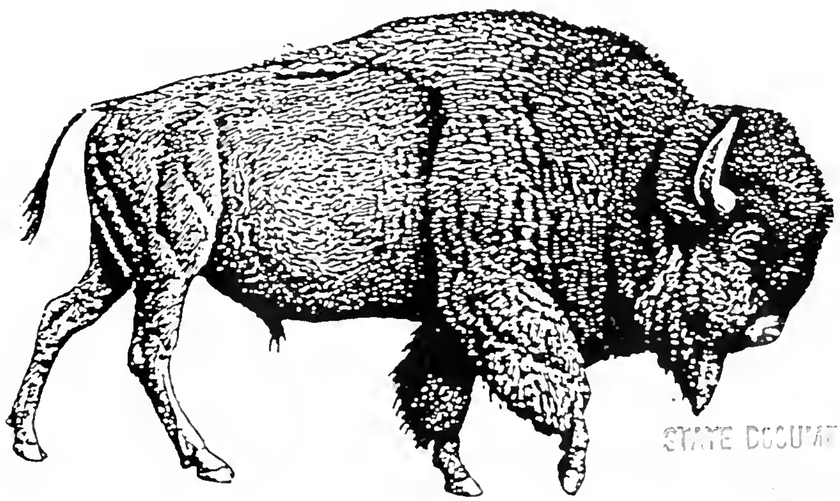
Some Population Characteristics of the Northern Yellowstone Bison Herd During the Winter of 1988-1989



Montana Department of Fish, Wildlife & Parks

Some Population Characteristics of the Northern Yellowstone Bison Herd During the Winter of 1988-1989

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SPECIAL NOTE

We gratefully extend a very special acknowledgement to the late Dan Palmisciano of the Montana Department of Fish, Wildlife and Parks (1965-1988) who was instrumental in realizing the need for bison research and the possible ramifications of the bison hunts in Montana near Yellowstone National Park.

ABSTRACT

Large hunter harvest of bison during the 1988-89 bison reduction outside of Yellowstone National Park provided an opportunity to obtain and document population characteristics of the bison which are normally confined to the park. Total bison killed was 569, including 53 calves of the year and 516 older animals. Sex ratios were 57% male and 43% female. Eighty-five percent (484) of harvested bison were tested for brucellosis; 54% tested positive to the presence of *Brucella abortus* antibodies. More males than females tested positive. Age structure of harvested animals was analyzed using three methods. Ages ranged from ½ to 15 years, with a median age of four years. Seventy-four percent of females examined were pregnant. Fetal measurements indicated a prolonged calving season with most (76%) calves born by early June. Physical measurements of harvested adults are presented.

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INTRODUCTION

In 1988-89 an opportunity arose to obtain physical information on free-ranging bison (*Bison bison*) emigrating from northern Yellowstone National Park (YNP) into southern Montana. The data collected, which eventually represented 60% of Yellowstone's northern bison herd, were thus available for comparison with previous collections. The usual biases associated with partial sampling was avoided because of the high percentage of the herd actually examined.

In 1985, the Montana Legislature designated bison as a game animal and allowed the Montana Department of Fish, Wildlife and Parks to use the public as a method of removing bison which entered Montana from YNP.

During the winter of 1988-89, large numbers of bison crossed the northern boundary of YNP into Montana. During the summer of 1988, National Park Service personnel recorded the largest bison population within YNP in over a century. Concurrently this was also a summer of severe drought and the most extensive forest fires in YNP's recorded history.

Bison leaving Yellowstone National Park and entering the State of Montana can potentially infect livestock with brucellosis (Davis et al. 1990). Montana cattle were certified as brucellosis free in 1985, a status achieved only through the investment of considerable time, money, and other resources.

Previous research on YNP bison has been presented by Meagher (1973), McHugh (1958), Locker (1953), Tunnicliff and Marsh (1935), and Rush (1932).

Objectives of this project were to gather population data from Yellowstone National Park bison harvested in Montana. Major data sets include the following:

1. Age and sex composition
2. Incidence of Brucellosis seropositive
3. Physical measurements
4. Reproductive parameters

AREA OF HARVEST

The bison reduction occurred primarily north of Yellowstone National Park in an area of approximately 80 km^2 near Gardiner, Montana (Figure 1). In addition, one animal was killed near Cooke City, Montana, and two near West Yellowstone, Montana.

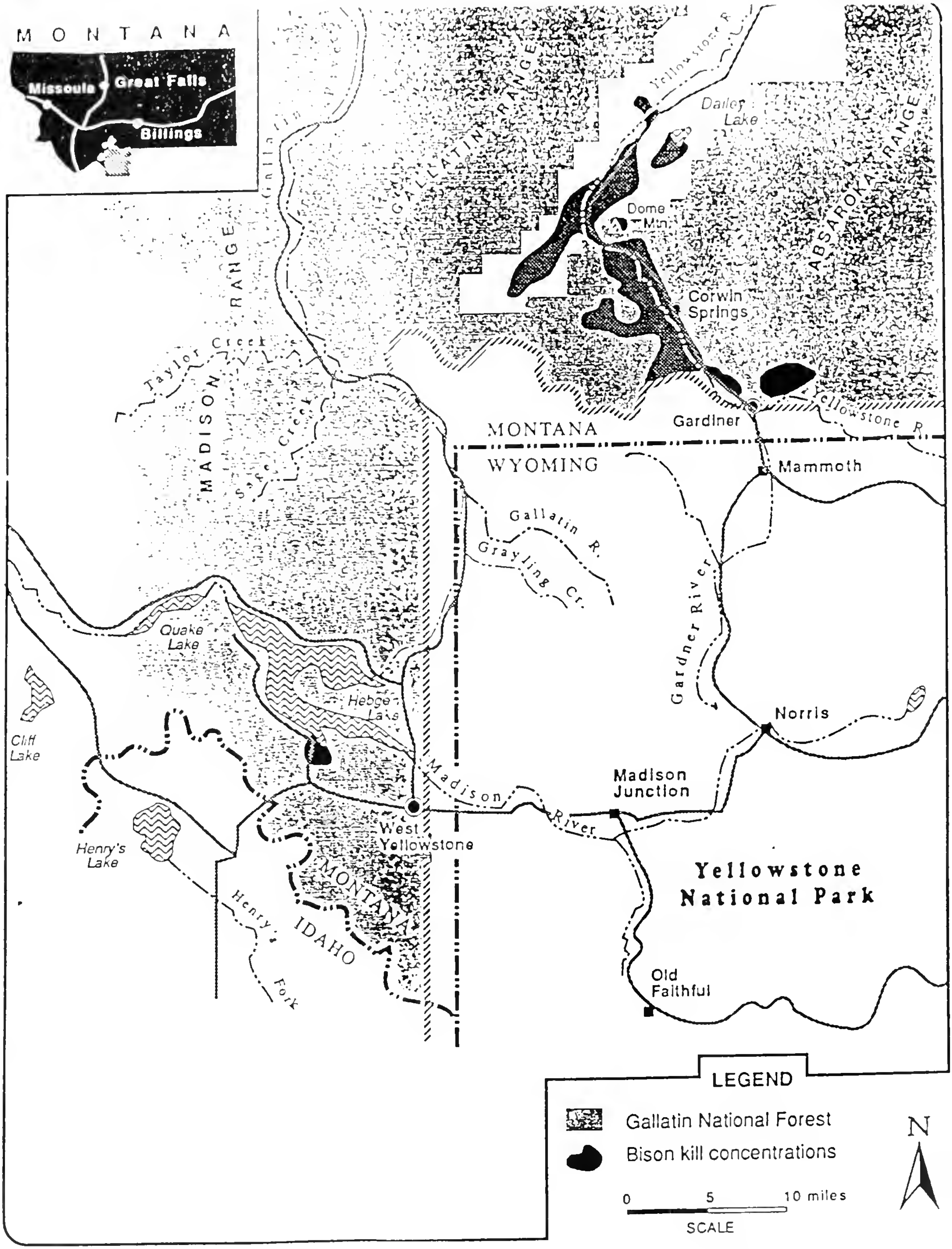

Figure 1. The distribution of bison harvest in 1988-89.

