BEEF CATTLE FIELD DAY

U. S. Range Livestock Experiment Station

Miles City, Montana **MAY 8, 1970**

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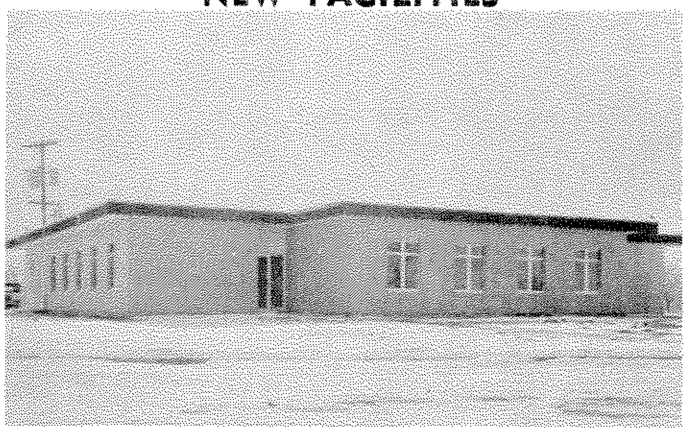

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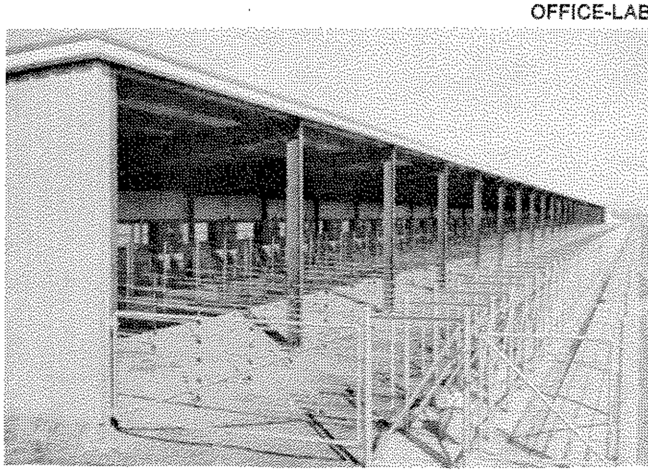

FEED UNITS

VEHICLE STORAGE

Animal Husbandry Research Division

Agricultural Research Service
United States Department of Agriculture
in cooperation with
Montana Agricultural Experiment Station
and
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CURRENT STATUS OF CROSSBREEDING RESEARCH AT THE MILES CITY STATION

by
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A study to evaluate the merits of crossing beef cattle breeds was started at the U. S. Range Livestock Experiment Station in 1961. The program was designed in three successive phases to: (1) estimate hybrid vigor in important traits of first-cross offspring (two-breed crosses) developed to breeding or slaughter age; (2) estimate hybrid vigor in maternal qualities of first-cross females; (3) evaluate the merits of rotational crossing schemes. The Hereford, Angus and Charolais breeds are being used to evaluate hybrid vigor from crossing. A limited introduction of Brown Swiss breeding is being used to provide some information on beef X dairy crosses.

Analyses of the data on first crosses to breeding or slaughter age are essentially completed. The results are tabulated in detail in this report. Preliminary information from the maternal and rotational crossing studies is summarized briefly.

Performance of Two-Breed Crosses to Slaughter or Breeding Age

Cows and calves were managed under range or pasture conditions to weaning time. Male offspring were tested on a feedlot ration of about 68% TDN until slaughter weights of about 1,000 to 1,050 lb. were reached. Heifers were fed hay and grain as necessary after weaning to produce an overall average gain of 0.8 lb. per head daily to about 361 days of age (April). The heifers were then grown out on roughage to about 547 days of age (October). Heifers produced in two of the four calf crops involved were bred as yearlings (June 15 to July 31).

For this phase of the study, two-breed crosses from matings among the three beef breeds were compared with contemporary straightbreds of the three beef breeds. Averages of various breeding groups and hybrid vigor expressed as differences between crossbred and straightbred groups, in actual measure and percentage of straightbred averages, are shown in the following tables. Beef X Brown Swiss crossbred groups from mating beef bulls to Brown Swiss cows were compared with the beef X beef crossbred groups sired by the same bulls. For readers interested in statistical significance of the differences reported, the significance levels are indicated by asterisks. These markings indicate where the greatest probabilities of real differences were found by analyses.

Information on beef X beef crossbreds and beef straightbreds to weaning is summarized in table 1 (steers) and table 2 (heifers). Significant advantages of crossbreds over straightbreds were evident for steers only. Hybrid vigor in all crossbred steers combined ranged from about 3.5% to 4.3% for growth traits and was about 2.2% for weaning grade. Corresponding percentages for heifers were about one-half as large or less. Hybrid vigor for preweaning growth traits tended to be higher in crosses of the British breeds than in the British-Charolais crosses. The reverse was true for weaning grade. Because of the greater growthiness of the Charolais, the British-Charolais crosses did, however, average higher than the Hereford-Angus crosses in all weights and in preweaning gain. Grade differences among the three crossbred groups were small.

Only the significant differences in preweaning and weaning traits of reciprocal crosses are shown in tables 1 and 2. Significant differences occurred only in comparisons of HxC vs. CxH and AxC vs. CxA. These comparisons are dependent to a large extent on the merits of the breeding stock used and could be altered considerably by selection of parent stock.

Postweaning information on beef X beef crossbred and beef straightbred steers is summarized in table 3. Significant advantages of crossbreds over straightbreds were confined almost entirely to initial weight and time required to reach the desired slaughter weight range. Hybrid vigor for growth traits of all crossbreds combined was in the range of 3.2% to 4.2%. Hybrid vigor for slaughter and carcass grades was estimated to be 2.6% and 1.1%, respectively. Hybrid vigor for initial weight and rate of gain in the feedlot tended to be higher in crosses of the British breeds than in the British-Charolais crosses. The reverse was true of slaughter and carcass grades. Because of the greater growthiness of the Charolais, average initial weights and ADG of British-Charolais crosses did exceed the averages for the Hereford-Angus crosses.

Gain per cwt. of TDN consumed was somewhat higher for crossbreds than for straightbreds in all comparisons but usually not by a significant amount. These values were, however, adjusted for differences in mid-weight of the various groups during the feeding period and were thus adjusted somewhat for differences in maintenance requirements. Although one would normally expect gain per cwt. of TDN to decrease with increase in mid-weight, the opposite was shown by the analyses in this study. Gain per cwt. of TDN increased about 0.7 lb. (nonsignificant) with an increase of 100 lb. in mid-weight. This was probably because the initially heavier and somewhat faster gaining animals tended to maintain their gains reasonably well to the final weight range and were removed from test under relatively favorable weather conditions. The initially lighter and slower growing animals required additional time on feed, were fed into relatively hot weather, and tended to show reduced gains before reaching the final weight range without a corresponding reduction in feed intake.

Crossbred heifers (table 4) showed nonsignificant advantages over straightbreds in all postweaning growth traits except ADG from 361 days (April) to 547 days (October). Crossbreds showed significant advantages in 547-day scores only.

Consistent with records up to weaning time, the significant differences in postweaning traits of reciprocal crosses (tables 3 and 4) were confined to CxH vs. HxC and AxC vs. CxA. As previously indicated, these comparisons can be altered appreciably by the breeding merit of parent stock used.

Each beef X Brown Swiss crossbred group obtained by mating beef bulls with Brown Swiss cows was compared with the beef X beef crossbred groups sired by the same bulls. Comparisons through weaning are summarized in table 5. The beef X Brown Swiss crosses showed advantages in all growth traits, but the beef X beef crosses generally showed advantages in weaning grade. Relatively heavy birth weights of beef X Brown Swiss crosses were seemingly associated with the relatively large size of the Brown Swiss dams. Even in lower average condition, the Brown Swiss cows outweighed the Hereford, Angus and Charolais cows by about 123, 180 and 70 lb., respectively. Relatively high milk production of the Brown Swiss dams apparently contributed to the growth advantage of their calves to weaning, but the milk supply did not prove to be excessive.

Comparisons of the beef X Brown Swiss and beef X beef crosses for postweaning traits are summarized in table 6. The beef X Brown Swiss crossbred steers were initially heavier than the beef X beef crosses, which accounted largely for the shorter feeding period required to reach the slaughter weight range of 1,000 to 1,050 lb. Slaughter grades of the beef X Brown Swiss crosses averaged consistently below those of the beef X beef crosses as the animals of Swiss breeding appeared to lack finish. On the rail, the beef X Brown Swiss crosses showed marbling and other characteristics justifying grades similar to those of the beef X beef crosses. The beef X Brown Swiss heifers weighed heifers at 361 and 547 days (table 6). This was547 days (table 6. This was due more to the advantage in weaning weight than to superiority in postweaning gain. The beef X beef heifers consistently scored higher than the beef X Brown Swiss heifers at 547 days of age.

Maternal Qualities of First-Cross Females

The straightbred and first-cross females previously discussed were mated with crossbred bulls for their first calves. All calves were three-breed crosses. The evaluation of these data is in preliminary form and subject to modification.

In comparisons with the beef straightbred females, the beef X beef crossbred females, showed advantages of 2.0 percentage points in net calf crop weaned and 2.2% in all growth traits to weaning for the calves produced. These combined effects resulted in production of about 5% more calf weight at weaning per exposed cow by the beef X beef crossbred females. These are estimated effects of crossbreeding in the dams only.

In comparisons with the beef X beef crossbred females, the beef X Brown Swiss females showed an advantage of 5.5 percentage points in net calf crop weaned. This advantage requires verification from further observations. The calves from the beef X Brown Swiss dams exceeded those of beef X beef dams by 6.7% in birth weight and about 11.0% in preweaning gain and weaning weight. The 50% Brown Swiss breeding in the dams undoubtedly contributed to their milk production and to the relatively heavy weaning weights of their calves. Advantages in net calf crop and calf growth resulted in production of 19.8% more calf weight at weaning per exposed cow by the beef X Brown Swiss females.

Rotational Crossing

This phase of the crossbreeding study is in progress and information is still limited. The straightbred and first-cross females previously discussed were used to start this phase after they dropped their first calves in the maternal study. These females have been bred to Hereford, Angus and Charolais bulls to produce straightbred, backcross and three-breed cross calves.

In comparison with straightbred matings to date, backcross matings, involving the beef breeds only, showed an advantage of about 1.2 percentage points in net calf crop at weaning. Backcross calves had an advantange of 4.3% to 5.8% in growth traits to weaning. Backcross matings resulted in about 7.2% more calf weight at weaning per exposed cow. Backcross calves graded slightly higher at weaning than straightbreds. Data are still too limited to provide a clear comparison of backcrossing with initial three-breed crossing.

The first-cross beef X Brown Swiss females were bred to the same beef bulls used in the production of beef backcrosses. Calves produced were three-breed crosses, all carrying about 25% Brown Swiss breeding. Net calf crop weaned was about the same as that of beef X beef females bred for backcross calves. The three-breed cross calves of 25% Swiss breeding excelled backcross calves by 9.0% to 11.0% in growth traits to weaning. The two groups were essentially alike in weaning grade. The beef X Brown Swiss females produced about 11.9% more calf weight at weaning per exposed cow than did the beef X beef females bred for backcross calves.

Summary

In comparison with straightbred cattle of the Hereford, Angus and Charolais breeds, first crosses among these breeds (two-breed crosses) showed evidence of hybrid vigor in most preweaning and postweaning growth traits and grades. As the three beef breeds were represented in this study, Charolais breeding contributed to growth trait averages of crossbreds and the British breeds contributed to postweaning grade averages of crossbred steers. In comparison with the first crosses of the beef breeds, first cross beef X Brown Swiss cattle out of Brown Swiss dams showed advantages in preweaning weights and gains and postweaning weights. First crosses of the beef breeds showed advantages in all live-animal grades, but the two groups of crossbreds were similar in average carcass grade.

Based on preliminary comparisons of first crosses (beef X beef) and beef straightbreds as breeding females, crossbreeding in the dams accounted for 5.0% more calf weight at weaning per exposed cow. The beef X Brown Swiss females weaned 19.8% more calf weight per exposed cow than did the beef X beef crossbred females.

Based on preliminary comparisons, first cross females (beef X beef) bred for backcross calves weaned 7.2% more calf weight per exposed cow than did beef straightbred females bred for straightbred calves. The beef X Brown Swiss females (first crosses bred to a second beef breed) produced about 11.9% more calf weight at weaning per exposed cow than did the beef X beef females bred for backcross calves.

Table 1. Performance of straightbred and first-cross beef steers to weaning.

Item[a]	No.	Weights: Birth (lb.)	Weights: 205 days (lb.)	ADG, birth to weaning (lb.)	Score,[b] weaning (Units)
H x H	25	79.9	439	1.76	77.5
A x A	38	70.5	459	1.90	80.0
C x C	25	93.4	559	2.27	78.8
Hybrid vigor (crossbreds minus straightbreds)[c]					
Crossbreds	156	84.1	504	2.05	80.5
Straightbreds	88	80.6	486	1.98	78.8
Difference		3.5**	18**	0.07*	1.7**
Percent		4.3	3.8	3.5	2.2
HxA & AxH	58	78.8	478	1.95	80.1
H & A	63	74.2	449	1.83	78.8
Difference		4.6**	29**	0.12**	1.3*
Percent		6.2	6.5	6.6	1.6
HxC & CxH	52	89.6	516	2.08	80.2
H & C	50	85.6	499	2.02	78.2
Difference		4.0*	17	0.06	2.0**
Percent		4.7	3.4	3.0	2.6
AxC & CxA	46	84.0	518	2.11	81.2
A & C	63	82.0	509	2.08	79.4
Difference		2.0	9	0.03	1.8**
Percent		2.4	1.8	1.4	2.3
Differences between reciprocals[c]					
H x C	28	82.9		2.16	
C x H	24	96.2		2.01	
Difference		-13.3**		0.15*	
A x C	23		539	2.23	82.8
C x A	23		496	2.00	79.6
Difference			43**	0.23**	3.2**

[a]Hereford (H), Angus (A) and Charolais (C). For crosses (example HxA) breed of sire is always listed first.

