FIELD DAY

U. S. Range Livestock Experiment Station
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TABLE OF CONTENTS

PREDICTING BODY PROPORTIONS OF BEEF CATTLE BY PHOTOGRAMMETRY

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Photogrammetry may be defined as the science of obtaining reliable measurements by means of photography in order to determine characteristics of an object such as size, shape, surface area, or position of the photographed object.

Photogrammetry is not new but dates back to about 1850 when the Frenchman Aimé Laussedat first began to use photography for measuring purposes. Its most frequent use today is in aerial photogrammetry for making terrain or land contour maps.

Stereophotogrammetry, or double-image photogrammetry, is the process of taking two photographs simultaneously using two cameras a certain distance apart. A stereoscope is then used on the two photographs which enables one to interpret in terms of depth as well as length and breadth. These principles are now being applied in several areas including biological fields such as the medical and dental professions. One interesting application that was recently developed was the determining of the exact body shape from a contour map of the human body for use in designing form-fitting protective garments that insure pilot survival at high altitudes. German animal scientists have experimented with stereophotogrammetry with livestock and have published contours of cattle and sheep.

This study was conducted in cooperation with the Great Plains Institute of Animal Reproduction, Topeka, Kansas. Photographs were taken and the points on the animals were plotted by the Institute's staff.

The objective of the investigation I am reporting on today was to study the relationships of various length, width, and depth measurements obtained by stereophotogrammetry with the wholesale cuts of beef and to develop equations which would be predictive of these wholesale cuts or body proportions.

The animals used in the study were 38 Hereford steers raised here at the Range Station during the year 1961-62. The steers were weaned in late October 1961 at an average age of six months and were then group fed for 252 days. The steers were individually weighed and stereophotographs were obtained in a specially designed chute 16 days before the end of the feeding period. Reference targets were placed on the center line of the back with rubber contact cement and a fourth target was attached to the navel with paper clips (figure 1). White waterbase paint rings were applied on the hide for reference points following palpation of anatomical structures. Each animal was dusted lightly with white wheat flour to break the continuous color pattern of the hair coat. The various points that were actually used in the analysis from which the length, width, and depth distances were calculated are shown in figure 2.

All steers were slaughtered on the same day in early July 1962 and chilled carcass weights were obtained approximately 26 hours after slaughter. Weights of the forequarter, hindquarter, and wholesale cuts including the round, loin, rib, chuck, flank, short plate, brisket, and foreshank were recorded. The weights of the short plate, brisket, and foreshank were grouped and called rough cuts for purposes of this analysis. The weights of the flank and kidney knob were not used in the analysis.