METHODS

The bison reduction provided the opportunity to collect data on a large proportion of the animals that were harvested.

Bison were field aged by examining incisor and canine teeth for eruption and replacement (Hogben 1980, Frison and Reher 1970, Fuller 1959) through age class 5. Wear of permanent incisors and canine teeth was examined for all older ages.

Physical size, shape of horns, and number of horn rings provided another confidence indicator of age groups for both sexes.

Teeth were obtained for cementum ages in the field or by mail request after bison removal. Cementum ages were assigned by Matson's Laboratory in Milltown, Montana, using criteria described by Armstrong (1965) and Novakowski (1965). When possible, the first incisor (I_1) was sectioned to determine cementum annuli. If (I_1) was unavailable, other teeth were used.

A modified age was assigned under the following circumstances. The age determined by either cementum annuli or in the field was used when that was the only age available. If both cementum and field ages were available for an individual animal and they did not agree, they were handled as follows:

1. If there was only one year difference, the field age was used for ages < 7 years, while the cementum age was used for ages 7 and over.
2. If the difference was greater than one year, an average of the ages obtained by the two methods was used.

Sex of animals and the pregnancy status of females were determined in the field when animals were eviscerated. Fetuses were collected and frozen for later measurement at the MDFWP Wildlife laboratory in Bozeman. Weight, crown-rump length, and sex were recorded for all fetuses.

Blood was collected by individual hunters and by MDFWP officials and the serum was analyzed for the presence of brucella antibodies by the Montana Veterinary Diagnostic Laboratory, Bozeman, MT., using standard laboratory procedures (NADL 1967).

Measurements of bison taken in the field included:

- horn length (HRLN): outside of curve from hairline at base of horn to tip
- hornspread (HRSP): distance between horns from tip to tip
- base (BASE): circumference of horn at hairline around base
- base spread (BASESP): distance of inner length between bases of horns at hairline
- head length (HDLN): distance from base of skull (interparietal bone) to nose (approximately even with pre-maxillary bone)
- total length (TOTALLEN): distance of tip of tail to base of skull plus HDLN.

Lungworm determination was conducted by the Montana Veterinary Molecular Biology Laboratory, Bozeman, MT., from fecal samples collected in the field.

Computer software employed in data analysis included DBase, Harvard Graphics, SAS, and StatGraphics.

RESULTS AND DISCUSSION

HARVEST AND HUNTER STATISTICS

A summary of bison harvested in the State of Montana from 1974-1989 is presented in Table 1.

The 569 bison killed during the 1988-89 removal included 567 taken from the northern herd, (566 near Gardiner, and one near Cooke City). Two others were removed from the Mary Mountain Herd near West Yellowstone. Hunters harvested 494 bison (87%) while wardens shot 75 (13%). Most of the harvest occurred in January and February of 1989 (Table 2). A total of 516 adults and 53 calves was killed. Sex ratios were 57% male and 43% female which supported other studies on populations of free-ranging bison showing a majority of adult males (Meagher 1986).

Table 1. A summary of bison harvested in Montana, 1974-1989.

	Age Composition				Sex Composition			Brucellosis		Bison Numbers Harvested By:	
YEAR	TOTAL	Adult	Calves	Unk	Males	Females	Unk	% Pos	% Neg	Hunters	Wardens
1974-83 Northern	13	--	--	13	4	7	2	--	--	0	13
1984-85 Northern	88	80[A]	8		47	41	0	56	44	0	88
1985-86											
Northern	41	41	0		26	15	0	--	--	41	0
Western[B]	16	16	0		16	0	0	--	--	16	0
Total	57	57	0		42	15	0	42	58	57	0
1986-87 Western	7	7	0		5	2	0	17	83	6	1
1987-88											
Northern	2	2	0		2	0	0	--	--	2	0
Western	37	37	0		25	7	5	--	--	37	0
Total	39	39	0		27	7	5	16	84	39	0
1988-89											
Northern	567	514	53		294	226	47	54	46	492	75
Western	2	2	0		2	0	0	0	100	2	0
Total	569	516	53		296	226	47	54	46	494	75
Grand Total	773	699	61	13	421	291	61	51	49	596	177

[A] - These 80 adults included 42 males and 37 females, plus 1 of unknown sex
[B] - Animals harvested near West Yellowstone, Montana

Table 2. Percentage of bison harvested by month in the 1988-89 removal.

Month	Percentage
October 1988	1
November 1988	0
December 1988	8
January 1989	25
February 1989	57
March 1989	8
April 1989	1
Total	100

Initially, hunters selected for adult males when available, then adult females. All calves of the year (animals <1 year old) were taken by MDFWP personnel. By late April 1989, bison which remained in Montana were successfully hazed back into YNP as new forage sources became available.

A total of 2,557 hunter applications was processed for the 1988-89 bison reduction. Of 547 hunters called, 494 were able to be at the hunt site at the appointed time. All 494 hunters were successful in harvesting an animal, and all but two hunters were Montana residents.

BRUCELLOSIS

Eighty-five percent (484) of the harvested sample was tested for brucellosis. Overall, 54% tested reactive (R) or suspicious (S) to the presence of the Brucella antibody (Table 3). The incidence of brucellosis has been documented previously in Yellowstone National Park bison by Rush (1932), Tunnicliff and Marsh (1935) and by Meagher (1973). Those studies showed 53%, 54-74%, and 28-59% seropositive, respectively.

Table 3. Brucellosis test results by sex for bison harvested in 1988-89.

	Brucellosis test results				
	Total Positive[1]		Total Negative		Total Tested
	N	%	N	%	N
Male	169	61	110	39	279
Female	89	44	113	56	202
Unknown	1		2		3
Total	259		225		484

[1] Includes 27 males and 16 females that tested suspicious

A recent study by Davis et al. (1990) indicated that *B. abortus* can infect cattle and bison to the same degree. Serologic tests only indicate presence of the antibody (i.e. that the animal has been exposed); it does not indicate whether the animal actually can transmit and has symptoms of the disease. According to Jubb et al. 1985... "Once infection is established in sexually mature animals, females especially, it tends to persist indefinitely. Some, perhaps many, animals will recover completely, but which ones will, and when they will, cannot be predicted." A significantly higher percentage of males (61%) tested positive to the brucella antibody than females (44%) ($p<.05$). This could be related to male courtship behavior which exposes them to greater potential contact with the organism.

AGE STRUCTURE OF HARVESTED BISON

Ages of harvested bison determined by the three techniques used are shown in Table 4 and Fig. 2.

A total of 131 teeth was submitted for cementum aging (Appendices A and B). Ages varied from 1 to 15 years, with a mean age of 4.96 years.

A total of 312 animals was aged in the field (Appendices C and D). Calves were included, giving a more complete harvest age structure. However, the older age segment (>12 years old) was not represented, biasing the results toward a younger age structure.

The modified or assigned aging technique provided the most comprehensive sample of the harvested population (Figs. 3 and 4). This method provided an assigned age for 382 animals or 67% of the total harvest.

The modified method was tested on individual animals that were aged by both of the other techniques (n=59) using the Wilcoxon's Signed Rank Test. Field and cementum methods did not differ significantly ($P>.05$) when a half year was subtracted from the cementum age (cementum age overestimated field age by six months). June 1 was assumed as the birth date for bison by the laboratory conducting the cementum aging. Age assignment was complicated by the fact that calving can occur from mid April to early August.

Table 4. Age distribution of bison harvested in the 1988-89 removal by three aging methods.