[b]Scores of 71 to 85 are low to high choice feeder grade.

[c]Statistical significance shown for differences between crossbreds and straightbreds and between reciprocal crosses, *(P<.05), **(P<.01).

Table 2. Performance of straightbred and first-cross beef heifers to weaning.

Item[a]	No.	Weights: Birth (lb.)	Weights: 205 days (lb.)	ADG, birth to weaning (lb.)	Score,[b] weaning (Units)
H x H	30	76.2	437	1.76	78.8
A x A	20	69.7	446	1.84	80.0
C x C	30	87.5	529	2.15	79.1
Hybrid vigor (crossbreds minus straightbreds)[c]					
Crossbreds	174	79.1	479	1.95	79.6
Straightbreds	80	77.8	471	1.92	79.3
Difference		1.3	8	0.03	0.3
Percent		1.7	1.7	1.6	0.4
HxA & AxH	62	73.2	454	1.86	79.3
H & A	50	73.0	442	1.80	79.4
Difference		0.2	12	0.06	-.1
Percent		0.3	2.7	3.3	-.1
HxC & CxH	54	84.4	489	1.97	79.2
H & C	60	81.8	483	1.96	79.0
Difference		2.6	6	0.01	0.2
Percent		3.2	1.2	0.5	0.3
AxC & CxA	58	79.6	496	2.03	80.4
A & C	50	78.6	488	2.00	79.6
Difference		1.0	8	0.03	0.8
Percent		1.3	1.6	1.5	1.0
Differences between reciprocals[c]					
H x C	27	79.0			
C x H	27	89.8			
Difference		-10.8**			
A x C	26	76.7			81.3
C x A	32	82.4			79.6
Difference		-5.7**			1.7*

[a]Hereford (H), Angus (A) and Charolais (C). For crosses (example HxA) breed of sire is always listed first.

[b]Scores of 71 to 85 are low to high choice feeder grade.

[c]Statistical significance shown for differences between crossbreds and straightbreds and between reciprocal crosses, *(P<.05), **(P<.01).

Table 3. Postweaning performance of straightbred and first-cross beef steers.

Item[a]	No.	Initial wt.	ADG	Gain/ cwt. TDN[b]	Days on test	Sltr. grade[c]	Carc. grade[c]
		(lb.)	(lb.)	(lb.)		(Units)	(Units)
H x H	19	416	2.09	18.11	274	11.7	13.0
A x A	25	437	2.03	15.72	271	11.5	10.4
C x C	15	525	2.41	18.78	221	17.0	16.6
Hybrid vigor (crossbreds minus straightbreds)[d]							
Crossbreds	101	479	2.26	18.11	244	13.0	13.2
Straightbreds	59	459	2.18	17.54	255	13.4	13.3
Difference		20**	0.08	0.57	-11*	-.4	-.1
Percent		4.2	3.7	3.2		2.6	1.1
HxA & AxH	38	454	2.18	17.32	259	11.9	11.8
H & A	44	426	2.06	16.91	273	11.6	11.7
Difference		28**	0.12	0.41	-14*	0.3	0.1
Percent		6.4	5.8	2.4		-2.8	-.9
HxC & CxH	32	496	2.36	19.44	233	13.7	14.6
H & C	34	471	2.25	18.45	248	14.4	14.8
Difference		25*	0.11	0.99*	-15	-.7	-.2
Percent		5.4	5.1	5.4		4.5	1.1
AxC & CxA	31	486	2.23	17.57	239	13.5	13.1
A & C	40	481	2.22	17.25	246	14.2	13.5
Difference		5	0.01	0.32	-7	-.7	-.4
Percent		1.0	0.6	1.9		5.1	2.7
Differences between reciprocals[d]							
C x H	13		2.55		220		13.6
H x C	19		2.18		246		15.7
Difference			0.37**		-26*		-2.1*
A x C	14					12.2	12.0
C x A	17					14.8	14.2
Difference						-2.6**	-2.2*

[a]Hereford (H), Angus (A), Charolais (C). For crosses (example HxA), breed of sire is always listed first.
[b]Adjusted for differences in mid-weight.
[c]High, middle, and low choice = 8, 10, 12, respectively. High, middle, and low good = 14, 16, 18, respectively.
[d]Statistical significance shown for differences between crossbreds and straightbreds and between reciprocal crosses, *(P<.05), **(P<.01).

Table 4. Postweaning performance of straightbred and first-cross beef heifers.

Item[a]	No.	Weights 190 days (lb.)	Weights 361 days (lb.)	Weights 547 days (lb.)	ADG 190-361 days (lb.)	ADG 361-547 days (lb.)	Score[b] 547 days (Units)
H x H	29	413	529	735	0.68	1.10	77.1
A x A	20	420	557	745	0.80	1.01	76.6
C x C	30	499	654	873	0.90	1.18	71.3
Hybrid vigor (crossbreds minus straightbreds)[c]							
Crossbreds	174	449	591	795	0.83	1.09	77.3
Straightbreds	79	444	580	784	0.79	1.10	75.0
Difference		5	11	11	0.04	-.01	2.3**
Percent		1.1	1.9	1.4	5.1	-.9	3.1
HxA & AxH	62	422	557	751	0.79	1.05	77.2
H & A	49	417	543	740	0.74	1.06	76.9
Difference		5	14	11	0.05	-.01	0.3
Percent		1.2	2.6	1.5	6.8	-.9	0.4
HxC & CxH	54	459	600	815	0.82	1.15	77.2
H & C	59	456	591	804	0.79	1.14	74.2
Difference		3	9	11	0.03	0.01	3.0**
Percent		0.7	1.5	1.4	3.8	0.9	4.0
AxC & CxA	58	465	617	817	0.89	1.08	77.5
A & C	50	460	605	809	0.85	1.09	73.9
Difference		5	12	8	0.04	-.01	3.6**
Percent		1.1	2.0	1.0	4.7	-.9	4.9
Differences between reciprocals[c]							
C x H	27				0.89		
H x C	27				0.76		
Difference					0.13*		
C x A	32				0.95		
A x C	26				0.83		
Difference					0.12*		

[a]Hereford (H), Angus (A) and Charolais (C). For crosses (example HxA) breed of sire is always listed first.
[b]Scores on 100-point basis, with higher value being more desirable.
[c]Statistical significance shown for differences between crossbreds and straightbreds and between reciprocals, *(P<.05), **(P<.01).

Table 5. Performance to weaning of beef X Brown Swiss and beef X beef crossbred calves by the same sires.

Item[a]	No.	Weights: Birth (lb.)	Weights: 205 days (lb.)	ADG, birth to weaning (lb.)	Score,[b] weaning (Units)
Steers:					
H x B	20	88.0	577	2.39	78.6
A x B	20	90.6	553	2.26	78.4
C x B	14	112.2	609	2.43	77.6
Average	54	96.9	580	2.36	78.2
Comparisons[c]					
HxB - HxA	20/33	9.0**	93**	0.41**	-1.3
HxB - HxC	20/28	4.2	53**	0.24**	-2.1*
AxB - AxH	20/25	9.7**	76**	0.32**	-1.7*
AxB - AxC	20/23	7.7*	13	0.03	-4.4**
CxB - CxH	14/24	15.2**	99**	0.41**	-2.1*
CxB - CxA	14/23	25.4**	110**	0.41**	-2.0*
Heifers:					
H x B	12	85.3	537	2.20	79.0
A x B	10	89.5	534	2.17	77.6
C x B	12	105.8	580	2.31	78.0
Average	34	93.5	550	2.23	78.2
Comparisons[c]					
HxB - HxA	12/29	13.9**	89**	0.36**	0.0
HxB - HxC	12/27	6.8*	49**	0.20**	-.6
AxB - AxH	10/33	15.2**	76**	0.30**	-2.1*
AxB - AxC	10/26	13.0**	39*	0.13	-3.8**
CxB - CxH	12/27	16.1**	92**	0.37**	-.9
CxB - CxA	12/32	23.8**	86**	0.30**	-1.6

[a]Hereford (H), Angus (A), Charolais (C), Brown Swiss (B). Breed of sire is listed first for all crosses.

[b]Scores of 71 to 85 are low to high choice feeder grades.

[c]Statistical significance shown for differences between beef X Brown Swiss and beef X beef crossbreds, *(P<.05), **(P<.01).

Table 6. Postweaning performance of beef X Brown Swiss and beef X beef crossbreds by the same sires.

Item[a] Steers:	No.	Initial wt. (lb.)	ADG (lb.)	Days on test	Gain/ cwt. TDN[b] (lb.)	Sltr. grade[c] (Units)	Carcass grade[c] (Units)
H x B	14	532	2.27	220	17.90	16.6	14.0
A x B	15	512	2.16	238	17.12	16.1	12.0
C x B	8	565	2.35	209	17.66	19.2	15.1
Average	37	536	2.26	222	17.56	17.3	13.7
Comparisons[d]							
HxB - HxA	14/25	80**	0.15	-43**	0.80	4.4**	3.0**
HxB - HxC	14/19	35*	0.09	-27*	-.96	3.3**	-1.4
AxB - AxH	15/13	63**	-.10	-18	-.33	4.6**	-.1
AxB - AxC	15/14	15	-.03	-2	-.20	3.8**	-.3
CxB - CxH	8/13	77**	-.18	-13	-2.41**	5.2**	1.3
CxB - CxA	8/17	87**	0.08	-29*	-.12	4.3**	0.6

Item[a] Heifers:	No.	190-day wt. (lb.)	Average daily gain 190-361 days (lb.)	Average daily gain 361-547 days (lb.)	Weights 361 days (lb.)	Weights 547 days (lb.)	Score[e] 547 days (Units)
H x B	12	504	0.70	1.13	624	835	73.6
A x B	9	505	0.92	1.10	662	867	69.8
C x B	12	542	0.91	1.20	699	922	67.6
Average	33	517	0.84	1.14	662	875	70.3
Comparisons[d]							
HxB - HxA	12/29	84**	-.09	0.09	69**	87**	-3.3*
HxB - HxC	12/27	47**	-.06	0.01	36*	39	-3.4*
AxB - AxH	9/33	81**	0.14	0.05	106**	115**	-7.7**
AxB - AxC	9/26	40*	0.10	0.06	56**	68*	-7.8**
CxB - CxH	12/27	83**	0.02	0.02	87**	90**	-9.9**
CxB - CxA	12/32	79**	-.05	0.09	72**	89**	-9.8**

[a]Breeds as defined in table 5.
[b]Adjusted for differences in mid-weight.
[c]High to low choice = 8 to 12; high to low good = 14 to 18.
[d]Statistical significance shown for differences between groups by same sires, *($P<.05$), **($P<.01$).
[e]Scores on 100-point basis, with higher value being more desirable.

RELATIONSHIPS AMONG WEIGHT GAINS, AGE AT PUBERTY AND REPRODUCTIVE PERFORMANCE IN HEIFERS

by
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Many experiments have shown that variations in feed intake will affect the age at which heifers reach puberty. However, little information is available on how differences in age at puberty induced by varying feed intake or weight gains actually relate to later reproductive performance. Age at puberty becomes critical under current management systems where heifers are bred at 14-15 months of age in order to first calve at 24 months of age. More information is needed to know what rate of gain is necessary for replacement heifers to insure maximal reproductive performance. Under normal ranch conditions, heifers receive supplemental feed during the winter months then all heifers are turned out on grass in the spring. Therefore, it becomes important to know at what level heifers should be wintered and what effect differences in winter gains have on subsequent growth and reproduction.

The following experiment was conducted to determine what effects varying rate of gain between 7 and 12 months of age would have on subsequent growth and reproduction of heifers.

Materials and Methods

Eighty-nine reciprocal crossbred Angus-Hereford heifer calves were used in this study. They were weaned on November 6, 1967, and held in feedlots until being placed on experiment. On December 6, 1967, the heifers were weighed and randomly allotted to one of three wintering treatments. Their average weight at this time was 327 lb. (range, 266-398) and their average age was 210 days (range, 182-232). Heifers were held in feedlots and the three treatment groups were fed to gain approximately .5, 1.0 or 1.5 lb. per day for the low, medium and high groups, respectively. They were weighed two weeks following being placed on experiment and approximately every four weeks thereafter. Weight gains were controlled by adjusting the rations at each weigh day. Average weight gains and amounts of hay and grain consumed are shown in table 1. These treatments were continued until there was adequate range forage available. Range forage was considered adequate when an average height of 6 in. of new growth was attained on Western wheatgrass. On May 7 adequate forage was available and all heifers were weighed and placed in the same pasture. All groups were then treated the same and remained on pasture until the end of the experiment on October 16, 1968. No supplemental feed was given while on pasture except for having free access to a salt-bone meal mix.

In order to get a measure of condition, fatness over the rib cage and withers was scored (1 = thinnest to 10 = fattest) by two persons. A total of the two scores was used as an estimate of condition. Skeletal growth was estimated by taking pelvic measurements. Condition scores and pelvic measurements were taken at the beginning of the experiment, when the heifers were put on range, and at the end of the experiment.

Table 1. Design of experiment.

	Winter gain group		
	Low	Medium	High
No. heifers	30	29	30
Avg. feed consumption[1] 12/6 to 5/7 (lb./day)			
Hay	10.2	10.5	11.6
Grain	0	1.9	4.4
Avg. daily gain (lb./day)			
12/6 to 5/7	0.62	0.99	1.50
5/7 to 6/12	1.32	1.14	0.92

[1]Hay was average quality grass-alfalfa and the grain (15% protein) consisted of 70% barley, 12-1/2% linseed meal, 12-1/2% wheat bran and 5% molasses.

