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PRODUCTION FACTORS IN RANGE CATTLE UNDER NORTHERN GREAT PLAINS CONDITIONS
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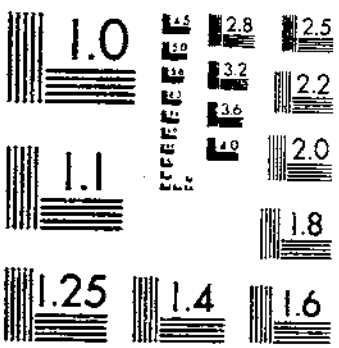

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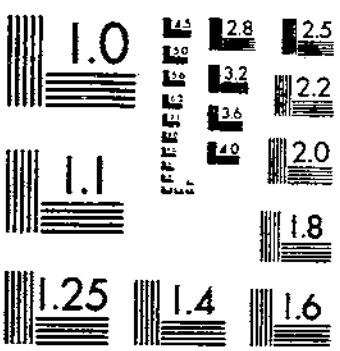

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Production Factors in RANGE CATTLE

Under Northern Great Plains Conditions

by R. T. Clark, C. E. Shelby,
J. R. Quesenberry, R. R. Woodward,
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CONTENTS

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Production Factors In RANGE CATTLE

Under Northern Great Plains Conditions[1]

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INTRODUCTION

Range cattle production is the chief enterprise of the northern Great Plains. In this area of more than 100 million acres lying principally in eastern Montana, northeastern Wyoming, and western North and South Dakota, the natural resources are devoted principally to production of range grasses, a crop most efficiently used as forage for beef cattle and sheep. The area has a great variety of soil types, and has a semiarid climate characterized by wide extremes of heat and cold. In the vicinity of Miles City, Mont., where the data presented in this bulletin were collected, annual rainfall averages about 13.2 inches, temperatures average about 14.5° F. for January and 72.9° for July, and the growing season lasts about 158 days. Yield of range forage depends largely on the amount of precipitation during the growing season. Livestock production within the area is markedly affected by severe droughts and extremely cold winters.

For reasons of climate and because of management trends, ranchers in the northern Great Plains ordinarily market feeder calves from a cow-and-calf type of operation. When range and feed conditions permit, some operators may hold calves over, winter them, and sell them as feeders when they are long yearlings. Factors affecting economy of production and accuracy in selecting highly productive breeding stock are extremely important to the rancher.

This bulletin reports findings regarding relations between various cow and calf characteristics and the influence of environmental factors on these characteristics.

REVIEW OF LITERATURE

Knapp et al. (*6*)[3] discussed the results of record-of-performance tests at the United States Range Livestock Experiment Station, Miles City, Mont. (This station is referred to hereafter in this section as "the Range Livestock Experiment Station.") A gross correlation of +0.34 and an intra-year correlation of +0.32 between birth weight and gain from

[1] The study reported here was carried out cooperatively in the period 1926–53 by the United States Department of Agriculture and the Montana Agricultural Experiment Station. This bulletin is a contribution from Western Regional Project W–1, The Improvement of Beef Cattle Through the Application of Breeding Methods.

[2] The authors wish to acknowledge assistance received during the course of the study from the late A. L. Baker, animal husbandman, and Bradford Knapp, Jr., formerly animal husbandman, United States Department of Agriculture.

[3] Italic numbers in parentheses refer to Literature Cited, p. 22.

birth to weaning were obtained in a group of Hereford steers. These correlations were highly significant.

Knapp et al. (7) made a study of growth and production factors in range cattle based on data collected at the Range Livestock Experiment Station from 1926 to 1940. The study included records on 770 calves from 112 Hereford cows that had remained in the breeding herds for at least 9 years. The factors studied were birth weight, weaning weight, gain from birth to weaning, age at weaning, annual rainfall, and previous-fall weight of the cow.

Birth weight varied relatively little from year to year except in years following drought. Male calves averaged 5.8 pounds heavier at birth than females. This difference was highly significant statistically. Sex accounted for about 10 percent of the total variance. Calves from 2-year-old cows were about 10 pounds lighter than those from mature cows. Change in age of cow had little effect on birth weight after the age reached 4 years. A correlation of +0.26 was found between birth weight of calf and previous-fall weight of dam.

Weaning weight and gain from birth to weaning varied greatly from year to year. Low annual rainfall was reflected in low weights. Male calves averaged 22 pounds heavier than females. This difference was highly significant statistically. When the effects of differences in age at weaning were removed by analysis of covariance, sex accounted for about 7 percent of the total variance. In relation to age of cow, weaning weight (adjusted to an age of 175 days) showed the following trends: 2 to 4 years, rapid increase; 4 to 6 years, gradual increase; 6 to 7 years, slow decrease; 7 to 11 years, rapid decrease. The differences in weaning weight associated with differences in age of cow were statistically significant.

The correlation of weaning weight of calf and previous-fall weight of dam was +0.10. Weaning weight was correlated a little more closely with spring weight of dam and still more closely with weight of dam at weaning. Previous-fall weight did not materially influence milk production; nutrition of the dam during the suckling period influenced it to a greater extent. Poor condition of the cow as indicated by weight in the previous fall did not materially affect calf production.

Average weights of cows from birth to 10 years of age were plotted. Growth was relatively rapid from birth to 2½ years. Maturity in weight was attained at approximately 5 years, with little change after 3½ years. Calves of maximum birth weight were produced by 4-year-old cows, and calves of maximum weaning weight by 6-year-old cows. With regard to feeder calves, the best producing period of the range cows was ages 4 to 8 years and the most productive age was 6 years. The investigators recommended that cows be marketed at 9 years of age.

Knox and Koger (9) studied the effect of age on the weight and production of range cows. Both weight and production were greatest at the ages of 6 to 8 years. At a weaning age of 205 days, calves from 2-, 3-, and 4-year-old cows were 60, 42, and 18 pounds lighter than those from 6-year-olds. The investigators concluded that cows should be sold at 8 to 10 years of age.

Koger and Knox (12) measured the effect of differences in sex on the weaning weight of calves. Weights of steers, adjusted to an age of 205 days, were 32 pounds greater than those of heifers.

Knapp and Nordskog (8) studied the relationship of live-animal scores and grades and certain carcass characteristics in a group of Hereford steers at the Range Livestock Experiment Station. Weaning weight and score were highly correlated (+0.68)

Koger and Knox (*13*) studied the repeatability of yearly production of range cows. They corrected records for sex by adding 30 pounds to the weights of heifer calves. Highly significant differences in weaning weight at 205 days and significant differences in weaning grade were found to be associated with differences in age of dam.

Woolfolk and Knapp (*16*) measured the effects of three rates of stocking on gain in range calves at the Range Livestock Experiment Station. Among calves produced on range areas subjected to light, medium, and heavy grazing, respectively, bulls were 3.3, 4.6, and 4.8 pounds heavier at birth than heifers, and steers were 24, 23, and 40 pounds heavier at weaning than heifers. Growth from birth to weaning showed essentially a straight-line trend for animals on moderately and lightly grazed areas.

Gregory et al. (*4*) analyzed some of the factors affecting the birth weights and weaning weights of Hereford calves at the North Platte and Valentine substations of the Nebraska Experiment Station. Average birth weight of males exceeded that of females by 5 pounds at North Platte and by 4 pounds at Valentine. No appreciable difference between sexes in weaning weight or gain was found at the North Platte station. Differences of 14 pounds in weaning weight and 11 pounds in gain were noted between males and females at the Valentine station, but these differences were not significant. Calves were weaned at 200 days of age at North Platte and at 150 days of age at Valentine. Birth weight was correlated with gain from birth to weaning only to a very slight extent (+0.07) at North Platte but to a greater extent (+0.44) at Valentine; its correlation with weaning weight was slight (+0.27) at North Platte but high (+0.60) at Valentine.

The following correlations of cow and calf characteristics were noted: Birth weight with cow weight after calving, +0.21 at North Platte; birth weight with cow weight on the last weigh day prior to calving, +0.32 at Valentine; weaning weight with cow weight at weaning, +0.20 at North Platte and −0.11 at Valentine; gain of calf and gain of cow, −0.12 at North Platte and −0.34 at Valentine.

Koch (*10*) studied the weight of calves at weaning as a permanent production characteristic of selected range Hereford cows at the Range Livestock Experiment Station. Selected bull calves were 44 pounds heavier than heifer calves at a weaning age of 182 days. In contrast, the steer calves were only 13 pounds heavier than the heifer calves.