Age	Field Method		Cementum Method		Modified method	
	N	(%)	N	(%)	N	(%)
0.5	53	17	0	0	53	14
1	47	15	11	8	55	14
2	51	16	6	5	49	13
3	40	13	26	20	54	14
4	36	12	34	26	54	14
5	29	9	15	11	37	10
6	22	7	8	6	28	7
7	14	4	6	5	14	4
8	13	4	7	5	17	4
9	2	0.6	5	4	6	2
10	1	0.3	7	5	8	2
11	2	0.6	1	0.8	1	0.3
12	2	0.6	3	2	4	1
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	2	2	2	0.5
Total	312		131		382	

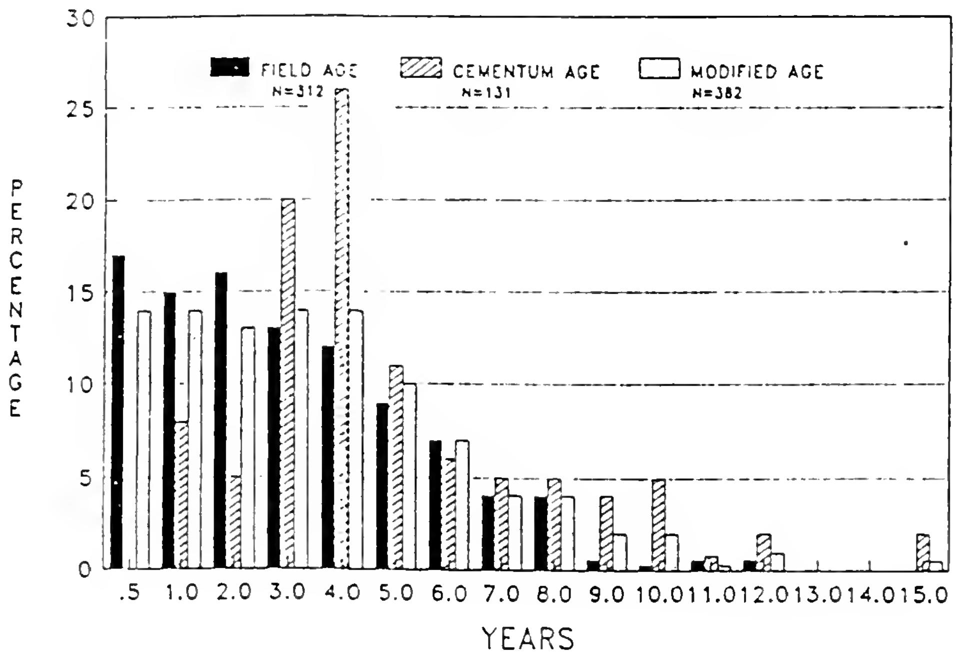

Figure 2. Age structure by three aging methods for bison harvested during 1988-89.

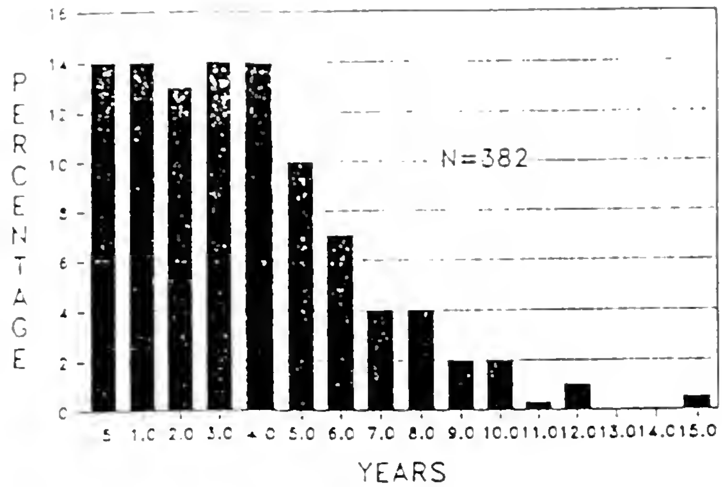

Figure 3. Modified age structure of bison harvested in 1988-89 (including unknown sex animals).

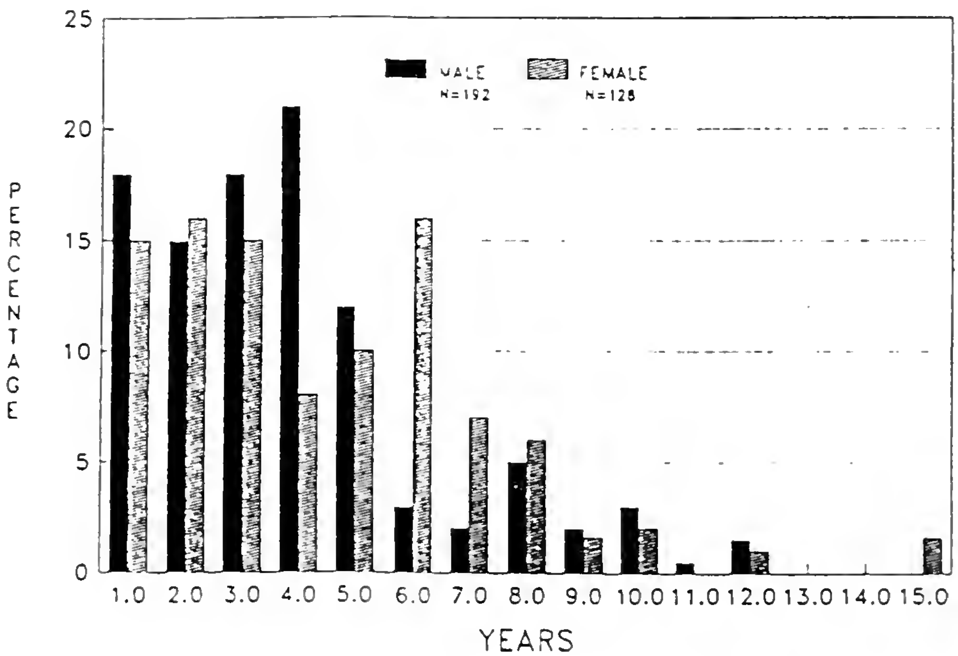

Figure 4. Modified age structure of bison harvested in 1988-89 by sex.

Age structure of female (Appendices E and F) and male bison (Appendices G and H) indicated more males in the younger age classes (1-4 years) and more females in the mature age classes (5-9 years). Similar numbers of both sexes were recorded in the older age classes (10-15 years), but the two oldest animals (15 years) were both females. Old age in bison has been documented at 12-15 years (Fuller 1959) with an occasional animal reaching 20 years (Meagher 1973).

Percentages of calves, yearlings, $2\frac{1}{2}$ year olds, $3\frac{1}{2}$ year olds, and adults in 1964-65 (Meagher 1973) were 19, 14, 6, 11, and 49, respectively. In 1988-89, the percentages were 14, 14, 13, 14, and 45, for the same age classes, respectively.

AGE STRUCTURE BY BRUCELLOSIS TEST RESULTS

Age structure of animals by sex and brucellosis test result is presented in Table 5. Age structure of females testing negative for brucellosis versus females testing positive were statistically similar ($p<0.05$). Male age structures were also similar between reactive and non-reactive animals ($p>0.05$). There was no difference between reactive and non-reactive male age structures compared to reactive and non-reactive female age structures ($p>0.05$). This shows strong confirmation that the brucellosis organism does not preferentially infect any age group.

Table 5. Age structure (modified technique) of bison harvested in 1988-89 by brucellosis test results and sex.

