Reproductive ecology of bison on Antelope Island, Utah

Michael L. Wolfe
Utah State University

Milan P. Shipka
Utah State University

John F. Kimball
Utah Division of Wildlife Resources, Salt Lake City, Utah

Follow this and additional works at: https://scholarsarchive.byu.edu/gbn

Recommended Citation
Available at: https://scholarsarchive.byu.edu/gbn/vol59/iss2/1

This Article is brought to you for free and open access by the Western North American Naturalist Publications at BYU ScholarsArchive. It has been accepted for inclusion in Great Basin Naturalist by an authorized editor of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.
REPRODUCTIVE ECOLOGY OF BISON ON ANTELOPE ISLAND, UTAH

Michael L. Wolfe, Milan P. Shipka, and John F. Kimball

ABSTRACT.—Autumn musters of bison (Bison bison) on Antelope Island State Park, Utah, conducted annually since 1987, provided data on temporal and age-specific reproductive patterns and a basis to evaluate the efficacy of management measures implemented to elevate reproductive performance in the herd. Pregnancy rates were variable and low (X = 46.2%) in comparison to other free-ranging, noncommercial bison herds in North America. Cows in the 3- and >6-yr age classes exhibited lower-than-expected pregnancy rates (P < 0.05). Annual pregnancy rates showed a significant (r = 0.64, P = 0.047) linear decline of 2.5% per annum. Variance in distribution of fetal ages observed in 6 yr indicates substantial temporal fluctuation. Long-term reproductive performance of cohorts born prior to implementation of management measures did not differ from that of cohorts born subsequent to these changes.

Key words: bison, Bison bison, nutrition, reproduction, Utah, Antelope Island.

A population of bison has existed on Antelope Island, Utah, for over a century. This herd originated from a very small (n = 12) founder population (Popov and Low 1950), and its subsequent population growth was punctuated by reduction to very low levels (i.e., <30 animals) on at least 2 occasions, increasing the potential of low levels of genetic variability and raising questions concerning possible demographic effects of the small founder population and subsequent bottlenecks. Preliminary field observations of reproductive patterns in the herd by Wolfe and Kimball (1989) revealed an unusually protracted calving period for this herd. Other reproductive anomalies may also exist. Alternative hypotheses to explain the long calving period are the absence of predation and a low-quality and temporally unpredictable forage resource.

Prior to 1981 Antelope Island State Park (AISP) encompassed only a small area at the north end of the island. In that year the Utah Division of Parks and Recreation (UDP&R) acquired the remainder of the island, including the bison herd, which was thought to number 250-280 animals. Initially, the population was subject to minimal management with the removal of only 3 male bison reported during the following 6-yr period.
In 1987 the UDP&R initiated an active bison management program featuring annual musters, selective culling, inoculation of animals, artificial winter feeding of calves, and limited hunting of adult males. In 1987 grazing by approximately 1500 domestic cattle on the island was also terminated. The annual roundups provided an opportunity to collect information on reproductive patterns in the population and test hypotheses regarding the impact of these management changes on reproductive patterns within the population. Specifically, we hypothesized that a presumably improved nutritional plane resulting from the management program would increase reproductive rates and synchrony of parturition. Shipka et al. (1995) provided a preliminary analysis of the data obtained through 1992. This paper includes data collected subsequently and more comprehensive analysis.

**STUDY AREA**

Antelope Island has been described previously by Wolfe and Kimball (1989). Briefly, it is the largest (104 km$^2$) of several islands in the Great Salt Lake, lying approximately 6 km from the mainland. Topographically, the island is characterized by a north-south ridge (maximum elevation above lake level = 600 m) with steep west-facing escarpments and generally more gentle east-facing slopes.