Burris and Blunn (*2*) examined some factors affecting gestation length and birth weight in Angus, Hereford, and Shorthorn cattle. Males of the 3 breeds, respectively, averaged 5.3, 4.5, and 4.9 pounds heavier at birth than females. Differences between years were not significant statistically. Calves from 2- to 3-year-old cows averaged 4.7, 4.9, and 6.0 pounds lighter at birth than calves from 4- to 5-year-old cows, and calves from 3- to 4-year-old cows averaged 3.0, 1.3, and 1.9 pounds lighter than those from 4- to 5-year-old cows. Birth weight reached its maximum when cows of the Angus, Hereford, and Shorthorn breeds, respectively, were 10 to 11, 11½ to 12, and 10 to 11 years old.

Guilbert and Gregory (*5*), in a study of growth and development of Hereford cattle, plotted the weights of cows as determined at monthly intervals from 3 weeks to 6 years of age. The greatest weights were attained at 5 years. Average weight of cows at 5 years exceeded those at 2, 3, and 4 years by 277, 141, and 67 pounds, respectively.

Botkin and Whatley (*1*) measured

the repeatability of production in Hereford cows. Male calves were 4.4 pounds heavier than females at birth and 25 pounds heavier than females at a weaning age of 210 days. Corrections of 4 and 2 pounds at birth and 35 and 15 pounds at weaning for offspring of 3- and 4-year-olds, respectively, were used to adjust weights of calves to a mature-cow basis. Cows were considered mature at 5 years of age.

Gifford (*3*) observed a relationship between milk production of dam and growth rate of calf in Aberdeen-Angus, Hereford, and Shorthorn cattle. The gross correlation between total milk production of dam and weaning (8-month) weight of calf was +0.60 for 50 dam-offspring comparisons in the Hereford breed. Milk production was least between the ages of 2 and 3 years and increased to the age of 6 years.

Rollins and Guilbert (*14*) studied factors affecting growth of calves during the suckling period in the purebred Hereford herd of the California Agricultural Experiment Station at Davis, Calif. At a weaning age of 240 days, male calves were 68 pounds heavier than females and calves from 3- and 4-year-old cows were 21 and 13 pounds lighter than those from 7- to 10-year-old cows. The effect of age of dam was smaller for female than for male calves. Cow productivity reached its optimum at 6 or 7 to 10 years of age.

Woodward et al. (*15*) studied relationships between preslaughter and postslaughter evaluations of beef cattle in a group of Hereford steers at the Range Livestock Experiment Station. Gross, within-line, within-year, and within-line-and-year correlations were computed. The correlations between birth weight and weaning weight unadjusted for age at weaning were +0.41, +0.38, +0.36, and +0.31.

Koch and Clark (*11*) studied the effects of sex, season of birth, and age of dam on birth weight, weaning weight, weaning score, fall yearling weight, and fall yearling score of beef cattle, using records of 5,952 Hereford calves raised at the Range Livestock Experiment Station.

Bull calves averaged 5.6 pounds heavier at birth, 26.2 pounds heavier at weaning, and 0.13 unit higher in score than heifers. Because the physiological effects of castration could not be separated from the effects of selection for size, records for bull and steer calves were not evaluated separately.

Differences between sexes in weight and score were consistent among the different age groups. Means for calves produced by 3- and 4-year-old cows were noticeably affected by age of dam. The difference between 6 and 10 years in age of dam was found to have little effect on characteristics of calf.

Calves from 3-, 4-, and 5-year-old cows, in comparison with calves from cows 6 to 10 years of age, weighed 5, 2, and 1 pound less at birth, weighed 44, 20, and 9 pounds less at weaning, and were scored 0.6, 0.4, and 0.3 unit lower. (Adapted from table 1 (*11*).)

Factors for adjusting calf weights and weaning scores to a mature-dam basis were computed by two methods, and the results were averaged. The final adjustment factors, applicable to average weights and scores for calves, are as follows:

Age of cow (years)	*Adjustment factors*		
	Birth weight (pounds)	*Weaning weight (pounds)*	*Weaning score*
3	4	41	0.6
4	2	18	.3
5	0	6	.2
6	0	0	.0
7	0	3	.0
8	0	6	.1
9	0	12	.2
10	2	24	.4

EXPERIMENTAL CONDITIONS AND PROCEDURE

The study reported here was based on data collected at the United States Range Livestock Experiment Station, Miles City, Mont., over the 28-year period 1926–53. The data represent 7,436 Hereford calves from 2,131 cows. They extend over a longer period than those used in the study of Koch and Clark (*11*), which comprised 5,952 of the calf records presented in this bulletin. The factors studied were birth weight, weaning weight, gain from birth to weaning, weaning score, previous-fall weight of cow, spring weight of cow (taken during the last 2 to 4 weeks of the gestation period), and fall weight of cow.

The cows were registered and unregistered Herefords born between 1912 and 1950. Customarily, heifers were first bred as 2-year-olds, to calve as 3-year-olds. Only 24 calves from 2-year-olds were included. In the early years of the experiment, cows were retained, if still productive, to the age of 15 years. From 1936 to 1946 they were discarded at 11 years of age, and from 1946 onward at 10 years of age. Cows were discarded also for infertility, low productivity, prolapse of the vagina or uterus, cancer eye, and other reasons of health. The cows were a highly selected group—probably more highly selected than are those in the typical herd on the northern Great Plains. In selecting cows for retention, less emphasis was placed on type than on characteristics such as progeny performance and weight for age.

The age composition of the herds was typical for the northern Great Plains. Environmental conditions were fairly typical for ranches in this area. In general, conclusions drawn from study of this group of cattle can be applied throughout the northern Great Plains. Caution would be necessary in applying them to cattle on range areas where management methods and nutritional plane differ radically from those on the study area.

Customarily, bulls were placed in breeding herds of 25 to 30 cows for a period of 45 days, from June 15 to July 29. After the completion of the breeding season the unregistered and registered herds were grazed in two large pastures. Cows were grazed on native range throughout the year. They were turned on fall range about October 20, when the calves were weaned, and were moved to winter pasture about the first of January. They were fed varying amounts of protein supplements. Hay was provided when weather was extremely cold or prevented normal grazing, and during prolonged dry spells. Changes in cow weights depended on the amount of vegetation, the severity of the weather, and the amount of supplement fed. Cows were moved at calving time to two large pastures where calves were dropped.

Each calf at birth was given an individual eartag number in which a serial number was preceded by the last number of the year of birth. For example, the eartag number of each animal born in 1945 carried the prefix "5." This identifying number was later branded on any female retained for breeding purposes.

Birth weights were obtained by range riders within the first 24 hours after birth. Spring scales were used to weigh each calf. Birth weight, sex, eartag of the dam, eartag of the calf, and breeding herd were recorded

at this time. Calves remained on the range with their dams until weaned. Range vegetation was the only source of nutrients available to calves other than the milk of their own dams. Male calves were castrated in the grade herd at about 6 weeks, and in the purebred herd at about 20 weeks, when bull calves were selected. Calves were weaned on the Monday closest to the 20th of October in each year except 1936, when weaning took place in September. Weights of both cow and calf were taken at weaning time.

From 1939 onward, calves were scored at weaning by a three-man committee using form AH–522. Scores, expressed in percentages on a scale on which the ideal animal scored 100, were given to 5,174 calves out of the total 7,436. In 1939 and 1940, only registered calves were scored. A different committee did the scoring each year, some men acting on more than one committee.

METHOD OF ANALYSIS

Efforts were made to estimate the magnitude of several influences on production characteristics under the conditions existing on the experimental range area. The significances of observed differences were tested in each case according to the scheme outlined in table 1. Each estimate was based on means for all the data pertaining to the factor under study. For example, estimated differences in birth weight according to sex are based on averages for all calves of each sex born in all years to dams of all ages. This method is based on the assumption that there are no interactions between the different factors studied. The extent to which such interactions exist and possibly introduce biases into the estimates is unknown.

Correlations between the characters studied have been calculated on a "within subclass" basis. This method gives unbiased estimates. The loss it entails in degrees of freedom is unimportant in a study including such large numbers of records.

