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Distribution of Meningeal Worm (*Parelaphostrongylus tenuis*) in South Dakota

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ABSTRACT: Heads of hunter-harvested deer (*Odocoileus* sp.) and elk (*Cervus elaphus*) were collected from meat processing plants throughout South Dakota (USA) from 1997 through 1999 to determine distribution of meningeal worm (*Parelaphostrongylus tenuis*) in eastern and western South Dakota. A total of 2,848 white-tailed deer (WTD) were examined for *P. tenuis,* of which 578 (20.3%) were infected with the parasite. Of 578 deer infected, 570 (98.6%) were harvested east of the Missouri River. Our results indicate that *P. tenuis* is widely distributed throughout eastern South Dakota and limited to the southcentral region of western South Dakota. Infected WTD were documented in 37 of 44 counties in eastern South Dakota and three of 22 counties in western South Dakota. No meningeal worms were found on the meninges or cranial surfaces of 215 mule deer (*Odocoileus hemionus*) or 344 elk examined. These findings further define the distribution of the parasite throughout the state. We suggest that the Missouri River acts, in part, as a physical barrier to the westward expansion of *P. tenuis* to the grasslands of western South Dakota.

Key words: *Cervus elaphus,* elk, meningeal worm, mule deer, *Odocoileus hemionus, O. virginianus,* parasite, *Parelaphostrongylus tenuis,* South Dakota, white-tailed deer.

Meningeal worm (*Parelaphostrongylus tenuis*) is a parasitic nematode of white-tailed deer (WTD; *Odocoileus virginianus*) that occurs throughout the deciduous mixed-hardwood forests of eastern North America (Lankester, 2001). The parasite has been reported as far west as western Nebraska (USA) in the United States (Oates et al., 2000) and western Manitoba in Canada (Bindernagel and Anderson, 1972). *Parelaphostrongylus tenuis* has not been reported from areas having sandy soils and pine-dominated forests (Kocan et al., 1982) in the United States or the boreal mixed-wood forest of northcentral and western Canada (Wasel et al., 2003).

With the increased translocation of wild ungulates to restock historic ranges (Bryant and Maser, 1982) and to augment declining ungulate populations (Aho and Hendrickson, 1989), there is growing concern among wildlife biologists regarding the translocation of infected animals and the accidental introduction and subsequent establishment of *P. tenuis* in the western United States and provinces of Canada. In addition, increased translocations of ungulates to meet the demands of the growing game farm industry has dramatically increased the danger of inadvertently transmitting *P. tenuis* to previously uninfected areas (Samuel et al., 1992). Moreover, there is concern that *P. tenuis* might be expanding its range westward through the aspen parkland ecoregion, eventually arriving in western North America, where WTD occur sympatrically with susceptible ungulate populations (Samuel and Holmes, 1974; Wasel et al., 2003). The objective of this study was to determine the distribution of *P. tenuis* in the grassland biome of eastern and western South Dakota (USA).

Deer and elk (*Cervus elaphus*) heads were collected during the 1997–99 hunting seasons from meat processing plants distributed throughout the state by employees of South Dakota Department of Game, Fish and Parks (SDGFP) and South Dakota State University (SDSU). Meat locker and/or SDSU personnel attached ear tags labeled with the hunting unit to deer and elk harvested during the respective hunting seasons. Heads were transported to SDSU (Brookings, South Dakota) for processing. Heads were stored in a walk-in cooler pending necropsy.

Prior to examination, deer were classified as fawn, yearling, or adult based on patterns of mandibular tooth eruption and wear (Severinghaus, 1949). Elk adult age classes were estimated by extracting teeth and sectioning via the cementum annuli method (Keiss, 1969). The techniques and procedures utilized for inspecting heads for *P. tenuis* were described in Oates et al. (1999). Four *P. tenuis* specimens were entered in the parasite collection housed in the Harold W. Manter Laboratory of Parasitology (University of Nebraska, Lincoln, Nebraska; assession numbers HWML 16756-16757; HWML 16758-16759).

Of 2,948 WTD collected during the 3-yr collection period, 2,848 were examined for *P. tenuis* (100 were discarded due to unknown origin, severe cerebral hemorrhage, advanced stage of decomposition, or incomplete data). Overall prevalence of infection for all WTD was 20.3%. In addition, 306 mule deer (*Odocoileus hemionus*, MD; 91 were discarded due to unknown origin, severe cerebral hemorrhage, or incomplete data) and 410 elk (66 were discarded due to unknown origin, severe cerebral hemorrhage, or incomplete data) also were collected and examined for *P. tenuis.* No meningeal worms were found on the meninges or cranial surfaces of 215 MD or 344 elk examined. Because the cranial nerves, medulla, and other locations within and around the brain and spinal cord were not examined, it is possible that the percent of infected MD and elk was higher than what was recorded. Infected WTD were documented in 37 of 44 counties in eastern South Dakota and three of 22 counties in western South Dakota (Fig. 1). Prevalence of infection with *P. tenuis* was significantly higher in WTD examined in eastern (n=2,271) than in western South Dakota (n=577) (χ^2=159.933; df=1; P<0.0001). Of the 578 WTD infected with *P. tenuis,* 570 (98.6%) were harvested east of the Missouri River (Fig. 1).

