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Cover Photo: Bison cow cleans the birth site while her newborn calf takes its' first steps. (NPS-Carrie Byron)

Parturition in Yellowstone Bison

Jennifer D. Jones[1], John J. Treanor[1], Rick L. Wallen[1]

[1] National Park Service, Yellowstone National Park, Wyoming

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ABSTRACT: Bison (*Bison bison*) are managed at the boundary of Yellowstone National Park to reduce the risk of brucellosis transmission from bison to cattle. This disease is caused by *Brucella abortus*, which can be shed during parturition. Bison tend to migrate outside Yellowstone during late winter and early spring as the parturition season nears. We intensively monitored radio-collared bison from April to mid-June during 2004-2007 to gain a better understanding of birth processes influencing brucellosis transmission risk, including bison behavior and the timing and frequency of infectious parturition events. We observed 45 live births, 13 stillborn calves, 11 placenta retentions with no calves present, six placenta retentions with a calf present, and five deaths of females during birthing. Yellowstone bison exhibit a high degree of birth synchrony, with the peak birthing period from April 25 to May 26. We observed 56 complete birthing, stillborn, or placenta retention events, during which 71 bison made contact with expelled birth materials. Contact of at least one bison with potentially infectious material was observed during 30% (17 events) of these parturition events, and contact was most frequently made by adult (≥3-years-old) females (35%) and adult bulls (33%). Sixty-three samples (i.e., 14 fetuses, 21 tissues, and 28 swabs) from 47 different parturition events and one motor vehicle accident yielded only three positive cultures for *B. abortus.* Birthing females meticulously cleaned birth sites and typically left the site within two hours. The birth synchrony and cleaning behavior of bison females, combined with *Brucella* environmental persistence data from previous studies, indicates that the risk of brucellosis transmission from bison to cattle is minuscule after May.

INTRODUCTION

The disease brucellosis is caused by the bacterium *Brucella abortus* and infects bison (*Bison bison*) and elk (*Cervus elaphus*) in the greater Yellowstone area. Maintenance and transmission of *B. abortus* in cattle is well understood, but information on infection processes in free-ranging bison is limited (Meagher and Meyer, 1994; Dobson and Meagher, 1996). Bison in Yellowstone National Park were first diagnosed with brucellosis in 1917 (Mohler, 1917), but the disease did not become a management concern until the growing population began migrating out of the park in the late 1980s. Transmission to cattle near the park boundary could result in economic loss from slaughtering infected herds and imposed trade restrictions on the entire state of Montana (Godfroid, 2002).

Approximately 40-60% of the bison in Yellowstone National Park have been exposed to the *B. abortus* pathogen (Treanor et al., 2007), though only about one-half of these seropositive bison are estimated to be actively infectious (Roffe et al., 1999). In female bison, *B. abortus* typically localizes in the lymph nodes and then spreads into reproductive organs and tissues (e.g., placenta, uterus, mammary glands) during pregnancy (Blood and Radiostits, 1989). The clinical symptom of *Brucella* infection is the induction of late-term abortions (Meyer and Meagher, 1995; Williams et al., 1997), with the highly infectious fetus serving as an important source of transmission to susceptible individuals that ingest or contact infected tissues (Thorne, 2001). The disruption of hormonal controls following a *Brucella*-induced abortion often results in retention of the infected placenta, thereby extending the transmission period in time and space (Meyer and Meagher, 1995; Williams et al., 1997; Thorne, 2001). Additionally, the placental tissues and birth fluids associated with newborn calves can be infectious, making live births a potential transmission source (Cheville et al., 1998; Thorne, 2001).