Brucellosis Test Results								
	Total Positive (Reactive and Suspicious)				Total Negative			
Age[1]	Female		Male		Female		Male	
	N	%	N	%	N	%	N	%
1	4	8	14	13	14	20	21	28
2	6	12	17	15	14	20	9	12
3	9	17	20	18	10	14	14	19
4	4	8	26	24	6	9	13	18
5	6	12	15	14	6	9	6	8
6	11	21	3	3	9	13	2	3
7	5	10	1	1	3	4	3	4
8	3	6	7	6	4	6	1	1
9	0	0	2	2	2	3	1	1
10	3	6	3	3	0	0	2	3
11	0	0	1	1	0	0	0	0
12	0	0	1	1	0	0	2	3
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	1	2	0	0	1	1	0	0
Total	52		110		69		74	

[1] No calves were tested for brucellosis

REPRODUCTION

Pregnancy Rates

One hundred and two adult females were examined for pregnancy, with 74 (75%) testing pregnant. Records from Yellowstone dating back to 1931 show a range in pregnancy rates of 52-94% (Meagher 1973). There was no difference ($p>0.05$) between pregnancy rates of animals testing positive (R+S) for exposure to brucellosis (72%) and those that tested negative (72%) (Table 6).

Table 6. Pregnancy results for bison harvested in 1988-89 by brucellosis test results.

	Brucellosis Test Results					
	Total Positive[A]		Total Negative		Total Tested	
	N	%	N	%	N	%
Number Pregnant[B]	33	72	36	72	69	72
Number Not Pregnant	13	28	14	28	27	28
Total	46	100	50	100	96	100

[A] Includes 5 pregnant and 1 not pregnant animal that tested suspicious for brucellosis

[B] An additional 6 females were tested for pregnancy but not tested for brucellosis. All 6 were pregnant. Therefore, out of 102 females that were tested for pregnancy, 75 were pregnant.

Fetal Sex Ratios

A total of 52 fetuses was collected. A significantly higher proportion of females (58%, n=30) to males (n=22) were found in utero ($p<.05$). Previous studies showed higher percentages of male fetuses in utero (Meagher 1986, Reynolds et al. 1982). Rutberg (1986) found a significantly higher percentage of non-lactating compared to lactating cows carrying male fetuses. He concluded that females in good condition produce more male offspring. However, Wolff (1990) and Shaw and Carter (1989) found all females equally likely to produce male and female calves. Lactation and body condition were not determined in this study but would be of interest in future collections since fetal sex ratios are significantly different than previously documented.

Conception/Calving Dates

Fetal weights varied from 1.3 to 35.0 pounds. Crown - rump measurements varied from 23.9 to 93.9 cm with similar means for female (54.0 cm) and male (53.8 cm) fetuses. (Appendix I).

Bison and cattle fetal weight and crown-rump measurements are comparable (L. Stackhouse D.V.M. personal communication). Size and characteristics of bovine fetuses (Roberts 1956) were extrapolated to estimate bison fetal conception and calving dates (Appendix I). Meagher (1973) reported most calving occurred in early May with completion by late May. However, she also indicated that as the population increases, the calving season is extended. Our data support this observation, suggesting that the calving season is even more prolonged than previously documented. Most calving (76%) was completed by early June (Table 7).

Rutberg (1984) suggests that birthing synchrony in bison is an adaption to minimize stress related to winter severity The two winters preceding the reduction (1986-87, 1987-88) in YNP were less severe than normal (Merrill et al. 1988), which could partially explain the prolonged calving season indicated by our data.

Effects of brucellosis on calving success of YNP bison is unknown and may also influence the length of the calving season.

Table 7. Determination of conception and potential calving periods for 50 bison fetuses collected during the 1988-89 removal.

	Percentage of Bison Fetuses
Conception late June/early July, calving mid-April	10
Conception mid-July, calving late April/early May	36
Conception late July/early Aug, calving mid-May	12
Conception mid-August, calving late May/early June	18
Conception late August/early Sept, calving mid-June	12
Conception mid-Sept, calving late June/early July	6
Conception late Sept/early Oct, calving mid-July	2
Conception mid-Oct, calving late July/early August	4

ADULT PHYSICAL MEASUREMENTS

Physical measurements were obtained from 158 bison in the field. Appendix J shows measurements by age class and sex.

PARASITE TESTS

Lungworm Results

Fecal samples from eight (37.5%) animals were tested for lungworm larvae. Three (37.5%) were positive for Dictyocaulus, with an average of 0.24 larvae per gram (range = .13 -.35). Meagher (1966) reported 3 of 39 (7.6%) animals testing positive for lungworm in the northern herd.

CONCLUSION

The northern Yellowstone bison herd tested 54% brucellosis seropositive in 1988-89, within the range of previous tests of this population. More males tested positive than females but the incidence was not age specific. The incidence of brucellosis seropositivity did not indicate adverse effects on reproduction.

The age structure of this wild bison population was best determined using a combination of field aging and cementum annuli counts. This provided ages for 67% of the harvest. Age structure of the population in 1988-89 was very similar to that determined during reductions carried out in YNP during 1964-65.

The pregnancy rate of 74% was within the ranges previously documented for this population, with the majority of fetuses in utero, females. The prolonged calving season indicated by our data may reflect previous mild winters and an expanding population.

RECOMMENDATIONS

Incidence of the actual brucellosis organism rather than the brucellosis antibody should be determined as part of an attempt to document actual affects on bison and possible transmission to cattle.

During any future reductions, data should continue to be collected on brucellosis, age, and reproductive parameters for comparative purposes. There should also be a continual surveillance of other diseases and parasites. In addition, it would be of value to record lactation and kidney fat parameters to assess physical condition. If a high priority was placed on collection of biological data, a great deal of important information necessary for making sound management decisions could be obtained.

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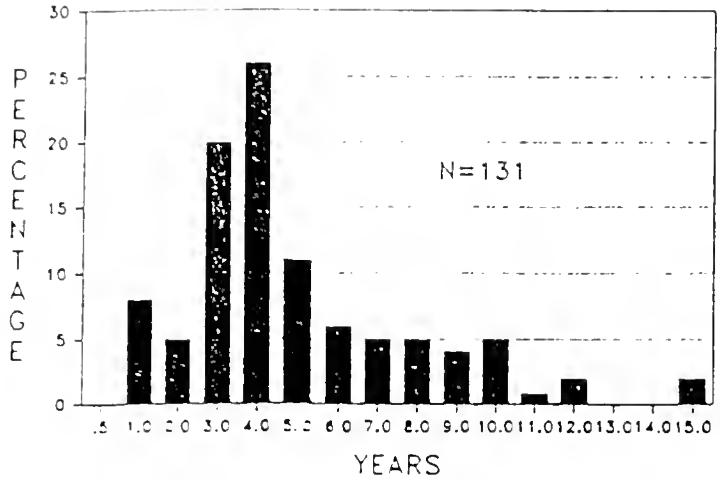
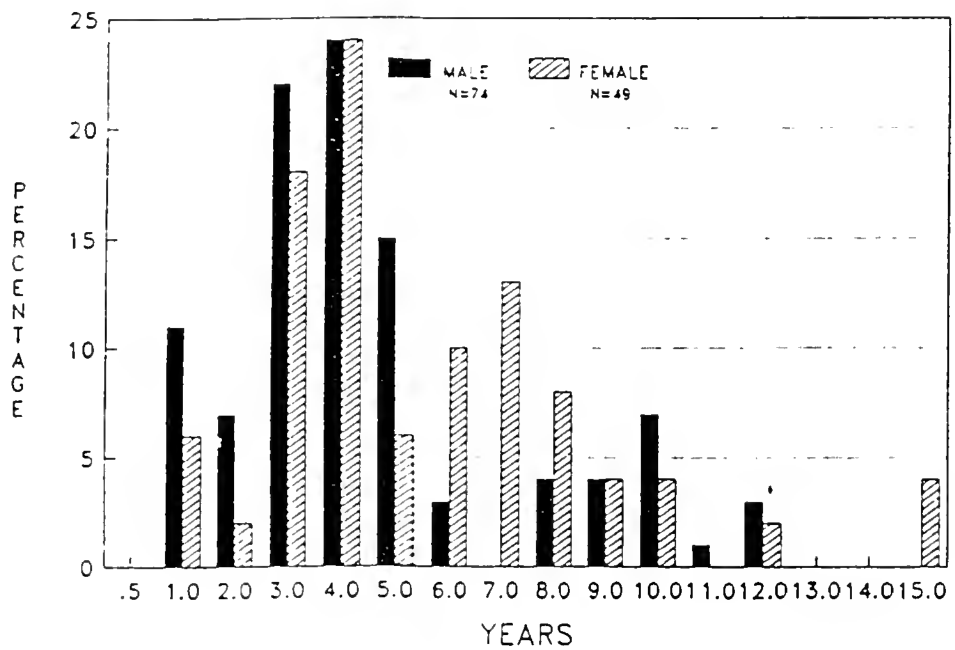
APPENDIX TABLES