TABLE 1.—*Theoretical analysis of variance and covariance, with mean-square equations used to obtain components of variance and covariance* [1]

Sources of variation	Degrees of freedom	Mean squares and covariances			Expected mean squares
		X_1^2	X_1X_2	X_2^2	
Total	$t-1$	R_1^2	R_1R_2	R_2^2	$\sigma_e^2+k_7\,\sigma_s^2+k_8\,\sigma_a^2+k_9\,\sigma_y^2$
Among years	$y-1$	Q_1^2	Q_1Q_2	Q_2^2	$\sigma_e^2+k_4\,\sigma_s^2+k_5\,\sigma_a^2+k_6\,\sigma_y^2$
Among ages of dam within years	$a-y$	P_1^2	P_1P_2	P_2^2	$\sigma_e^2+k_2\,\sigma_s^2+k_3\,\sigma_a^2$
Among sexes within ages of dam within years	$s-a$	O_1^2	O_1O_2	O_2^2	$\sigma_e^2+k_1\,\sigma_s^2$
Among records within sexes within ages of dam within years	$t-s$	N_1^2	N_1N_2	N_2^2	σ_e^2

[1] t is the total number of records. y is the number of year subgroups. a is the number of year-age subgroups. s is the number of year-age-sex subgroups. σ_e^2, σ_s^2, σ_a^2, and σ_y^2 are the variances due to error, sex, age of dam, and year of birth.

Correlations were computed by use of the formula

$$r_{x_i x_j} = \frac{\sigma_{e_i e_j}}{\sqrt{\sigma^2_{e_i} \sigma^2_{e_j}}}$$

in which $\sigma^2_{e_i}$, $\sigma^2_{e_j}$, and $\sigma_{e_i e_j}$ are the variances and covariances of variables x_i and x_j.

Weaning weight and gain from birth to weaning were adjusted to an age of 180 days. Each record was adjusted individually on the basis of the actual rate of gain from birth to weaning.

RESULTS AND DISCUSSION

Means for the production characteristics and for annual and seasonal rainfall in each year of the period 1926–53, and for weaning scores given in each of the years 1939–53, are presented in table 2. Means both of actual weights and gains at time of weaning and of these weights and gains adjusted to the age of 180 days appear in the table. Annual rainfall (at the Miles City airport) averaged 12.6 inches for the 28 years included in the study period. Rainfall during the growing season, from April 1 to September 30, averaged 9.3 inches. Extreme drought, with not more than 4 inches of rainfall during the growing season, markedly affected production characteristics. Differences among years were highly significant for all the characteristics.

Means by age of dam are given for bull, steer, and heifer calves in table 3. The effect of age of dam and that of sex are confounded with each other and with that of year. More precise estimates could have been obtained by a least-squares analysis. The actual means tabulated should indicate roughly the differences due to these effects. Differences according to age of dam were highly significant for all the characteristics studied except birth weight.

Means by sex are summarized in table 4. About 50.8 percent of all calves were males, and about 75.5 percent of these were castrated prior to weaning. Differences between sexes with regard to birth weight, gain from birth to weaning, weaning weight, and weaning score were highly significant.

Birth Weight

Birth weights of all calves averaged 76 pounds. The frequency distribution of birth weights by 5-pound intervals is given in figure 1. The distribution is normal. About 71 percent of the calves weighed between 66 and 85 pounds, and about 96 percent weighed between 56 and 95 pounds. Since the cows in the study were highly selected, the average birth weights may be slightly higher than should be expected, on an average, for calves produced by range cows in the northern Great Plains.

Birth weight varied considerably among years. In general it decreased markedly after a year of extreme drought (one with not more than 4 inches of precipitation during the growing season) or after an extremely severe winter. Extreme drought conditions prevailed in 1931, 1934, 1936, and 1949. Extremely severe winters were experienced in 1935–36 and 1948–49. Birth weights were low in 1935, 1936, 1937, 1949, and 1950. In 1935, a seasonal precipitation of 7.54 inches evidently did not suffice for recovery of the range from the extreme drought conditions of the previous year. In general, birth weight seemed to be little affected by environmental conditions unless they were extremely severe. Differences among years, which were highly significant statistically, accounted for 16.3 percent of the total variance in birth weight.

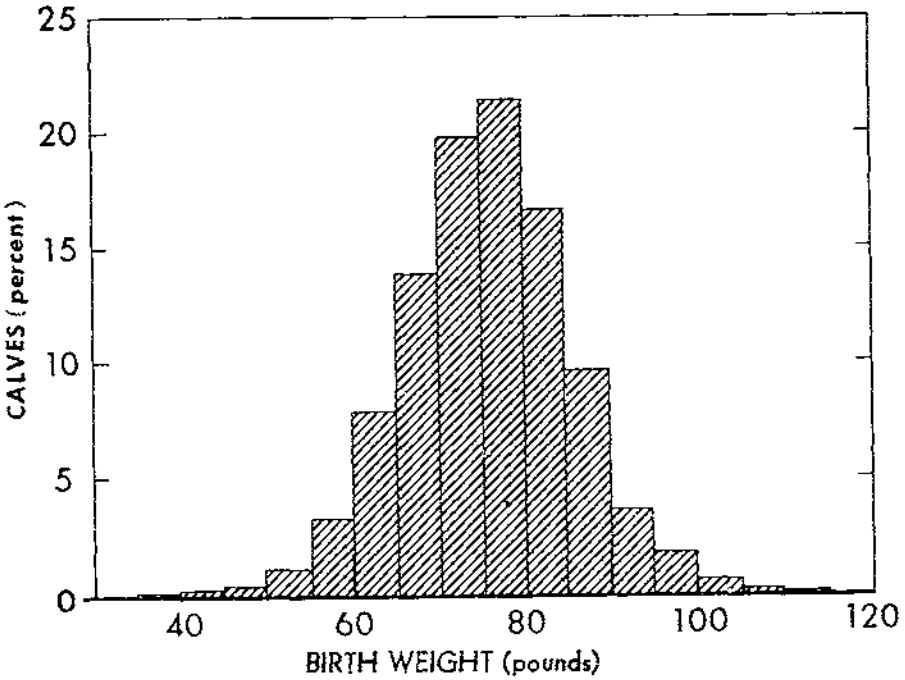

FIGURE 1.—Frequency distribution of birth weights of calves produced by cows aged 2 to 15 years.

An upward trend in birth weights is apparent through the study period. Except in the 5 years just listed, birth weight was fairly uniform from 1926 through 1937 and from 1938 through 1953, but it was slightly higher in the second than in the first of these periods. This trend can be attributed to genetic change and improved feeding and management.

Age of dam had an effect on the birth weight of calves from 3-year-old cows as compared with calves from older cows but otherwise was of little importance in relation to birth weight (fig. 2). Male and female calves from 3-year-olds averaged 4 pounds lighter at birth than those from 5- to 10-year-old cows. Male and female calves from 4-year-olds averaged 1 and 2 pounds lighter, respectively, than those from this older class.

Birth weights differed importantly between sexes, males averaging 5 pounds heavier (79 pounds) than females (74 pounds). Differences according to sex, which were highly significant statistically, accounted for about 16 percent of the total variance in birth weight.

Weaning Weight

Weaning weights are of primary importance for the breeder of range cattle. If he sells his stock as feeder calves, weaning weights are essentially sales weights. The major factors influencing weight of calf at weaning are the milk production of the dam, the condition of the range, and the calf's inherited ability to utilize the available nutrients.

Since all calves grown on the station in a given year were weaned on the same day, age at weaning varied by 6 to 8 weeks. It averaged 180 days. The annual average ranged approximately between 170 and 190

TABLE 2.—*Means of some production characteristics, of weaning scores, and of rainfall for the period 1926–53, by year* [1]