The timing and location of bison parturition events, defined here to include natural births and other terminations of pregnancy, directly relate to the risk of brucellosis transmission from bison to cattle. Monitoring the birth process to correlate timing with the probability of bacterial survival provides insight into how brucellosis is maintained in the Yellowstone bison population. The infrequency of observed *Brucella*-induced abortions in Yellowstone bison (Meyer and Meagher, 1995; Cheville et al., 1997; Rhyan et al., 2001) suggests that infectious live births may be an important transmission event. Monitoring the interactions of group members with newborn calves and culturing tissues left at birth sites will help identify the infectiousness of these events.

We monitored bison in Yellowstone National Park during 2004-2007 to: 1) develop a better understanding of birth processes influencing transmission risk; 2) identify bison group behavior at parturition that may influence intra-specific transmission; 3) determine the frequency of infectious parturition events; and 4) provide federal and state managers with information to facilitate decision making regarding the transmission risk bison pose to livestock near the boundaries of Yellowstone National Park.

MATERIALS AND METHODS

Yellowstone National Park lies in the northwest corner of Wyoming and covers 8,987 square kilometers (km^2) with elevation ranging between 1500 to 2600 meters (m). After bison were nearly extirpated from the greater Yellowstone ecosystem in the early twentieth century, the population was restored in Yellowstone National Park through intensive husbandry, protection, and the reintroduction of bison into the Hayden and Firehole valleys (Meagher, 1973). Today, bison in Yellowstone function as two semi-distinct herds or subpopulations (Fuller et al., 2007; Olexa and Gogan, 2007). The central herd generally occupies the central plateau of Yellowstone, extending from the Pelican and Hayden valleys with a maximum elevation of 2400 m in the east to the lower-elevation and thermally-influenced Madison headwaters area in the west. The northern herd generally uses a decreasing elevation gradient (2200 to 1600 m) along the northern portion of the park, extending approximately 90 km between Cooke City and Gardiner, Montana.

We visually monitored radio-collared, adult, female bison (45 in 2007, 24 in 2006, 28 in 2005, and 24 in 2004) during the calving season from April through mid-June. We attempted to observe births by using visual cues (e.g., belly size, presence and fullness of udders, swollen vulva, contractions, behavior demonstrating discomfort, and tissues or fluids exuding from the vulva) to determine the nearness of parturition. We obtained a global positioning system (GPS) location during each observation and at every birth or termination site. Results from a previous study (Atkinson et al., 2005) that identified bison birth sites using vaginal transmitters were included in these locations. We also recorded interactions of other bison in the group with potentially infectious material expelled by the radio-collared animal during the parturition event. Physical contact by other bison with expelled birth material was typically made by nosing or licking birth tissues, fluids, and newborn or stillborn calves.

We divided parturition events into five categories: 1) birth; 2) termination of pregnancy; 3) placenta retention; 4) vaginal secretion; and 5) collared female with newborn calf. Birth events were identified by direct observation of the birth or the presence of a wet newborn calf with birth tissue attached to the birthing female. Termination of pregnancy included stillborn calves and females that died from complications during the birthing process. Placenta retention was used as an indicator of recently terminating a pregnancy if a calf was not present. For radio-collared

females observed with a dry calf, the date of birth was estimated based on previous observations of the pregnant female.

Aborted fetuses, birth tissues, and discharged fluids were collected from bison birth sites. Sample collection was limited by the tendency of birthing females to consume afterbirth material. All biological samples were kept cold and transported within three days to the Montana Department of Livestock Diagnostics Laboratory in Bozeman, Montana for *Brucella* culture.

RESULTS

We observed 143 bison parturition events, of which 56 included the potential for herd member interactions with birth tissues and fluids. Parturition events were widely distributed across the bison winter range, with most events occurring on the Blacktail Deer Plateau on the northern range, and on the lower geyser basin, along the river corridor between Madison Junction and Seven-mile bridge, and on the Horse Butte peninsula (outside the park) on the central range *(Fig 1)*. The first newborn calf was observed in late March or early April each year, and the last known birth was observed in late May or early June *(Table 1)*.