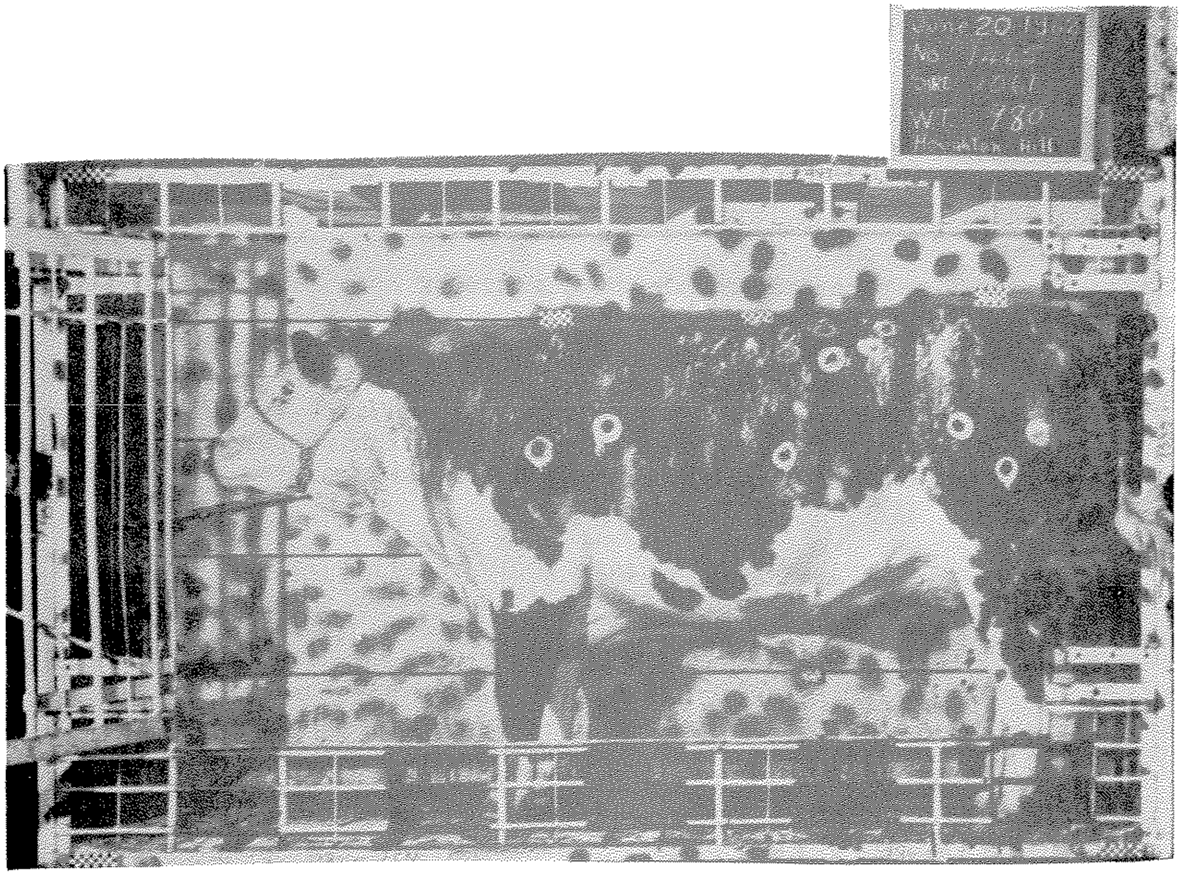

Figure 1.--Enlargement made from right plate of stereophotographs showing steer 1045 in chute. Note targets along center line of back and on navel.

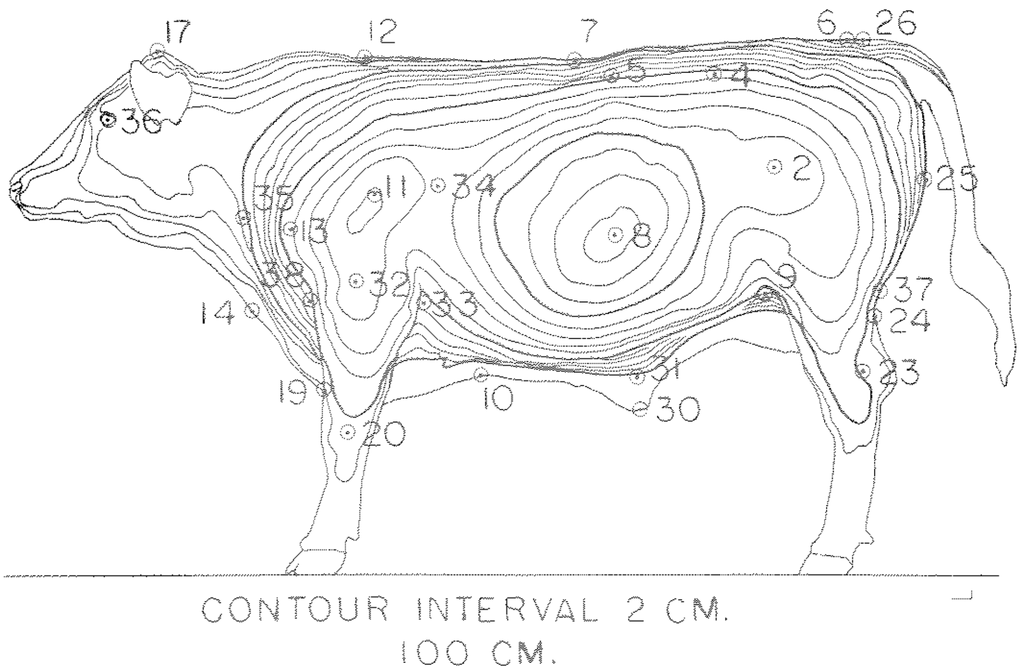

Figure 2.--Orthographic projection of steer 1045 showing contour of animal. Numbers indicate actual locations of points selected and plotted which were used to calculate length, width, and depth measurements.