Annual grasses constitute the principal vegetation on the island, with cheatgrass (*Bromus tectorum*) and threeawn (*Aristida* sp.) comprising the dominant taxa. These conditions are the result of range deterioration due to overgrazing, erosion, and recurrent wildfires (Jones 1985). Isolated pockets of juniper (*Juniperus osteosperma*) and big tooth maple (*Acer grandidentatum*) occur primarily on steeper slopes and canyons on the western side where they have been protected from fire. There are also limited stands of sagebrush (*Artemisia tridentata*) on some of these higher slopes. Some portions of the eastern slopes have been reseeded with perennial grasses and grass-legume mixtures.

Weather records for Antelope Island exist only for the period 1952–1972. During that interval annual precipitation averaged 39.3 cm, with snowfall of 25.1 cm. Average maximum summer (Jun.–Aug.) temperatures were 32.7°C, while minimum winter (Dec.–Feb.) temperatures were -6.2°C. Lower elevations on the island experience about 200 frost-free days annually, higher elevations about 150.

**METHODS**

The UDP&R has conducted an annual roundup of the Antelope Island bison herd in the last week of October or first week of November since 1987. These gatherings employ helicopters and ground support on horseback and in wheeled vehicles to haze the bison into large holding paddocks at the north end of the island. All animals in the herd are captured in the roundup or are at least accounted for during follow-up flights. Bison typically remain in the holding paddocks for approximately a week prior to being processed through a set of working chutes. During the period 1987–1997 this operation typically commenced on Julian day 309 and lasted 3–4 d.

Upon entering the squeeze chute, adult animals are identified and weighed. Every bison in the Antelope Island herd is permanently identified by means of metal ear tags, and calves are branded according to their birth year. Beginning in 1991, animals were also identified by means of microchip implants in their ears. Adult females were examined for pregnancy by rectal palpation. In 1987, 1988, 1990, 1992, 1993, and 1994 fetal age was estimated during pregnancy palpation.

During the 1987 roundup, provisional ages were assigned to younger animals based on the schedule of replacement of lacteal incisiform teeth (incisors and canines) as described by Hogben (in Larson and Taber 1980). The series of "known-age" cohorts established by marking calves of the current year provided the opportunity to verify this sequence and subsequently correct initial assignments of animals in the 1987 roundup through 4-yr-old age classes (Kimball and Wolfe 1989). The lingual-labial width of the central incisors (I1) of most older bison was also measured during the 1987 and 1988 musters (Novakowski 1965). Further estimates of age were obtained by counts of cementum annulations in I1 teeth collected from 32 animals (mortalities and hunter-killed animals). I1-width data collected during the 1987 roundup were regressed against age estimates from cementum annulation counts.
and animals derived from known-age cohorts. For the purposes of this analysis, we established the following age categories: 2, 3, and 4 yr olds, 5-6 yr, and >6 yr.

Statistical analysis of reproductive data utilized procedures outlined by Cochran and Cox (1957) for categorical data. Two discrete categories (i.e., pregnant—not pregnant) were analyzed by chi-square procedures for a $2 \times n$ contingency table using the following formula:

$$
\chi^2 = \frac{\sum a_t p_t - \bar{p} \sum (a_t)}{(\bar{p})(\bar{q})}
$$

where:  
$a_t =$ number in category 1 within the $t$th age class, 
$\bar{p} =$ overall proportion of the total population in category 1, and 
$\bar{q} =$ $1 - \bar{p} =$ overall proportion of the total population in category 2.

This procedure allows for the examination of within-population differences when a known or expected value is not available. In addition, one-way ANOVA was used to evaluate the observed difference in pregnancy rates among various age classes with years being pooled. Differences between individual age classes were analyzed by means of Bonferroni $t$ tests. Bartlett's test for homogeneity of variance was used to evaluate observed differences in the distribution of fetal ages.