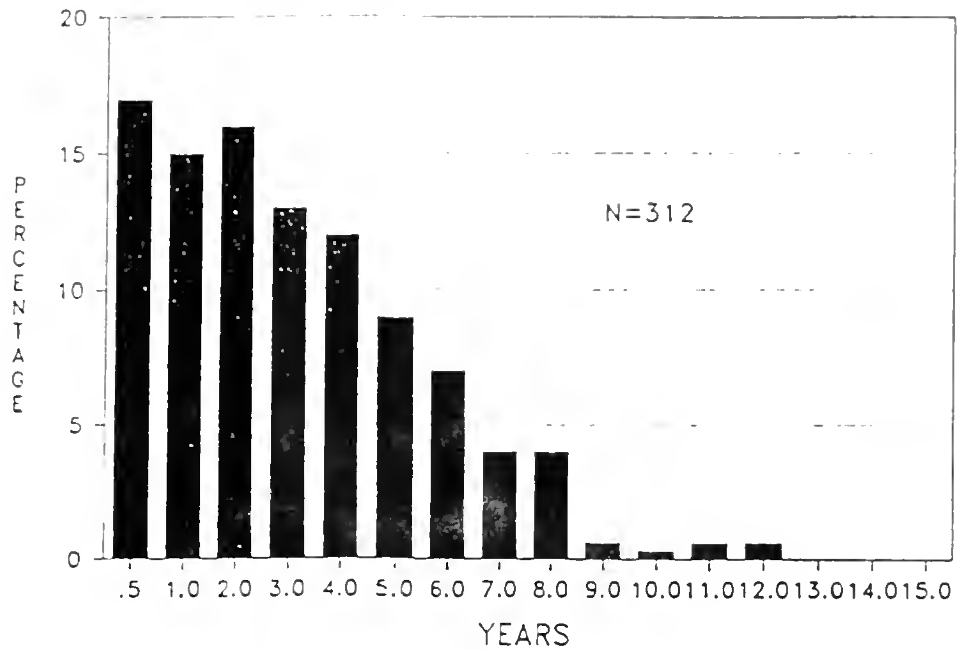
APPENDIX A. Cementum age structure of bison harvested in 1988-89.



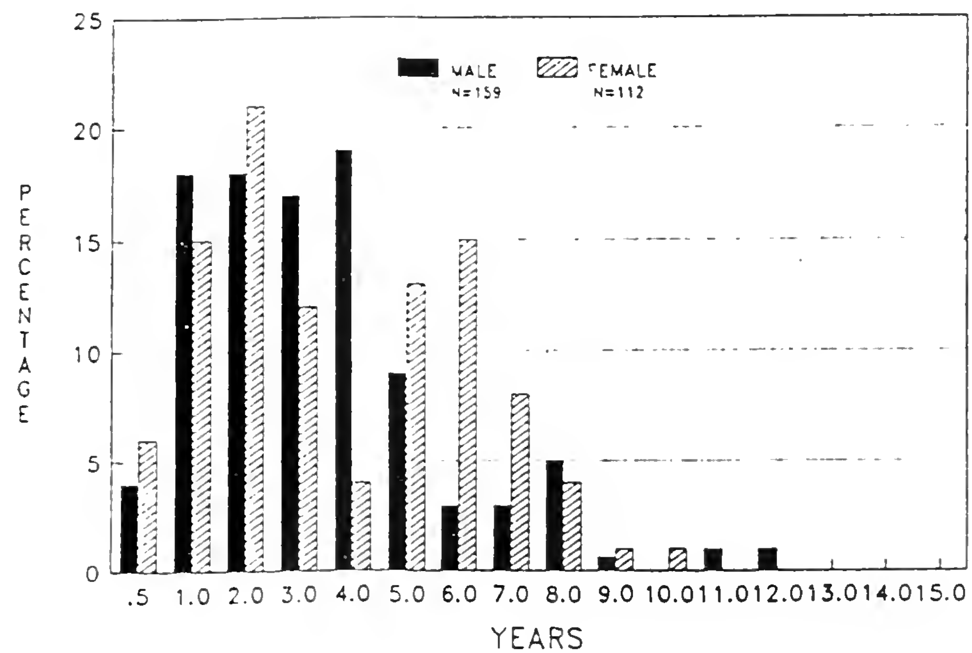
APPENDIX B. Cementum age structure of bison harvested in 1988-89 by sex.



APPENDIX C. Field age structure of bison harvested in 1988-89.



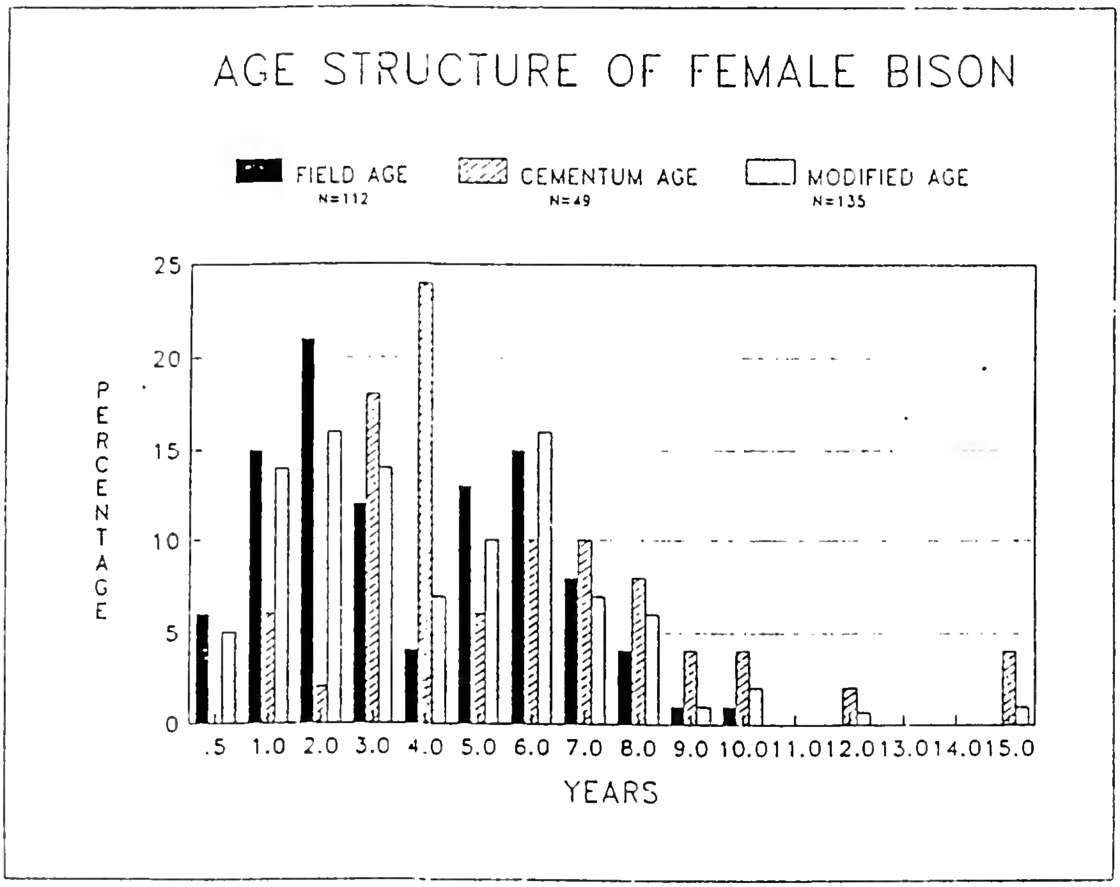
APPENDIX D. Field age structure of bison harvested in 1988-89 by sex.