Year	Calves born	Birth weight	Age at weaning	Weaning weight	Gain from birth to weaning	Weaning weight adjusted to 180 days	Gain from birth to weaning adjusted to 180 days	Weight of cow in—			Annual rainfall [2]	Rainfall [2] in growing season (Apr. 1–Sept. 30)	Calves scored [3]	Weaning score [3]
								Previous fall	Spring	Fall				
	Number	*Pounds*	*Days*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Inches*	*Inches*	*Number*	*Percent*
1926	71	72	164	373	300	402	330	1,027	1,000	1,067	9.9	6.3	.....	.....
1927	95	72	182	378	307	375	303	1,064	1,024	1,100	18.6	14.5	.....	.....
1928	124	75	175	371	296	379	304	1,088	1,017	1,063	12.4	9.0	.....	.....
1929	124	72	175	389	316	398	326	1,070	1,036	1,116	13.8	8.7	.....	.....
1930	156	74	177	401	327	406	332	1,105	1,097	1,177	10.4	8.0	.....	.....
1931	200	76	185	379	303	370	294	1,155	1,146	1,035	6.2	4.0	.....	.....
1932	229	73	184	379	305	375	302	1,027	1,062	1,050	15.0	10.1	.....	.....
1933	217	76	168	341	265	361	285	1,064	1,027	1,075	10.2	6.4	.....	.....
1934	229	73	173	301	228	310	237	1,050	1,069	972	5.5	3.5	.....	.....
1935	212	69	176	366	297	373	303	955	1,019	1,052	11.5	7.5	.....	.....
1936	203	68	[4] 142	245	177	292	224	1,028	989	953	6.1	3.6	.....	.....
1937	141	66	198	376	309	348	281	971	986	1,049	10.4	7.5	.....	.....
1938	195	76	172	351	275	364	288	1,038	1,038	1,122	11.2	8.0	.....	.....
1939	154	79	172	386	307	399	320	1,103	1,099	1,143	9.9	8.5	123	74
1940	180	77	181	388	311	386	309	1,101	1,145	1,091	14.1	9.3	160	75
1941	266	79	177	393	315	400	321	1,084	1,172	1,172	17.8	14.8	266	75
1942	280	79	172	373	294	386	307	1,151	1,107	1,128	14.0	11.4	280	73
1943	321	76	173	363	286	375	299	1,111	1,044	1,095	15.0	11.7	321	69
1944	337	77	176	370	293	377	300	1,082	1,020	1,103	19.0	16.4	337	75
1945	369	79	173	367	288	378	299	1,092	1,077	1,097	12.6	10.2	367	73
1946	433	80	178	395	315	400	320	1,078	1,098	1,050	17.8	12.9	432	68
1947	432	81	185	407	326	398	317	1,037	1,062	1,093	11.8	9.2	432	73
1948	472	79	190	418	339	399	320	1,084	1,065	1,089	16.1	13.5	469	74
1949	379	69	187	297	228	289	220	1,074	1,015	941	8.8	4.0	379	59
1950	300	72	185	386	315	378	307	987	1,046	1,125	13.7	9.6	299	76
1951	457	80	188	434	354	418	338	1,107	1,141	1,154	14.9	12.2	451	73
1952	431	77	189	411	334	395	318	1,147	1,120	1,131	9.9	7.2	429	75
1953	429	81	188	435	354	420	339	1,143	1,182	1,172	16.6	13.0	429	77
Total or average	7,436	76	180	380	303	380	303	1,079	1,078	1,090	12.6	9.3	5,174	72

[1] Differences by year were highly significant for all characteristics.

[2] As measured at Miles City airport.

[3] For various reasons, in some years of the period in which scores were given some calves were not scored.

[4] Calves were weaned at an early age in 1936 because of drought conditions.

TABLE 3.—*Means of some production characteristics and of weaning scores for bull, steer, and heifer calves for the period 1926–53, by age of dam* [1]

Age of dam (years)	Birth weight						Weaning weight adjusted to 180 days								Gain from birth to weaning adjusted to 180 days							
	All calves		Bulls		Heifers		All calves		Bulls		Steers		Heifers		All calves		Bulls		Steers		Heifers	
	No.	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*
2	24	64	12	65	12	63	24	294	6	331	6	263	12	290	24	230	6	268	6	200	12	227
3	1,645	73	833	76	812	71	1,645	351	147	391	686	354	812	341	1,645	277	147	313	686	278	812	271
4	1,462	76	750	79	712	73	1,462	376	162	421	588	381	712	362	1,462	300	162	342	588	302	712	289
5	1,170	78	585	81	585	74	1,170	388	152	430	433	389	585	377	1,170	310	152	348	433	308	585	302
6	934	78	478	80	456	75	934	394	137	423	341	398	456	382	934	316	137	342	341	318	456	307
7	736	78	379	80	357	75	736	395	108	432	271	393	357	386	736	318	108	352	271	314	357	311
8	601	78	306	80	295	76	601	398	87	437	219	405	295	382	601	321	87	356	219	326	295	306
9	436	78	223	81	213	74	436	392	56	417	167	401	213	378	436	314	56	336	167	321	213	304
10	279	77	137	81	142	73	279	396	30	434	107	402	142	384	279	319	30	353	107	322	142	311
11	94	75	43	76	51	73	94	370	21	374	22	380	51	365	94	295	21	301	22	300	51	291
12	27	74	19	74	8	73	27	357	12	357	7	367	8	349	27	284	12	284	7	291	8	276
13	16	72	4	78	12	71	16	328	4	313	.....	.....	12	332	16	255	4	236	.....	.....	12	262
14	8	69	4	75	4	64	8	346	3	344	1	355	4	346	8	277	3	267	1	286	4	282
15	4	76	2	74	2	76	4	309	1	241	1	318	2	338	4	234	1	165	1	245	2	262
Total or average	7,436	76	3,775	79	3,661	74	7,436	380	926	418	2,849	382	3,661	368	7,436	303	926	338	2,849	304	3,661	294

[1] Differences according to age of dam were highly significant for all the characteristics studied except birth weight.

TABLE 3.—*Means of some production characteristics and of weaning scores for bull, steer, and heifer calves for the period 1926–53, by age of dam* [1]—Continued

Age of dam (years)	Weaning score								Cow weights											
									All cows				Wets				Drys			
	All calves		Bulls		Steers		Heifers		Previous fall		Spring	Fall	Previous fall		Spring	Fall	Previous fall		Spring	Fall
	No.	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Lbs.*	*Lbs.*	*Lbs.*	*No.*	*Lbs.*	*Lbs.*	*Lbs.*	*No.*	*Lbs.*	*Lbs.*	*Lbs.*
2	2	42	....	....	1	41	1	43	24	748	796	821	....	....	....	....	24	748	796	821
3	1, 194	69	100	73	511	68	583	68	1, 645	981	973	1, 000	36	892	900	978	1, 609	983	974	1, 001
4	1, 050	72	106	76	435	71	509	71	1, 462	1, 032	1, 036	1, 066	1, 173	1, 010	1, 021	1, 056	289	1, 119	1, 096	1, 105
5	843	73	110	77	304	73	429	73	1, 170	1, 095	1, 098	1, 108	974	1, 075	1, 082	1, 097	196	1, 195	1, 175	1, 165
6	639	75	90	76	239	74	310	74	934	1, 123	1, 124	1, 126	791	1, 107	1, 113	1, 118	143	1, 214	1, 186	1, 171
7	503	74	67	77	189	74	247	74	736	1, 149	1, 150	1, 145	640	1, 132	1, 138	1, 137	96	1, 262	1, 228	1, 193
8	424	75	57	79	164	75	203	74	601	1, 163	1, 161	1, 154	512	1, 148	1, 153	1, 151	89	1, 252	1, 207	1, 171
9	298	74	30	79	121	74	147	74	436	1, 170	1, 162	1, 148	392	1, 161	1, 155	1, 144	44	1, 249	1, 220	1, 188
10	189	74	20	76	77	74	92	74	279	1, 169	1, 167	1, 164	246	1, 159	1, 160	1, 164	33	1, 244	1, 216	1, 170
11	32	70	....	....	11	73	21	69	94	1, 177	1, 148	1, 141	90	1, 179	1, 152	1, 142	4	1, 141	1, 058	1, 124
12	....	....	....	....	....	....	....	....	27	1, 130	1, 116	1, 122	24	1, 136	1, 129	1, 133	3	1, 086	1, 012	1, 033
13	....	....	....	....	....	....	....	....	16	1, 170	1, 100	1, 117	14	1, 175	1, 104	1, 131	2	1, 133	1, 072	1, 020
14	....	....	....	....	....	....	....	....	8	1, 088	1, 059	1, 069	6	1, 080	1, 051	1, 072	2	1, 110	1, 082	1, 060
15	....	....	....	....	....	....	....	....	4	1, 130	1, 072	1, 059	3	1, 120	1, 072	1, 039	1	1, 160	1, 070	1, 120
Total or average	5, 174	72	580	76	2, 052	72	2, 542	72	7, 436	1, 079	1, 078	1, 090	4, 901	1, 092	1, 097	1, 109	2, 535	1, 054	1, 039	1, 052

[1] Differences according to age of dam were highly significant for all the characteristics studied except birth weight.