Fifty percent of the cumulative births occurred by May 6 (within 40 days), 80% by May 16 (within 50 days), and 95% by May 27 (61 days; *Fig 2*). Eighty percent of calving occurred during the 32 days from April 25 to May 26. We observed 45 live births, 13 stillborn calves, 11 placenta retentions with no calves present, six placenta retentions with a calf present, and five deaths of females during birthing *(Fig 3)*. Twenty-two of the 29 pregnancy terminations (stillborns, placenta retention without a calf, and death during birth) occurred by the end of April, which is prior to the onset of the calving season and may indicate complications during pregnancy or *B. abortus*-induced abortions

We observed 56 complete birthing, stillborn or placenta retention events during which 71 bison made contact with expelled birth materials *(Figs 4-6)*. Contact of at least one bison with potentially infectious material was observed during 30% (17 events) of these parturition events. For bison identified as making contact with birth material, 37 could be classified based on sex and age. Adult females ($\geq$3-years-old) most frequently made contact (35%), followed by adult bulls (33%), immature bulls (19%), calves (8%), and immature females (5%*)*. Eleven percent of the births and pregnancy terminations during March and the first half of April occurred without any other group members contacting birthing material. The majority of contact (52%) occurred during the first half of May, which coincided with 43% of the births and terminations *(Table 2)*. Observed contact by other bison with birthing materials decreased as the percentage of births and terminations decreased over the second half of May.

The number of bison making contact with expelled birth tissues was usually small (<5 animals) during the majority (68%) of events. However, we observed two mobbing events that comprised 42% of the observed contacts by bison. During these events, several bison were observed interacting with the birth site and new born calf *(Fig 7)*. In June 2004, at least 20 bison in a group of approximately 60 animals mobbed a birthing female. In May 2007, at least 10 bison made contact with a stillborn calf.

Sixty-three samples (i.e., 14 fetuses, 21 tissues, and 28 swabs) were submitted for culture from 47 different parturition events and one motor vehicle accident. *B. abortus* was cultured from three samples, including one stillborn fetus, a swab from a birth site, and a retained placenta that was expelled. The positive culture on the stillborn was from a female held at the Stephens Creek capture facility near Gardiner, Montana. The culture positive swab was from

bloody fluid found 3 m from a culture-negative stillborn calf during 2007. The culture-positive retained placenta was found snagged on a downed tree during 2006. The female produced a healthy calf and the placenta was retained for three days following calving.

DISCUSSION

The phenomenon of reproductive synchrony, where birthing occurs in a short time frame or pulse, has been documented in a number of animals, including caribou and bison (Berger and Cain, 1999). Reproductive synchrony is a strategy that minimizes environmental or energetic stress on mothers and offspring, and reduces predation effects by lowering individual risk through satiation or confusion (Rutberg, 1984). Gogan et al. (2005) suggested bison calving was highly synchronized if 50% of births occurred within 13-27 days and 80% of cumulative births occurred within 23-60 days. During 2004-2007, Yellowstone bison displayed a high level of reproductive synchrony, with 50% of births occurring in 15 days and 80% of cumulative births occurring in 32 days. Field observations indicate that nearly all bison calving is completed by the end of May.

The infrequency of observed abortions (n = 24), and the even rarer identification of *Brucella* from these abortions, supports claims that *Brucella*-induced abortions are rare events for Yellowstone bison (Meyer and Meagher, 1995; Dobson and Meagher, 1996). There have been seven documented, seropositive abortions in Yellowstone, including two from captive bison in 1917 (Mohler 1917), one in 1992 (Rhyan et al., 1994), and four during 1995-1999 (Rhyan et al., 2001). Only 2 of 25 samples collected from 15 termination events were culture positive for *B. abortus*. Ten stillborn calves have been submitted for culture testing and only one has been positive for *B. abortus.* Terminated pregnancies can occur for a multitude of reasons in bison (Williams et al., 1997), and *B. abortus* appears to play less of a role in inducing abortions than previously thought. Parturition events indicating a loss of pregnancy were typically observed prior to the onset of the bison calving season.

