* spp.) and elk (*Cervus elaphus nelsoni*) and was first recognized in 1967 by researchers studying captive mule deer (*Odocoileus hemionus*) in Colorado (Williams and Young, 1980). To date, CWD has been diagnosed in captive cervid populations from Nebraska, Oklahoma, Kansas, Montana, Colorado, Wyoming, and South Dakota, USA, as well as in facilities from the Canadian provinces of Alberta and Saskatchewan (US Animal Health Association 2001; Canadian Food Inspection Agency, 2002). At present, the sole epidemic focus of CWD in free-ranging cervids spans contiguous portions of northeastern Colorado and southeastern Wyoming, USA, where up to 15% of mule deer and 1% of elk may be affected in localized management units (Miller et al., 2000; Gross and Miller, 2001).

Bovine tuberculosis (TB) is caused by infection with the bacterium *Mycobacterium bovis* (Clifton-Hadley and Wilesmith, 1991). Bovine tuberculosis has been well documented in captive cervids and was first diagnosed in captive fallow deer (*Dama dama*) in Michigan in 1965 (Tower et al., 1965; Tower, 1968). Since then, TB has been documented in captive cervids throughout North America (Stumpff, 1982; Miller et al., 1991; Essey and Meyer, 1992) and Eurasia (Beatson and Hutton, 1981; Shilang and Shanzhi, 1985; Stuart et al., 1988; Jorgensen, 1989). Although considered relatively rare in the wild, Schmitt et al. (1997) reported an epidemic of TB in free-ranging white-tailed deer (*Odocoileus virginianus*) in Michigan.

Both CWD and TB affect regulated transport of wild and domestic species across state and federal borders because of the potential for spread of disease to animals or humans. Hence, our objectives were to document prevalence of CWD and TB and to make recommendations for

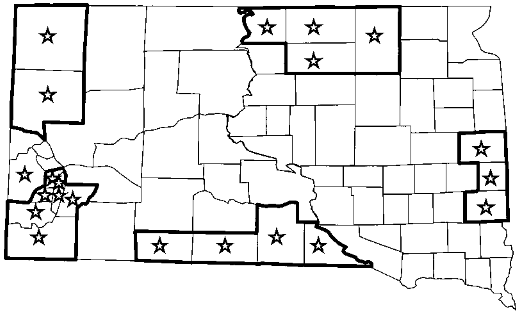

FIGURE 1. Adult deer and elk chronic wasting disease (CWD) surveillance areas (within thick lines) in eastern and western South Dakota, 1997–April 2002. Surveillance areas are comprised of specific management units (stars) established by respective state wildlife management agencies to aid in deer and elk population management. Thin lines throughout the state delineate management unit boundaries.

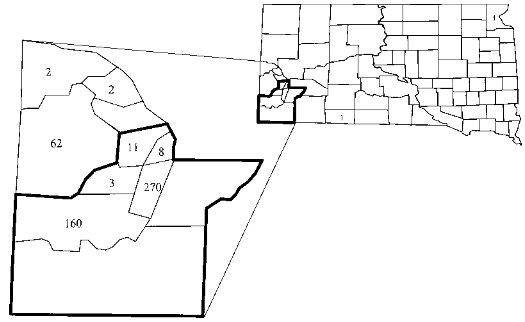


FIGURE 2. Distribution of adult elk sampled for chronic wasting disease in South Dakota, 1997–2001. Numbers indicate the total number of elk sampled in the Black Hills surveillance area (within thick lines).

monitoring these diseases in free-ranging cervid populations in South Dakota. In addition, we report the first documented occurrence of CWD in a free-ranging white-tailed deer harvested during the 2001 South Dakota firearm season in the southern Black Hills, South Dakota.

## STUDY AREA AND METHODS

Cervid tissue samples obtained throughout South Dakota (approximately 43–46°N, 97–104°W) were tested for TB during fall 1998–99. In 1997, the western region of South Dakota was sampled for CWD (Fig. 1). Five CWD surveillance areas were established throughout the state during the fall of 1998 following confirmed cases of the disease in captive populations in the Black Hills and northcentral South Dakota and in states adjacent to South Dakota (Fig. 1). Heads of hunter-harvested deer and elk were collected from meat lockers and head "drop off" collection sites distributed throughout designated CWD surveillance areas for use in determining infection of free ranging cervids with CWD and TB.

Tissue samples from the medulla oblongata of the brain at the obex were used to diagnose CWD (Williams and Young, 1993; Spraker et al., 1997; Peters et al., 2000). Brain samples were fixed in neutral-phosphate buffered 10% formalin prior to being transported to the National Veterinary Services Laboratories (NVSL; Ames, Iowa, USA) for analyses. Samples from the obex were examined by immunohistochemistry (IHC) for presence of protease-resistant prion protein ($PrP^{res}$) using hydrated autoclaving (Miller et al., 1994). Cerebellum was assayed using western blot (Miller et al., 1993) if IHC on brain was equivocal.