APPENDIX E. Age distribution of female bison harvested in 1988-89 by three aging methods.

	Field Method		Cementum Method		Modified method	
Age	Number	%	Number	%	Number	%
0.5	7	6	0	0	7	5
1	17	15	3	6	19	14
2	23	21	1	2	21	16
3	13	12	9	18	19	14
4	5	4	12	24	10	7
5	14	13	3	6	13	10
6	17	15	5	10	21	16
7	9	8	5	13	9	7
8	5	4	4	8	8	6
9	1	1	2	4	2	1
10	1	1	2	4	3	2
11	0	0	0	0	0	0
12	0	0	1	2	1	0.7
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	2	4	2	1

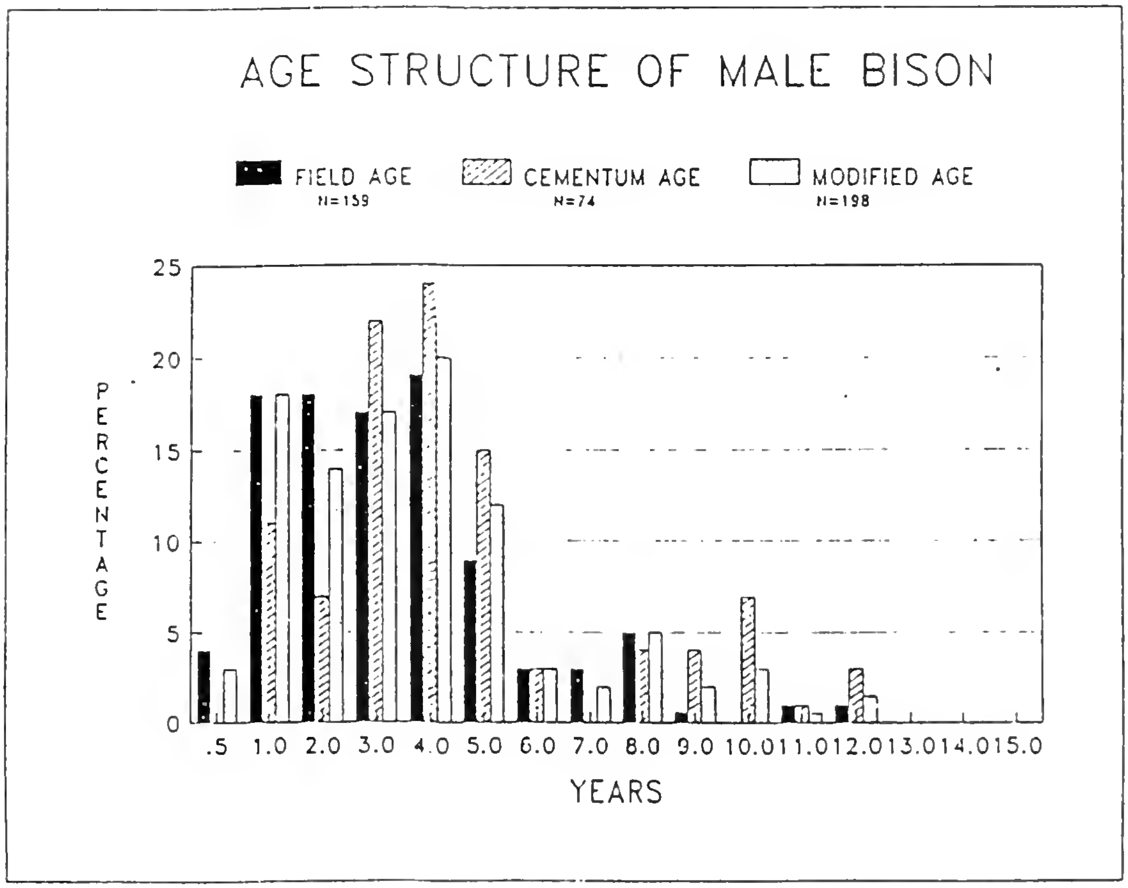
APPENDIX F. Age structure of female bison harvested in 1988-89 by three aging methods.



APPENDIX G. Age distribution of male bison harvested in 1988-89 by three aging methods.

	Field Method		Cementum Method		Modified method	
Age	Number	(%)	Number	(%)	Number	(%)
0.5	6	4	0	0	6	3
1	29	18	8	11	35	18
2	28	18	5	7	28	14
3	27	17	16	22	34	17
4	31	19	18	24	40	20
5	15	9	11	15	23	12
6	5	3	2	3	6	3
7	5	3	0	0	4	2
8	8	5	3	4	9	5
9	0	0.6	3	4	4	2
10	0	0	5	7	5	3
11	2	1	1	1	1	0.5
12	2	1	2	3	3	1.5
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0

APPENDIX H. Age structure of male bison harvested in 1988-89 by three aging methods.



APPENDIX I. Bison fetus information, 1988-89.

Adult #	Sex	Weight (lbs)	L (cm)	Age (months)	Date killed	Approx. Date Conceived	Approx. Calving Date	Mother Brucel-losis Test[1]	Mother Age[2] (yrs)
115	M	--	--	--	1/16	--	--	R	6C
240	F	7.13	41.0	5.0	2/11	9/11	6/30	N	2F
242	F	18.2	56.2	7.0	2/11	7/11	4/30	R	5F
252	M	8.8	43.9	5.5	2/11	8/30	6/15	R	5F
257	M	24.5	60.0	7.0	2/11	7/11	4/30	N	7C
258	M	11.5	44.2	6.0	2/11	8/11	5/30	S	4C
276	M	10.7	43.8	6.0	2/14	8/14	5/30	R	6F
277	F	20.0	58.4	7.0	2/14	7/11	4/30	N	5F
278	M	8.0	44.6	5.5	2/14	8/30	6/15	N	3F
279	F	15.9	52.6	6.0	2/14	8/14	5/30	R	5F
281	M	20.5	57.7	7.0	2/14	7/14	4/30	R	5F
283	F	16.9	55.1	6.0	2/14	8/14	5/30	N	2F
285	M	25.0	63.3	7.0	2/14	7/14	4/30	R	3C
286	M	25.5	59.8	7.0	2/17	7/17	4/30	R	6F
288	F	17.9	58.1	7.0	2/15	7/15	4/30	R	6F
306	F	19.0	57.0	7.0	2/16	7/16	4/30	N	3F
307	M	15.0	50.6	6.0	2/16	8/16	5/30	R	3C
308	F	16.9	54.8	6.5	2/16	7/1	5/15	R	4C
310	F	18.8	54.7	7.0	2/16	7/16	4/30	R	7C
315	F	9.0	44.0	5.5	2/16	8/30	6/15	N	--
328	F	20.0	56.8	7.0	2/17	7/17	4/30	S	3F
329	F	17.0	57.0	6.5	2/17	7/1	5/15	N	6C
330	F	5.0	36.0	5.0	2/17	9/17	6/30	R	3C
368	M	15.2	51.8	6.0	2/18	8/18	5/30	N	1F
369	F	27.0	62.7	7.0	2/18	7/18	4/30	N	8F
381	F	26.5	63.4	7.0	2/19	7/19	5/4	N	8-11C
384	F	4.8	38.5	5.0	2/19	9/19	7/4	N	6F
386	M	25.5	59.8	7.0	2/19	7/19	5/4	N	9C
412	F	18.5	54.6	7.0	2/21	7/21	5/6	N	8F
415	M	14.0	48.0	6.0	2/21	8/21	6/7	N	6F
417	F	19.0	55.4	7.0	2/21	7/21	5/6	N	2F