The behavior a female exhibits at parturition influences the probability of brucellosis transmission to other bison. Risk increases when a birthing female remains within or near a group during parturition. Also, group size dictates the number of bison at risk for exposure during these events. Bison gave birth alone during 6 of 56 observed events, but were within or near a group of bison during the other 50 events. Group behavior during parturition events may explain how *B. abortus* is maintained in Yellowstone bison despite the low frequency of observed *Brucella*-induced abortions. During observed live births, the majority (66%) of the time no contact was made by other bison with birth material. However, less frequent, but potentially large exposure events were observed where many bison interacted with the birth site. These "mobbing" events may be an important transmission source of brucellosis in Yellowstone bison.

During most live births, the actual birth site is confined to a relatively small area (approximately 3 x 3 m) where most of the potentially infectious material is shed as the calf is delivered. The duration of parturition in bison varied from 51-159 minutes. The length of time that a female remained at the birth site with the newborn calf after nursing varied from 5-420 minutes, with most bison leaving within two hours. It is during this period that within group transmission may occur through interactions between other bison and a birthing female or newborn calf. Female bison meticulously clean birth sites by consuming all birth tissues, eating the vegetation, and licking the soil *(Fig 8).* Thus, the potential for brucellosis transmission to cattle resulting from infected tissues left at birth sites appears low.

Females were observed shedding birth fluids prior to delivery while traveling alone or within a group. However, travel distance was typically <0.8 km and the small amount of fluid shed suggests there is a low probability for exposure to other bison not traveling with the female. As travel time and group size increases, the risk of exposure to other bison also increases. Some females were observed walking nearly 5 km with protruding birth material *(Fig 9)*. Retained placentas increase the risk of transmission by prolonging the post-parturition exposure period in space and time. Radio-collared females that were relocated daily following calving have been observed with retained placentas up to three days later.

Studies of the environmental persistence of *B. abortus* in the Yellowstone area indicate that its survival decreases rapidly with increasing ultraviolet exposure, heat, and dry conditions (Cook et al., 2004). *B. abortus* has been observed to survive on the protected underside of a fetus for an average of 60.5 days in February, but only 4.7 days in June (Cook et al., 2002). Environmental conditions on the surface of fetuses significantly decreased the survival time of *Brucella* to an average of 17.1 days in February and 0.3 day in June (Cook et al., 2002). A similar study conducted near Yellowstone found *B. abortus* survived longer on the underside of the fetus than on the top, and longer in February (81 days) than mid-May (21 days; Aune et al., 2004).

Most aborted fetuses are removed by scavengers. Cook et al. (2004) found that fetuses disappeared on average within 26.8 hours from Wyoming's National Elk Refuge, 40.7 hours from state feed grounds, and 57.5 hours from Grand Teton National Park. Most fetuses (90%) were scavenged within 2.9 days from both the National Elk Refuge and state feed grounds, and within 5.9 days from Grand Teton National Park (Cook et al., 2004). Another study found that fetuses were scavenged sooner inside Yellowstone National Park (7.5 days) than outside (13.0 days), with the month of deployment having no effect on length of time to disappearance (Aune et al., 2004).

Management of YNP bison currently relies on spatial and temporal separation of bison and cattle. The location, timing, and lack of infectious material left at birth sites reduce the transmission risk that bison live births pose to cattle. Additionally, *B. abortus* has a short survival period during late spring and early summer, and scavenging intensity quickly removes most aborted fetuses. The risk of brucellosis transmission between bison and cattle requires that pregnant, infectious bison shed *B. abortus* outside the park, which is later ingested by susceptible cattle. Based on field observations presented in this report, the potential for brucellosis transmission from bison to cattle is minimal by June 1 and essentially non-existent by June 15. Thus, the current haze back date of May 15 (i.e., the date after which bison are not tolerated outside the park) may be unnecessary from a disease transmission risk perspective.