Numbers of worms recovered were recorded in 472 of 578 infected WTD. Mean intensity of infection was 1.64 (±0.05 SE) worms per head. Maximum number of worms per deer was 11, which was recovered from a 2.5-yr-old female. Single worms were recovered from 62.7% (n=296) of all infected WTD. Two worms were recovered from 23.9% (n=113) of infected deer. Furthermore, three or more worms were recovered from only 13.4% (n=63) of infected deer. Most adult nematodes were embedded in the dura mater of the parietal regions of the brain. Ages of infected deer ranged from fawn to an 8.5-yr-old female. Inflammatory exudates of the cranial lining and meninges were documented in 17 additional deer in which *P. tenuis* was not found.

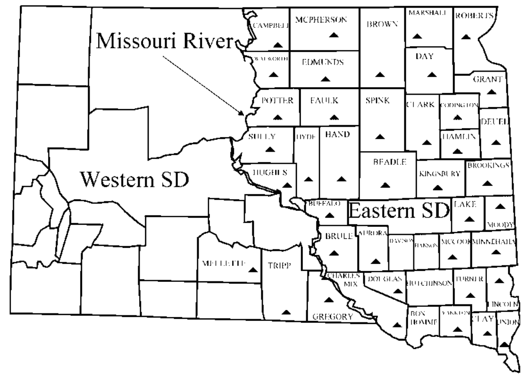

FIGURE 1. Distribution of meningeal worm in eastern and western South Dakota. Note separation of eastern from western South Dakota by the Missouri River. Black lines delineate individual boundaries while names identify specific counties. ▲ denotes counties with *Parelaphostrongylus tenuis* infected white-tailed deer throughout eastern and western South Dakota.

Distribution of *P. tenuis* in South Dakota, originally determined by Oates et al. (1999) to be the southcentral region of the state, can now be extended throughout eastern South Dakota and potentially the southcentral region of western South Dakota. In this study, four of eight deer infected in western South Dakota were females (three adults, one yearling), suggesting that these individuals may have been resident deer with established home ranges within the counties in which they were harvested. However, given the dispersal ability of WTD, it is possible that infected animals in western South Dakota emigrated from eastern South Dakota. Nevertheless, Grassel (2000) documented dispersal distances of less than 34 km for 20 radio-collared WTD in the Missouri River breaks region of central South Dakota; seasonal movement across the Missouri River by female WTD was documented in only one of 21 deer. Moreover, Nixon et al. (1991) documented female dispersal distances of less than 50 km in fragmented landscapes in Illinois (USA). Thus, dispersal movements in this region of the state seem to be minimal.

Our results indicate that to date, MD and elk populations throughout the state remain uninfected with *P. tenuis.* However, because only the meninges and cranial surfaces were examined for the parasite, the percentage of infected MD and elk may have been higher than what was recorded. However, Oates et al. (2000) documented the only occurrence of *P. tenuis* in a free-ranging MD in North America. Furthermore, prevalence of infection in elk in areas with infected WTD are not well documented (Lankester, 2001). Consequently, prevalence of infection in free-ranging MD and elk populations throughout South Dakota are likely minimal.

Samuel and Holmes (1974) suggested that an ecological barrier associated with prairie habitat may affect the survival of first-stage larvae (Shostak and Samuel, 1984), thereby preventing the western spread of *P. tenuis* with dispersing WTD. Furthermore, Lankester and Samuel (1997) suggested that the central grasslands may represent a physical barrier preventing the parasite from moving westward with dispersing white-tailed deer. Wasel et al. (2003) stated that this hypothesis was supported in Canada, where the present western-most distribution of *P. tenuis* in Saskatchewan has changed little from the late 1960s. In the United States, however, Oates et al. (2000) stated that prairie habitat did not act as a natural barrier to westward expansion of *P. tenuis* and that first-stage *P. tenuis* larvae could survive in prairie environments around rivers, streams, wet meadows, and lakes in sufficient numbers to infect WTD.

Our results indicate that the majority of WTD infected with *P. tenuis* were collected east of the Missouri River. Deer collected in all eight counties immediately adjacent to the Missouri River in eastern South Dakota were infected with *P. tenuis,* while infected deer were found in only one of five counties immediately adjacent to the Missouri River in the western region of the state. These results support the hypothesis that the Missouri River might possibly be acting, in part, as a physical barrier to the westward expansion of *P. tenuis* to the grasslands of western South Dakota. Furthermore, it is possible that the mixed grass prairie habitats of western South Dakota and the semiarid climate associated with this region restricts distribution and abundance of intermediate hosts, thereby limiting westward expansion of *P. tenuis* across the state. Most MD and all elk in South Dakota occur sympatrically with WTD populations in western South Dakota. Thus, wildlife managers should continue to monitor for *P. tenuis,* especially in areas of western South Dakota where the range of other susceptible ungulates overlaps that of the WTD.

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