Sterile bulls with marking harnesses were run with the heifers until the end of the breeding season to detect estrus for determining age at puberty and for artificial insemination during the breeding season. All heifers were palpated 5-11 days following the puberal estrus to confirm ovulation. Seven heifers had not reached puberty by the end of the breeding season. These were palpated weekly until the end of the experiment (October 16, 1968) to detect recent ovulations for estimating age at puberty. One heifer had not reached puberty by the end of the experiment. She was assigned a puberty date of the following day (October 17).

There was a 60 day breeding season for these heifers from June 15 to August 13. They were bred artificially 12 hours following first being detected in estrus using semen from one Angus bull. All heifers were palpated for pregnancy at the end of the breeding season and at the end of the experiment.

Results and Discussion

Initial body measurements were not different among the three groups (table 2). However, by the end of the 153 day winter period there were marked differences in body weight, pelvic area and condition score. As feed level increased all measurements increased. The relative differences induced by feed level seemed to be greatest for condition score and progressively less for body weight and pelvic area. Although this was not tested statistically, it may suggest that feed level was having a greater effect on soft tissue development than on skeletal growth.

Table 2. Effect of winter feed level on body size, condition and age at puberty.

Feed level	Body weight (lb.) Initial	Body weight (lb.) On range	Body weight (lb.) Final	Pelvic area (sq. in.) Initial	Pelvic area (sq. in.) On range	Pelvic area (sq. in.) Final	Condition score Initial	Condition score On range	Condition score Final	Age at puberty (days)
Low	321	414*	629*	16.1	20.9*	29.1*	9.2	6.5*	10.5*	434*
Medium	330	481	667	16.6	22.5	30.4	8.2	9.8	11.7	412
High	331	559	708	16.6	23.7	31.0	8.8	13.6	12.7	388

*Differences due to feed level are significantly different, $P<.01$.

By the end of the experiment the differences between the three winter feed groups were less. Apparently there was some compensatory growth in the medium and low groups after going on pasture. However, the three measurements on the medium and high groups were still significantly greater than those on the low group (table 2). The differences between the medium and high groups were less pronounced as pelvic area did not differ, condition score tended to be different and only body weight was significantly different.

Winter feed level had a marked influence on age at puberty. As feed level increased, age at puberty decreased (table 2). Even though the medium and low groups gained progressively more than the high group after going on pasture (table 1), age at puberty was still delayed in these two groups. These data agree with the findings of several other workers who also found that increasing feed level would decrease age at puberty.

Differences in age at puberty were reflected in the proportion of heifers who had their first estrus either before or during the 60 day breeding season (table 3). Eighty-three percent of the high group were in estrus prior to the breeding season as compared to 24% in the medium group (25/30 vs. 7/29, table 3). Only 80% of the low level heifers were in estrus before or during the breeding season as compared to 97 and 100% in the medium and high groups (24/30 vs. 28/29 and 30/30, table 3). Practically this is important because heifers that were in heat prior to or during the breeding season had a chance to produce a calf. Six of the heifers in the low group were never bred as compared to only one in the medium group and none in the high.

Table 3. Relationship of puberty to the breeding season.[1]

Treatment group	No. heifers expressing first estrus in relation to 60 day breeding season			Total
	Before	During	After	
Low	2	22	6	30
Medium	7	21	1	29
High	25	5	0	30
Total	34	48	7	89

[1]Breeding season went from June 15 to August 14.

Differences in winter feed level also had an effect on the day of the breeding season that heifers were first bred and day conceived (table 4). The low level heifers were bred the first time later in the season and also tended to conceive later than either the medium or high groups.

Table 4. Effect of wintering feed level on day of the breeding season heifers were first bred and day conceived.[1]

Feed level	Day 1st breeding		Day conceived	
	No. heifers	Avg.	No. heifers	Avg.
Low	24	23[2]	19	21[3]
Medium	28	14	26	16
High	30	11	27	14

[1]Breeding season went from June 15 to August 14.
[2]Differences due to feed are significant, $P<.01$.
[3]Low group tended to conceive later, $P<.10$.

Pregnancy rates were also affected by winter feed level as shown in table 5. The proportion of heifers pregnant either at the August or October palpation was only 63% in the low group as compared to 90% for the medium and high groups

(19/30 vs. 26/29 + 27/30, table 5). No significant differences were observed between the medium and high groups at either palpation. The final pregnancy rate in October was lower in the low group than in either the medium or high groups (15/30 vs. 25/29 + 26/30, table 5). The poor October pregnancy rate of 50% in the low level heifers was an accumulation of fewer being bred and fewer becoming pregnant that were bred but there was an indication that these heifers also had a greater early embryonic loss. More of the heifers in the low group lost pregnancies from October to August than either of the other two groups (4/16 vs. 1/24 + 1/26, table 5).

Table 5. Effect of winter feed level on number of heifers pregnant.

Pregnancy status[1]			Winter feed level		
August	October		Low	Medium	High
P	P		12	23	25
P	O		4	1	1
O	P		3	2	1
O	O		11	3	3
		Total	30	29	30

[1]P = pregnant, O = open.

Summary and Conclusions

Eighty-nine crossbred heifer calves were wintered at three different levels to gain approximately .5, 1.0 or 1.5 lb. per day to study the effects of differences in feed level on body growth, age at puberty and subsequent reproductive performance. At the end of the 153 day wintering period body weight, pelvic area and condition score were all increased by increasing the feed level. Following the wintering period all three groups were run in the same pastures. Daily gains on pasture were highest for the heifers wintered on a low level and decreased progressively for the medium and high groups. Even though there was some compensatory gains on pasture for the low and medium groups the fall weights were still progressively larger for the medium and high groups. Increasing the wintering feed level decreased age at puberty. During a 60 day breeding season only 24 of 30 heifers in the low group were bred as compared to 28 of 29 in the medium and 30 of 30 in the high groups. Pregnancy rates in October were reduced to only 50% in the low group as compared to 86 and 87% in the medium and high groups. This low pregnancy rate in the low group was a result of fewer heifers being bred, fewer heifers settling that were bred and more heifers losing calves from August to October. When heifers are bred to calve at two years of age, they should be wintered to gain at least 1.0 lb. per day. Gains of as much as 1.5 lb. per day are also acceptable but are probably not economical because reproductive performance is not increased. These recommendations are assuming that adequate range forage will be available following the wintering period.

SOME FACTORS RELATED TO CALVING DIFFICULTY

by
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Calf losses at or shortly after birth result in a major economic loss to the Montana beef producer. The national average for calves lost at birth is approximately 5%. This means that approximately 63,000 calves are lost annually in Montana. Research from this Station has found a major portion of the losses are due to difficult calving. Determining the causes of calving difficulty could possibly reduce this loss and result in more calves available for sale.

A study has been conducted at the U. S. Range Livestock Experiment Station to determine the major causes of calving difficulty. This study involved 95 Hereford and 103 Angus 2-year-old, first-calf heifers. All dams were bred artificially to a single Angus or Hereford bull to produce reciprocal crossbred calves. Factors studied included precalving weight and size of the pelvic opening of the dam, sex and birthweight of the calf and gestation length. Heifers were held in feedlots during gestation and gained 0.67 lb. per day from breeding to calving. Height and width measurements of the pelvic opening were obtained and multiplied together to obtain an estimate of the pelvic area.

Calving difficulty was scored in the following manner: 1 = no difficulty; 2 = difficulty but the calf pulled without the use of a mechanical calf puller; 3 = difficult and required the use of a mechanical calf puller; 4 = extreme difficulty, extreme traction with a mechanical calf puller or caesarean section. Abnormal presentations (4 calves) were not included in the analyses. Sex and birthweight of the calf were obtained immediately after parturition. For purposes of statistical analyses, calf sex was coded 1 for male and 2 for female. Since calves produced were reciprocal crossbreds, breed of dam and sire effects on calving difficulty were confounded. Thus, analyses were conducted within breed of dam only.

Table 1 shows the average precalving body weights and pelvic areas of the Hereford and Angus dams.

Hereford dams averaged 42 lb. heavier prior to calving and this difference was highly significant. The Angus dams had a slightly larger pelvic area but the difference was not significant.

Table 2 shows the average birth weights and the average calving difficulty percentages for the male and female calves from the Hereford and Angus dams.

Two pounds of pellets containing 32% protein, minerals, vitamin A and 180 mg monensin were fed per head to all three groups of steers. Ground barley made up the rest of the concentrate portion of the diet. All steers were started on free choice forage (pasture or corn silage), 4 pounds of ground barley and 2 pounds of protein supplement per head per day. During an adaptation period (18 days for the HR steers and 26 days for HC steers), the barley portion was gradually increased each day until steers received the planned levels of concentrate. Feeding was ad libitum once daily in the morning. All steer weights, initial, interim and final, were taken before the morning feeding. The trial was to end when 60% of the steers in the HC group visually graded U.S. Choice. Steers were on feed for a total of 91 days.

Results and Discussion

Postweaning and Pasture Performance

Steers gained an average of 1.1 pounds daily for the 140-day period and consumed an average of 10.9 pounds of dry matter per day of the corn silage-protein supplement feed. Steers may have gained at a more rapid rate particularly near the end of the study except the amount of feed offered was limited to about 33 pounds per head daily.

While on Russian wild rye-alfalfa pasture from April 6 through May 31 (55 days), steers gained an average of 164 pounds or 2.98 pounds/head/day. These gains demonstrate the potential gaining ability of steers on high quality, improved pastures from sires selected for growth rate.

From May 31 to August 2 for 63 days, steers gained 153 pounds or 2.43 pounds/head daily. Thus, gains of the steers in the present study for the entire 118-day grazing period averaged 2.68 pounds per day, which is similar to the gains of crossbred steers on pasture (2.65 pounds daily) in a study reported previously in the 1984 Station Field Day Report. On August 2, steers averaged 1016 pounds which is much heavier than steers commonly entering the feedlot.

Results of the Finishing Phase

Average daily dry matter intake by the steers in the finishing phase is shown by treatment in Table 2. The average dry matter consumption of steers on the HR diet for the 91-day period was 26.9 pounds per day, which is similar to the 26.7 pounds for the steers fed the HC diet. Concentrate intake of the HC steers (22.1 pounds/day) and concentrate intake of P steers (21.8 pounds/day) were also similar (Table 3).

The difference in gain for the 91 days for steers fed HR (3.74 pounds/day) and the HC diet (3.92 pounds/day) was not significant. Steers fed on pasture gained only 2.80 pounds daily for the 91-day period, which was lower than the other two feed groups. At the end of the 91-day feeding period, steers in the HR, HC and P groups averaged 1357, 1372 and 1272 pounds, respectively.

Carcass weights of the three groups of steers were HR diet, 785 pounds; HC diet, 791 pounds; and P diet, 735 pounds. Some of the steers approached the 900-pound weight, which is near the upper weight limit preferred by packers. No significant differences were found in dressing percent of steers on the three treatments. The percent of steers grading U.S. Choice was 33, 41 and 6% for HR, HC and P groups, respectively. All other steers graded U.S. Good.

TABLE 2. SUMMARY OF PERFORMANCE OF YEARLING STEERS PLACED ON FEED FOR 91 DAYS.

Dry matter in diet	HR	HC	P
Roughage, %	42	20	
Concentrate, %	58	80	
Place	Drylot	Drylot	Pasture
Number of head	18	17	17
Initial weight, pounds	1017	1015	1017
Feed offered daily for 91 days, pounds			
Concentrate portion	16.7	22.1	21.8
Total amount	55.2	44.6	
Dry matter (pasture not included)	26.9	26.7	19.4
Total concentrate offered, 91 days, pounds	1523	2011	1980
Total feed offered (pasture not included), pounds	5023	4056	--

Carcasses of steers fed the HR diet and the HC diet and the P diet averaged 0.54 and 0.49 and 0.39 inches of fat over the loin, respectively. Many of the steers failed to grade U.S. Choice because of lack of marbling. The yield grade of all steers in all groups were either U.S. 2 or 3.

The P steers differed ($P<0.01$) from the RC and HC groups in fat thickness over the loin, percent kidney and pelvic fat, carcass grade, yield and cutability estimate. They did not differ from the average of the other two lots in rib eye area. The HR and HC groups did not differ from each other in any of the growth or carcass traits studied ($P>0.10$).

Relationship to weight and growth. The larger steers, which were larger as calves at weaning, gained the most weight during the summer and feedlot periods and maintained the same relative weight position from the beginning to the end of the study.

Economic values. Based on prices received by producers for steer calves 1982-1985,[1] for steers 1983-1986[1] at a Montana Auction and for fed steers 1983-1986, Table 4 was constructed. No attempt has been made to estimate

[1] Prices supplied by Montana Agricultural Experiment Station agricultural economists.

costs of production. If range grass is plentiful, however, and can be produced economically, grazing steers in the spring and early summer would be a good method to increase income. The table shows steers increased an average of $1.80 per day while on the cow, $0.69 per day during the winter, $1.03 per day during the grazing period, and those in drylot increased an average of $1.65 per day on the finishing period.

TABLE 3. GROWTH RATE AND CARCASS CHARACTERISTICS OF STEERS BY DIET AND LOCATION

Diet designation	HR	HC	P
Average daily gain in feedlot, pounds			
1st 28 days	4.27	3.89	1.66
2nd 28 days	3.55	3.97	3.69
Final 35 days	3.46	3.90	2.99
Entire 91 days	3.74	3.92	2.80
Final weight, pounds	1357	1372	1272
Carcass weight, pounds	785	791	735
Dressing %	57.82	57.62	57.79
Fat thickness, loin, eye, inches	0.54	0.49	0.39
Rib eye area, square inches	12.2	12.8	12.6
Kidney and pelvic fat, %	0.86	0.82	0.65
Carcass grade score[a]	10.9	11.2	10.1
Choice, %	33	41	6
Good or Good Plus, %	67	59	88
Good Minus, %	0	0	6
Yield grade	3.0	2.7	2.3
Cutability estimate	49.2	50.0	51.1

[a] Good = 10, Good Plus = 11, Choice Minus = 12, Choice = 13.

TABLE 4. INCREASE IN VALUE PER DAY FOR STEERS FINISHED IN DRYLOT FROM BIRTH TO SLAUGHTER.