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FIGURES AND TABLES

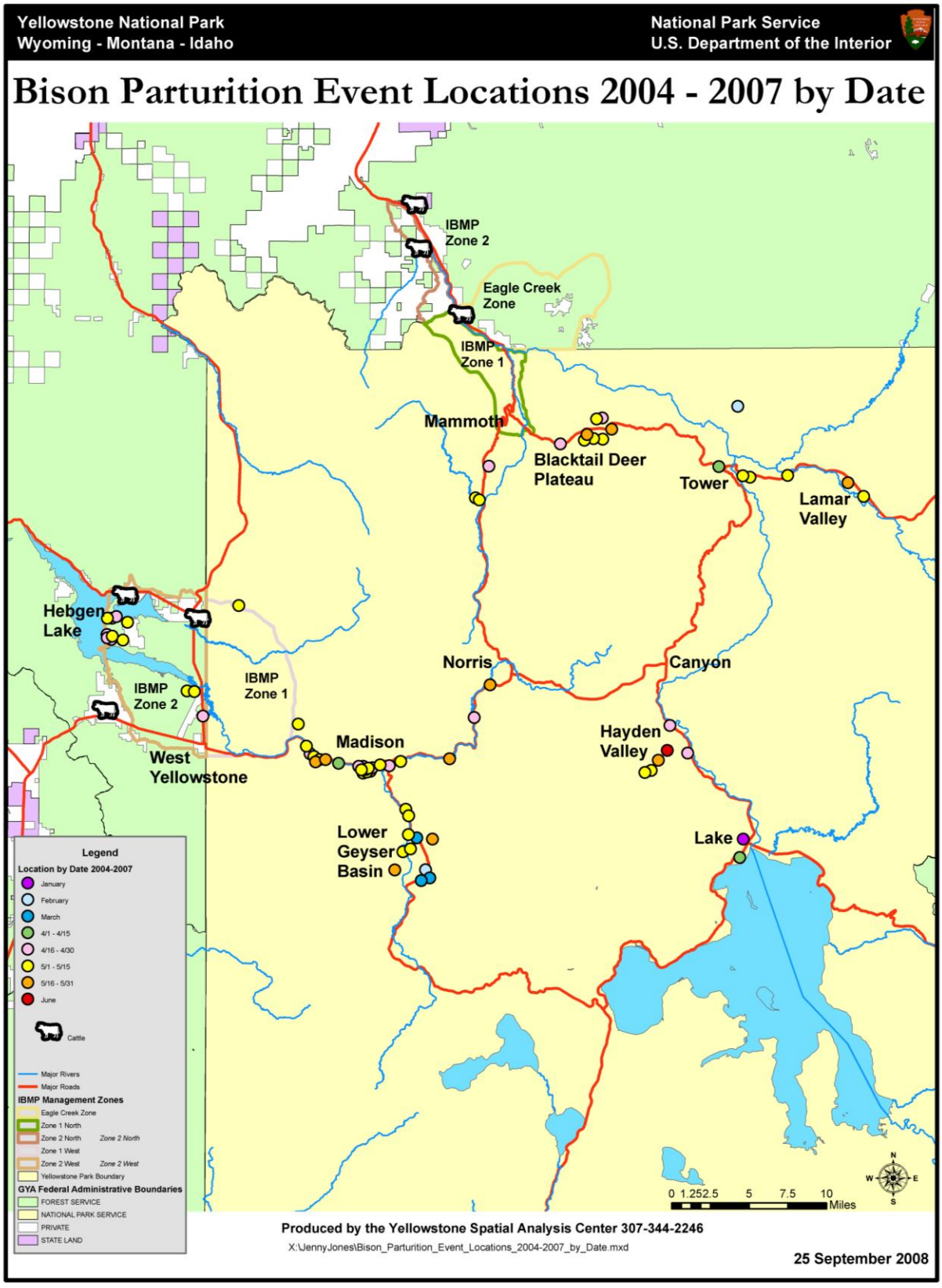

Figure 1. Most bison parturition events occurred inside Yellowstone National Park from late April through late May.

