Am. Midl. Nat. (2015) 173:162–167

Notes and Discussion

Extended Duration of Parturition Season in North American Elk (Cervus elaphus)

Abstract.—The timing of births in ungulates has significant implications for juvenile survival and population growth. For North American elk (*Cervus elaphus*), typical parturition season ranges from late May to early Jun., and juveniles born outside of this peak characteristically exhibit lowered survival. We observed abnormally long parturition seasons in free-ranging elk populations in Missouri and South Dakota during 2012. Both populations exhibited late births; the last known births occurred on 26 Sep. in Missouri and 4 Sep. in South Dakota. Duration of parturition season was 112 and 119 d in Missouri and South Dakota, respectively. In Missouri, late births likely resulted from breeding by both yearling females and males. Late parturition in South Dakota may be caused by extended estrous cycles of elk that occurred on high quality range where few adult males were located.

Introduction

Birth synchrony in ungulates influences juvenile survival and population growth. Synchrony of births is hypothesized to be an evolutionary adaptation to avoid neonatal predation (Sinclair *et al.*, 2000). Additionally, individual neonates born early or late in the parturition period may be subject to higher mortality caused by adverse weather conditions, poor nutritional quality of forage available to the mother, and less time to store adequate fat reserves for winter survival (Guinness *et al.*, 1971; Nelson and Leege, 1982). All these factors contribute to lowered survival of juveniles born outside the peak of parturition (Guinness *et al.*, 1978).

Typical parturition season for elk through much of its range is late May to early Jun. (Morrison *et al.*, 1959; Hudson *et al.*, 2002). Although timing of breeding and parturition season in temperate and northern ungulates fundamentally is constrained by photoperiod (Budde, 1983), extensive variation does occur. The reported duration of elk parturition seasons ranges from 50 d in California (McCullough, 1969), to 15–22 d in Montana (Johnson, 1951; Harris, 2007), and 37–67 d in southeastern Kentucky (Larkin *et al.*, 2002).

We documented lengths of parturition seasons in elk populations in southern Missouri and western South Dakota. Elk were translocated from Kentucky to Missouri in 2011 and 2012, in an effort to re-establish a free-ranging elk population in the state. The elk population in the southeastern portion of the Black Hills, South Dakota, recently has exhibited lower population growth. A study of juvenile survival and recruitment was initiated in an effort to understand the factors contributing to the lower population growth in this herd.

Methods

Study Area

Missouri.—The elk restoration zone included an 896 km^2 area within the Ozark Highlands physiographic region of southcentral Missouri. Elk were released on the Peck Ranch Conservation Area (latitude 37.039363, longitude −91.141520 DD, NAD 1983) and Chilton Creek Preserve (latitude 37.088499, longitude −91.081999 DD, NAD 1983). The study areas were composed primarily of mixed oak (*Quercus* sp.) hickory (*Carya* sp.) forest and woodland and lesser amounts of shortleaf pine (*Pinus echinata*) forest and woodland.

South Dakota.—The study area was located in Custer and Pennington counties in southwestern South Dakota (latitude 43.813724, longitude −103.510897 DD, NAD 1983) and consisted of interspersed public and private land in the southern part of the Black Hills physiographic region (Flint, 1955). The study area was dominated by ponderosa pine (*Pinus ponderosa*) forest, with smaller patches of aspen (*Populus tremuloides*), bur oak (*Quercus macrocarpa*), paper birch (*Betula papyrifera*), and white spruce (*Picea glauca,* Larson and Johnson, 1999).

FIELD METHODS

Missouri.—On 5 May 2011 the Kentucky Department of Fisheries and Wildlife and the Missouri Department of Conservation (MDC) translocated 34 elk [15 adult females (AF), six two-year-old males (AM), five yearling females (YF), eight yearling males (YM)] to Missouri from Kentucky (hereafter the 2011 release cohort). Elk were held in facilities at the Peck Ranch Conservation Area (PRCA) for a 27 d quarantine. Elk were released from the facilities on 1 Jun. 2011.