RESULTS

Pregnancy Rates

Pregnancy determination for the period 1987-1997 indicated a mean annual pregnancy rate of 46.2% (range = 32.5-66.6%, Fig. 1). The rates observed in 1993 and 1997 were significantly higher ($\chi^2 = 40.9$, df = 9, $P < 0.0005$) and lower ($\chi^2 = 25.0$, df = 9, $P < 0.005$), respectively, than expected. Regression of annual pregnancy rates against time indicated an average annual decline of 2.5% ($r = 0.64$, $P = 0.047$). The value for 1987 was excluded from this analysis because we reasoned that pregnancy rates in that year were not affected by management changes described above. Regressions using pregnancy rates weighted by sample size and excluding the 1993 value, an “unusual” observation but not technically an outlier, yielded qualitatively similar results.

We further tested the hypothesis that cohorts subject to the effects of management changes should have a higher reproductive rate than animals born before the changes were implemented. The long-term (≥ 5 yr of consecutive data) histories of females ≥ 2 yr of age and born during the period 1987-1991 were compared with similar performances of those females which had already achieved reproductive age in 1987 (Table 1). The mean long-term pregnancy rates of cows born during the 2 time intervals, 0.53 and 0.49, respectively, did not differ significantly ($z = 0.46$, $P = 0.32$). Likewise, maximum numbers of consecutive pregnancies between the 2 groups were virtually identical, 2.6 and 2.7, respectively ($t = 0.35$, $P = 0.72$).

One-way ANOVA revealed significant differences ($F = 4.05$, $P = 0.007$) among mean pregnancy rates for various age classes for the 11-yr period 1987-1997 (Fig. 1). Bonferroni $t$ tests indicated that pregnancy rates in the 3- and >6-yr-old groups were significantly lower ($P < 0.05$) than the other age groups (Fig. 2).

Fetal Ages

Fetal ages were available for 6 yr of the study (Table 2) and indicated that 1988 had the lowest measures of central tendency with a suggestion of bimodal distribution. It should be noted, however, that the sample size in that year was less than half of the next lowest year. The results of Bartlett's test for homogeneity of variance suggested a tendency ($P = 0.098$) for this population to experience random fluctuations in the variance of fetal ages over time (Fig. 3).
Table 1. Reproductive performance of Antelope Island bison cows in relation to management changes.

<table>
<thead>
<tr>
<th>Cohorts</th>
<th>Sample size (n)</th>
<th>Years observed (x)</th>
<th>Pregnancy rate (x ± s_2)</th>
<th>Maximum number of consecutive pregnancies (x ± s_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Born before 1987</td>
<td>79</td>
<td>6.4</td>
<td>0.53 ± 0.06</td>
<td>2.7 ± 0.21</td>
</tr>
<tr>
<td>Born 1987–1991</td>
<td>61</td>
<td>6.5</td>
<td>0.49 ± 0.06</td>
<td>2.0 ± 0.18</td>
</tr>
</tbody>
</table>

Table 2. Summary statistics for estimated fetal ages of Antelope Island bison.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample size</th>
<th>Median (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>53</td>
<td>113.5</td>
</tr>
<tr>
<td>1988</td>
<td>31</td>
<td>105</td>
</tr>
<tr>
<td>1990</td>
<td>82</td>
<td>105</td>
</tr>
<tr>
<td>1992</td>
<td>61</td>
<td>121.2</td>
</tr>
<tr>
<td>1993</td>
<td>179</td>
<td>132.2</td>
</tr>
<tr>
<td>1994</td>
<td>106</td>
<td>120.7</td>
</tr>
</tbody>
</table>

Fig. 2. Age-specific pregnancy rates of Antelope Island bison cows, 1987–1997.

