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Elk Use of Wallows and Potential Chronic Wasting Disease Transmission

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ABSTRACT: Deposition of prions into the environment by infected animals may contribute to transmission and spread of chronic wasting disease (CWD) among free-ranging cervids, and identification of such environmental sources may provide an avenue for managing CWD. We evaluated the role that wallow use by elk (*Cervus elaphus*) may play in CWD transmission by monitoring wallows with animal-activated cameras throughout their period of use. We monitored 39 wallows from 5 August 2005 to 14 October 2005. Elk visited 20 sites; we recorded 22 events when only male elk wallowed and 374 additional events when male and female elk had naso-oral contact with wallow contents. Because wallows are foci of male elk activity, behaviors at wallows could potentially contribute to the maintenance and transmission of CWD. Our findings, however, suggest that because wallows are only used an average of one or two times a season they may not be important in CWD transmission. The data also suggest that mineral licks could be more important in CWD transmission because they were used more frequently and by three species that contract CWD.

Key words: *Cervus elaphus*, chronic wasting disease, elk, transmission, wallow.

Chronic wasting disease (CWD) is a naturally occurring transmissible spongiform encephalopathy that affects North American cervids such as deer (*Odocoileus* spp.), elk (*Cervus elaphus*; Spraker et al., 1997), and moose (*Alces alces*; Kreeger et al., 2006). Chronic wasting disease is a serious concern for wildlife managers, hunters, and the farmed-cervid industry throughout North America (Williams et al., 2002). Pathologic isoforms of prions, the infectious agents of CWD, are shed in saliva (Mathiason et al., 2006) and potentially in feces (Salman, 2003) and urine of cervids (Seeger et al., 2005). Chronic wasting disease prions may accumulate in the environment and persist ≥2 yr in soil (Johnson et al., 2006), thereby complicating efforts to eradicate CWD (Miller et al., 2004).

Communal use of relatively small areas, such as wallows, by cervids may facilitate transmission of CWD by serving as reservoirs for prion accumulation. Wallows are bowl-shaped depressions (Ripple et al., 1988), usually filled with muddy water, and are typically created near springs (Struhsaker, 1967) or within mineral licks (Murie, 1951). Although wallows are most easily identified after recent use, they can be recognized for years as small pools (Murie, 1951).

The behavior of wallowing is common among a variety of species in North America including bison (*Bos bison*; McMillan et al., 2000), elk (Struthsaker 1967), and moose (Altmann, 1959). During the breeding season (rut), male elk create a wallow or refresh an existing wallow with their antlers and hooves (Geist, 2002). They then urinate (Geist, 2002), occasionally ejaculate, and lie down, rubbing their sides, neck, antlers, and muzzle in the resultant odoriferous mud (Struthsaker 1967). Likely functions of wallowing include claiming territory (de Vos et al., 1967), cooling (Murie, 1951), repelling insects (Graf, 1956), and self-marking (Geist, 2002). Multiple elk may use a single wallow (Struthsaker 1967) and individuals occasionally revisit wallows (Geist, 2002). Communal use of wallows may increase the risk of CWD transmission through the shared use of a site contaminated with bodily excretions potentially including CWD prions. Our objectives were to examine the use of wallows by elk and to determine if activity at wallows were likely to facilitate CWD transmission.

We conducted our study in Rocky Mountain National Park (RMNP) in north-central Colorado (40°47′N, 105°75′W). Chronic wasting disease in elk was first recognized in RMNP in 1981 (Spraker et al., 1997). Prevalence rates of CWD in elk in game management units (GMUs) immediately adjacent to the region of RMNP where we conducted the study (GMUs 19 and 20) were 1.2 and 1.7% respectively (Miller, 2006). Our study area encompassed about 23 km^2 of meadows, coniferous forest, and alpine tundra ranging in elevation from 3,018 m to 3,463 m. We predicted locations of wallows based on topography and the presence of springs by reviewing topographical maps and aerial photography. We conducted ground searches during June and July 2005 to locate potential wallows. We considered depressions 1–2 m in diameter, >0.1 m in depth, and devoid of vegetation as potential wallows.

We collected data at wallows 24 hr/day, 7 days/wk using animal-activated digital cameras (Reconyx Silent Image, La Crosse, Wisconsin, USA). We installed cameras approximately 10 m to the south of wallows (to reduce the likelihood of overexposed images); cameras were attached low on trees (0.5 m above ground) to minimize damage by elk rubbing their antlers. We programmed cameras to take 99 images over a 2-min period upon activation with no lag between activations. Time, date, and temperature were recorded on each image. Images were stored on 512-MB compact flash cards capable of storing as many as 12,000 images, or 120 activations. We replaced flash cards and batteries twice/month.

We viewed images using Silent Image Map View Professional Software (Reconyx Silent Image). We defined each activation in which an animal was recumbent within a wallow a "wallowing event." Furthermore, we recorded a "contact event" for activations in which an animal did not lie down but made naso-oral contact with wallow contents. If >5 min lapsed between the end of an activation and beginning of another, it was considered independent unless we could confirm the same elk initiated both activations. We used unique physical characteristics (e.g., antlers) to differentiate among animals for estimating minimum numbers of individuals using wallows. To eliminate the possibility of recounting individuals, we used the maximum number of indistinguishable animals (e.g., unmarked cows and calves, typical mature bulls) captured in one image as the minimum number of individual animals using a wallow, likely resulting in conservative estimates. Lastly, when discernable, we documented urine spraying and naso-oral contact by wallowing individuals.