Time	Days	Gain in value per day $
Birth to weaning	178	1.80
Winter period	175	0.69
Grazing period	118	1.03
Finishing period	91	1.65

Summary

Steers from sires selected for growth rate gained rapidly at all stages, were larger steers at weaning, and also gained and weighed the most when slaughtered. There is considerable latitude in the ratio of concentrates to roughage that can be fed in finishing diets and still obtain satisfactory feedlot gains for a short feeding period. Steers fed concentrates on pasture did not make as rapid gains as steers fed a complete diet in drylot.

Utilization of summer pasture was a good system to obtain greater weight and economical gains on steers. As the industry and consumer moves to the acceptance of leaner beef, various methods of growing and finishing beef utilizing pasture grasses and a shortened finishing period can be used by the beef cattle producer.

REPRODUCTIVE TRAITS AND GROWTH TRAITS OF TWO-BREED AND THREE-BREED CROSS BEEF CATTLE

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Introduction

A beef cattle genetics project at the Station is testing the effectiveness for combining breeds of beef cattle to determine if the composite developed is adapted to the range environment. This is being accomplished by mating Charolais (C) and Tarentaise (T) sires to Red Angus (RA) females. The RA were chosen as the female component to provide highly fertile, medium sized cows with a medium level of milk production and to produce calves with low to medium birth weights that could be finished in the feedlot at 1,000-1,200 pounds. Half of the RA cows were mated by artificial insemination (A.I.) to C sires and the other half to T sires.

The Charolais (C) breed was used to contribute medium to rapid calf growth rate and increase the lean tissue component of the carcass. Charolais bulls were polled and came from established American breeders. Sires were selected within breed from information available from breed associations and from artificial insemination companies and individuals. If available, the information used was calf birth weight, calving ease scores, pre- and post-weaning growth rate and mature bull size.

The Tarentaise (T) breed was used to contribute a medium birth weight to the calves, udder shape and teat placement, medium pre- and post-weaning growth rate and medium size of mature cows. Most of the Tarentaise semen came from private individuals. Sires known to sire large birth weight calves of either breed were not used in the study. Therefore, data derived from the study is not intended to represent breed comparisons by offspring for sires within a breed for the various traits used.

Breeding System

In the formative stage (Phase I), T and C sires were mated to RA dams. In the next phase (Phase II), the CRA males were mated to the TRA females and the TRA males to the CRA females to produce 25% C, 25% T and 50% RA offspring. These 25% C, 25% T and 50% RA were then mated together in the present Phase III program. A 45-day breeding season was used in all phases of the study. Matings in Phase II and Phase III are still in progress. The three-breed crosses are offspring of the two-breed crosses and therefore are younger.

Replacement sires are selected for rapid growth to 12 months except that heavy birth weight individuals weighing 95 pounds or over are not retained for breeding. Yearling heifers are used as replacements. Heifers and cows that are open after the 45-day breeding season are culled.

Results

The purpose of this report is to present data on reproduction and growth rate of Phase II of the study and Phase III where three-breed cross males (25% C, 25% T and 50% RA) are mated to females of the same genetic composition. Reproductive traits where the crossbred males were mated to the crossbred females showed that pregnancy rate of the TRA yearlings was slightly higher (93%) than that of the CRA yearlings (85%) (Table 1). Pregnancy rates of the three-breed cross to the three-breed cross was 85%. The percent of cows experiencing difficulty at calving was slightly higher for calves born to TRA dams than calves born to CRA dams. Calving difficulty has been very low, 1.5 and 1.4%, respectively, for the CRA and TRA dams that are 3 years of age or older. Also, calf death losses are low (2.8%) for calves from TRA dams. Pregnancy rates of 92% and over for 3-year-old and older cows would indicate these cows are all very fertile.

TABLE 1. REPRODUCTIVE PERFORMANCE OF CROSSBRED FEMALES MATED TO CROSSBRED BULLS (1981-1986).

Breed of sire Breed of dam	Phase II Tarentaise-R Angus Charolais-R Angus	Phase II Charolais-R Angus Tarentaise-R Angus	Phase III 3-breed cross 3-breed cross
Yearling heifers			
Number	167	151	241
% pregnant	85	93	85
2-year-old			
Calv. difficulty, %[1]	29	36	23
Calf death loss, %	5.8	4.4	7.0
% pregnant	87	86	88
3-year old or older			
Calv. difficulty, %	1.5	1.4	--
Calf death loss, %	6.9	2.8	--
Pregnancy rate, %	92	95	94

[1] Calving difficulty scores were: 1=unassisted, 2=easy pull, 3=hard pull, 4=cesarean section, 5=abnormal presentation.

Comparison of the birth weights and weaning weights of all calves and the post-weaning gains of male calves from the crossbred sires and crossbred dams for 2 years are shown in Table 2. Calves from the TRA dams have consistently had a slightly higher growth rate and heavier 200-day weight. This, however, can be due to the specific mating cross, CRA mated to TRA rather than to the effect of breed of dam.

TABLE 2. WEANING AND POSTWEANING PERFORMANCE OF CALVES FROM CROSSBRED SIRES AND CROSSBRED DAMS (1985 AND 1986; 2 YEARS).

Breed of sire Breed of dam	Tarentaise-R Angus Charolais-R Angus	Charolais-R Angus Tarentaise-R Angus	3-breed cross 3-breed cross
Birth weight, lb.	82	86	81
Actual ADG, lb.	1.98	2.04	1.86
200-day weight[a], lb.	502	518	536
Postweaning growth rate (1 year)			
Males			
ADG, 168 days, lb.	3.19	3.29	3.24
Final weight, lb.	1018	1036	1027

[a] Adjusted by age of dam and sex to female base.

Post-weaning growth rates of all calves have been near 3.2 pounds daily. All bulls are fed a high roughage ration (54% dry matter) and finished on roughage. Performance of calves from three-breed cross cows was similar to the performance of calves from two-breed cross cows.

Some differences do exist in the pregnancy rates of yearling F_1 dams, with the TRA females having a higher pregnancy rate than the CRA females. When both crossbreds are bred to crossbred sires, no difference was found in pregnancy rates of 2-year-old and older cows. Calf death losses were low in this study, and few cows required assistance. Pregnancy rates in a 45-day breeding period of 3-year-old and older cows were 92% or higher. Weaning weights of calves were slightly over 500 pounds for all breed groups, with calves from TRA dams being slightly higher in pre- and post-weaning growth rates than in calves from CRA dams. Three-breed cross calves which were from younger cows were generally intermediate between the two-breed cross groups.

EFFECTS OF VARIOUS FACTORS ON ABORTIONS CAUSED BY PINE NEEDLES

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Introduction

In the last year, ranchers have reported pine needle induced abortions starting as early as late fall and continuing through the winter. Apparently abortions caused by pine needles are just as big a problem as ever. At our last field day, we reviewed the status of this problem so this report will mainly be an update on our research in this area since then. Several experiments have been conducted in an attempt to better understand and solve the problem of pine needle induced abortions.

Experimental Procedures

Experiment 1. This study was conducted to compare the abortion response of pine needles collected in winter to those collected in summer when fed to cows at eight months of pregnancy. Pine needles were also fed to open cows to determine if physiological changes occur in nonpregnant as well as pregnant cows. The experiment is summarized in Table 1.

TABLE 1. SUMMARY OF TREATMENTS AND RESULTS FOR EXPERIMENT 1.

Animal status	Season PN collected	Diet (lb) PN	Diet (lb) hay	No. cows	No. aborted	Interval to (d) Abort	Interval to (d) Calving
Pregnant	Winter	6	6	5	5	9	--
Pregnant	Summer	6	6	5	5	11	--
Pregnant	--	--	12	5	0	--	30
Pregnant	Winter, 1 day feed	6	6	4	1	3	30
Open	Winter	6	6	5			
Open	--	--	12	5			

Fresh needles were collected from the John Day, Oregon area. The needles were dried and then stored until being ground in a hammer mill before feeding. Pregnant cows were fed needles starting at 8 months of pregnancy and continued until abortion or calving occurred. The group of cows which were given pine needles only once had their dose of needles administered in a slurry pumped directly into the rumen. Open cows were fed needles starting on day 8 of a synchronized estrous cycle and continued until the next estrus.

Winter and summer needles were equally effective in causing abortions and a single exposure of winter needles caused one of four cows to abort. There was no effect of pine needle feeding observed on the open cows -- cycle lengths and progesterone profiles were similar between pine needle-fed and control cows.

Experiment 2. Most abortions caused by pine needles are observed during the winter. We don't know whether pine needles will cause cows to abort at other stages of pregnancy or whether this time of year is the only time when cows eat pine needles. This experiment was done to determine what effect varying stage of pregnancy would have on the abortion response to feeding pine needles. Cows were bred at a synchronized estrus at one of four different times of the year so that four stages of pregnancy would be represented on a given date in the fall of 1985. A summary of this experiment is shown in Table 2.

TABLE 2. SUMMARY OF STAGE OF PREGNANCY EFFECTS IN EXPERIMENT 2.

Average stage of pregnancy (d)	No. cows	% aborted	Days to abort
254	7	100	5.3
215	6	50	8.0
167	8	38	21
116	7	0	--

Pine needles collected from Custer County, Montana were handled as in Experiment 1. Cows were group fed a diet of 6 pounds ground, dried needles and 6 pounds ground hay until abortion occurred or for 3 weeks. As stage of pregnancy decreased, the response to pine needles decreased. A response decrease was evident by a decrease in the percent that responded and by an increase in the interval to abortion.

Experiment 3A. In the past, our research with pine needles has used a level of feeding that was determined by how much a cow will consume. Most cows will eat about 6 pounds per day of dried needles if they are hungry and the needles are mixed with an equal amount of hay. The effects of smaller amounts of pine needles are not known. Also little is known about the length of exposure required to cause abortions. Therefore, the objective in this experiment was to explore the effects that varying both amount and length of feeding pine needles have on induced abortions. A secondary objective was to determine whether injections of vitamin A would prevent pine needle induced abortions. Cows were assigned at random to one of the treatments summarized in Table 3.

TABLE 3. EFFECTS OF VITAMIN A AND LENGTH AND AMOUNT FED ON PINE NEEDLE (PN) ABORTION.

Treatment designation	No. cows	Amount Fed (lb.) PN	Amount Fed (lb.) hay	No. d fed PN	% aborted	Interval (d) to calving
Control	14	0	12	0	0	33
1.5 PN	10	1.5	10.5	21	80	19
3 PN	10	3	9	21	90	17
6 PN	10	6	6	21	100	10
PN-3	10	6	6	3	30	26
PN-1	9	6	6	1	10	34
VA+PN[a]	6	6	6	14	83	11

[a] This group was injected with 4.5 million i.u. of vitamin A before PN feeding started.

Pine needle feeding started on about 250 days of pregnancy and continued until abortion occurred or until the specified number of pine needle feeding days was reached. Feeding the lower amounts of pine needles still caused most cows to abort, but the interval to abortion increased as the amount fed decreased. Decreasing the number of days needles were fed drastically reduced the abortion response although some response was still observed since 30% aborted after 3 and 10% after 1 day of feeding. Vitamin A did not prevent abortions.

Experiment 3B. This experiment was run concurrently with 3A and was conducted to determine if pine needles would cause abortions in other ruminants. Pregnant sheep and goats were fed pine needles from the same batch as that fed to cows in Experiment 3A. Sheep were fed either 1.5 pounds of hay and 1.5 pounds of pine needles (treated) or 3 pounds of hay (control), and goats were fed either 1 pound hay + 1 pound pine needles (treated) or 2 pounds hay (control). No effects were observed in either goats or sheep as a result of the pine needle feeding.

Experiment 4. The site of action of the pine needle agent is not known. The corpus luteum (CL) and placenta both produce progesterone during late pregnancy, thereby both then contribute to the maintenance of that pregnancy. We attempted to pinpoint whether the pine needle agent is affecting the corpus luteum or the placenta in this experiment. One-half of the cows were injected with $PGF_2\alpha$ (Lutalyse®) on days 236 and 237 of pregnancy to cause regression of the CL. Then half of each of these groups were fed pine needles (4.5 pounds/day starting on day 250 of pregnancy. This experiment is summarized in Table 4.

TABLE 4. EFFECTS OF REGRESSING THE CORPUS LUTEUM ON ABORTION RESPONSE OF COWS FED PINE NEEDLES.

Treatment	PN fed	No. cows	Interval to calving (d)
Control	No	8	37
Control	Yes	8	11
CL regressed	No	8	19
CL regressed	Yes	8	14

Pine needles caused abortions just about the same regardless of whether or not the CL was present so apparently the site of action does not directly involve the CL. This conclusion is also supported by the results of Experiment 1.

Experiment 5. This is the last study in this sequence that has been conducted although hormone assays are not completed. In the previous experiments, blood samples were taken during the pine needle feeding period to explore some of the mechanisms that are involved in the resulting abortions. We have not presented these data because they are not all complete and in some cases somewhat confusing or conflicting. Our data in the last field day report showed that there was a marked and consistent rise in progesterone (P_4) associated with pine needle feeding which dropped before abortion occurred (although it was still higher than controls at the time of parturition). Changes were also observed in estrogen and cortisol but those changes were more associated with parturition rather than pine needle feeding. Preliminary summaries of hormone changes in subsequent experiments have shown these hormone changes are not consistent and may in some way be related to external stresses (either independently or in combination with pine needle feeding). This last experiment was conducted in an attempt to sort out this puzzle. The first objective was to test whether the stress of daily tail bleeding affects the abortion response to pine needle feeding. A second objective was to determine if pine needles can be pelleted and still maintain their abortifacient effects. Three bleeding stress treatments were used: none, tail bleeding started 20 days before pine needle feeding or tail bleeding started 2 days before pine needle feeding. This experiment is summarized in Table 5.

TABLE 5. EFFECT OF BLEEDING STRESS AND PELLETING OF PINE NEEDLES (PN) ON PINE NEEDLE INDUCED ABORTION.