Medial retropharyngeal and submandibular lymph nodes were collected for use in determining infection of cervids with TB. Lymph tissue was sliced using surgical scalpels and visually inspected for lesions or abnormalities suggestive of TB. Lymph tissues that contained gross lesions suggestive of TB (i.e., pale caseogranulomas, gritty texture present on incision, purulent material present on incision, yellow discoloration and softening present on incision [Schmitt et al., 1997]) were collected for examination. A portion of each suspect lymph node was fixed in 10% neutral-phosphate buffered formalin for histopathology and the remainder was chilled prior to mycobacterial culture. Histopathology using routine hematoxylin and eosin and acid-fast staining (Prophet et al., 1992) was conducted at the Animal Disease Research and Diagnostics Laboratory (ADRDL; South Dakota State University, Brookings, South Dakota). Chilled portions of suspect lymph nodes were shipped to NVSL for mycobacterial culture using the methods of Payeur et al. (1993).

## RESULTS

A total of 537 hunter-harvested elk collected primarily from the southern Black Hills and Custer State Park (CSP) during the 1998–99 and 2001 hunting seasons was sampled for CWD. Of these, 452 (84%) were collected within the Black Hills surveillance area (Fig. 2). In addition, 66 elk collected from hunting units outside the Black Hills surveillance area, 17 elk from the Black Hills whose exact origin was unknown, one adult male elk killed in Rob-

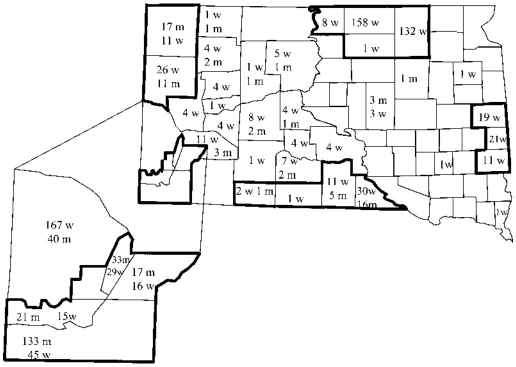

FIGURE 3. Distribution of adult mule (m) and white-tailed (w) deer sampled for chronic wasting disease in South Dakota, 1997–April 2002. Numbers indicate the total number of deer sampled in each management unit (within thin lines). Thick lines delineate chronic wasting disease surveillance area boundaries.

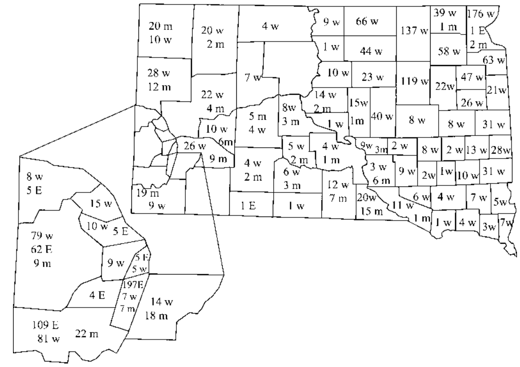

FIGURE 4. Distribution of adult white-tailed deer (w), elk (E), and mule deer (m) sampled for bovine tuberculosis in South Dakota, 1998–99. Numbers indicate the total number of deer and elk sampled in each management unit (within thin lines).

erts County (eastern South Dakota), and one adult female elk harvested in Bennett County (southcentral South Dakota) also were sampled for CWD (Fig. 2). Overall prevalence (and 95% confidence interval) of infection in elk harvested from the Black Hills was 0.0% (0–0.003%). Similarly, prevalence of infection in elk harvested from the Black Hills surveillance area was 0.0% (0–0.004%) (Fig. 2).

A total of 813 white-tailed deer and 322 mule deer also was sampled for CWD. Overall prevalence of infection in white-tailed deer and mule deer was 0.001% (0–0.007%) and 0.0% (0–0.011%), respectively. Only one of 105 (0.009%, 0–0.052%) white-tailed deer harvested in the Black Hills surveillance area tested positive for $PrP^{res}$. None of 204 (0.0%, 0–0.018%) mule deer harvested from the Black Hills surveillance area tested positive for $PrP^{res}$. Estimated prevalences in white-tailed deer harvested from the northwest, northcentral, eastcentral, and southcentral surveillance areas (Fig. 3) were 0.0% (0–0.095%), 0.0% (0–0.012%), 0.0% (0–0.070%), and 0.0% (0–0.082%), respectively. Similarly, estimated prevalences in mule deer harvested from the northwest and southcentral surveillance areas were 0.0% (0–0.123%) and 0.0% (0–0.149%), respectively. Because deer densities in the targeted surveillance areas were unknown, percent of the population sampled for CWD could not be estimated.