We calculated scaled activity indices to account for inconsistencies in camera operation (due to effects of differing levels of animal activity on battery life) and to standardize values. We first defined the wallowing period as the total number of hours cameras were functioning between first and last events for a given wallow. We then calculated a wallowing index (WI) for each wallow based on the wallowing period divided by 24 hr (D=total number of days the cameras were functioning). Lastly, we divided the total number of wallowing events (WE) by D ($WI=WE/D$). Additionally, we used a similar method to describe general use involving nonwallowing naso-oral contact with wallow contents (contact index, CI), but focused on the number of days that cameras were functioning between the first and last contact events (contact period). We divided the total number of contact events (CE) by days ($CI = CE/D$).

We monitored 39 focal sites (32 wallows and seven mineral licks in which wallowing occurred) from 5 August 2005 to 15 October 2005. Most wallowing events (17 of 22; 77%) occurred between 2:00 PM and 9:00 PM and occurred between 29 August and 8 September 2005 (16 of 22; 73%). The 22 wallowing events occurred at 13 sites and we documented a minimum of 16 male elk wallowing. The minimum number of animals involved in wallowing events ranged from one at nine sites to three at two sites. We were able to ascertain the act of urine spraying during 36% of the wallowing events and naso-oral contact in 86%. Most wallowing events ($n=16$) occurred in distinct wallows and the remaining six occurred in mineral licks. We also noted six events when elk established new wallows <5 m from previously existing wallows. Three pairs of events likely involved the same individual wallowing for two consecutive events though we could not confirm identities. We recorded one wallowing event at seven sites, two events at four sites, three events at one site, and four events at one site. We once documented two young males wallowing concurrently. The total *WI* was 0.09 (range: 0.04–0.31; $n=13$). The site with the highest *WI* (M2; 0.31) was a mineral lick that also received a high level of contact events.

Prevalence rates of CWD in mule deer in the RMNP vicinity have been higher in adult males than in sympatric adult females (Wolfe et al., 2004) and a similar trend has been documented in elk (Colorado Department of Natural Resources, 2003). We found that only males wallowed, and males having ≥four points/antler represented the majority of elk wallowing (21 of 22; 95%) and 14 events (65%) involved males having ≥five points/antler. Thus, most animals we documented wallowing represent the sex and age class most likely to contract CWD.

In addition to wallowing-specific behaviors, we also documented 374 contact events in which elk (52% males) made naso-oral contact with contents of sites. Furthermore, 63 mule deer (86% females) and 2 female moose made naso-oral contact with contents of sites. Contact events occurred at 20 sites, including all sites where wallowing occurred. The total *CI* was 0.39 (range: 0.00–3.25; $n=20$). The minimum number of animals involved in contact events ranged from zero at four distinct wallows to 17 at a mineral lick.

Of the sites monitored, only 13 were visited for wallowing purposes during the study, suggesting that not all wallows are used annually. We found no visual evidence of wallowing until the third week of August and none after 19 September. The rut typically begins 2 wk prior to the autumnal equinox (22 or 23 September; Hudson and Haigh, 2002), which coincided with the beginning of a weeklong period in which we recorded no wallowing activity. Thus, the duration of potential exposure to prions through the act of wallowing was only about 3 wk.

Based on existing literature, the behaviors associated with wallowing elk lend to a probable scenario for disease transmission. However, the low frequency of wallow use that we documented combined with the low number of individuals wallowing suggests the risks associated with wallowing were low within our study area. Our data on use of mineral licks accentuate the greater potential for disease transmission therein.

In addition to wallowing within mineral licks, we noted communal use involving naso-oral contact with lick contents within and among susceptible cervid species. Naso-oral contact included drinking, consumption of soil, or inhalation and these are all actions that may lead to disease transmission. Oral contact with contaminated materials is an effective means for contracting disease by grazing and foraging animals and may result in the dissemination of prions in saliva (Bartz et al., 2003; Mulcahy, 2004).

The potential for the transmission of disease agents increases when individuals concentrate and share resources (Miller et al., 2004). Wallowing can lead to resource sharing and has been hypothesized to result in transmission of anthrax in bison (*Bison bison*; Dragon et al., 1999), *Cryptosporidium parvum* oocysts and

Giardia in feral hogs (*Sus scrofa*; Atwill et al., 1997), and paratuberculosis in farmed elk (Manning et al., 1998). Dependent on environmental stability, infectious agents shed in bodily excretions could potentially reside in wallows. Consequently, animals may coat their pelage with contaminated mud and potentially ingest infectious agents through grooming (DeJoia et al., 2006). Furthermore, the frequency of grooming by elk peaks in autumn (Mooring and Samuel, 1998), increasing the risk of contracting prions (Wolff and Van Horn, 2003).

A better understanding of CWD transmission among wild cervids is needed. In particular, the roles of direct animal-to-animal transmission relative to environmental transmission routes should be quantified. If transmission via environmental contamination predominates, then the ability to manage CWD could hinge on whether it occurs uniformly or patchily within cervid habitats. Assuming effective environmental decontamination and pharmacologic management tools can be developed; identification of spatial hotspots of transmission could make some form of spatially focused management of CWD feasible in wild populations. The behaviors we documented at both wallows and mineral licks make them logical candidate sites for disease transmission. Our data, combined with existing literature, suggest use of wallows by elk has limited potential to contribute to the spread of CWD and other diseases when compared to mineral licks.

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