The means (averages) and standard deviation (measures of variation among the animals) of the wholesale cuts and live weight are listed in table 1. The wholesale cuts do not sum to 100 percent since the flank, kidney knob, and cutting loss are not included in the figures.

Table 1. Means and standard deviations of wholesale cuts and live weight.

Trait	Pounds		Percent of chilled carcass	
	Mean	Standard[1/] deviation	Mean	Standard[1/] deviation
Live weight	975	108		
Chilled carcass	604	77		
Forequarter	314	42	52.0	.8
Hindquarter	290	36	48.0	.9
Round	137	15	22.7	1.0
Loin	110	14	18.3	.6
Rib	57	7	9.5	.4
Chuck	160	20	26.6	.7
Rough cuts	96	15	15.9	.7

1/ The standard deviations are a measure of variability among animals with approximately two-thirds of the animals being in the range of plus or minus one standard deviation from the mean.

These figures are listed to provide some background information on the weight ranges and type of cattle we were working with. One interesting point indicated by these figures is that although live weight and weights of the wholesale cuts varied considerably, the amount of variability in percentages of the wholesale cuts of the chilled carcass is very small.

The distances that were used in the study were picked to outline the areas on the live animal that corresponded to the wholesale cuts in the carcass. The distances were calculated from points on the stereophotographs.

The relationships of the various distances with the wholesale cuts were studied by computing the correlations between the distances and the wholesale cuts. Since listing all of the correlations would be prohibitive here, we have listed only those pertaining to the round which are listed in table 2 along with the prediction equations for pounds and percent round. All length, width, and depth distances were positively associated with pounds of round which is expected since the larger animals have greater distances and more pounds of round. The correlation of live weight with pounds of round was 0.93 which indicates that live weight is a good indicator of pounds of round in itself. However, if progress for increased proportions of the higher priced cuts is expected, objective measurements other than live weight alone must be used.

Length measurements pertaining to the round were generally positively related to percent round whereas width and depth measurements were slightly negatively related to percent round. The correlation of live weight with percent round of -.43 indicates that as live weight increases, the percent of round of the chilled carcass decreases. Other correlations obtained in the study indicate that as live weight increases, the percent forequarter and especially percent rough cuts increases and that percent hindquarter, round, loin, and rib decrease.

The prediction equations, shown as partial regression coefficients, for pounds and percent of round are given on the bottom of table 2. Since several length, width, and depth measurements are included in the equations, it is difficult to interpret the individual partial regressions without looking at the set as a whole. The "R" values in table 2 are the multiple correlations of the distances and live weight with pounds and percent of round. They indicate the relationship of the actual and predicted values of pounds and percent round. The "R^2" values indicate the amount of the total variation in the round accounted for by the distances used and live weight. In other words, 93 percent of the variation in pounds of round and about 80 percent of the variation in percent round can be accounted for by differences in the distances and live weight.

We have applied the prediction equations developed in this study to three yearling Hereford bulls from the carcass line. The estimates of the various wholesale cuts adjusted to a 1000 pound live weight basis for comparision purposes are shown in table 3.

Table 3. Predicted pounds of wholesale cuts--1000 pound live weight basis.

	Trait						
Bull Number	Forequarter	Hinquarter	Round	Loin	Rib	Chuck	Rough cuts
1012	330	304	157	122	51	166	105
1177	313	299	142	112	52	164	100
1459	325	289	146	109	60	166	102

Bull 1012 was predicted to have somewhat more forequarter and hindquarter (dress out higher) with more especially in the round and loin areas. There was very little difference among bulls for chuck and rough cuts.

The work we have done with photogrammetry thus far is of a preliminary nature and other distances may be added and some we are now using that have only a small influence could be dropped. A minimum number of distances with high accuracy is what we are striving for. Also, areas of various cross sections of the animal's body estimated from the stereophotographs could be used in prediction of body proportions.

Some of the advantages of using photogrammetry over the conventional methods of measuring are:

(1) Photographs can be taken fairly rapidly and are not influenced as greatly by cattle movements as measurements taken directly on the live animal.