Bleeding stress	PN fed	No. cows	Interval (d) to parturition
None	No	8	30
	Yes	8	5.5
20 d before	No	7	34
	Yes	7	7.9
2 d before	No	8	29
	Yes	8	15
None	Pelleted	8	15

Tail bleeding stress had a marked effect on the interval to abortion in the pine needle fed cows. Cows that were not tail bled or run through a chute very consistently aborted in a short time (5.5 days). When cows were run through a chute daily and tail bled starting only 2 days before pine needle feeding, that interval was delayed to 15 days and it was highly variable (range, 5-23 days). This stress effect was prevented by giving the cow a 3-week adjustment period before feeding started (7.9 days).

Cows fed pelleted needles also aborted (15 days) but the response was much delayed from that of cows fed needles from the same batch but not pelleted (5.5 days).

Discussion and Conclusions

The results from these experiments provide us with useful clues in unravelling the pine needle abortion puzzle. Unfortunately, we have not progressed to the point of being able to prevent these abortions (other than making sure cows don't have access to needles). On the bright side though, these clues are helpful enough that we are encouraged to forge ahead and will come back with better recommendations in the future.

Our conclusions from these studies are:

1. Both winter and summer collected needles cause abortion.

2. Adverse effects are observed in pregnant but not open cows. Apparently the effects of the pine needle agent are on the utero-fetal unit rather than the ovary.

3. Pine needles have their greatest effect during late (8 months) pregnancy although some effects can be seen as early as 5 months. This agrees with reports from producers last fall where cows aborted in pine trees in November-December.

4. Some effects of pine needles are observed when needles are fed for only 1 or 3 days and at amounts as low as 1.5 pounds/day, but the greatest response was seen when needles were fed longer and at higher levels (6 pounds/day).

5. No evidence was found that vitamin A will prevent the abortions caused by pine needles.

6. The presence or absence of a CL does not affect the response so this is further evidence that the site of action is the utero-fetal unit rather than the ovary.

7. Stress in addition to the pine needle feeding can delay but not prevent the response. Future research will need to take this complication into account.

8. Pelleting partially destroys or removes the abortifacient effects of pine needles.

9. Sheep and goats did not abort when fed pine needles. Unfortunately, they cannot be used as a "laboratory model".

10. Pine needles collected in Custer County, Montana are just as much a problem as those collected in Utah or Oregon.

A SELECTION EXPERIMENT TO CONTROL BIRTH WEIGHT IN CATTLE

J. J. Urick, W. L. Reynolds and R. A. Bellows

Birth weight has been identified as the single most important factor affecting difficult calving problems. Estimates of genetic correlations of birth weight with subsequent weights in Hereford cattle at Miles City ranged from 0.5 to 0.6 indicating that there should be some latitude for control of birth weight while continuing to increase subsequent growth to yearling weight. This selection study was initiated in 1977 to study the effect of restricting birth weight of bulls selected for herd sires on subsequent progeny growth and reproduction traits.

To initiate the experiment, about 160 females of the Line 1 herd were randomly divided into 2 subherds designated as Y and YB. Bull calves were fed 168 days in the feedlot after a 14-day adjustment period following weaning. The diet consisted of primarily corn silage with oats, corn, soybean oil meal supplement added. The heifers were fed 140 days in small areas following a 28-day adjustment after weaning. The heifers' ration consisted of primarily corn silage and soybean as supplement.

In the Y herd, sire replacements are selected for high yearling weight which is measured at 365 days. No restriction is placed on birth weight in Y. The subherd YB sire replacements are selected for the same criteria but with the restriction that birth weights are average or below average of the Line 1 herd. All herd sire replacements are given a breeding soundness examination at approximately 13 months of age.

The heifer selection is at 18 months of age off grass. Selection criteria for heifers are similar as for bulls except in YB there has been very little restriction on heavy birth weight. On the average, 75% of the heifers in each subherd are retained for replacements. Heifers not pregnant in a normal breeding season (60 days) and those with a low yearling weight are culled. Cows are culled if they become physically unsound and if they fail to conceive in a normal breeding season. With a few exceptions, cows are replaced at 10 years of age.

For this report, data were from sires used in the breeding seasons of 1977-1985, and their progeny produced in years 1978-1986 within each of the Y and YB herds. Yearling weight data are from 1979-1985.

Results

The average performance data for the Y and YB sires used to produce calves in years 1978-1986 are shown in Table 1, and the corresponding preweaning and postweaning performance of their calf progeny is shown in Tables 2 and 3.

TABLE 1. AVERAGE PERFORMANCE OF SIRES SELECTED FOR Y AND YB HERDS (CALF YEARS, 1978-1986)

Herd	No.[1] sires tested	Average[2] birth weight (lb)	Average[2] 205-day weaning weight (lb)	Average daily gain on feedlot test (lb)	365-day[2] yearling weight (lb)
Y	21	92.5	556	3.17	1037
YB	21	79.8	543	3.10	1007
Y minus YB sires (lb)		12.7	13.0	0.07	30.0
% difference		13.7%	2.4%	2.2%	2.8%

[1] Sires were repeated for 2 consecutive years.
[2] Adjusted to the 5 to 9 year mature age group.

The records shown in Table 1 are for 21 individual sires in each of the Y and YB herds. Most of these bulls were used for 2 consecutive years starting at either 1 or 2 years of age. The average differences of Y and YB sires for growth traits are shown in Table 1. These differences resulted because of the restrictions placed on heavy birth weight. The YB sires in comparison to the Y sires had smaller birth weights of 12.7 pounds (13.7%), weaning weights of 13.3 pounds (2.4%), postweaning feedlot ADG gain of 0.07 pounds (2.2%) and yearling weights of 29.7 pounds (2.8%). These Y and YB sire performance comparisons show that the intense negative selection pressure for birth weight in YB sires still allowed for selection of sires with a slightly reduced but acceptable preweaning and postweaning growth.

TABLE 2. BIRTH AND WEANING WEIGHTS OF CALVES IN Y AND YB HERDS, 1978-1986.

				Bulls and heifers combined					
				Birth weight (lb)[1]			180-day weight (lb)[2]		
Age of dam	Generation of Calf[3]	No. obs. Y	No. obs. YB	Lbs Y	Lbs YB	Y-YB Difference	Lbs Y	Lbs YB	Y-YB Difference
2 yr.	g1	28	31	72.3	65.7	6.6	418	425	-7
	g2	42	23	74.2	70.1	4.1	451	431	20
	g3	27	23	76.9	72.1	4.8	458	416	42
3 yr.	g1	39	24	79.5	73.0	6.5	430	408	22
	g2	24	27	83.6	79.8	3.8	464	435	29
4 yr.	g1	28	37	76.0	79.5	-2.5	427	420	7
	g2	24	29	85.0	81.4	3.6	479	470	9
5 yr. +	g1	84	77	81.6	82.4	-.8	431	438	-8
	g2	50	50	82.8	82.4	.4	459	451	8

1 Actual birth weight of calf--no adjustment for age of dam.
2 Adjusted for age of dam to the 5-9 age mature group.
3 The original dams and sires used were designated as generation 0. The generation of calf is calculated as follows: (sire generation + dam generation) ÷ 2 + 1.

TABLE 3. WEIGHTS (365-DAY) OF BULLS AND HEIFERS IN Y AND YB HERD, 1979-1985.

		365-day weight[1] bulls (lbs)			365-day weight[1] heifers (lbs)		
Age of Dam	Generation[2] of Calf	Lbs Y	Lbs YB	Y-YB Difference	Lbs Y	Lbs YB	Y-YB Difference
2 yr.	g1	927	936	-9	700	699	1
	g2	980	953	27	729	699	30
	g3	951	871	80	713	674	39
3 yr.	g1	1,003	994	9	693	660	33
	g2	1,009	965	44	740	725	15
4 yr. +	g1	980	994	14	690	680	10
	g2	991	991	0	739	727	12

1 Adjusted for age of dam to 5-9 age mature group.
2 See footnote (3) under Table 2 for explanation of generation.

Discussion of Results

The changes in growth of progeny of the Y and YB sires over several generations and the differences among the two herds within ages of dams are shown in Tables 2 and 3. In these preliminary comparisons, there was a partial confounding of years with generation, which could have reduced the accuracy of the overall estimates of growth responses presented. However, the trends of the generation responses to selection among the Y and YB herds within ages of dams were generally consistent and allowed for some meaningful conclusions to be drawn.

For pre-weaning traits of the calves (bulls and heifers combined) from 2-, 3- and 4-year-old dams, there were trends of increases in birth weight and weaning weight in the later generations in both Y and YB herds. The YB calves from 2-year-old heifers averaged over three generations, had 5.1 pounds smaller birth weights and 18 pounds lighter weaning weights than Y calves. In the 2-year-old heifers, the weaning weight differences of Y-YB increased from -7 pounds in generation 1 to 42 pounds in generation 3 in favor of Y calves. The trends of differences between the Y and YB calves from the 3- and 4-year dams over generations were similar to trends of the differences between Y and YB calves of the 2-year-old dams. The average birth and weaning weights of calves of 5-year and older dams in Y and YB were similar. Part of the 5+ year-old dams were the original dams which were similar in Y and YB.

For post-weaning growth of bulls and heifers (Table 3), the main trait included in these comparisons was 365-day yearling weight. The trends of Y-YB differences for 365-day weight of bulls and heifers within ages of dams were similar to those for pre-weaning growth of calves. The results indicate that the 365-day weight advantages in both bulls and heifers were carryover advantages from weaning. The average post-weaning 168-day gains among the Y and YB bulls were similar. Among the Y and YB heifers, the 140-day post-weaning test gains were similar.

Comparisons of Calving Results:

One objective of the study was to evaluate the effect of the reduction of birth weight in calves on calving difficulties. On the average, calves from the 2-year-old heifers in YB had 5.1 pounds smaller birth weights than the Y calves, which resulted in fewer (8%) calves having to be assisted in comparison to Y herd. The percentage of non-assisted births in YB and Y 2-year-old heifers respectively were 52 and 44%. Calves from 3-year-old heifers in YB were 5.2 pounds lighter than from Y, but the percentage of unassisted births were similar (90% in YB vs. 90% in Y). The average calf birth weight of the 4 year and 5+ year aged groups of dams in YB was 81.4 pounds, the same as for the Y cows. The percentage of unassisted births in YB and Y for the older cows was similar (97% in YB vs. 96% in Y). The results showed that selecting for reduced birth weights in the sires was mainly beneficial for reducing calving difficulty in the 2-year-old heifers.

Conclusions

Calf birth weights were reduced through selecting sires with lower birth weight, but the benefit of reducing calving difficulty resulted mainly in the 2-year-old heifers. The lighter birth weights in calves were associated with smaller weaning weights and yearling weights in the 2- and 3-year-old heifers. These results are from a relatively highly inbred herd of Hereford cattle selected for growth.

CALVING DIFFICULTY STUDIES

R. A. Bellows, D. J. Patterson, D. A. Phelps and W. L. Milmine

Introduction

Calf deaths occurring from birth to weaning result in a major reduction in production efficiency of beef herds. Two areas of research are summarized in this report. Area 1 is a survey of calf losses at LARRS over a 15-year period. Area 2 is a study conducted to determine effects of combining induced calving and early obstetrical assistance on calf survival, vigor and growth and subsequent reproduction of the dam.

Area 1

Data from 13,296 calvings collected over a 15-year period indicated 893 calves died from birth to weaning for a 6.7% average loss (Table 1).

TABLE 1. CALVINGS AND CALF LOSSES PER YEAR: 1963-1977[a]

Year	Number females calving	Number calves lost/year**	Annual loss (%)	Total loss (%)[b]
1963	667	50	7.5	5.6
1964	672	44	6.5	4.9
1965	730	59	8.1	6.6
1966	719	48	6.7	5.4
1967	947	46	4.8	5.2
1968	798	28	3.5	3.1
1969	917	58	6.3	6.5
1970	938	58	6.2	6.5
1971	950	44	4.6	4.9
1972	923	46	5.0	5.2
1973	938	52	5.5	5.8
1974	981	91	9.3	10.2
1975	1,110	147	13.2	16.5
1976	976	58	5.9	6.5
1977	1,030	64	6.2	7.2
Total	13,296	893	6.7[c]	100.0

[a] Losses represent deaths occurring from birth to weaning.
[b] Percent of total loss over the 15-year period.
[c] Average calf mortality percentage.
** $P<0.01$.

Calf deaths from first-calf 2- and 3-year-old dams accounted for 41.0% of total mortality. Losses within groups were: first-calf 2-year-olds, 10.9%; first-calf 3-year-olds, 8.7%; second calf 3-year-olds, 4.1%; second-calf 4-year-olds, 8.3%; multiparous 4-year-olds, 4.8%; and dams 5 years and older, 5.3% (Table 2).

TABLE 2. CALVINGS AND CALF DEATHS BY DAM AGE AND PARITY.

Age and parity of dam	Number of dams calving	Calf deaths within dam age and parity group: Number**	Calf deaths within dam age and parity group: Percent	Percent of all deaths
2-yr	2,257	245	10.9	27.4
1st-calf 3-yr	1,394	121	8.7	13.5
2nd-calf 3-yr	1,461	60	8.1	6.7
2nd-calf 4-yr	1,262	105	8.3	1.8
3rd-calf 4-yr	1,032	50	4.8	5.6
5-yr	1,760	76	4.3	8.5
6-yr	1,406	65	4.6	7.3
7-yr	1,050	64	6.1	7.2
8-yr	753	44	5.8	4.9
9-yr	486	30	6.2	3.4
10-yr	298	22	7.4	2.5
11-yr	104	9	8.6	1.0
12-yr	28	2	7.1	0.2
13-yr	5	0	0.0	0.0
Total	13,296	893	--	100.0

** P<0.01.

Calves lost from birth through day 3 postcalving account for a 4.6% loss with an additional 2.1% loss from day 4 through weaning (Table 3).