DISCUSSION

Pregnancy rates in the AISPI herd are low compared to some other free-ranging bison herds (Table 3). The only herd known to have a lower pregnancy rate than that on Antelope Island is the Santa Catalina herd. Lott and Galland (1987) suggested that the low reproductive rate in that herd was likely due to nutritional deficiency. Because forage quality appears to be low at the AISPI location, that hypothesis may also be true for Antelope Island. Calves received supplemental winter feed during the latter portion of this study, which may have affected pregnancy rates among 2-yr-old cows. Puberty will be achieved at an earlier age, within a species group, among those individuals enjoying a higher plane of nutrition (Bronson 1989). An explanation for the lower-than-expected pregnancy rate among 3- and >6-yr-old animals is more elusive, however. Kirkpatrick et al. (1993) suggested that calving rates of 35–55% imply an every-other-year or every-third-year calving pattern. Whether this applies to Antelope Island bison is less certain, but some variant of less-than-every-consecutive-year pregnancy does operate. Approximately 1/3 of the females with known reproductive histories spanning intervals of 5–8 yr produced 2 calves during those intervals, while 23% and 11% produced a single calf or 3 calves, respectively. Only 13% gave birth to ≥5 calves.

Nutritional stress combined with metabolic requirements of lactation may limit the ability of first-calving bison cows to raise a calf and replenish body reserves sufficient to return to estrous cyclicity. Forage quality on Antelope Island is thought to be poor due to decades of overgrazing combined with erosion. Despite increased digestive efficiency by bison compared to cattle (DeLiberto 1993), poor forage quality may limit energy availability to young bison cows. Bronson (1989) showed that estrous cyclicity is related to whole body energy balance. Furthermore, suckling has a negative effect on the return to estrous cyclicity in domestic cattle (Short et al. 1990), and Kirkpatrick et al. (1993) have recently demonstrated, through physiological data, that lactational suppression of ovarian activity reduces fecundity in bison.

Wolfe and Kimball (1989) presented data on the apparently asynchronous calving pattern of the Antelope Island bison population in comparison to other herds (Meagher 1973, Haugen 1974, Rutberg 1986, Shaw and Carter 1989). They reported that calves were born from March through October, with 40% of the
### Births occurring from August through October

Green and Rothstein (1993) used the length of time from the first birth until 80% of the year's calves were born as a measure of birthing synchrony among bison in Wind Cave National Park (WCNP). Berger and Cunningham (1994) cited those data combined with data of Ruthberg (1987) from the National Bison Range (NBR) and data collected from the Badlands National Park (BNP) bison herd, indicating that 80% of bison calves were born during 23, 49, and 55 days at NBR, WCNP, and BNP, respectively. Within the AISF bison herd, estimates of fetal ages by rectal palpation (Fig. 3) indicated more than 60 d spread in ages of the oldest fetuses in all 6 yr these data were collected. Additionally, during 3 of those 6 yr this interval was greater than 90 d in length. This extrapolates to an asynchronous period of parturition in comparison to the bison herds cited above, especially considering that the loss of any of those fetuses to abortion or resorption would only serve to lengthen this period during the calving season. Anecdotal reports by AISF personnel confirm the occurrence of very young (<3 months of age) calves as evidenced by their reddish tan coloration (Meagher 1979) during every month of the year.

Synchrony of parturition has been examined among populations of wild ungulates (Estes 1976, Rachlow and Bowyer 1991) and related to various causal mechanisms, namely predation effects and availability of forage. Bison

---

**Fig. 3.** Distribution of fetal ages in Antelope Island bison cows. Days pregnant refers to midpoints of monthly intervals as determined by rectal palpation.
Table 3. Pregnancy rates of some free-ranging North American bison herds.

<table>
<thead>
<tr>
<th>Location</th>
<th>Pregnancy rate (%)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Bison Range</td>
<td>88.2</td>
<td>Rutberg (1986)</td>
</tr>
<tr>
<td>Niobrara National Wildlife Refuge</td>
<td>78.4</td>
<td>Haugen (1974)</td>
</tr>
<tr>
<td>Witchita Mountains Wildlife Refuge</td>
<td>71.8</td>
<td>Shaw and Carter (1989)</td>
</tr>
<tr>
<td>Badlands National Park</td>
<td>64.3</td>
<td>Berger and Cunningham (1994)</td>
</tr>
<tr>
<td>Henry Mountains</td>
<td>63.0</td>
<td>Van Vuren and Bray (1986)</td>
</tr>
<tr>
<td>Yellowstone National Park</td>
<td>52.0</td>
<td>Meagher (1973)</td>
</tr>
<tr>
<td>Antelope Island</td>
<td>46.2</td>
<td>This study</td>
</tr>
<tr>
<td>Santa Catalina Island</td>
<td>35.0</td>
<td>Lott and Galland (1987)</td>
</tr>
</tbody>
</table>

