2019

Quantifying Signpost Usage by Captive Male White-Tailed Deer

Cassie L. Auxt

Eric S. Michel

Jonathan A. Jenks

QUANTIFYING SIGNPOST USAGE BY CAPTIVE MALE WHITE-TAILED DEER — White-tailed deer (*Odocoileus virginianus*) use rubbing of signpost structures to communicate during the breeding season. Rubbing of signpost structures allows deer to communicate via visual and chemical cues, which allows them to establish dominance hierarchies and maintain hierarchal status throughout the breeding season (Moore and Marchinton 1974, Miller et al. 1981, Hewitt 2011). Once a living tree is rubbed, the exposed light-colored sapwood creates a stark contrast in wooded areas, increasing visibility and further enticing deer to investigate the structure (Oehler et al. 1995). Anatomically, the tubular apocrine sudoriferous glands of white-tailed deer are located at the antler base on the forehead (Atkeson and Marchinton 1982), which creates a challenge when depositing gland secretions to either vertical or horizontal signposts. When at the rub, chemical communication ensues via olfactory senses because of the unique gland secretions deposited from the tubular apocrine sudoriferous glands (Atkeson and Marchinton 1982). Signpost communication via secretions allows males and females to gather reproductive information, leading to potential breeding opportunities (Sawyer et al. 1989, Miller et al. 1991). Signpost communication is important during the breeding season because male breeding success is limited by breeding attempts, and using signpost structures increases the potential for a male to find a mate (Moore and Marchinton 1974).

Understanding specific characteristics of signpost use (e.g., period of maximum use during breeding season, day vs. night, horizontal vs. vertical) is important to further understand communication among deer during the breeding season. Signpost use frequency declines through the breeding season after hierarchies are established and maintained (Ozoga and Verme 1985), although secretions left by males continue to convey information on dominance and their physiological state (Sawyer et al. 1989). Crepuscular activity patterns are common among male deer with midday activity being less than their female counterparts (Beier and McCullough 1990), though diurnal use increases throughout the breeding season for males (DeYoung and Miller 2011). Regardless, given the increased diurnal activity of males during the breeding season, the role of signpost structures in visual or olfactory communication is unknown. Specifically, it is unknown if signpost use is more important as a visual or olfactory communication method.

Our objective was to quantify characteristics of signpost use among captive male white-tailed deer. We specifically assessed the period of maximum use during the breeding season (e.g., pre-, peak-, or post-breeding), variation in use between diurnal and nocturnal periods, and whether or not use varied between horizontal and vertical signposts. We predicted that signpost use would be maximized during the pre-breeding season, that males would use signpost structures more during daylight hours compared to night due to increased visibility during daylight hours, and that vertical signposts would be favored due to anatomical location of scent glands.

We conducted our study at the South Dakota State University Wildlife Research Unit in Brookings County, South Dakota, USA. The 1.01-ha facility housed 20 males and 6 females, and all individuals had access to the same areas within the facility. We placed one horizontal and one vertical signpost structure on the North, South, and West ends of the facility. We placed horizontal and vertical signpost structures about 3 meters apart with motion activated cameras (Moultrie M-880 Gen 2) placed about 5 meters away and perpendicular to each signpost structure. We programmed cameras to take three pictures in a burst with a 15-second interval between successive pictures. We deployed cameras on 5 October 2017 and removed them 1 December 2017. We examined pictures weekly through the 9-week study period to determine maximum signpost use by week and time of day, as well as whether or not vertical or horizontal signposts were favored. We estimated peak-breeding dates by backdating 210 days (mean gestation length; Demarais et al. 2000) from the peak-parturition date reported from captive white-tailed deer in North Dakota (Michel et al. 2017). Michel et al. (2017) reported peak parturition occurring from 27 May to 16 June, when 71% of total birthing events were observed. Based on those dates, we defined the pre-breeding season as 5 October to 28 October, the peak-breeding season as 29 October to 8 November, and post-breeding season as 9 November to 1 December. We classified signpost usage as occurring diurnally if rubbing behavior occurred from 30 minutes before sunrise through 30 minutes after sunset. We defined rubbing behavior as males displaying a braced body stance with their antler base contacting the signpost (Moore and Marchinton 1974). We considered rubbing events as independent if a male removed his head and body away from the structure and then returned to the signpost structure and displayed rubbing behavior. We used t-tests in Program R (R version 3.4.3, 2017) to assess if diurnal use differed from nocturnal use and if use of vertical structures differed from horizontal structures ($\alpha = 0.05$).