TABLE 3. CALF LOSSES BY TIME OF DEATH AND CATEGORY OF GREATEST LOSS.

	Calf deaths			Greatest death category			
						Percent of deaths	
Time of death[a]	No.	%**	Cumulative loss (%)	Category	No.	Within day	Of total deaths
0	513	57.4	57.4	Dystocia	357	69.6	40.0
1	48	5.4	62.8	Dystocia	19	39.6	2.1
2	26	2.9	65.7	Dystocia	8	30.8	0.9
3	27	3.0	68.8	Dystocia	9	33.3	1.0
4	18	2.0	70.8	Euthanasia	4	22.2	0.4
5	11	1.2	72.0	Accidental death	6	54.5	0.7
6	13	1.5	73.5	Pneumonia; scours	6	46.2	0.7
7	14	1.6	75.0	Pneumonia; scours	6	42.9	0.7
8	15	1.7	76.7	Pneumonia; scours	4	26.7	0.4
9	13	1.5	78.2	Pneumonia; scours	5	38.5	0.6
10	10	1.1	79.3	Pneumonia; scours	4	40.0	0.4
11-41	87	9.7	89.0	Pneumonia; scours	35	40.2	3.9
42-101	51	5.7	94.7	Missing/unknown[b]	25	49.0	2.8
102-wean	47	5.3	100.0	Missing/unknown[c]	23	48.9	2.6
Total	893	100.0	100.0		511	--	57.2

[a] Day 0 = death occurred within the first 24 hours postcalving; Day 1 = death occurred 24 to 48 hours postcalving, etc.
[b] Of the 25 missing/unknown calves that died during days 42 to 101, 3 were found dead and 22 were missing and not found.
[c] Of the 23 missing/unknown calves that died during days 102 to weaning, 5 were found dead and 18 were missing at weaning and not found.
** $P<0.01$.

The majority of calf deaths (57.4%) occurred within the first 24 hours post-calving with 75% of the total occurring days 0 through 7 and was similar among all dam age and parity groups. Calf death due to dystocia accounted for the single largest loss category through the first 96 hours postcalving, resulting in 69.6, 39.6, 30.8 and 33.3% of the loss incidence for day 0, 1, 2 and 3 postcalving, respectively. More ($P<0.01$) male calves (510; 57.6%) died than females (376; 42.4%).

Backward presentations occurred more frequently ($P<0.01$) than breech (1.6 vs. 0.6% of all births, respectively). Incidence of backward presentation was 2.3%, 5.6% and 0.9% for first-calf 2-year-old, 3-year-old and multiparous dams, respectively ($P<0.01$); 64.2% of the backward calves were males and 35.8% females ($P<0.01$). Survival of calves in backward presentation exceeded ($P<0.01$) that of breech calves (70.7 vs. 32.9%) (Table 4).

TABLE 4. BACKWARD AND BREECH PRESENTATION DATA SUMMARIZED BY DAM AGE-PARITY AND CALF SEX[a].

Item	Backward				Breech			
	Percent total births in study	Born No.	Born %	Survival (%)	Percent total births in study	Born No.	Born %	Survival (%)
First-calf								
2-yr-old	2.3[b]	52	24.2	59.6	0.5	11	13.9	54.5
Sex: M		34	65.4*	61.8		7	63.6	57.1
F		18	34.6	55.6		4	36.4	50.0
3-yr-old	5.6[c]	78	36.3	80.8	0.6	9	11.4	33.3
Sex: M		49	62.8*	81.6		5	55.6	40.0
F		29	37.2	79.3		4	44.4	25.0
Multiparous	0.9[d]	85	39.5	68.2	0.6	59	74.7	28.8
Sex: M		55	64.7*	70.9		27	45.8	37.0
F		30	35.3	63.3		32	54.2	21.9
Total	1.6[e]	215	100.0	70.7[g]	0.6[f]	79	100.0	32.9[h]
Sex: M		138	64.2*	72.5		39	49.4	41.0
F		77	35.8	67.5		40	50.6	25.0

[a] Data summary based on all calvings in 15-year study, includes both live and dead calves.
[b,c,d] Backward presentation-dam age comparisons, $P<0.01$.
[e,f] Total incidence of backward vs. breech presentations, $P<0.01$.
[g,h] Survival of backward vs. breech presentation, $P<0.01$.
* $P<0.05$, male vs. female.
** $P<0.01$, male vs. female.

Fall pregnancy rate of dams that lost calves and reentered the breeding herd that same year was 72.4% compared to 79.4% ($P<0.01$) for contemporary females that did not lose calves (Table 5).

TABLE 5. SUBSEQUENT PREGNANCY RATES OF COWS LOSING CALVES.

Age and parity of dam	Number females exposed for breeding	Pregnancy rate year following calf loss	
		Number pregnant	%[a]
2-yr-olds losing calves	196	137	69.9
Contemporary 2-yr-olds[b]	2,053	1,536	74.8
1st calf 3-yr-olds losing calves	112	87	77.7
Comtemporary 3-yr-olds[b]	1,377	1,081	78.5
Multiparous dams losing calves	414	299	72.2[c]
Contemporary multiparous dams[b]	9,481	7,630	80.5[d]
Total losing calves[e]	722	523	72.4[c]
Contemporary total	12,911	10,247	79.4[d]

[a] Row percentages.
[b] Contemporary dams were within same year and age grouping but calved without calf loss.
[c,d] Percentages with different superscripts differ ($P<0.01$).
[e] Represents total number retained for breeding; see text for explanation of additional 171 head.

The depression in pregnancy rate was not specifically due to dystocia but apparently to some general effect of calf loss.

Autopsies were completed on 798 calves lost from birth to weaning over the 15-year period. Autopsies determined cause of death and anatomical normalcy of the skeletal, muscle and organ systems and lung functional status. Of the 798 calves, 78% were anatomically normal and 22% abnormal ($P<0.01$) and 75% of the total deaths of abnormal calves occurred by day 2 postcalving. Internal hydrocephalus was identified and confirmed heritable as a lethal recessive. The number of calves lost from dystocia (406 calves; 51%) exceeded losses from all other causes (392 calves; 49%). Lung status was determined for 492 calves dying at birth with 40% and 60% having functional and nonfunctional lungs, respectively ($P<0.01$, Table 6).

TABLE 6. SUMMARY OF NECROPSY FINDINGS.

	Number	%
Total calves lost (15 years)	893	100
Calves autospied	798	89
Time of death		
Day 0	492	62[a]
Days 1-10	187	23[a,b]
Days 11-41	72	9[b]
Days 42-101	25	3[b]
Days 102-weaning	22	3[b]
Anatomical status		
Normal	620	78[c]
Abnormal	178	22[d]
Calf sex		
Male	458	57[c]
Female	340	43[d]
Major cause of loss		
Dystocia	406	51
Nondystocia	392	49
Lung status (calves lost at birth)		
Functional	195	40[c]
Nonfunctional	297	60[d]

[a,b] Different superscripts indicate differences, ($P<0.05$).
[c,d] Different superscripts indicate differences, ($P<0.01$).

Diseases, mainly scours and pneumonia, ranked second in importance as cause of death (13%) followed by exposure-chilling (6%) due to cold and wet conditions. Abnormalities observed included heart anomalies (24 calves), hydrocephalus (38 calves) and a missing segment of the hind gut (8 calves). Multiple abnormalities were found in 15 calves with finding similar to those resulting from maternal consumption of toxins from poison hemlock (Conium maculatum) during gestation. Twelve calves died from peritonitis resulting from a perforated abomasal ulcer caused by accumulated hair.

Of the 373 dystocia deaths in anatomically normal calves, 121 (32%) involved abnormal presentation with calves involved in backward or breech presentation accounting for 62% of the losses from abnormal presentation. Calves experiencing hiplock or retained front leg(s) were heavier ($P<0.05$) than calves presented in normal, backward or breech positions. Dystocia scores were assigned to 253 calves dying at parturition. Percentage losses within score were 53, 7, 32 and 10 ($P<0.05$; Table 7). Birth weights were 75, 80, 86 and 82 pounds ($P<0.05$) for scores of 1, 2, 3 and 4, respectively.

TABLE 7. DATA FROM ANATOMICALLY NORMAL CALVES LOST FROM DYSTOCIA.

	Number	%
Total	373	100
Presentation at birth		
Normal	252	68[a]
Backward	38	10[b]
Breech	37	10[b]
Hiplock	16	4[b]
Retained front leg	20	5[b]
Retained head	4	1[b]
Other	6	2[b]
Dystocia score		
1	133	53[c]
2	17	7[c]
3	78	32[c,d]
4	25	10[d]

[a,b] Means with different superscripts differ, $P<0.01$.
[c,d] Means with different superscripts differ, $P<0.05$.
[e] Dystocia scores not given first 2 years of the study; scores shown for normal presentations only.

We conclude from this work that calf loss reduces production efficiency through both calf deaths and lower subsequent pregnancy rates of dams that lost calves. The magnitude of these losses could be reduced through improved management. This improved management would be close observation of the pregnant dam near calving and identifying and correcting dystocia problems. Incidence of calf abnormalities could be reduced by control of poisonous (teratogenic) plants and use of herd sires free from genetic defects.

Area 2

Crossbred beef females (33 second-calf cows and 73 first-calf heifers) that had been bred to a single Hereford sire were assigned to a study involving age of dam, natural or induced calving and late emergency or forced early obstetrical assistance. Calving was induced with a 10-mg injection of flumethazone given between 2:00 PM and 4:00 PM on day 272 of gestation. Early assistance was given when the cervix and birth canal were fully dilated. Average induced calving occurred 39.6 hours postinjection and 95.3% of the treated dams responded (within 60 hours postinjection). Dystocia score (from

1=no assist to 4=major traction required and 5=abnormal presentation) was 1.12 vs. 2.40 for late and early assistance, respectively (P<0.01), and 11% of late assistance dams vs. 84% of early assistance dams were assisted (P<0.01, Table 8). Calf vigor score (1=normal to 3=depressed or dying) at birth was improved by induction (1.3 vs. 1.1, P≈0.06) and depressed by early assistance (1.1 vs 1.3, P<0.05). This latter effect was due to reduced vigor of calves experiencing abnormal presentation.

TABLE 8. MEANS FOR CALVING DATA.

		Dam data				Calf data		
		Induction						
	No.	Time (h)	Response (%)	Retained placenta (%)	Gestation length (d)	Birth weight (lb)	Calving difficulty score[b]	Vigor[b] score
Dam age								
Heifer	73	39.4	94.7	12.3	275.1	67.9	1.80	1.18
Cow	33	39.9	95.9	9.1	276.0	71.9*	1.73	1.23
Parturition								
Natural	61	--	--	10.0	277.0†	71.7	1.81	1.31†
Induced	45	39.6	95.3	13.0	274.1	69.4	1.72	1.10
Obstetrical assistance								
Late	55	41.9	94.7	10.0	275.8	69.9	1.12	1.08
Early	51	37.4	95.9	11.8	275.3	70.1	2.40**	1.33*
Calf sex								
Male	51	38.4	96.4	7.8	275.2	71.0	1.77	1.26
Female	55	40.9	94.2	14.5	275.9	68.8	1.75	1.15

[a] Means are from induced dams only.
[b] See text for description of scores and discussion of any interactions.
† P<0.10.
* P<0.05.
** P<0.01.

Birth weight and weaning weights of calves from cows exceeded those from heifers, but induction and early assistance had no significant effect on either birth (Table 8) or weaning weight (Table 9).

TABLE 9. MEANS FOR DAM AND CALF WEIGHTS AND GAINS.

		Dam data weight change			Calf data weight gain		
Item	No.	Calving to prebreed[b] (lb/d)	Calving to October (lb/d)	Weaning body wt[c] (lb)	Birth to prebreed[b] (lb/d)	Birth to weaning (lb/d)	Weaning body wt[c] (lb)
Dam age							
Heifer	63	0.22†	0.13**	900	1.59	1.43	345
Cow	30	-0.22	-0.18	999**	2.25**	1.94*	465**
Parturition							
Natural	52	-0.22	-0.22	950	1.94	1.72	407
Induced	41	0.22	-0.22	948	1.90	1.67	402
Obstetrical assistance							
Late	50	0.11	0.22	927	1.81	1.63	387
Early	43	-0.09	-0.04	972	2.03†	1.74	422
Calf sex							
Male	44	-0.09	-0.04	930	1.87	1.67	405
Female	49	0.08	-0.22	968†	1.96	1.70	405

[a] See text for discussion of interactions.
[b] Prebreeding weight = begin breeding season, June 15.
[c] Weaning = October 17.
† P<0.10.
** P<0.01.

Effects of induction and early assistance on postpartum interval, conception rate and fall pregnancy percentage were not significant. Fall pregnancy was improved by 13.3 percentage points (P<0.10) in early assisted dams and induction tended (P≈0.08) to reduce number of breedings per conception (Table 10).

TABLE 10. LEAST-SQUARE MEANS FOR REPRODUCTION TRAITS OF DAM[a].

Item	Number	Postpartum interval (d)	Services per conception[b] (no.)	October pregnancy (%)
Dam age				
Heifer	63	47.3	1.17	81.9
Cow	30	47.6	1.22	91.8
Parturition				
Natural	52	46.9	1.29†	86.5
Induced	41	47.9	1.09	87.2
Obstetrical assistance				
Late	50	48.0	1.24	80.2
Early	43	46.9	1.15	93.5†
Calf sex				
Male	44	50.2	1.17	88.4
Female	49	44.6	1.22	85.2

[a] See text for interaction.
[b] Calculated on pregnant dams only.
† P<0.10.

Interaction effects of induction and early assistance on dam reproduction and weight change and calf growth were nonsignificant. We conclude that, when done correctly, induction and early assistance can be combined to predict when calving will occur and to hasten the calving process without detrimental effects on either dam or calf. This combination could be used by cattlemen to schedule and manage intensive calving periods by hastening completion of induced calvings but should not be viewed as a means to improve calf growth or reproductive performance of the dam. The success of this practice would be fully dependent on adequate calving facilities, accurate determination of birth canal dilation, application of correct obstetrical techniques and intensive disease prevention and control measures, including treatment of retained placentas. The lower (13.3%) pregnancy rate noted in dams having prolonged labor agrees with previous Miles City work. The results obtained in both studies are interpreted to mean this effect can be overcome by early obstetrical assistance.