On 19 May 2012 an additional 35 (22 AF, four AM, three YF, and four YM) elk, including one neonate born in the Kentucky holding pens, were transported to PRCA (hereafter the 2012 release cohort). The elk were held for a 30 d health quarantine and the pregnant and lactating females were released directly from the PRCA holding facility on 19 Jun. 2012. Some female elk reached parturition while in holding pens before release and these neonates were released with their dams from the PRCA facility on 19 Jun. 2012. The yearling, nongravid females, 1 gravid female, and male elk were transported to temporary holding facilities on Chilton Creek Preserve on 21 Jun. 2012 and released on 23 Jun. 2012.

Before release in Missouri each year, we fitted each adult and yearling elk with a GPS-PTT radiocollar (Northstar Science and Technology, King George, VA). We monitored movements of free-ranging female elk to determine when they may be calving. When GPS locations demonstrated that a female elk had become isolated from other individuals and had restricted its movement, we scheduled a field search. We downloaded a cluster of the locations of the female to a handheld GPS unit (Garmin GPS map76CSx, Garmin International, Inc, Olathe, KS) for location in the field. We searched in a grid around this cluster of locations with crews that consisted of 2–16 people to locate the neonate. We also monitored the location of the female with handheld VHF receivers and antennas. If a female was observed in the field we searched terrain between ourselves and the location of the female. When a neonate was located, we restrained it manually and estimated the birth date by the appearance of umbilicus, hoof formation (Johnson, 1951), and the timing of movements by the female.

South Dakota.—We captured adult female elk by use of tranquilizer dart guns from helicopters (QuickSilver, Peyton, Colorado) during Feb. in both 2011 and 2012. Elk were sedated with butorphanol, azaperone, and medetomidine sedation protocol (Mich *et al.*, 2008). After elk were sedated, we blindfolded and fitted them with store-onboard satellite radio-collars (Telonics Inc., Mesa, AZ; Advanced Telemetry Systems Inc., Isanti, MN). We aged elk through evaluation of cementum annuli from an upper canine tooth extracted during capture (Matson's Lab, Milltown Montana; Hamlin *et al.*, 2000). We also collected approximately 20 ml of blood from captured elk. Female elk were inspected for pregnancy with rectal palpation (Greer and Hawkins, 1967; Vore and Schmidt, 2001). Females suspected of being pregnant were fitted with a vaginal implant transmitter (Advanced Telemetry Systems, Isanti, MN). We used serum from blood to verify pregnancy based on protein B specific for pregnancy via radioimmunoassay (Noyes *et al.*, 1997). We used vaginal implant transmitters to determine parturition dates and locate calves postpartum (Barbknecht *et al.*, 2009). A veterinarian was present to extract teeth, test for pregnancy, and implant transmitters.

We located female elk by use of radio-collars daily from 1 Apr.–31 Oct. From 1 Nov.–31 Mar., elk were located 5 d per week. We estimated the locations of female elk by triangulation with a handheld yagi antenna, and when possible used telemetry to visually confirm the location of the elk. When female elk behavior indicated possible parturition (*i.e.*, isolation and limited movements), we located female elk twice daily and monitored VIT signals in the morning and evening. When the VIT signal indicated parturition, one or two investigators with telemetry gear located and observed the female that had the neonate. After the female elk was located additional investigators were brought into the area to search for the neonate. The group of investigators searched a grid around the location of the female elk to find the neonate. Birth date was estimated based on the VIT signal. Additionally, we evaluated the appearance of umbilicus and hoof formation (Johnson, 1951) to confirm the initial estimate of timing from the VIT signal.

RESULTS

MISSOURI

In 2011, we captured seven neonates born to 2011 release cohort females that were bred in Kentucky. All of these neonates were captured inside the holding facilities at PRCA before the elk were released.