We observed 13 males that interacted with signpost structures 169 times during the 9-week period. Males displayed a general pattern of use occurring most frequently during the pre-breeding time period (66%), followed by post-breeding (19%), and then peak-breeding (15%). Diurnal signpost use was greater ($\bar{x} = 0.91 \pm 1.05$ uses/day; $t_{326} = 3.43$, $P < 0.001$, $n = 169$) than nocturnal use ($\bar{x} = 0.55 \pm 0.87$). Males used vertical signpost structures more frequently ($\bar{x} = 1.22 \pm 1.02$ uses/day, $t_{270} = 10.93$, $P < 0.001$, $n = 169$) than horizontal signposts ($\bar{x} = 0.24 \pm 0.59$ uses/day).

Our results support our prediction that greatest use of signpost structures would occur during the pre-breeding time period. From signposts, males and females gather information regarding reproductive and dominance status (Sawyer et al.

1989, Miller et al. 1991), which can occur through physical and non-physical interactions (DeYoung et al. 2006). Males use signposts as dominance areas where portions of home ranges are marked by rubs (Moore and Marchinton 1974). Additionally, males increase use of signposts during the pre-breeding period as female reproductive periods are linked to photoperiod and females begin communicating information regarding their receptivity during the pre-breeding period when changes in day length occur (Verme et al. 1987, Miller et al. 1991, Dye et al. 2012). Heavy male white-tailed deer with large antlers are generally more dominant than lighter males with smaller antlers and thus, tend to have increased breeding opportunities as females enter estrus (Ozaga and Verme 1985, DeYoung et al. 2006, Festa-Bianchet 2012). Increased reproductive attempts are facilitated by the use of signposts during the pre-breeding season (Moore and Marchinton 1974), stressing the importance of signpost communication in the early breeding season.

Males displayed diurnal signpost use 60% more than nocturnal use, suggesting signposts may be important for visual communication. Oehler et al. (1995) also showed that males rub trees with a mean first branch height of 69.9 cm (Oehler et al. 1995) to reduce interference from branches and leave more open space at rub height for optimal visibility. When signposts are more visible, males are visually led towards the rub site, where males can rub the signpost, leaving their own scent so olfactory communication can ensue (Hirth 1977, DeYoung and Miller 2011). Male deer actively search for female counterparts during the breeding season (Hirth 1977), and signpost visibility should be important in allowing males to use visual and olfactory communication

Our results also support our prediction that males would use vertical signpost structures more than horizontal structures. Deer tend to target standing trees for signpost use in wild herds (Moore and Marchinton 1974), and frequent use of vertical structures in the captive herd could be due to innate behaviors. The sudoriferous glands are located on the forehead of the deer and need to be agitated to deposit secretions on a signpost (DeYoung and Miller 2011). Given the general configuration of male antlers, vertical signposts are likely the most effective structure to use by male deer when making contact with the forehead region to deposit secretions.

Overall, signpost use is a crucial communication tool that provides several pieces of information among individuals. We do not fully understand how far olfactory cues are transmitted from signpost structures; therefore, locating signpost structures via visual aid may be important to maximize olfactory communication by better allowing males to see these communication sites during daylight hours. Signpost use during the daylight hours is important to the entire breeding process because males establish and maintain dominance hierarchies by attracting individuals to their mark locations, which then communicates via olfaction the individuals that have visited the location. Signposts are most visible during the day, allowing males to notice and interact with rubs to gain important information. Although extrapolation of our results from captive to free-ranging populations should be done with caution, this study provides a baseline of rubbing characteristics in the northern Great Plains for comparison to those populations.

We thank Southeast South Dakota Branch of the Quality Deer Management Association for financial assistance, as well as the Department of Natural Resource Management at South Dakota State University for providing the study area.—*Cassie L. Auxt, Eric S. Michel, and Jonathan A. Jenks. Department of Natural Resource Management, South Dakota State University, Brookings, SD 57007–1696, USA. Corresponding author: eric.michel@state.mn.us.*

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Submitted: 21 Sep 2018. Accepted: 13 May 2019
Associate Editor: Colter Chitwood