(2) An almost identical optical model can be made from the stereophotographs which enables one to obtain as precise measurements as usually needed.

(3) A permanent record is obtained which can be referred to at any time for repeated or entirely new measurements.

Table 2. Correlations of distances and live weight with pounds and percent of round.

Trait	Distance and Live Weight[1]												
	9-26L	9-24L	9-25L	4-26L	4-25L	9-37L	26-4W	26-2W	26-9W	26-9D	26-23D	26-2D	LW
Round													
Pounds	0.05	0.52	0.42	0.39	0.61	0.53	0.16	0.33	0.07	0.65	0.70	0.50	0.93
Percent	.38	.19	.27	.00	-.18	.25	-.23	-.11	-.01	-.33	-.23	-.07	-.49

Prediction Equation for Round

Pounds

$$-80 + 8.86L_1 - .65L_2 - 8.42L_3 - 8.25L_4 + 9.36L_5 + 3.80L_6 - .94W_1 + 4.57W_2 - 1.35W_3 + .48D_1 + .39D_2$$
$$+ 1.03D_3 + .09LW \qquad R = .96 \quad R^2 = .93$$

Percent

$$10 + .34L_1 + .29L_2 - .43L_3 - .19L_4 + .21L_5 + .32L_6 - .29W_1 + .59W_2 + .02W_3 + .07D_1 + .45D_2$$
$$- .01D_3 - .01LW \qquad R = .80 \quad R^2 = .64$$

1/ L = length, W = width, D = depth, LW = live weight.

PRELIMINARY RESULTS OF REPRODUCTIVE PHYSIOLOGY AND GROWTH STUDIES AT THE U. S. RANGE LIVESTOCK EXPERIMENT STATION

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Introduction

With profitable livestock production becoming more dependent upon efficiency of operation it is important that ways be explored by which efficiency may be increased. A typical 17-year summary of the percent of cows giving birth to a live calf at this Station, showed percentages ranging from 66 to 92 percent. Thus, one of the most apparent ways to increase efficiency is to boost the percent calf crop.

It is a common practice to breed heifers to drop their first calf as two-year olds, thus eliminating one year of non-profit "board bill". However, if heifers have not reached puberty (sexual maturity) and do not come into heat during the breeding season the resultant calf crop will be poor. But just getting a heifer to come into heat isn't the entire story. If the first calf heifer is small and underdeveloped and has trouble at calving time, work on the part of the rancher is increased as well as veterinary expense. In addition, there is the possibility of injury to the heifer that could drastically decrease her lifetime production.

How young can a bull be when he's turned into a breeding pasture and the rancher be reasonably certain he can expect a calf crop? While puberty is expressed in a heifer by her coming in heat and ovulating, puberty in the bull is expressed as the production of sperm and the ability to breed. Using a young bull will again cut that non-profit "board bill" but if a bull has not reached puberty the probability of a satisfactory calf crop is poor.

From work at this Station it was found that the yearly percentage of calves stillborn or dying shortly after birth is approximately four percent. It was also found that the frequency of stillbirths was highest in first calf (three-year old) heifers. All dead calves were autopsied and the most frequent findings were bruises and hemorrhages indicative of slow or difficult birth. This was especially true if the calf was large. If these calving difficulties could be reduced, theoretically the number of live calves should increase.

Studies are now underway at the U. S. Range Livestock Experiment Station to determine the effects of breed and feed level on body growth and age at puberty in both bulls and heifers. The study of causes of stillborn calves is being continued and extended. One of the prime objectives of these studies is to boost the percent calf crop.

Projects and Preliminary Results

Heifer puberty studies

A study of the effects of ration energy level on growth and reproduction of range heifers is being conducted as a cooperative project with the Animal Science and Range Management Department of Montana State College.

Forty-eight weaned heifer calves were assigned to this study November 30, 1962, and are grazed on range together throughout the trial. The design of the experiment is shown in Table 1. Two levels of supplemental feeding were used during the winter feeding period (Nov. 30 to April 15) and heifers were individually fed their respective ration every other day. Rations were formulated to provide equivalent amounts of phosphorus, vitamin A and protein but contain either a high or low level of energy. Feeding rates were two pounds every other day of the 40 percent protein pellet and four pounds every other day of the 20 percent protein pellet. Ration compositions are shown in Table 2.