HISTORICAL PERSPECTIVE
FORT KEOGH LIVESTOCK AND RANGE RESEARCH STATION

The Custer Massacre of June 25, 1876 was the spring-board for the establishment of Fort Keogh as an Army cavalry post and led to the founding of Miles City. In 1879, Miles City, Montana was designated the county seat of Custer County and the first court session was held there in May 1879.

Congress established the Fort Keogh Military Reservation, July 22, 1876. Fort Keogh was named after Captain Myles Keogh, an adjutant to General George Custer, killed in the Battle of the Little Big Horn on June 25, 1876. Establishment and early development of Fort Keogh was under the direction of General Nelson A. Miles. Both Fort Keogh and Miles City have remained to serve the vast ranching areas of southeastern Montana and the surrounding Northern Great Plains.

In 1907, all infantry troops were withdrawn and in 1910 Fort Keogh became a Remount Station for the U. S. Army. This Remount Station was very active in World War I. During this period more horses were processed here than at any other army post in the United States. Horses were shipped worldwide. In 1922, the Army relinquished the land and the Fort Keogh military withdrawal was terminated on February 2, 1924.

By an Act of Congress dated April 15, 1924 (43 Stat. 99) jurisdiction of the Fort Keogh Military Reservation was transferred to the U.S. Department of Agriculture for experiments in stock raising and growing of forage crops. On site remains of the original Fort include the parade grounds, two officers quarters built in 1877 and 1879, a wagon shed built in 1883, the flag pole erected in 1887, and seven other structures built prior to 1924.

The size of the original Fort Keogh Military Reservation was 100 square miles or 64,000 acres. The Fort Keogh Livestock and Range Research Station now occupies about 56,500 acres. In 1878, a large piece of land east of the Tongue River was released by the Army and is now the present site of the City of Miles City. Since that time, additional land has been released for the Miles City industrial sites, Custer County fairgrounds, the warm-water fish hatchery and Spotted Eagle Recreation Area. Approximately 1,800 acres are under irrigation in the Yellowstone River Valley west of the Station headquarters. About 625 is in cultivated crops and 1150 in irrigated pastures. The remainder of the Station is rough, broken badlands typical of range cattle producing areas of the Northern Great Plains.

Animal herd size is presently about 2000 head which includes approximately 700 calves. The beef breeding herd is maintained in 30 to 50 animal unit herds. In 1979, there were 3250 head of cattle on the Station and there were 1681 cows bred in 72 separate sire groups. This was the largest cattle inventory in the history of the Station. Decreasing range conditions and severe drought during the 1980's forced reductions from that number. Replacement heifers, young bulls and steers, herd bulls and cattle on reproduction, range nutrition or range forage experiments make up the remainder of the inventory.

A total of 45 permanent employees are involved in Station research studies. Twelve of these positions are with the U. S. Department of Agriculture and include 8 professional scientists, a Location Statistician, Administrative

Officer, Purchasing Agent, Federal Secretary and Maintenance Foreman. Thirty-three positions are with the Montana Agricultural Experiment Station. This includes 4 Professional Research Associates who function in program supervision positions. Twenty-nine are classified personnel with MAES and are employed under two union contracts. An additional 10 to 20 temporary positions are used to support research studies depending on time of year and project needs. These positions are both union, non-union and student employees.

The early Station was a widely diversified unit. There were approximately 1200 Rambouillet ewes on experiment during the early days. Ewes and lambs were on breeding and feeding experiments and wool studies. All sheep were transferred to the U.S. Sheep Experiment Station, Dubois, Idaho, in 1941.

There was also a Milking Shorthorn dairy herd maintained on the Station. The milk was sold to the employees, but the animals were not used extensively for research purposes. The herd was dispersed in the late 1930's.

There have also been many horses on experiments. In 1934, the inventory showed 250 head on breeding, feeding and reproduction studies involving purebred Belgian, Morgan and Thoroughbred sires. Some of the early work to develop successful semen collection and artificial insemination techniques in horses was conducted at this Station. The Thoroughbred breeding herd was maintained until 1964. There are now 30 to 40 horses on the Station that are used entirely in cattle-moving operations.

Research on turkeys was also conducted at the Station. Studies with Bronze turkeys started in 1929 and involved approximately 1500 young turkeys and 350 breeding hens. Studies consisted of feeding, breeding and rearing experiments, and the original crosses and the early work lead to development of the Beltsville White breed.

Previous swine research was directed largely toward production of Wiltshire Sides for the European pork market. In 1930, pork from the U.S. Range Livestock Experiment Station was reported to be the best American Wiltshire Sides on the London market. The swine work is most famous for the development of the Montana No. 1 breed. This was produced by crossing the Danish Landrace and the Black Hampshire breed. Crosses were inbred and through selection, one of the first meat-type breeds was established. Federal funding for Station swine research was terminated in 1968 and, since that time, swine work was directed by staff members in the Animal and Range Sciences Department at Montana State University. Work involving the Montana No. 1 and the Yorkshire breeds was terminated in 1971 and a crossbred herd was established to supply animals for studies directed by Montana State University nutritionists. The swine research was moved from Fort Keogh to Bozeman in 1986 and the swine unit closed out.

BEEF CATTLE RESEARCH

The broad goal of the beef research program at this Station is to increase the efficiency of beef production from cattle maintained in a range environment. The work involves research studies in the areas of animal breeding, physiology of reproduction, animal nutrition and range pasture development, improvement and management. In addition, some studies on various diseases have also been conducted. It is believed that scientists at this Station were the first to investigate methods for control of brucellosis that were applicable to range and semi-arid conditions. Other studies have involved determining methods for control of eye cancer and the effects of vaginal and uterine prolapse on cow productivity. Funding for research is by the appropriation process through USDA-ARS. No appropriated funds are received from the State of Montana. Funds on this side of the ledger are from income funds from receipts for the sale of cattle.

CATTLE BREEDING

Beginning in 1930, the Station pioneered in the development of methods for evaluating performance in beef cattle. All beef performance testing programs now active in the United States and much of the remainder of the world trace to these pioneering activities. Perhaps the most important contribution of these experiments was the determination of heritability estimates for economically important traits in beef cattle. This gave knowledge of the comparative influences of heredity and environment in performance and has greatly improved selection techniques.

The first large-scale linebreeding studies in beef cattle in the United States were initiated at the Station. A number of lines of purebred Hereford cattle have been developed and have been or are being tested for production potential. These studies have resulted in the development of highly productive lines of cattle, Line 1 being the most famous. The objective of these experiments is to determine the improvement that can be made in a closed population of beef cattle starting from a superior genetic base. The oldest line (Line 1) has not had an introduction of either bulls or cows since 1934. Animals surplus to the research program are sold at an annual production sale, and animals from this line are now widely used in purebred and commercial beef herds throughout the Unites States. In 1980, Station scientists received a Superior Service Award from the USDA for development of this Line and the impact it has had on the Hereford breed.

One of the first findings in the line breeding study was that linebreeding is profitable only when practiced with cattle that exceed the breed average for most production traits. Despite the fact that the original lines in the studies were selected from presumed top herds, many did not respond to linebreeding and had to be discarded. However, the success of several lines, notably Lines 1, 12 and 14, has proved that a linebreeding program, coupled with strict selection for performance, is an economically feasible method of improvement for beef cattle.

Semen was collected from Line 1 bulls in 1955, 1965 and 1975 and used for breeding within a common group of females. This work was conducted to determine the permanent genetic progress or change established through selection. Results indicated that selection permanently improved all economically important traits, and the improvements actually observed agreed closely with the predicted values based on heritabilities of the various traits.

The long-term linebreeding research involving Line 1 was modified in 1977 to include selection for low birth weights. Calving difficulty problems are increasing nationwide and high birth weights have been identified as the main contributing factor. This work is designed to determine if selection of replacement sires with below average birth weight offers promise in alleviating this problem. Thus, Line 1 has been sublined with one-half of the Line being maintained with low birth weight as an added selection criterion. To date, this selection has resulted in a 5% decrease in birth weight of bull calves, but this was accompanied by lower weaning weights and gains on test.

Several of the lines have been crossed in a study to determine if hybrid vigor or heterosis would result. This work has shown that the linecross animals excelled the average production of the parents for all economically important traits studied. The greatest increases were realized from crossing of the highest producing lines. Additional work has indicated that continued crossing of lines within the breed can result in increased production. However, results show that topcrossing a linebred sire on unrelated females is the most practical method of realizing increased production.

Other work with inbred lines of cattle indicates that the maximum improvement in weaning weight or yearling weight, for example, can be obtained by selecting replacements for high weaning weights or yearling weights, respectively. Cattle have also been involved in a study to determine what effect selecting herd sires with low back fat thickness might have on subsequent fat and lean composition in their progeny. Results indicated sires with lower back fat thickness produced offspring with a higher proportion of lean in the carcass.

A selection study designated the Selection Criteria Study involves a Hereford herd of randomly selected males and females. The objective of this study is to determine the relationships among measures of growth, fertility and nutrient requirements in bulls, heifers and cows managed under range conditions in order to identify alternative selection criteria that can maximize total production by maintaining rapid growth rate accompanied by high fertility in both males and females.

A genetic environmental interaction study started in 1961 involved exchange of cattle between Miles City and Brooksville, Florida. Results showed both herds performed best at their place of origin. These results suggest that seedstock for a specific type environment should be obtained from a similar type environment if optimum production is to be realized. This work further indicated that animals transferred to a new location go through an adjustment or adaptation period and that selection within the new environment will result in adapted, high-producing animals.

Several crossbreeding studies have been conducted at this location. The early work, started in 1935, involved Hereford, Angus and Shorthorn breeds. Later studies starting in 1961 involved Hereford, Angus, Charolais and Brown Swiss breeds to evaluate the merit of two- and three-breed rotational crossing. A three-breed composite population was used for the preweaning and postweaning performance. Maximum production among three-breed crossing systems over the straightbred average was obtained by the three-breed rotation followed by the composite group and two-way rotation, in that order. A four-breed composite of the Angus, Hereford, Charolais and Brown Swiss breeds had a higher preweaning and postweaning growth rate than the crosses involving the beef breeds only.

Puberty information has indicated crossbred bulls and heifers are potentially fertile at younger ages than are straightbreds. Comparisons have also been made of feedlot performance of bulls and steers. Bulls had heavier weaning weights and continued to grow faster in the feedlot. Bulls required less time in the feedlot, were more efficient gainers, had a higher percentage of lean in the carcass, but produced lower grading carcasses than steers. Marketing and consumer acceptance problems must be overcome, however, before bull feeding can prove profitable.

A more recent crossbreeding study was designed to evaluate the crossbred female for performance as a brood cow under range conditions. First cross females from sire breeds representing medium cow size, medium level of milk production; medium cow size, higher level of milk production; larger cow size, medium level of milk production; and large cow size, higher level of milk production were evaluated. These females were mated to Shorthorn sires as yearlings and to Charolais sires as cows. Crossbred offspring were evaluated for growth performance in the feedlot and carcass characteristics. Results suggest that the forage available from ranges in semi-arid areas is not adequate to permit large, high milk-producing breeds to perform at an acceptable level.

A new selection-crossbreeding study was initiated in 1979 to determine rate of progress when selection is made within a multibreed composite population. Three breeds are involved in this study, Red Angus (RA), Polled Charolais (C) and Tarentaise (T). The breeds were selected to compliment each other in terms of total productivity and to determine rate of progress when selection is made in a multibreed population. In the formative stage, C and T sires were bred to RA dams by artificial insemination. In the next phase (Phase II), the CRA first cross males were mated to TRA females and the TRA males to the CRA females to produce offspring of the same genetic composition (25% C, 25% T, 50% RA) but produced from different mating systems. In Phase III, these 25% C, 25% T, 50% RA will be mated together. Semen will be collected from Phase III crossbred bulls to determine genetic change on future generations. Evaluation of Phase III females and their offspring will be made under different range management systems.

REPRODUCTION

The objective of research in reproductive physiology is to increase reproductive efficiency of range cattle. Areas of work are directed toward increasing the percent calf crop to optimum levels in conjunction with the other disciplines at the Station, increasing the pounds of calf produced per acre and per cow exposed to breeding. It has been found that the largest single reason that cows do not wean calves is because they fail to become pregnant during the breeding season. The second largest loss occurs because cows lose calves at or shortly after birth. These areas are receiving major emphasis in reproduction research studies.

Approximately 15% to 20% of the beef breeding herd is replaced yearly. Thus, replacement heifers make up about one in every seven females in the breeding herd. Assuring a high pregnancy rate in the replacement heifer is the objective of puberty research at the Station, and this work has shown that proper nutritional and genetic management of the heifer can increase conception rates by 20%. Simply feeding heifers in separate groups based on heavy or light weaning weights resulted in a 19% increase in pregnancy rate during the first breeding season with no increase in total feed costs. Station research has shown that feeding heifer calves monensin during the first winter following weaning hastens puberty. Additional work has shown heifers must be on a nutritional plane that will allow maximum skeletal growth so growth of the pelvic opening will not be reduced and result in increased calving problems. Recent studies have shown puberty and conception can be induced in young heifers by hormonal treatments but altering day length (photoperiod) had no effect. Implanting heifers with zeranol (Ralgro®) increased gain but pregnancy rates were reduced. Use of Ralgro® in young bull calves reduced testicle size, thus the use of this compound in potential breeding animals is not recommended. Recent work has shown that up to 22% of replacement heifers will show a nonpuberal behavioral heat early in development of their reproductive potential prior to puberty. This nonpuberal heat is not considered an abnormal condition since subsequent pregnancy rates following its occurrence are the same as in heifers in which it was not observed. Another study has shown that replacement heifers bred at their third heat had a 23% higher conception rate that heifers bred at their first or puberal heat. These studies clearly show that heifers should be managed so they are cycling before the beginning of the breeding season. These findings are important, not only in terms of increased calf crop, but also because early puberty means potential early conception and calving. Research in this area expands the flexibility producers have in selecting programs for managing replacement animals.