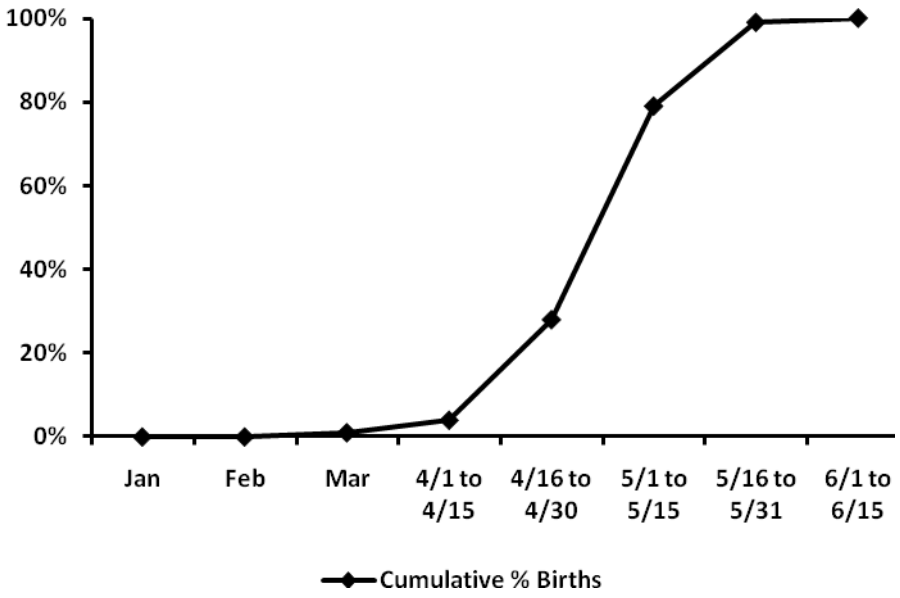

Figure 2. Eighty percent of calving by bison in Yellowstone National Park occurred between April 25 and May 26 during 2004-2007.

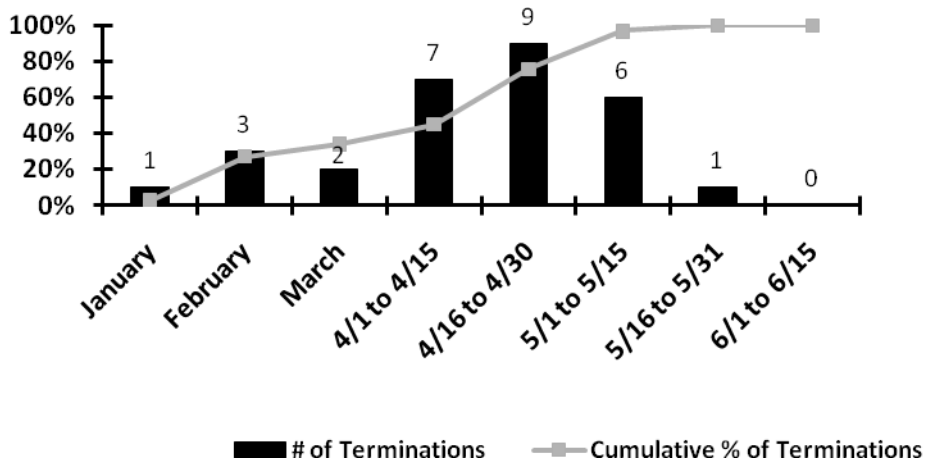

Figure 3. Terminations including stillborns, placenta retention without a calf, and females that died while giving birth, primarily occurred before May with a peak in late April and were completed by May 19th.

