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ASSESSING PARTURITION DATE SYNCHRONY FOR NORTH DAKOTA UNGULATES

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ASSESSING PARTURITION DATE SYNCHRONY FOR NORTH DAKOTA UNGULATES—Reproductive parameters such as conception date, and therefore parturition date, influence offspring characteristics such as sex ratio and birth mass. For example, late-conceiving reindeer (*Rangifer tarandus*) produced more female than male offspring compared to those who conceived early (Holand et al. 2006). Females that conceive later and therefore give birth later also can produce lighter offspring compared to those who conceive early (Schwartz et al. 1994, Holand et al. 2006). Because birth mass is positively related to adult body mass (Michel et al. 2015), conception and parturition date likely affect adult phenotype. In turn, this may influence survival because heavy birth mass increases the probability of overwinter survival of ungulates at northern latitudes (Loison et al. 1999, Côté and Festa-Bianchet 2001).

Knowing parturition dates can help in managing wildlife populations. For example, mean parturition dates for a population can be used as an indicator of population health because high-density populations are generally above nutritional carrying capacity and, as a result of nutritional limitations, will likely display mean parturition dates later than other populations (e.g., white-tailed deer, *Odocoileus virginianus*; Demarais et al. 2000). Knowing when peak parturition occurs is important to management; however, currently there are no parturition date estimates available for ungulate species in North Dakota, USA. Reporting mean parturition dates for these species will serve as baseline information that wildlife managers can use for comparison to free-ranging populations. Wildlife managers also can derive estimates of mean conception dates from reported parturition dates, which allows for them to adjust hunting seasons to coincide with peak breeding. Adjusting hunting season structure may be desired as male movement generally increases during the breeding season (Webb et al. 2010).

Our objective was to summarize reproductive data and assess whether parturition date synchronization occurs for captive female moose (*Alces americanus*), mule deer (*O. hemionus*), and white-tailed deer located in North Dakota, USA. Ungulates found in northern temperate regions synchronize parturition to coincide with spring green up (Sekulic 1978) even in the absence of predators (Post et al. 2003). This ensures the highest quality vegetation is available during late gestation and lactation, the most energetically demanding time periods during female reproduction (Pekins et al. 1998, Parker et al. 2009). Parturition date synchronization also is used as a predator avoidance strategy because predators reach satiation before they are able to consume all offspring (Ims 1990, Sinclair et al. 2000). Therefore, we predicted that parturition would be highly synchronized, with 80% of all parturition events occurring within two weeks of mean parturition as documented for other ungulate species (e.g., Bowyer et al. 1998, Côté and Festa-Bianchet 2001).

We collected parturition data from the Dakota Zoo, Bismarck, North Dakota, USA, and the Roosevelt Park Zoo, Minot, North Dakota, USA. The Dakota Zoo housed moose, mule deer, and white-tailed deer while the Roosevelt Park Zoo housed white-tailed deer only. Zoos acquired all animals from North Dakota (or individuals were born in captivity at the zoo) and parturition data we report occurred from 1982 through 2010. Zoo handlers separated all animals by species, with adults and young-of-the-year housed together. In the Dakota Zoo, one adult bull and one adult cow moose were housed together in a 0.60-ha enclosure. One male was housed with two adult females for mule deer and white-tailed deer exhibits. Each of the deer enclosures were 1.40 ha in size. In the Roosevelt Zoo, we obtained data only for white-tailed deer, which were housed as one adult male with one adult female in a 0.15-ha enclosure. All housing, display, and handling procedures followed the guidelines of the Association of Zoos and Aquariums (2016).

Parturition dates varied by species. Mean parturition date was earliest for moose (10 May ± 6.7 days, $n = 20$), followed by white-tailed deer (6 June ± 10.3 days, $n = 100$) and mule deer (June 18 ± 12 days; $n = 33$). Parturition dates were most synchronized for moose (80%), followed by white-tailed deer (71%) and mule deer (58%).

Our results for moose were consistent with our prediction, as parturition date was highly synchronized; 80% of births occurred within two weeks of mean parturition and all births occurred within the month of May. Synchrony in our study was comparable to two wild moose populations in Alaska, USA, where 80% (Bowyer et al. 1998) and 67% (Schwartz and Hundertmark 1993) of births occurred over an 11- and 7-day period, respectively. Some ungulates such as bighorn sheep (*Ovis canadensis*) are known to adaptively vary timing and synchrony of births to coincide with environmental changes (Whiting et al. 2011). However, the lack of variation in parturition date that we report for captive moose supports the conclusion of Bowyer et al. (1998) that moose may have adapted their parturition dates over long-term patterns of climate and presence of predators and, in turn, may not be as sensitive as other ungulates to abrupt changes in climate.

Our results for white-tailed deer partially supported our prediction, as parturition dates were moderately synchronized, with 71% of births occurring within two weeks of mean parturition and 93% occurring within one month of mean parturition. White-tailed deer are a highly adaptable species (Simard et al. 2008, Monteith et al. 2009, Michel et al. 2016). The range of parturition dates that we report for white-tailed deer supports this concept and suggests that the species may be more plastic and better able to adjust its breeding strategies relative to environmental cues compared to other ungulates.

Our results for parturition dates of mule deer did not support our prediction, as only 58% of births occurred within two weeks of mean parturition; however, 91% of births occurred within one month of mean parturition. Our results are in contrast to those of Freeman et al. (2014) who reported that synchrony was much greater for populations of mule deer in Utah (91.6%) and Colorado (89.8%). The discrepancy between our study and Freeman et al. (2014) suggests that mule deer in North Dakota may be more plastic and able to adjust parturition dates to coincide with their environment. These results emphasize the importance of understanding differences in life-histories among ungulate species when considering differences in breeding strategies.

Although we provide the first parturition date estimates from three captive ungulate species derived from North Dakota, USA, comparisons to wild populations should be made with caution. For example, some ungulate species are known to produce phenotypes consistent with their environment within two generations (about 10 years; Monteith et al. 2009, Michel et al. 2016). Parturition dates derived from captive populations may therefore become inconsistent with wild populations due to a lack of selective pressures (e.g., high nutritional quality and quantity, lack of predators) or because they vary across a species' range relative to changes in environmental conditions. Alternatively, parturition date may be a highly canalized trait, which in addition to forage quality and predation, also is influenced by regional climate. Heavy juveniles often display increased overwinter survival; thus, being born at an optimum time would allow for the longest growing period to reach an adequate body mass before winter (Loison et al. 1999, Côté and Festa-Bianchet 2001). Consequently, regional parturition synchrony would not be expected to vary between wild and captive populations; however, this is purely speculative. Regardless, our estimates provide baseline data for use by wildlife managers for comparisons to wild populations.

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