Failure of cows to rebreed or rebreeding late in the breeding season results in a 15-25% reduction in potential pounds of calf weaned per cow exposed to the bull. Station research has shown that the major cause of this reduction is a result of poor nutrition during one or both of two critical periods. The first critical period is during the last 3 months of pregnancy. Inadequate energy intake during this period in pregnant heifers can result in a 20% reduction in calf crop with little effect on calf birth weight and no benefit in reducing calf losses due to calving difficulty. The second critical period is during the time after calving until adequate grass is available on native range (usually from March through May). Unless adequate nutrition is supplied by proper supplementation or by providing pastures with early season introduced grasses, cows will lose weight and have lower calf crops.

Failure of females to breed at the appointed time, whether they be replacement heifers or mature cows, represents inadequate ovarian function. Research on ovarian function has provided detail on the nature of ovarian failures and how they are affected by such management factors as genetics and nutrition. These studies also provide means of controlling ovarian function to provide large numbers of ova (eggs) for embryo transfer programs.

Calf losses at birth result in a major reduction in the net calf crop. Data have shown 60% of these losses could be prevented by giving timely and proper assistance to dams experiencing difficulty during calving. In addition, the LARRL research has shown that proper, early obstetrical assistance will reduce the rebreeding problems often encountered in dams that experience calving difficulty. Other studies have shown that the feed level during gestation or exercise of the pregnant dam have little predictable effect on calving difficulty. Calf birth weight is the most important causative factor associated with calving difficulty. But, results of Station research indicate 70% of the identified variations in calving difficulty are either present or are established at conception and that ranking of birth weight differences exist prior to day 200 of gestation. This is why little can be done to alter calving difficulty by changing factors during gestation and emphasizes the importance of adequate heifer development and wise selection of sires for breeding to first calf heifers. Other Station studies indicate feeding pregnant dams in the evening resulted in 17% fewer calvings from midnight to 6 a.m. than when dams were fed at 8 a.m. Recent work has shown that precalving hormone changes in heifers that experience calving problems differ from those that calve without difficulty. This adds a new dimension to dystocia considerations and indicates that high birth weights and hormone abnormalities acting separately or together can cause calving difficulty. In another series of studies, we found that dams that experience rapid completion of calving (labor) had pregnancy rates 13% higher than dams in which labor was prolonged. These studies also found that calves experiencing rapid delivery gained 7 to 12% faster than calves experiencing prolonged labor. Brahman dams appear to have the ability to reduce the rate of calf growth in the uterus resulting in lower birth weights and less calving difficulty. Present research involves determining maternal effects on fetal growth. These studies are all directed toward discovering ways to reduce the estimated $600 million annual loss attributed to calving problems.

Suckling has a major delaying effect on the interval from calving to first postpartum estrus. The postpartum interval can be shortened by high levels of feeding, weaning the calf or by removal of the mammary gland. Additional data indicate suckling can alter the release of luteinizing hormone from the pituitary gland, the weaning effect can be mimicked by giving low dose injections of GnRH every 2 hours and these effects are quite different depending on whether the cow is fat or thin. Since degree of fatness or body composition is so important in reproduction as well as nutrition and genetics, extensive studies are underway to develop methods for determining body fat content in the live animal. Recent basic studies have attempted to determine how such effects as feed level, suckling and steroid hormone feedback control the release of pituitary hormones. The nervous system may be a part of this control through production of a class of compounds called endogenous opioid peptides (EOP). Our evidence is that EOP do have a role in the control of pituitary function in heifers and cows but that role is somewhat limited.

Station research has shown that conception rates following artificial insemination can be increased over 6% by massage of the reproductive tract (specifically the clitoris) following routine A.I. Benefits resulting include more pregnancies and less semen used because of fewer services per conception. Estimates indicate benefits could increase annual income over $200,000 in Montana and over $4 million nationally.

Effective methods for synchronization of estrus to obtain a high conception rate are definite possibilities. Recent Station results show a combination of a progesterone implant plus injected prostaglandin is the most promising.

Successful production of twins and triplets from beef cows has been accomplished at LARRL. This research was among the first to successfully combine synchronization of estrus and drug treatments for superovulation (increased production of ova or eggs). Calf crops of up to 119% were produced following a single breeding compared to 70% in untreated cows. This work has the potential of increasing the calf crop without an increase in the number of brood cows in the herd. Station research has shown that if twin and triplet calves receive colostrum and are weaned at birth they can be successfully artificially reared on cold milk or cold milk replacer plus grain and hay. This practice results in the added bonus that the dams will return to breeding condition and become pregnant very early following calving. Recent work is designed to develop methods to produce twins through use of embryo transfer. We have recently produced unrelated twins by transferring a frozen-thawed Brahman embryo into a crossbred cow that had been bred 8-days earlier to a Hereford bull. The twin sets consisted of a Brahman sired and a Hereford sired calf which were normal in all respects. Frozen embryos are also being used to produce identical twin offspring.

Superovulation is a critical part of any successful embryo transfer program, but results are often unpredictable. Research is underway to determine why and investigate mechanisms controlling growth of ovarian follicles and determine their response to hormonal stimulation. Oocytes are being obtained directly from follicles, fertilized in the laboratory (in vitro) and their subsequent growth determined. The next step will be to obtain viable pregnancies from these "cultured" embryos. Additional follicle work consists of determining hormone production within individual follicles, what controls ovulation rate in the cow and what determines which ovarian follicle is destined for growth and ovulation. These basic studies are designed to determine why approximately 20% of the nation's cow herd does not become pregnant during a normal breeding season.

Abortion losses are a significant problem to cattle producers. These abortions are caused by a variety of management variables and diseases, but the majority of causes are unknown. Ponderosa pine needles are known to cause abortions in the 17 western states, and we know little about why cows eat them, how or why the needles cause abortions or how to prevent these effects. We are conducting research to find out how pine needles cause abortions and are trying to devise treatments or methods to prevent these abortions. We have found that needles collected in winter or summer and from Oregon and Montana all caused abortions. Cows fed pine needles earlier in pregnancy (3-4 months) do not abort but as pregnancy progresses the abortion response increases until essentially all cows abort in the last few weeks of pregnancy. Level of feeding (1.5 to 6 pounds) and length of feeding (1 to 21 days) both cause an affect response. Feeding for only 1 or 3 days will cause some abortions, but longer feeding periods (10 to 14 days) are required to get all cows to abort. Vitamin A injections did not prevent abortions. Erratic and dramatic changes in hormone secretion patterns were observed but the corpus luteum does not appear to be the site of the action effect.

RANGE AND RANGE NUTRITION RESEARCH

Research in range improvement and management was initiated at Fort Keogh LARRL by the U. S. Forest Service in 1932. Early studies were designed to determine optimum stocking rates for cattle and sheep on Northern Great Plains rangelands. Recommendations were developed for proper use by both kinds of animals on different range sites and during different seasons. Also, the long- and short-term changes and effects of drought on vegetation and livestock performance were determined for these rangelands. The 30 acres per cow average stocking rate figure established in this work is used extensively by both ranchers and Federal agencies to establish proper stocking rates. Use of this stocking rate plus forage utilization standards of 50% use took the Plains out of an era of exploitation into one of grazing management. Use of these standards reduced soil loss, increased plant growth and increased production of both domestic livestock and wild animals. Value to the livestock industry and Montana agriculture on a sustained yield basis is conservatively estimated at over $1 billion. The research has also provided a foundation for making adjustments to drought such as those experienced in the late 1970's and mid 1980's. These stocking rate guides are now receiving additional research attention because of the increase in cow size from improved breeding and crossbreeding programs.

Other studies were made to determine the most effective methods of increasing forage production. These early studies included adaptability studies which tested more than 100 different plant species under various range conditions. Crested wheatgrass was found to be an outstanding species for seeding many range sites. Later research at LARRL, other Northern Great Plains institutions and in Canada has been instrumental in developing and promoting use of crested wheatgrass and Russian wildrye as introduced forage species and defining species tolerant of drought. These species have been planted on several million acres of Northern Great Plains rangelands. Studies at LARRL have shown a 17% increase in pounds of calf produced per cow in herds grazing introduced forage species during the critical postpartum rebreeding period.

Beginning in 1936, water spreading systems were developed by building diversion dams and contour dikes. These studies were among the first in the Nation to demonstrate that water normally lost to run-off could be used effectively to increase growth of native and introduced grasses. Over the years, studies have also been made of other methods of range improvements including furrowing, range pitting, and application of various kinds and amounts of mineral fertilizers. Recently a Range Improvement Machine (RIM) was developed and tested by LARRL and MAES. This machine and new varieties of plants show promise for substantially increasing plant and animal productivity from Northern Great Plains rangelands.

Cooperative research between scientists at LARRL and Logan, Utah, on new hybrid grass species and use of improved forage plants hold promise of increasing rangeland productivity as much or more than that experienced in the past. About 20 years of research by plant geneticists, plant breeders and range scientists have gone into plant development work. The promise of benefits to individuals and agriculture in Montana are enormous. Plants are being tested for growing in saline soils and restoring rangelands subject to saline seep. Hybrids are being developed and tested for increasing livestock production and growth. Other accessions are being evaluated for increasing productivity through more efficient use of limited water resources. Current range studies are designed to evaluate critically the range forage supply and determine methods of effectively increasing the quantity and quality of forages. Work is in progress on evaluating genetically superior grass hybrid selections for adaptability, viability and forage suitability. A number of forage species are being analyzed for their ability to contribute high quality grazeable forage at such critical times as very early spring, late fall and winter. Evaluations include seedling establishment, yield, post-harvest regrowth and vigor in relation to morphological and physiological attributes of both native and introduced plant species. Efforts are being directed toward determining the most effective management practices consistent with optimum response of individual species.

Work is also in progress to control or modify undesirable plant communities on potentially productive range sites through burning, mechanical and herbicide treatments. The objective is to increase forage productivity by introducing new species, increasing the growth and yield of established desirable plants, or by decreasing competition from undesirable species. A better understanding of how plants respond to environmental conditions and varied management treatments is basic to this research.

Nutrition studies were initiated at LARRL in 1971 and have shown the importance of proper winter supplementation as measured by improved conception rates, calf survival and cow and calf growth. Studies on protein, energy, vitamin A and phosphorous supplementation have been of importance to producers of yearling and cow-calf producers. More recent research has shown that a 10% savings in cost of winter supplement can be realized by gearing supplementation to the amount and kind of range forage available. This type of supplemental feeding can reduce the amount of feed required and also increase the efficiency of use of available forages.

Failure of the cow to conceive results in a substantial economic loss to the nation's beef producers and is a major factor reducing the production efficiency of beef herds. Pre- and postpartum nutritional status of the cow have a pronounced effect on body condition and weight changes, milk production and interval to first estrus and conception rate. One method of providing potentially deficient nutrients to cows during the critical postpartum and breeding periods is through supplement programs. However, these programs can be expensive. An effective alternative to supplement programs may be the development of pastures seeded to improved native or introduced species. Data are currently being collected to evaluate various combinations of seeded pastures and native range for the postpartum period (up to 1 week after parturition) and for the breeding season (45 days).

Range nutrition studies throughout the Northern Great Plains have shown that optimum animal performance is entirely dependent on adequate forage. Cooperative studies between LARRL and the Northern Great Plains Soil and Water Research Center at Sidney, Montana have shown important methods of increasing forage production. Contour furrowing of panspot areas increased forage production from only 350 pounds per acre to 1100 pounds per acre. Nitrogen fertilization of native range areas resulted in increased beef production roughly equivalent to 1 pound of beef for each 1 pound of available nitrogen added per acre. These two procedures could potentially result in an additional $15 million added income for Montana producers alone.

Winters in the Northern Great Plains can be long and cold. Loss of body weight by range cows has often been associated with harsh winter weather. Grazing trials here at LARRL have shown that reductions in the air temperature from 0 to -40 C resulted in a 50% reduction of daily grazing time. Forage intake was also significantly reduced at cold temperatures. Maintenance requirements of the cow are increased due to cold. Therefore, with low forage intake, a large negative energy balance in the cow would occur. Winter management strategies should therefore be developed which not only include increased energy requirements for cold but also account for low levels of forage intake. In another study, performance and behavior of cows of various body size and body condition were studied during the fall-winter grazing period. Grazing behavior was affected by cow size but not body condition.

Both body condition and body size affected forage intake and performance of the cow. Time spent grazing and forage intake were lower at colder than warmer temperatures for all cows.

Alfalfa cubes or a cottonseed meal-barley pellet was fed during the fall-winter periods to cows on native range to evaluate effects on animal performance. Supplements were fed to provide approximately 50% of the crude protein requirement. Supplementing cows with alfalfa cubes resulted in improved performance compared with cows given cottonseed meal-barley as a supplement to range forage and those consuming range forage with no supplemental feeds provided. Performance and behavior of large and small cows in either high body condition (fat) or low body condition (thin) grazing winter range were evaluated for effects of body condition on winter metabolism and performance. Forage intake was greater for large or thin cows than for small or fat cows, respectively. However, forage intake was lowest for large and fat cows when expressed on kg/100 kg of body weight basis. Forage digestibility was similar for all cows. Differences in time spent grazing were small between treatment groups. All of these factors are critical to maintaining range cattle in the Northern Great Plains and are of significant economic importance to the livestock industry.

An automated range-animal data acquisition system (ARADS) has been developed to collect individual animal data without human intervention. Records include date, time, identification, live-weight, water consumption, and weather variables. The system is presently being used to moniter free-ranging yearling steers and mature cows. ARADS is composed of seven portable scale units, a weather station, and a central computer all linked together through a radio communication network. The system is expandable to include additional data stations and parameters.