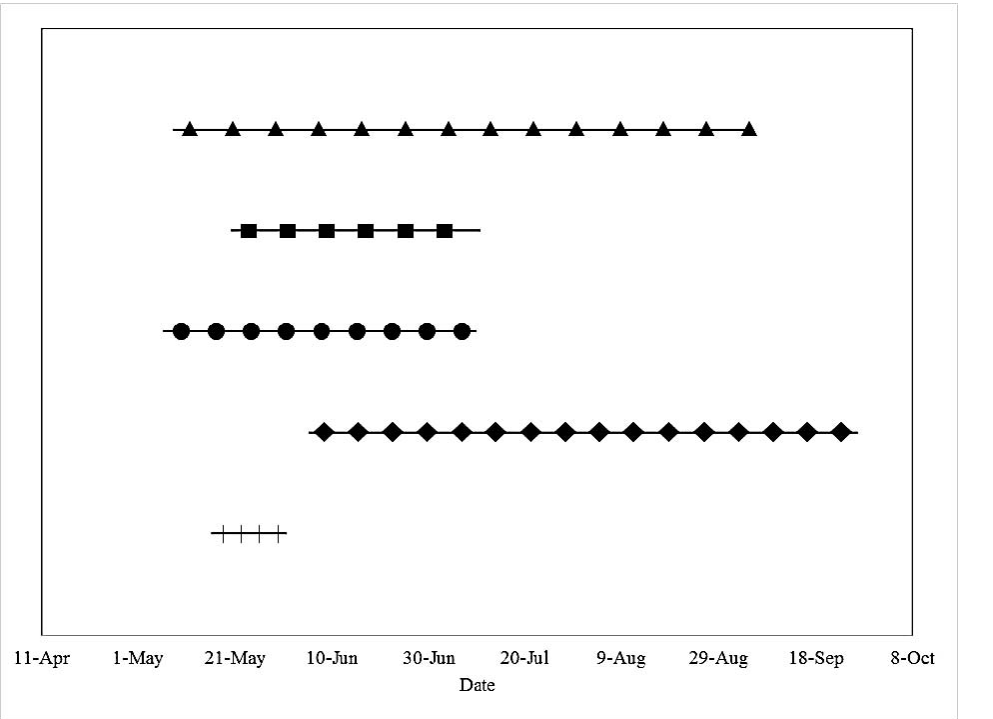

FIG. 1.—Duration of calving season for elk (*Cervus elaphus*) translocated to Missouri during 2011 in 2011 (+) and 2012 (♦), elk translocated to Missouri during 2012 in 2012 (●), and elk in the Black Hills of South Dakota in 2011 (■) and 2012 (▲)

The parturition season for these females ranged from 17 May to 31 May 2011, resulting in a parturition season duration of 15 d and median parturition date of 29 May (Fig. 1). We observed two additional elk neonates born outside the holding facilities for which we were unable to estimate parturition date.

During the 2012-parturition season, we captured nine neonatal elk born to 2011 release cohort females that were bred in Missouri. We estimated the parturition date based on behavioral cues of the female for one neonate that we were unable to capture but observed in the field. The parturition season for females bred in Missouri ranged from 6 Jun. to 26 Sep. 2012, resulting in a parturition season duration of 112 d and median date of 18 Jul. 2012 (Fig. 1). Three of five 2011 release cohort females that were yearlings during the 2011–2012 breeding season produced neonates in 2012. These three neonates accounted for the three latest births with dates of 27 Aug., 22 Sep. and 26 Sep.

During the 2012 parturition season, we captured 13 neonates born inside the pens at the PRCA to the 2012 release cohort females. After the elk were released, we captured three neonates born to the 2012 release cohort. We were unsuccessful in locating two neonates born to 2012 release cohort females that subsequently were seen alone with the female; we estimated those birth datee based on behavioral cues of the females. The parturition season for the 2012 cohort females bred in Kentucky ranged from 7 May to 9 Jul. 2012, resulting in parturition season length of 53 d and median date of 9 Jun. 2012 (Fig. 1).

During 2012, parturition was less synchronous in the 2011 release cohort contrasted to the 2012 release cohort. We observed a peak in parturition for both release cohorts during the 32 d period from 29 May to 21 Jun. This period accounted for five of the 2011 release cohort (50%) births and 15 of the 2012 release cohort births (83%).