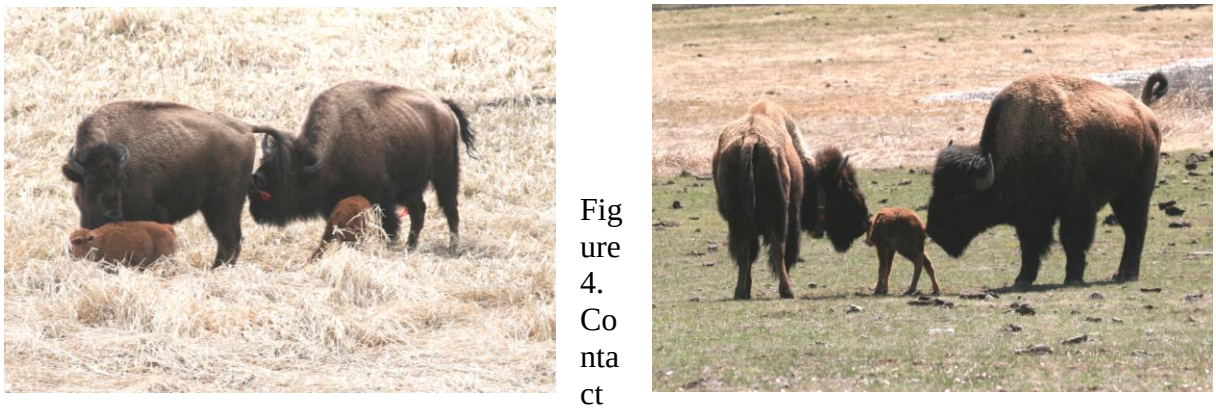

Figure 4. Contact with potentially infectious material can occur through birth tissues associated with the birthing female (*left*) or the new born calf (*right*).

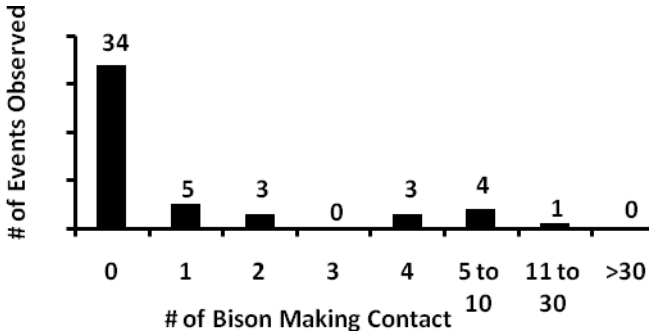

Figure 5. Most parturition events occur with other bison in the vicinity, but most of these bison do not make contact with the birth site.

Figure 6. Samples submitted for *Brucella* culture included birthing fluids (*left*) and tissues (*right*).

Figure 7. During rare "mob" events, large numbers of bison from the surrounding group investigate and make contact with birthing material. These events have high brucellosis transmission potential.

Figure 8. Female bison typically consume all birthing material including the placenta and will clean the birth site by grazing down the vegetation and even licking the soil, leaving very little evidence of the event.

Figure 9. Persistent birth material following calving and retained placentas can increase the area of exposure if a female sheds infectious material while traveling or is investigated by other bison.

	2004	2005	2006	2007
First Birth	---	April 17	March 28	April 22
Last Birth	June 5	May 26	May 31	May 30

Table 1. Dates of the first and last observed births by bison in Yellowstone National Park, Montana and Wyoming, during 2004-2007.

Date	No. of Contacting Bison	% Contact	% of Births and Terminations
January	0	0	1
February	0	0	3
March 1-31	0	0	3
April 1-15	0	0	8
April 16-30	7	10	26
May 1-15	37	52	43
May 16-31	7	10	15
June 1-15	20	20	1

Table 2. The number and percentage of bison in Yellowstone National Park making "contact" with birthing material, fluid or the newborn calf during 2004-2007.