TABLE 4.—*Summary of means of some production characteristics and of weaning scores for bull, steer, and heifer calves for the period 1926–53* [1]

Sex	Birth weight		Weaning weight adjusted to 180 days		Gain from birth to weaning adjusted to 180 days		Weaning score	
	Records	Average	Records	Average	Records	Average	Records	Average
	Number	*Pounds*	*Number*	*Pounds*	*Number*	*Pounds*	*Number*	*Percent*
Bulls	3,775	79	926	418	926	338	580	76
Steers	.....	.....	2,849	382	2,849	304	2,052	72
Heifers	3,661	74	3,661	368	3,661	294	2,542	72
Total or average	7,436	76	7,436	380	7,436	303	5,174	72

[1] Differences between sexes in all 4 factors were highly significant. The differences between bulls and steers may have been due partly or entirely to selection of heavier, higher scoring animals for retention as bulls.

days, but it was only 142 days in the drought year 1936.

Weaning weight averaged 380 pounds. The frequency distribution of weaning weights by 25-pound intervals is given in figure 3. It is skewed slightly toward the left. About 73 percent of the calves weighed from 326 to 450 pounds at weaning time, and about 96 percent weighed from 251 to 500 pounds.

Average weaning weight varied greatly among years. It was extremely low in the drought years

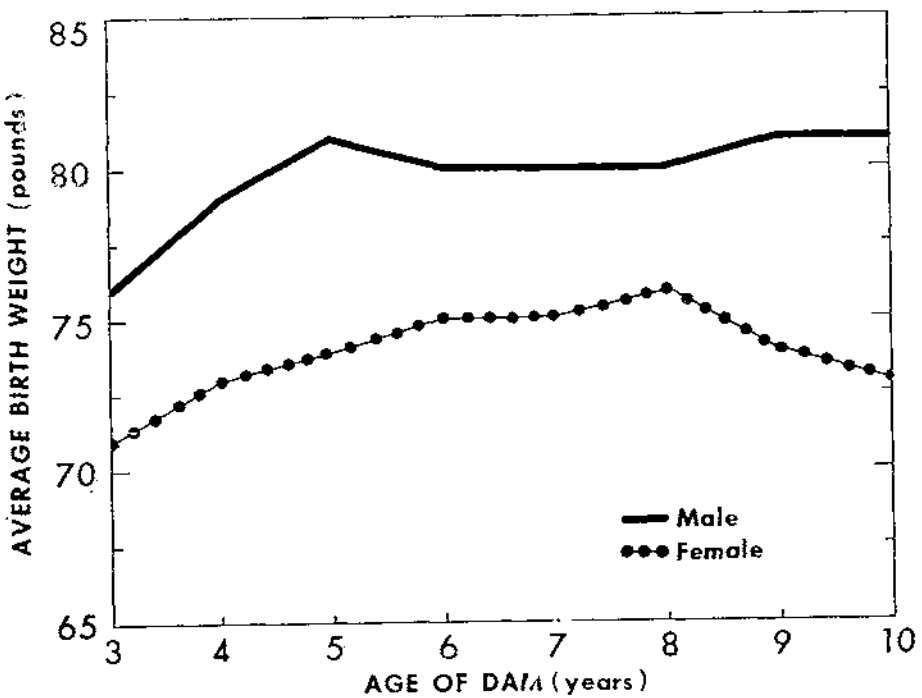

FIGURE 2.—Birth weights, by age of dam, of male and female calves produced by cows aged 3 to 10 years.

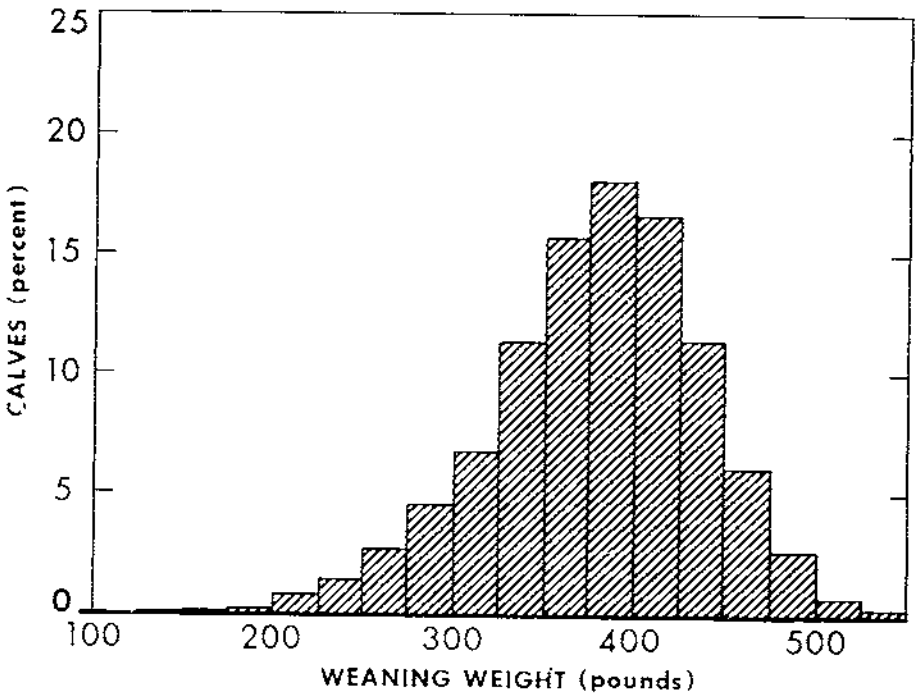

FIGURE 3.—Frequency distribution of weaning weights of calves produced by cows aged 2 to 15 years.

1934, 1936, and 1949. No distinct trend over the study period was apparent.

For normal range forage yield in eastern Montana, as indicated by weaning weight, 6 inches of rainfall within the growing season seemed to be adequate. Any excess of growing-season rainfall over 6 inches seemed to have little effect on weaning weights. Differences among years, which were highly significant statistically, accounted for 31 percent of the total variance in weaning weight.

Average weaning weights increased considerably as age of dam advanced from 3 to 5 years but increased little as it advanced from 6 to 8 years (fig. 4). Weaning weights of bull, steer, and heifer calves from 3-year-olds averaged 37, 45, and 42 pounds less than those of calves from 6- to 10-year-olds, and weaning weights of bull, steer, and heifer calves from 4-year-olds averaged 7, 18, and 21 pounds less than those of calves from cows in the 6-to-10-year age group. Differences according to age of dam, which were highly significant statistically, accounted for 8 percent of the total variance in weaning weight.

The fact that average weaning weight remained practically constant as age of dam increased from 6 to 10 years indicates that cows may remain productive longer than has been thought previously.

If the selection of potential breeding stock is to be most accurate, the effect of age of dam on the production record must be considered. Estimating the magnitude of the effects of differences in age of dam from herd records is complicated by several factors including effects of culling and effects of changing genetic composition of the herd. If low-producing cows are culled at early ages, then

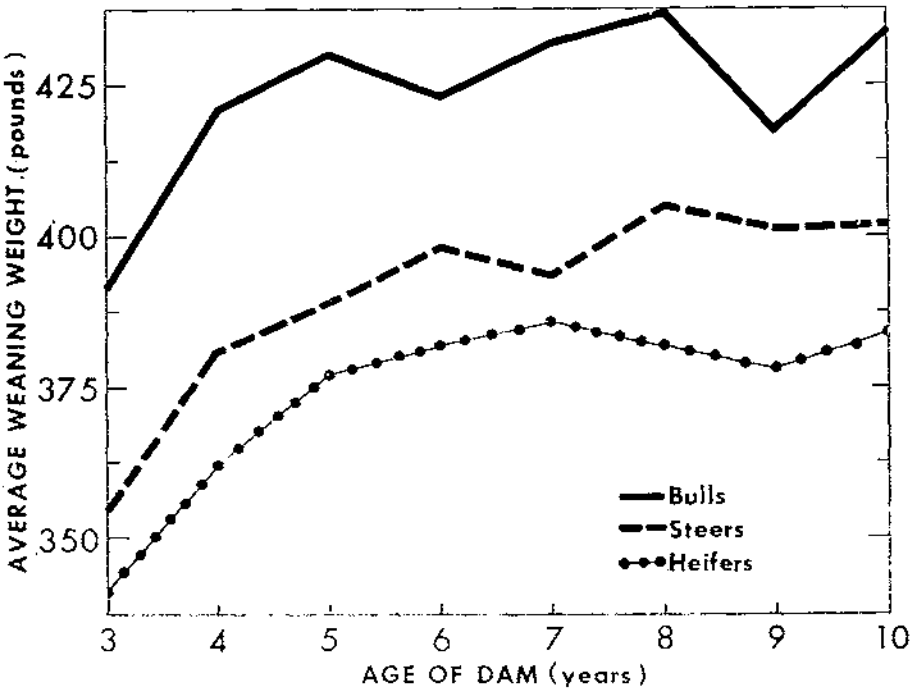

FIGURE 4.—*Weaning weights, by age of dam, of bull, steer, and heifer calves produced by cows aged 3 to 10 years.*

production differences associated with age differences are affected by the fact that the older age groups contain higher percentages of inherently high producers. If the inherent productivity of the population is increasing, the earlier age groups include cows superior in this regard and attributing production differences to age differences alone results in underestimating differences due to age in the age groups preceding those in which maximum production is attained. If heritability of the individual characteristic is low, or if the selection differential is small, the resulting bias is not important. If selection is based not on one characteristic but on several, the bias is less important for individual characteristics.