Adult #	Sex	Weight (lbs)	L (cm)	Age (months)	Date killed	Approx. Date Conceived	Approx. Calving Date	Mother Brucellosis Test[1]	Mother Age[2] (yrs)
419	F	27.0	62.6	7.5	2/21	7/7	4/21	N	3.5F
424	F	1.96	25.2	4.0	2/22	10/22	8/7	R	2F
426	F	3.48	32.4	4.5	2/22	10/7	7/22	R	--
429	M	18.2	54.7	7.0	2/22	7/22	5/7	N	4C
458	F	1.32	23.85	4.0	2/24	10/24	8/9	R	--
461	M	24.0	61.4	7.0	2/24	7/24	5/9	N	5F
464	F	11.9	50.1	6.0	2/24	8/24	6/9	R	--
466	F	22.5	62.2	7.0	2/26	7/26	5/15	N	6F
468	F	15.2	51.0	6.0	2/26	8/26	6/9	R	6F
469	F	13.2	49.4	6.0	2/26	8/26	6/90	R	10F
473	F	22.5	62.2	7.0	2/26	7/26	5/15	R	6F
474	F	18.0	56.8	7.0	2/26	7/26	5/15	R	5.5F
484	F	35.0	67.4	8.0	2/26	6/26	4/15	R	10C
503	M	33.0	67.1	8.0	3/8	7/8	4/23	R	10C
539	F		93.9	9.0	4/1	7/1	4/15	N	5C
552	M	8.8	43.9	5.5	2/18	8/30	6/18	R	6C
553	M	13.4	49.2	6.0	2/18	8/18	5/30	--	5C
556	M	19.0	55.8	7.0	unk	--	--	R	--
557	M	19.0	56.2	7.0	2/26	7/26	5/15	N	7F
558	F	22.0	60.0	7.0	2/20	7/20	5/10	--	--
559	M	23.5	61.1	7.0	2/20	7/20	5/10	--	--

[1] R = Reactive, S = Suspicious, N = Negative

[2] Letter following age indicates aging method:
C = cementum technique, F = field technique

APPENDIX J. Physical measurements for adult bison in 1988-89.[1]

SEX F

MODAGE	HRLN N	HRLN MEAN	HRLN STD	HRLN MIN	HRLN MAX	HRLN RANGE	HRLN STDERR
0.0	0.00	.	.	.	.	.	.
0.5	7.00	4.53	1.54	2.80	7.50	4.70	0.58
1.0	6.00	9.27	1.13	8.30	11.50	3.20	0.46
2.0	12.00	10.78	1.26	8.50	13.00	4.50	0.36
3.0	12.00	12.15	1.00	11.00	14.50	3.50	0.29
4.0	3.00	13.70	0.36	13.30	14.00	0.70	0.21
5.0	12.00	12.48	1.58	10.30	15.00	4.70	0.46
6.0	17.00	13.22	0.85	11.00	14.50	3.50	0.21
7.0	6.00	13.77	0.91	12.30	14.50	2.20	0.37
8.0	6.00	15.50	0.95	14.00	16.50	2.50	0.39
9.0	1.00	15.30	.	15.30	15.30	0.00	.
10.0	2.00	15.00	0.71	14.50	15.50	1.00	0.50
12.0	0.00	.	.	.	.	.	.
15.0	0.00	.	.	.	.	.	.

SEX M

MODAGE	HRLN N	HRLN MEAN	HRLN STD	HRLN MIN	HRLN MAX	HRLN RANGE	HRLN STDERR
0.0	0.00	.	.	.	.	.	.
0.5	6.00	5.48	1.00	4.00	6.80	2.80	0.41
1.0	8.00	12.60	1.20	11.00	15.00	4.00	0.42
2.0	10.00	14.10	1.60	12.00	16.50	4.50	0.50
3.0	12.00	16.11	0.99	14.00	17.50	3.50	0.29
4.0	7.00	16.61	1.07	15.00	17.50	2.50	0.40
5.0	8.00	15.80	1.03	14.80	18.00	3.20	0.36
6.0	2.00	16.00	2.12	14.50	17.50	3.00	1.50
7.0	0.00	.	.	.	.	.	.
8.0	1.00	16.00	.	16.00	16.00	0.00	.
9.0	0.00	.	.	.	.	.	.
10.0	2.00	15.50	2.83	13.50	17.50	4.00	2.00
11.0	0.00	.	.	.	.	.	.
12.0	0.00	.	.	.	.	.	.

SEX F

MODAGE	HRSP N	MEAN	STD	MIN	MAX	RANGE	STDERR
0.0	0.00	.	.	.	.	.	.
0.5	6.00	12.22	1.47	9.80	14.00	4.20	0.60
1.0	6.00	14.60	1.40	12.30	16.00	3.70	0.57
2.0	12.00	15.26	1.73	13.00	18.50	5.50	0.50
3.0	12.00	14.68	2.61	10.00	18.50	8.50	0.75
4.0	3.00	13.00	0.50	12.50	13.50	1.00	0.29
5.0	11.00	14.14	2.73	11.00	21.00	10.00	0.82
6.0	16.00	14.15	2.23	9.80	17.00	7.20	0.56
7.0	6.00	14.25	1.60	12.50	17.00	4.50	0.66
8.0	6.00	13.77	2.58	8.80	15.50	6.70	1.05
9.0	1.00	16.00	.	16.00	16.00	0.00	.
10.0	2.00	11.55	5.59	7.60	15.50	7.90	3.95
12.0	0.00	.	.	.	.	.	.
15.0	0.00	.	.	.	.	.	.

SEX M

MODAGE	HRSP N	MEAN	STD	MIN	MAX	RANGE	STDERR
0.0	0.00	.	.	.	.	.	.
0.5	6.00	15.13	2.02	12.00	17.30	5.30	0.83
1.0	8.00	20.69	1.03	19.00	22.50	3.50	0.37
2.0	10.00	22.65	1.96	20.50	26.00	5.50	0.62
3.0	12.00	21.35	2.47	18.00	25.80	7.80	0.71
4.0	8.00	21.01	2.69	16.50	26.00	9.50	0.95
5.0	8.00	21.12	1.71	17.50	23.00	5.50	0.60
6.0	2.00	19.75	0.35	19.50	20.00	0.50	0.25
7.0	0.00	.	.	.	.	.	.
8.0	1.00	21.00	.	21.00	21.00	0.00	.
9.0	0.00	.	.	.	.	.	.
10.0	2.00	23.00	0.00	23.00	23.00	0.00	0.00
11.0	0.00	.	.	.	.	.	.
12.0	0.00	.	.	.	.	.	.

SEX F

MODAGE	BASE N	BASE MEAN	BASE STD	BASE MIN	BASE MAX	BASE RANGE	BASE STDERR
0.0	0.00	.	.	.	.	.	.
0.5	7.00	4.96	0.63	3.80	5.80	2.00	0.24
1.0	5.00	6.70	0.45	6.00	7.00	1.00	0.20
2.0	12.00	7.12	0.36	6.50	7.80	1.30	0.11
3.0	11.00	7.35	0.36	7.00	8.00	1.00	0.11
4.0	3.00	7.60	0.36	7.30	8.00	0.70	0.21
5.0	8.00	7.80	0.67	7.30	9.30	2.00	0.24
6.0	16.00	7.49	0.41	6.80	8.00	1.20	0.10
7.0	6.00	7.60	0.51	7.00	8.50	1.50	0.21
8.0	6.00	7.88	0.38	7.50	8.50	1.00	0.15
9.0	1.00	7.50	.	7.50	7.50	0.00	.
10.0	2.00	7.00	0.71	6.50	7.50	1.00	0.50
12.0	0.00	.	.	.	.	.	.
15.0	0.00	.	.	.	.	.	.