SOUTH DAKOTA

In 2011, we captured 30 elk neonates and the parturition dates ranged from 21 May through 10 Jul. The parturition season was 51 d with a median date of 1 Jun. In 2012, we captured 37 elk neonates and parturition dates ranged from 9 May through 4 Sep. Parturition season duration was 119 d with a median date of 28 May. Parturition was less synchronous in 2012 than in 2011 (Fig. 1). We observed a peak in parturition during the 9 d period from 27 May through 4 Jun. that accounted for 76% of births in 2011 and only 54% of births in 2012.

DISCUSSION

We report atypical parturition season lengths for both Missouri and South Dakota elk herds in 2011 and 2012. Parturition seasons of 112–119 d are much longer than normal parturition season lengths and indicate asynchronous parturition. More typical parturition season dates would be 26–70 d in length (Barbknecht *et al.*, 2010; Griffin *et al.*, 2011). Ungulate parturition seasons may be extended in southern climates where the peak of nutritional quality of native forages is longer in duration contrasted to northern climates (Brokx, 1972; Bowyer, 1991), where the breeding male (Larkin *et al.*, 2002) or female (Albon *et al.*, 1986; Mitchell and Lincoln, 1973) population is skewed toward young-aged individuals, where the nutritional condition of females is poor (Albon *et al.*, 1986; Mitchell and Lincoln, 1973) or good as in areas where supplemental feeding occurs because of its effects on physiological condition of females (Smith, 1994). To our knowledge, only one other study reported a possible parturition in Sep. for a nonsupplementally fed elk herd. This study was based on a fetus from a hunter-harvested elk in Alberta (Wishart, 1981).

In Missouri, translocation likely played a role in the extended parturition season and late births observed for the 2011 release cohort during 2012, because prime-aged males were not translocated and the elk population was comprised of young males (≤2.5-years-old) during the 2012 breeding season. In general, breeding dominated by young males tends to increase the length of the breeding season and calving season (Noyes *et al.*, 1996; Larkin *et al.*, 2002). In contrast, the shorter parturition seasons of elk that were bred in Kentucky and released in Missouri reflect the effects of male demographics on calving season duration. Males were observed with female groups during the 2012 breeding season in Missouri, so it is unlikely that female groups were isolated from male groups as occurred in Kentucky shortly after release (Larkin *et al.*, 2002). However, the effects of chronic stress due to the extended holding period in Kentucky and Missouri on the ability of the females to enter estrus may also play a role in the late births that we observed.

Breeding of young females also can contribute to late parturition. The three latest births in the Missouri elk population were neonates born to two-year-olds. Yearling females must be in good nutritional condition and reach 65–70% of their adult mass to undergo estrus (Wisdom and Cook, 2000). Mild winters in southern Missouri may allow elk to continue to gain rather than lose weight during winter. Thus, Missouri yearlings may have entered estrus after achieving the threshold mass but not until Dec. and Jan.

In South Dakota, late parturition could be related to availability of higher nutritional forages and effects on physiological condition of females. Each year of the study late parturition events occurred on private land at the eastern edge of the study area. Elk in that portion of the study area foraged regularly in alfalfa (*Medicago sativa*) fields. Both female elk that had late parturition dates were prime aged females (six years old in 2011, seven years old in 2012). It is unknown why these females were not bred during the normal rut cycle of Sep. Perhaps it was related to the low density of elk in that management unit. Survey data indicate fewer than 0.001 elk per hectare in that management unit from 2011–2012 with adult male:female ratio <1:10 (SDGFP, unpublished data). Home range data and field observations during the breeding season indicated radio-marked female elk were in smaller groups (1–5 individuals) without adult males at varying times across the breeding season.

Acknowledgments.—Funding for this research was provided by the Rocky Mountain Elk Foundation, the University of Missouri, the Missouri Department of Conservation, and the South Dakota Department of Game, Fish and Parks. Field support in Missouri was provided by R. Houf, P. Mabry, M. Price, P. Vessels, S. Snow, T. Wolf, T. Schrautemeier, J. Ashling, D. Neel, J. Foggia, and S. Raiman.