The actual deviations from the average weaning weight of calves from cows 6 to 10 years of age are as follows:

Age of cow (years)	*Deviation (pounds)*
3	−14
4	−19
5	−7
6	−1
7	0
8	+3
9	−3
10	+1

Differences according to sex were highly significant statistically. Weaning weights of bulls, steers, and heifers averaged 418, 382, and 368 pounds, respectively; on an average, bulls exceeded heifers in weaning weight by 50 pounds, and steers did so by 14 pounds. Since the differences between bulls and steers were influenced to some extent by selection of the larger calves for retention as bulls through the preweaning period, these data do not provide a completely valid comparison of weaning weights of bulls and steers.

Gain From Birth to Weaning

Gain from birth to weaning indicates more adequately than weaning weight the milk production of the dam and the ability of the calf to utilize the available nutrients. Gain makes up a much larger fraction of weaning weight and varies much more than does birth weight. The gains made between birth and weaning by all animals in this study averaged 303 pounds. The frequency distribution of gains by 25-pound intervals is given in figure 5. Approximately 77 percent of the calves gained 251 to 375 pounds, and 97 percent gained 175 to 425 pounds.

Gain from birth to weaning varied greatly among years. It was very low in drought years. Interyear difference, which was highly significant statistically, accounted for 31 percent of the total variance.

Difference in age of dam had an important effect on gain (fig. 6). The curves for gain are almost identical with those for weaning weight. Bull, steer, and heifer calves from 3-year-old cows gained 34, 41, and 37 pounds less than calves from cows 6 to 10 years old, and bull, steer, and heifer calves from 4-year-old cows gained 5, 17, and 19 pounds less than calves from cows 6 to 10 years old. Difference according to age of dam, which was highly significant statistically, accounted for 9 percent of the total variance.

Differences according to sex were slightly less than for weaning weight but were highly significant statistically. Gains made by bulls, steers, and heifers averaged 338, 304, and 294 pounds, respectively; thus, on an average, bulls exceeded heifers in gain by 44 pounds, but steers did so by only 10 pounds.

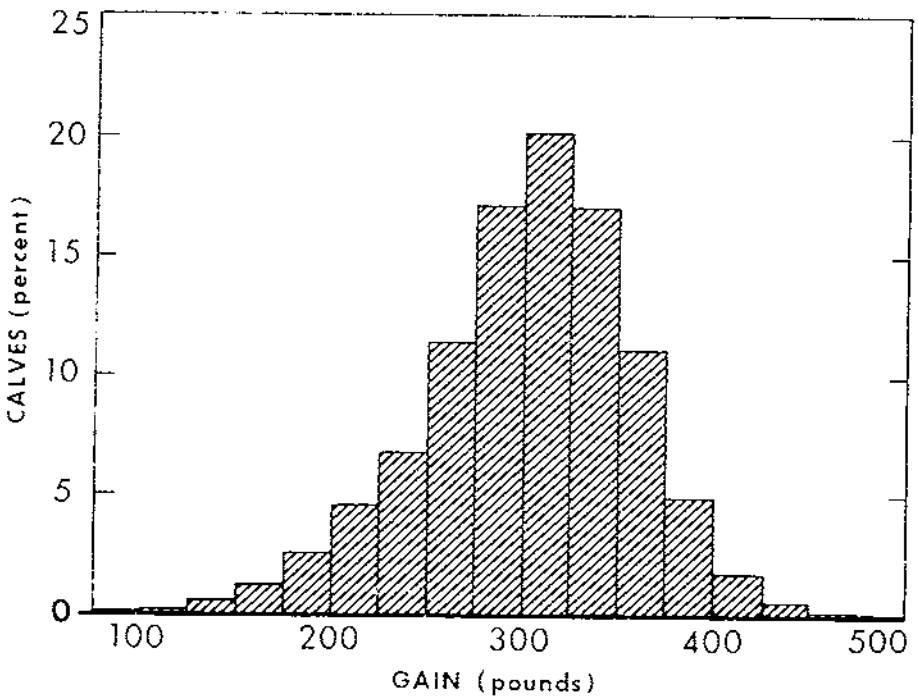

FIGURE 5.—Frequency distribution of gains from birth to weaning of calves produced by cows aged 2 to 15 years.

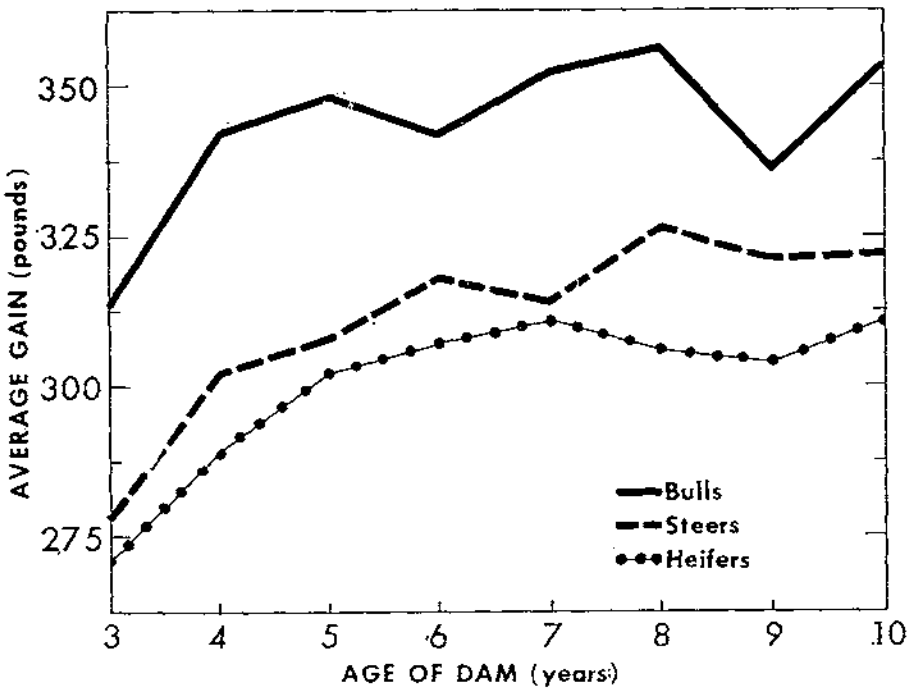

FIGURE 6.—Gain from birth to weaning, by age of dam, of bull, steer, and heifer calves produced by cows aged 3 to 10 years.

Weaning Score

Weaning scores averaged 72. About 68 percent of the scores fell within the range 66 to 80, and 93 percent fell within the range 56 to 85. The frequency distribution of the scores (fig. 7) was skewed moderately to the left. Judges appeared to have a prejudice against scoring calves high. Poor health of the animals lowered many scores.

Between-year differences in scores were highly significant statistically and accounted for 27 percent of the total variance. Scores were very low in 1949, a drought year.

Age of dam affected weaning score only slightly (fig. 8). Bull, steer, and heifer calves from 3-year-old cows scored 4, 6, and 6 percent lower than calves from cows 6 to 10 years of age. For calves from 4-year-olds the corresponding differences in score were 1, 3, and 3 percent, and for calves from 5-year-olds they were 0, 1, and 1 percent.

Bull calves scored 4 percent higher than either steers or heifers. Scoring may have been affected by the selection procedure that was practiced. The averages were 76 percent for bulls, 72 percent for both steers and heifers. Differences in score according to sex were highly significant statistically.