SEX M

MODAGE	BASE N	BASE MEAN	BASE STD	BASE MIN	BASE MAX	BASE RANGE	BASE STDERR
0.0	0.00	.	.	.	.	.	.
0.5	6.00	6.10	0.91	4.50	7.00	2.50	0.37
1.0	4.00	10.83	1.35	9.50	12.50	3.00	0.68
2.0	7.00	11.00	0.91	10.50	13.00	2.50	0.35
3.0	12.00	12.96	1.10	11.00	15.00	4.00	0.32
4.0	6.00	13.13	1.11	12.00	14.80	2.80	0.45
5.0	8.00	13.23	1.15	11.00	14.80	3.80	0.41
6.0	1.00	17.00	.	17.00	17.00	0.00	.
7.0	0.00	.	.	.	.	.	.
8.0	1.00	15.00	.	15.00	15.00	0.00	.
9.0	0.00	.	.	.	.	.	.
10.0	2.00	14.75	2.47	13.00	16.50	3.50	1.75
11.0	0.00	.	.	.	.	.	.
12.0	0.00	.	.	.	.	.	.

SEX M

MODAGE	BASESP N	MEAN	STD	MIN	MAX	RANGE	STDERR
0.0	0.00	.	.	.	.	.	.
0.5	6.00	7.18	0.77	6.00	8.00	2.00	0.31
1.0	4.00	10.00	0.41	9.50	10.50	1.00	0.20
2.0	7.00	11.43	1.46	9.50	14.00	4.50	0.55
3.0	12.00	13.15	1.20	11.50	15.50	4.00	0.35
4.0	6.00	13.88	1.67	11.80	16.00	4.20	0.68
5.0	8.00	13.75	0.76	13.00	15.00	2.00	0.27
6.0	1.00	14.00	.	14.00	14.00	0.00	.
7.0	0.00	.	.	.	.	.	.
8.0	1.00	16.00	.	16.00	16.00	0.00	.
9.0	0.00	.	.	.	.	.	.
10.0	2.00	13.25	0.35	13.00	13.50	0.50	0.25
11.0	0.00	.	.	.	.	.	.
12.0	0.00	.	.	.	.	.	.

F

MODAGE	BASESP N	MEAN	STD	MIN	MAX	RANGE	STDERR
0.0	0.00	.	.	.	.	.	.
0.5	7.00	7.41	0.53	6.80	8.30	1.50	0.20
1.0	5.00	8.38	0.80	7.30	9.30	2.00	0.36
2.0	12.00	9.09	0.67	8.30	10.50	2.20	0.19
3.0	11.00	9.39	0.84	8.00	11.00	3.00	0.25
4.0	3.00	9.60	0.96	8.50	10.30	1.80	0.56
5.0	8.00	9.71	1.35	6.80	11.00	4.20	0.48
6.0	15.00	9.98	0.67	8.80	11.00	2.20	0.17
7.0	6.00	10.08	0.49	9.50	11.00	1.50	0.20
8.0	6.00	10.47	0.71	9.50	11.50	2.00	0.29
9.0	1.00	10.50	.	10.50	10.50	0.00	.
10.0	2.00	10.40	0.14	10.30	10.50	0.20	0.10
12.0	0.00	.	.	.	.	.	.
15.0	0.00	.	.	.	.	.	.

SEX F

	HOLN						
	N	MEAN	STD	MIN	MAX	RANGE	STDERR
MODAGE							
0.0	0.00	.	.	.	.	.	.
0.5	7.00	17.40	0.99	16.00	18.50	2.50	0.38
1.0	6.00	20.25	1.47	19.00	22.00	3.00	0.60
2.0	12.00	21.23	0.89	20.00	22.50	2.50	0.26
3.0	12.00	22.58	0.87	21.50	24.00	2.50	0.25
4.0	3.00	22.50	1.32	21.50	24.00	2.50	0.76
5.0	11.00	22.37	4.24	10.30	26.00	15.70	1.28
6.0	17.00	23.38	1.24	21.50	27.00	5.50	0.30
7.0	6.00	23.47	0.85	22.00	24.30	2.30	0.35
8.0	6.00	23.00	1.70	21.00	25.00	4.00	0.70
9.0	1.00	23.00	.	23.00	23.00	0.00	.
10.0	2.00	23.25	1.06	22.50	24.00	1.50	0.75
12.0	0.00	.	.	.	.	.	.
15.0	0.00	.	.	.	.	.	.

SEX M

	HOLN						
	N	MEAN	STD	MIN	MAX	RANGE	STDERR
MODAGE							
0.0	0.00	.	.	.	.	.	.
0.5	6.00	16.90	1.81	13.30	18.30	5.00	0.74
1.0	8.00	21.98	1.83	20.00	26.00	6.00	0.65
2.0	10.00	23.65	1.51	22.00	26.00	4.00	0.48
3.0	12.00	25.03	2.01	22.00	29.00	7.00	0.58
4.0	6.00	25.30	1.26	23.50	26.50	3.00	0.51
5.0	8.00	27.48	1.31	25.50	29.00	3.50	0.46
6.0	2.00	28.50	3.54	26.00	31.00	5.00	2.50
7.0	0.00	.	.	.	.	.	.
8.0	1.00	30.00	.	30.00	30.00	0.00	.
9.0	0.00	.	.	.	.	.	.
10.0	2.00	28.50	2.12	27.00	30.00	3.00	1.50
11.0	0.00	.	.	.	.	.	.
12.0	0.00	.	.	.	.	.	.

SEX F

MODAGE	TOTALLEN N	MEAN	STD	MIN	MAX	RANGE	STDERR
0.0	0.00	.	.	.	.	.	.
0.5	7.00	85.97	5.24	76.00	93.50	17.50	1.98
1.0	3.00	98.33	12.86	89.00	113.00	24.00	7.42
2.0	8.00	107.35	4.40	101.00	114.00	13.00	1.56
3.0	7.00	112.71	4.28	106.50	118.00	11.50	1.62
4.0	3.00	109.67	1.44	108.00	110.50	2.50	0.83
5.0	10.00	113.43	6.08	100.00	120.00	20.00	1.92
6.0	10.00	111.58	9.41	89.00	125.00	36.00	2.98
7.0	6.00	116.30	2.13	113.00	118.00	5.00	0.87
8.0	4.00	116.70	4.14	112.50	121.30	8.80	2.07
9.0	0.00	.	.	.	.	.	.
10.0	2.00	115.25	0.35	115.00	115.50	0.50	0.25
12.0	0.00	.	.	.	.	.	.
15.0	0.00	.	.	.	.	.	.

SEX M

MODAGE	TOTALLEN N	MEAN	STD	MIN	MAX	RANGE	STDERR
0.0	0.00	.	.	.	.	.	.
0.5	6.00	87.10	5.58	76.00	90.80	14.80	2.28
1.0	8.00	107.10	10.06	95.00	122.00	27.00	3.56
2.0	6.00	110.67	7.50	102.00	121.00	19.00	3.06
3.0	10.00	118.08	6.68	107.00	128.00	21.00	2.11
4.0	4.00	119.12	11.54	104.50	132.50	28.00	5.77
5.0	6.00	125.13	3.48	122.00	131.50	9.50	1.42
6.0	2.00	132.50	12.02	124.00	141.00	17.00	8.50
7.0	0.00	.	.	.	.	.	.
8.0	0.00	.	.	.	.	.	.
9.0	0.00	.	.	.	.	.	.
10.0	1.00	140.00	.	140.00	140.00	0.00	.
11.0	0.00	.	.	.	.	.	.
12.0	0.00	.	.	.	.	.	.

[1] See description of measurements in methods section. All measurements are in inches.