herds at NBR, WCNP, BNP, and AISP are currently not subject to natural predators. Predation, other than hunting by humans, has not been a factor of consideration in any of these herds for at least 100 yr. In the absence of predation, environmental factors may become a more important determinant affecting synchronous parturition. Berger (1992) suggested that natural selection would still favor animals that calve at some optimal time that is linked to the annual peak bloom of spring forage to support lactation and calf growth. Spring forage blooms on Antelope Island are predictable but short lived. Furthermore, minor blooms may occur at widely disparate times of the year, whenever sufficient moisture is available to produce germination of annual grasses. These conditions may produce some interannual variation in the timing of forage availability.

Green and Rothstein (1993) postulated lifelong negative effects to late-born bison calves, citing reduced growth and reproductive success, and negative effects on early dominance relationships as examples of birth-order effects. In addition, Berger (1989) further indicated that earlier calving cows were in better body condition and came into estrus earlier in the breeding season than later calving cows.

An interesting question is the apparent inconsistency that exists between the observed rate of decline in the mean annual pregnancy rate and the continued increase in population size (~7.0% per year). This herd of bison experiences little natural mortality, has no natural predators, and hunting is limited to the removal of 6–10 bulls per year. Culling practices do occur each year during the fall muster with the removal of approximately 10% of the animals from the herd for commercial purposes. To determine whether the number of reproductively mature females could continue to increase as it has over the last 10 yr, while experiencing a decline in annual pregnancy rate, we constructed a model to generate animal number estimates. Using assumptions of 90% survival rate and 50% female calf crop along with the actual annual pregnancy rates, we arrived at estimates of reproductively mature female herd size that were very close to actual numbers of animals in this group through 1994. Estimates generated for 1995 through 1997 were higher than actual numbers of mature females observed; nevertheless, growth in numerical size of this herd observed over the period 1988 through 1997 is not inconsistent with the observed rate of decline in mean annual pregnancy rate.

It is noteworthy that each year during the roundup some 15–20 red calves are encountered. These animals are generally reunited with their dams following processing. At a minimum these cows would not have been pregnant at that time, and the return of their calves could result in a delayed onset of estrus during the following breeding season.

In conclusion, the data presented here indicate that the management program implemented to increase reproductive performance in this herd has not been successful in accomplishing that objective. Elimination of winter/spring grazing by domestic livestock in 1987 may have temporarily reduced grazing pressure on the island's limited forage resources. In the interim, however, the increased size of the bison herd and active selection for larger body size have likely more than offset these gains and resulted in a higher level of year-round herbivory. Supplemental feeding of...
calves during a portion of their first year of life may help females achieve reproductive condition at an earlier age (i.e., 2 yr). However, it does not adequately compensate for the underlying poor forage condition on the island in order to sufficiently elevate the nutritional plane of females throughout their reproductive life. Large-scale range improvements are likely the only measure appropriate for this purpose.

ACKNOWLEDGMENTS

We are grateful to personnel of the Utah Division of Parks and Recreation, in particular M. Larsson, J. Filpot, T. Smith, and K. Sherman, for assistance and logistical support provided throughout the course of the study. Numerous faculty members and graduate students of the Departments of Fisheries and Wildlife and Rangeland Resources, Utah State University, provided valuable assistance with data collection efforts. Finally, we appreciate the advice on statistical analysis provided by Drs. D.V. Sisson and R. Canfield as well as thoughtful reviews of the manuscript by Drs. T. DeLiberto and T. Morton.

LITERATURE CITED


Received 20 July 1997
Accepted 28 April 1998