A total of 401 hunter-harvested elk was sampled for TB during the 1998 and 1999 hunting seasons. All but two elk (one adult male elk killed in Roberts County, one elk harvested in Bennett County [Fig. 4]) were harvested in the Black Hills, although exact origin of 17 elk was unknown. About 5,565 elk inhabit the Black Hills and Custer State Park (South Dakota Department of Game, Fish and Parks, unpubl. data). In 1998, 175 elk (about 3% of the population) were sampled for TB. Similarly, in 1999, 226 elk (about 4% of the population) were sampled for the disease. Gross lesions suggestive of TB were observed in 10 elk. All 10 elk were negative for TB by histopathology and culture. Estimated overall prevalence of infection with TB in elk harvested in South Dakota was 0.0% (0–0.091%).

A total of 1,638 white-tailed deer and 207 mule deer also was sampled for TB during the 1998 and 1999 hunting seasons. Gross lesions suggestive of TB were observed in 12 deer but histopathology and culture were negative. Estimated overall prevalence of TB in white-tailed deer and mule deer harvested throughout South Dakota was 0.0% (0–0.002%) and 0.0%

(0–0.018%), respectively. Because deer densities were unknown, percent of the population sampled for TB could not be estimated.

## DISCUSSION

Estimated CWD prevalences among cervid populations we studied were lower than CWD prevalences reported in Colorado or Wyoming. This is not surprising because occurrence of CWD in a free-ranging white-tailed deer in southwestern South Dakota represents the first of 1,672 deer and elk examined since 1997 to test positive for $PrP^{res}$. This case possibly represents an isolated occurrence of CWD in free-ranging cervids throughout the state. Williams et al. (2002) suggested geographically distinct foci of infection recently reported in free-ranging cervids in western Saskatchewan, northwestern Nebraska, and southwestern South Dakota may represent spillover from infected farmed elk facilities near each of these cases; proximity of this infected animal to infected captive elk facilities in South Dakota and Nebraska supports this hypothesis.

In an attempt to model the dynamics of CWD in mule deer populations in Colorado and Wyoming, Gross and Miller (2001) reported that allowing CWD prevalence to increase from 1 to 5% before intervening doubles the time required for a 50% chance of eliminating the disease from infected populations. A disturbing result of this modeling exercise was the inability of the authors to identify a set of realistic parameters that permitted sustained coexistence of CWD in a wild deer population. Furthermore, CWD was naturally eliminated from simulated populations only under specific conditions. In some cases, CWD did not persist in a large population because transmission from infectious individuals was insufficient due to low transmission rates or to deaths of infectious individuals before transmission occurred (Gross and Miller, 2001). It is possible that low estimated prevalences reported for deer and elk populations in western South Dakota may permit sustained coexistence of CWD in these free-ranging populations. Furthermore, Gross and Miller (2001) reported slow initial rates of increase in prevalence of CWD and the eventual decimation of infected populations, which suggested that long-term persistence of CWD is likely to occur as a result of dispersal and the spatial structure of deer populations.

Southwestern South Dakota represents one of several recently identified geographically distinct foci of CWD. It is possible that white-tailed deer populations in southwestern South Dakota could provide a source of infection and lead to long-term persistence and geographic spread of CWD to regions of the state that presently harbor uninfected free-ranging cervid populations. An equally disturbing result from an epidemic model constructed by Miller et al. (2000) was that CWD could be sustained in cervid populations for decades and may have been spreading eastward along the North and South Platte rivers for over a decade. River bottom habitat is abundant throughout eastern and western South Dakota; seasonal movements of mule and white-tailed deer occupying the central river breaks region of South Dakota was described by Grassel (2000) as being highly variable. It is possible that white-tailed deer occupying river bottom habitats throughout South Dakota could aid in accelerating the spread of CWD in the future to regions of the state that presently harbor uninfected mule deer and elk populations.

The geographic targeted surveillance approach used here was an effective strategy for detecting a new geographically distinct CWD foci in southwestern South Dakota. Conner et al. (2000) reported that harvest based surveys likely produce relatively unbiased prevalence data and could serve as a reliable approach for assessing long-term spatial and temporal trends in CWD dynamics. Because CWD was documented in a farmed elk facility in north-central South Dakota (e.g., McPherson

County) in 1997, it is possible that some spillover to adjacent free-ranging deer populations occurred. Although targeted geographic surveillance of adjacent free-ranging deer populations has not detected the disease, it is recommended that this approach continue in the northcentral surveillance area (Fig. 1) because of the possibility of a new geographically distinct CWD foci. Moreover, it is recommended that a harvest based survey approach continue to be implemented in southwestern South Dakota to reliably assess long term CWD dynamics in this region.

Effective strategies for controlling or eliminating CWD in free-ranging cervid populations have not yet been identified. However, Gross and Miller (2001) suggested that selective culling may offer the greatest promise of reducing CWD prevalence, particularly when infected populations are detected early in the course of an epidemic. Because South Dakota is probably in the early phase of a CWD epidemic, we recommended that selective culling be implemented to aid in controlling or eliminating CWD in southwestern South Dakota. Although TB was not documented in this study, future surveillance is recommended to assess the prevalence of this disease in free-ranging cervid populations throughout the state.

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