Field support in South Dakota was provided by D. Fogarty, A. Coleman, K. Kaskie, N. Markl, L. Schmitz, T. Gingery, M. Lenny, G. Lenny, L. Flack, and K. Knudsen. Additional field assistance and technical support was provided by The United States Forest Service Rocky Mountain Research Station. All handling, marking, and monitoring procedures were approved by the South Dakota State University Research Committee (Animal Care and Use Committee Approval Number 11-012A) and the University of Missouri Research Committee (Animal Care and Use Committee Approval Number 6909).

LITERATURE CITED

ALBON, S. D., B. MITCHELL, B. J. HUBY, AND D. BROWN. 1986. Fertility in female red deer (Cervus elaphus): the effect of body composition, age, and reproductive status. *J. of Zool.*, **209**:447–460.

BARBKNECHT, A. E., W. S. FAIRBANKS, J. D. ROGERSON, E. J. MAICHAK, B. M. SCURLOCK, AND L. L. MEADOWS. 2010. Elk parturition site selection at local and landscape scales. *J. of Wildl. Manage.*, **75**:646–654.

———, J. D. ROGERSON, E. J. MAICHAK, W. S. FAIRBANKS, AND L. L. MEADOWS. 2009. Effectiveness of vaginal implant transmitters for locating elk parturition sites. *J. of Wildl. Manage.*, **73**:144–148.

BOWYER, R. T. 1991. Timing of parturition and lactation in southern mule deer. *J. of Mammal.*, **72**:138–145.

BROKX, P. A. 1972. Ovarian composition and aspects of the reproductive physiology of Venezuelan white-tailed deer (Odocoileus virginianus gymnotis). *J. of Mammal.*, **53**:760–763.

BUDDE, W. S. 1983. Effects of photoperiod on puberty attainment of white-tailed deer. *J. of Wildlife Manage.*, **47**:595–604.

FLINT, R. F. 1955. Pleistocene geology of eastern South Dakota. Geological Survey Professional Paper 262. U.S. Government Printing Office, Washington D.C.

GREER, K. R. AND W. W. HAWKINS, JR. 1967. Determining pregnancy in elk by rectal palpation. *J. of Wildl. Manage.*, **31**:145–149.

GRIFFIN, K. A., M. HEBBLEWHITE, H. S. ROBINSON, P. ZAGER, S. M. BARBER-MEYER, D. CHRISTIANSON, S. CREEL, N. C. HARRIS, M. A. HURLEY, D. H. JACKSON, B. K. JOHNSON, W. L. MYERS, J. D. RAITHEL, M. SCHLEGEL, B. L. SMITH, C. WHITE, AND P. J. WHITE. 2011. Neonatal mortality of elk driven by climate, predator phenology and predator community composition. *J. of Animal Ecol.*, **80**:1–12.

GUINNESS, F. E., S. D. ALBON, AND T. H. CLUTTON-BROCK. 1978. Factors affecting reproduction in red deer (*Cervus elaphus* L.). *Reprod.*, **54**:325–334.

———, G. A. LINCOLN, AND R. V. SHORT. 1971. The reproductive cycle of the female red deer, *Cervus elaphus* L. *J. of Reprod. and Fertility*, **27**:427–438.

HAMLIN, K. L., D. F. PAC, C. A. SIME, R. M. DESIMONE, AND G. L. DUSEK. 2000. Evaluating the accuracy of ages obtained by two methods for montane ungulates. *J. of Wildl. Manage.*, **64**:441–449.

HARRIS, N. C. 2007. Monitoring survival of young in ungulates: a case study with Rocky Mountain elk. M. S. Thesis, University of Montana, Missoula, Montana. 71 p.