Visual selection of potential breeding stock at weaning time tends to favor the heavier calves, which in many cases are also the older ones. Often a scorer unconsciously scores a calf higher just because it is heavier. If selection were based on weights at a constant age, fewer mistakes should be made in estimating the genetic worth of an animal.

Weight of Cow

Of the three cow weights determined, previous-fall weight was the

most variable. It varied greatly according to age of cow and according to whether the cow was wet or dry when weighed (fig. 9). Annual means for this characteristic varied slightly but reflect extreme weather conditions of the previous year. Differences among years and according to age of cow, which were highly significant statistically, accounted for 8 and 38 percent, respectively, of the total variance.

Spring weight varied only slightly less than previous-fall weight. Differences among years and according to age of cow, which were highly significant statistically, accounted for 12 and 29 percent of the total variance. Fall weight was slightly more variable than spring weight.

Previous-fall, spring, and fall weights of wet cows from 4 to 10 years of age averaged 1,091, 1,098, and 1,109 pounds, and those of dry cows within that age range averaged 1,191, 1,164, and 1,151 pounds, respectively; drys weighed 100, 66, and 42 pounds more than wets at these three stages.

Differences among years, which were highly significant statistically, accounted for 19 percent of the total variance in fall weight—a greater proportion than of total variance in either previous-fall or spring weight. Average fall weight was noticeably affected in years when precipitation during the growing season totaled 4 inches or less. In drought years, since the available feed supply is limited both for the cow and for the calf, an extreme hardship is placed on the cow. If the cow continues to produce milk by withdrawing essentials from her body, a pronounced drop in her weight is likely to occur. If she has lost body weight the previous winter, she has little chance to regain it in a drought year. This is shown by the fact that in

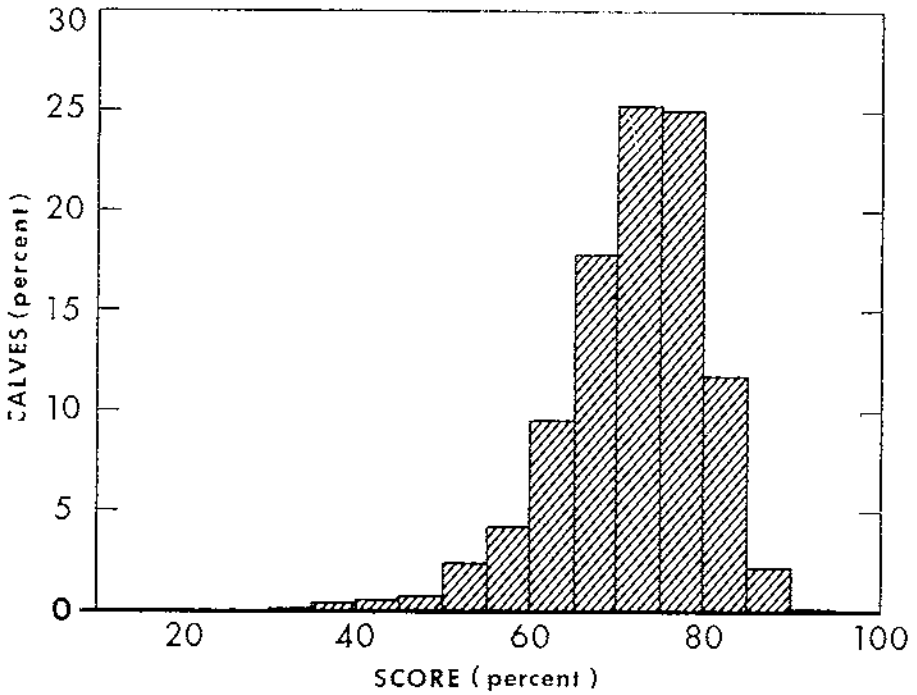

FIGURE 7.—Frequency distribution of weaning scores for 5,171 calves.

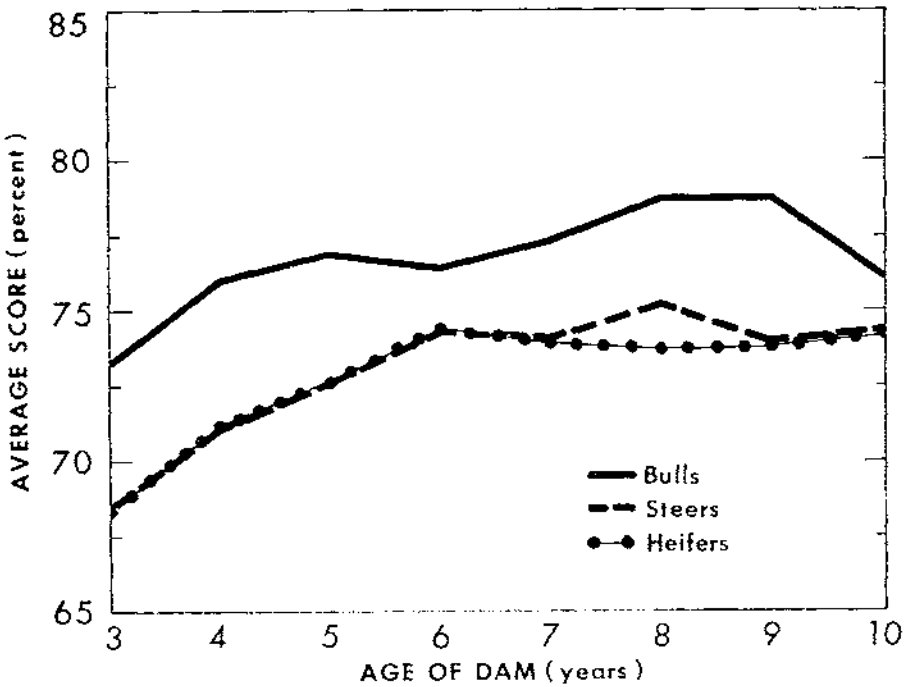

FIGURE 8.—Weaning scores, by age of dam, of bull, steer, and heifer calves produced by cows aged 3 to 10 years.

1931, 1934, 1936, and 1949 weight was distinctly less in the fall than in the previous fall or in the spring.

An excess of growing-season precipitation over 6 inches appears to have little effect on cow weights.

Response of cow weight to the growing-season precipitation depends both on the stage of the growing season at which the precipitation comes and on the species composition of the range grasses. (Species composition of forage on the station area varies according to soil type.)

The "wet" curves for previous-fall weight, spring weight, and fall weight in figure 9 parallel one another rather closely. The "dry" curves, based on fewer animals, are much more erratic. Weight increased only slightly after 5 years. Weights of 3-, 4-, 5-, 6-, and 7-year-old cows, respectively, averaged 154, 89, 46, 28, and 10 pounds less than those of the very highly selected 8- to 10-year-old group. The differences in weight according to age shown in figure 9, which were highly significant statistically, accounted for 25 percent of the total variance in fall weight. These differences may not be representative for range cows of the northern Great Plains in general.

Correlations Between Production Factors

Correlations between the various production factors studied are given in table 5. Correlations were based on 7,436 observations, with the exception that those for weaning scores were based on 5,174. The effects of differences according to year, age of dam, and sex were removed by analysis of variance (table 1). Weaning weight of calf and gain from birth to weaning were adjusted to 180 days of age.

A fairly large correlation appeared between birth weight and weaning

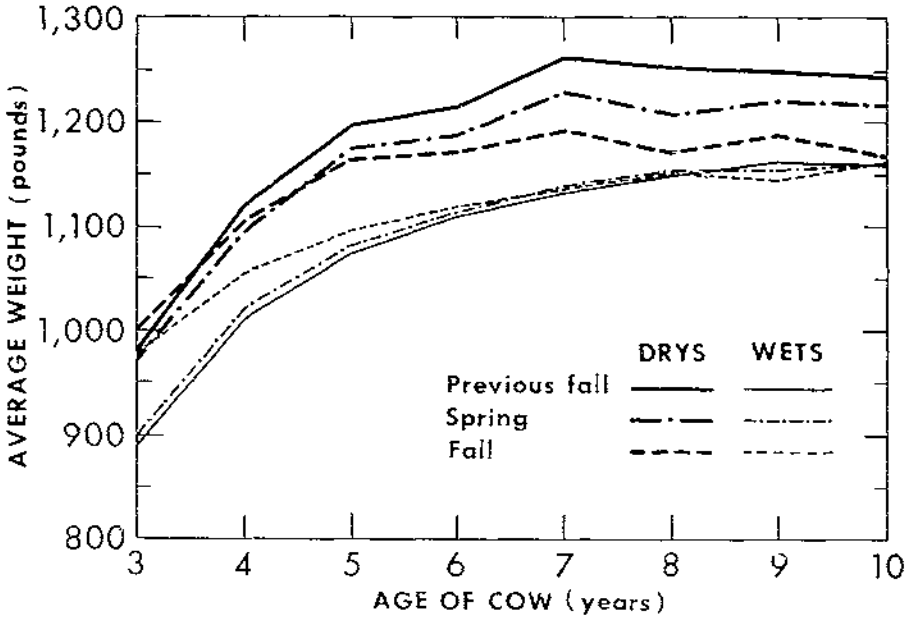

FIGURE 9.—Previous-fall, spring, and fall body weights of wet and dry cows by age.