HUDSON, R. J., J. C. HAIGH, AND A. B. BUBENIK. 2002. Physical and physiological adaptations, p. 199–258. *In:* D. E. Toweill and J. W. Thomas (eds.). North American Elk: ecology and management. Smithsonian Institution Press, Washington D.C. 1128 p.

JOHNSON, D. E. 1951. Biology of the elk calf, Cervus elaphus nelsoni. *J. of Wildl. Manage.*, **15**:396–410.

LARKIN, J. L., D. S. MAEHR, J. J. COX, M. W. WICHROWSKI, AND R. D. CRANK. 2002. Factors affecting reproduction and population growth in a restored elk Cervus elaphus nelsoni population. *Wildl. Biol.*, **8**:49–54.

LARSON, G. E. AND J. R. JOHNSON. 1999. Plants of the Black Hills and Bear Lodge Mountains: a field guide with color photographs. South Dakota State University, Brookings, South Dakota. 608 p.

MCCULLOUGH, D. R. 1969. The Tule elk: its history, behavior and ecology. University of California Publication in Zoology, Vol. 88. University of California Press, Berkley, California. 209 p.

MICH, P. M., L. L. WOLFE, T. M. SIROCHMAN, M. A. SIROCHMAN, T. R. DAVIS, W. R. LANCE, AND M. W. MILLER. 2008. Evaluation of intramuscular Butorphanol, Azaperone, and Medetomidine and nasal oxygen insufflation for the chemical immobilization of white-tailed deer, *Odocoileus virginianus*. *J. of Zoo and Wildl. Med.*, **39**:480–487.

MITCHELL, B. AND G. A. LINCOLN. 1973. Conception dates in relation to age and condition in two populations of red deer in Scotland. *J. of Zool.*, **171**:141–152.

MORRISON, J. A., C. E. TRAINER, AND P. L. WRIGHT. 1959. Breeding season in elk as determined from known-age embryos. *J. of Wildl. Manage.*, **23**:27–34.

NELSON, J. R. AND T. A. LEEGE. 1982. Nutritional requirements and food habits, p. 323–368. *In:* J. W. Thomas and D. E. Toweill (eds.). Elk of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania. 1128 p.

NOYES, J. H., R. G. SASSER, B. K. JOHNSON, L. D. BRYANT, AND B. ALEXANDER. 1997. Accuracy of pregnancy detection by serum protein (PSPB) in elk. *Wildl. Soc. Bull.*, **25**:695–698.

SINCLAIR, A. R., S. A. MDUMA, AND P. ARCESE. 2000. What determines phenology and synchrony of ungulate breeding in Serengeti? *Ecology*, **81**:2100–2111.

SMITH, B. L. 1994. Out-of-season births of elk calves in Wyoming. *Prairie Nat.*, **26**:131–136.

VORE, J. M. AND E. M. SCHMIDT. 2001. Movements of female elk during calving season in northwest Montana. *Wildl. Soc. Bull.*, **29**:720–725.

WISDOM, M. J. AND J. G. COOK. 2000. North American elk, p. 694–735. *In:* S. Demarais and P. R. Krausman (eds.). Ecology and management of large mammals in North America. Prentice-Hall, Upper Saddle River, New Jersey. 778 p.

WISHART, W. D. 1981. January conception in an elk in Alberta. *J. of Wildl. Manage.*, **45**:544.

BARBARA J. KELLER[1], AMY D. BLEISCH AND JOSHUA J. MILLSPAUGH, University of Missouri, Department of Fisheries and Wildlife Sciences, Columbia, MO 57730; CHAD P. LEHMAN AND JACKIE J. KRAGEL, South Dakota Department of Game, Fish, and Parks, Custer, SD 57730; LONNIE P. HANSEN AND JASON SUMNERS, Missouri Department of Conservation, Columbia, MO 65201; MARK A. RUMBLE, USDA Forest Service, Rocky Mountain Research Station, Rapid City, SD 57702; and GARY C. BRUNDIGE, Custer State Park, Custer, SD 57730. *Submitted 4 September 2013; accepted 8 April 2014.*

[1] Corresponding author: KellerBJ@missouri.edu