TABLE 5.—*Phenotypic correlations*[1] *between various production factors in beef cows within year of birth, age of dam, and sex*

Production factor	Correlation with indicated factor					
	X_2, Weaning weight of calf adjusted to 180 days	X_3, Gain from birth to weaning adjusted to 180 days	X_4, Weaning score of calf	X_5, Weight of cow in previous fall	X_6, Weight of cow in spring	X_7, Weight of cow in fall
X_1, Birth weight of calf	+0.41**	+0.24**	+0.20**	+0.24**	+0.29**	+0.20**
X_2, Weaning weight of calf (at 180 days)	.....	+0.98**	+0.65**	+0.11**	+0.20**	+0.07*
X_3, Gain from birth to weaning (at 180 days)	.....	.....	+0.65**	+0.07*	+0.15**	+0.04
X_4, Weaning score of calf	.....	.....	.....	+0.06*	+0.11**	−0.01
X_5, Weight of cow in previous fall	.....	.....	.....	.....	+0.86**	+0.80**
X_6, Weight of cow in spring	.....	.....	.....	.....	.....	+0.80**

[1] Correlations between scores at weaning and the various characteristics were computed on the basis of 5,174 observations; the others, on the basis of 7,436 observations. The degrees of freedom within subclasses were 4,928 and 6,926. 1 asterisk indicates significance at the 5-percent level; 2 asterisks, significance at the 1-percent level.

weight of calf. This was to be expected. Birth weight and gain from birth to weaning were correlated much less highly. Birth weight was only slightly correlated with weaning score. The calves that were the heaviest at birth showed a slight tendency to gain the most rapidly from birth to weaning and to score the highest at weaning. If the method of scoring tended to favor the heavier calves, the scores of calves weaned at greater ages are probably biased upward.

Low positive correlations appeared between birth weight of calf and weight of cow. Birth weight was more highly correlated with spring weight (taken during the last 2 to 4 weeks of the gestation period) than with either of the other cow weights.

Weaning weight was almost perfectly correlated with gain from birth to weaning and was rather highly correlated with weaning score.

Weaning weight of the calf was only slightly correlated with any of the cow weights.

Weight of the cow in the previous fall apparently had less effect on milk production than the condition of the range or the availability of feed during the suckling period. The correlation of spring weight with weaning weight was so slight as to have little predictive value. For fall weight of cow the correlation with weaning weight was still lower. If cows milking heavily fail to gain after calving, while cows milking less heavily tend to gain, the correlation between weaning weight and fall weight of the cow may even be negative, in spite of the fact that greater weaning weight of calf is associated with larger frame of cow.

Gain from birth to weaning, like weaning weight, was rather highly correlated with weaning score. Gain was only slightly correlated with spring weight of dam and was very slightly correlated with previous-fall weight. It was essentially unrelated to fall weight of dam.

Previous-fall weight of cow was very highly correlated with spring weight, and this correlation was almost matched by that of previous-fall weight with fall weight and that of spring weight with fall weight.

APPLICATIONS

In selecting herd replacements, the rancher should consider the fact that great differences in a cow's production occur between years, largely because of differences in environmental factors. A high record made by an individual cow in one year may not signify that high productivity is characteristic of the animal; it may merely reflect favorable environmental conditions existing in that year. Individual production records give a better idea of the breeding value of individual animals if expressed as percentages of herd averages for a given year rather than in pounds of calf weight or in weaning scores.

Estimating the breeding value of stock obtainable from other herds is more difficult. Often, differences between years and between herds are confounded. A rancher should observe caution when considering stock from a herd kept on a much higher plane of nutrition than his own. These animals may appear to be superior to those in a herd on a lower plane but in fact be inferior. Animals kept on similar planes of nutrition are fairly comparable.

When weaning weights of calves are used as a basis of comparison between various cows in a breeding herd, they should be adjusted to a constant age. The records can be adjusted by multiplying the average daily gain from birth to weaning by 180 or any other selected number of days and adding the product to birth weight.

Because age of dam has an important effect on most production characteristics, all records should be adjusted to a mature-dam basis in selecting breeding stock, as follows: Add 5 pounds to the birth weight of calves from 3-year-old cows; add 45, 20, and 10 pounds, respectively, to the weaning weights of calves from 3-, 4-, and 5-year-old cows; and add 5 percent to the weaning scores of calves from 3-year-old cows.

A heifer calf's birth weight can be adjusted to a bull basis by adding 5 pounds. Correction factors to be applied to weaning weights in herds

produced under northern Great Plains conditions could be developed on the basis of the fact that in the large populations included in this study the bulls and steers outweighed the heifers at weaning by averages of about 50 and 15 pounds, respectively. In using factors thus developed it would have to be kept in mind that the differences found in weaning weight may have been influenced by the manner in which the bull calves were selected.

Since low weight of a cow in the previous fall does not signify that the calf the cow produces will weigh less than average at weaning time, caution should be exercised in culling thin cows.

Weights of 3-, 4-, 5-, and 6-year-old cows are less than those of 8- to 10-year-olds by about 150, 100, 50, and 25 pounds, respectively.

Results of the study indicate that, in general, disposing of cows at the age of 10 years means eliminating them from the herd before their productivity has dropped more than slightly. The length of time a cow should be retained in a commercial breeding herd depends on the price of feeder calves and of cows, the availability of feed, the condition of the range, the amount of supplemental feed needed, the extra care required for older cows, and the productivity of the individual cow.

The method (described on p. 5) by which identifying numbers are assigned to animals at the Range Livestock Experiment Station enables a range operator to tell the age of each animal in his herd at a glance. It simplifies the practice of eliminating from the herd each year the cows that have reached culling age.

SUMMARY

Relations between various production characteristics of range cattle were investigated in the registered and grade herds at the United States Range Livestock Experiment Station, Miles City, Mont., by the Agricultural Research Service of the United States Department of Agriculture and the Montana Agricultural Experiment Station, cooperating. Records of 7,436 Hereford calves from 2,131 cows, taken in 1926–53, formed the basis of the study.

The characteristics studied were the calf's birth weight, weaning weight, and gain from birth to weaning and the cow's previous-fall weight, spring weight, and fall weight. For the correlation studies, effects of differences according to year, age of dam within year, and sex within age of dam were removed by analysis of variance.

For all characteristics, means varied greatly among years and annual differences were highly significant. Probable causes of this variation include variations in weather and changes in methods of management, in nutritional plane, and in genetic composition of the herd. When growing-season precipitation amounted to not more than 4 inches, gains from birth to weaning were materially reduced; when it amounted to more than 6 inches, the excess over that total seemed to have little effect on preweaning growth. The influence of environmental factors must be considered in comparing records made within the same herd in different years. Individual yearly records of animals born in the same herd but in different years can be compared when they are expressed as percentages of yearly herd averages. Before such comparisons are made, the records must be adjusted to a standard weaning age, to a mature-dam basis, and to the same sex.

Birth weight, weaning weight, and gain from birth to weaning showed highly significant differences according to sex.

Age of dam affected all the calf characteristics studied.

Productivity increased rapidly from 3 to 5 years of age, increased slowly from 5 to 8, and declined very slightly from 8 to 10.

The calves heaviest at birth showed only a slight tendency to gain the most rapidly from birth to weaning and to score the highest at weaning. Those heaviest at weaning scored highest. The calves produced by the heaviest cows showed a slight tendency to be the heaviest at birth and at weaning. Birth and weaning weights were associated more closely with spring weight than with fall weights of the dam. Weights of a cow at the three stated times were very highly correlated.

Weights of 3-, 4-, 5-, 6-, and 7-year-old cows averaged less than those of 8- to 10-year-old cows by 154, 89, 46, 28, and 10 pounds, respectively.

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