At the beginning of the experiment all heifers were weighed, measured and palpated. Average values of measurements obtained are shown in Table 3. All measurements, body weights and palpation information are obtained at 28-day intervals throughout the trial. The measurements will be used to study body and reproductive tract growth patterns as well as the effects of feed level.

Table 1. Design of experiment to study effects of ration energy level on growth and reproduction in range cattle.

Wintering phase[a]		Prebreeding phase[b,c]	
Two lb. 40% protein pellet	(24)[d]	Range	(12)
		Four lb. 20% protein pellet	(12)
Four lb. 20% protein pellet	(24)	Range	(12)
		Four lb. 20% protein pellet	(12)

[a]Fed every-other-day Nov. 30 to April 15.
[b]Fed every-other-day April 17 to June 15.
[c]No supplement during breeding
[d]Number of animals per group.

Table 2. Ingredients and composition of pelleted rations.

	Low level		High level	
	%	lb/ton	%	lb/ton
Ingredients:				
Barley	----	----	67.0	1340
Soybean oil meal	91.25	1825	26.25	525
Molasses	6.00	120	6.00	120
Monosodium phosphate	2.00	40	0.375	15
Calcium carbonate	0.375	15	0.375	15
Vitamin A (I.U. per lb. feed)	20,000		10,000	
Approximate composition:				
Protein (%)	40		20	
Calcium (%)	0.50		0.25	
Phosphorus (%)	1.00		0.50	
Vitamin A (I.U. per lb. feed)	20,000		10,000	
Amount fed every other day	2 lb.		4 lb.	
Total lb. grain wintering phase (per head)	138		276	
Cost per lb. grain	$ .053		$ .034	
Total grain cost wintering phase(per head)	$7.31		$9.38	

A sterile bull with a marking harness containing pigmented grease is run with the heifers to determine estrual (heat) activity. In addition, the ovarian activity of all heifers is determined via rectal palpation. Factors being studied in regard to reproduction include time of first ovulation, time of first estrus and ovarian and reproductive tract growth as well as pelvic growth.

At the end of the wintering phase the heifers were weighed, measured and palpated and on April 17, 1963, each wintering ration group was divided into those receiving supplement and those on range only prior to breeding. The ration will be the same as the high level fed during the wintering period, i.e., four pounds of the 20 percent protein pellet, fed individually every other day. This feeding regime will continue until June 15, 1963, which is the beginning of the breeding season. Heifers will then be exposed to a fertile bull wearing a marking harness so breeding dates can be determined. Factors studied will be number of heifers bred, conception rate and embryonic survival.

Table 3. Summary of wintering phase of heifer puberty study.

Ration	Low level			High level		
Time Period	On Treatment (Nov. 30)	End Wintering (Apr. 17)	Increase on Treatment	On Treatment (Nov. 30)	End Wintering (Apr. 17)	Increase on Treatment
Body wt. (lb.)	386.5[a]	509.8	123.3	390.0	524.9	134.9
Avg. daily gain (140-days)		0.88			0.96	
Shoulder width (in.)	12.0	13.4	1.4	12.0	13.6	1.6
Hip width (in.)	13.1	14.6	1.5	13.2	14.6	1.4
Body length (in.)	42.0	45.9	3.9	42.3	46.8	4.5
Wither height (in.)	34.9	39.1	4.2	34.5	39.5	5.0
Body depth (in.)	19.3	21.8	2.5	19.1	21.6	2.5
Reproductive tract:						
Right horn (mm.)[b]	10.6	17.3	6.7	9.9	17.1	7.2
Left horn (mm.)	10.4	18.7	8.3	9.7	18.3	8.6
Uterus (mm.)	14.0	23.5	9.5	13.4	23.4	10.0
Right ovary (mm.)	38.5	64.8	26.3	39.5	63.7	24.2
Left ovary (mm.)	36.9	64.8	27.9	35.7	61.1	25.4
Pelvic opening:						
Height (cm.)	10.7	12.4	1.7	10.4	12.3	1.9
Width (cm.)	9.5	11.1	1.6	9.2	10.9	1.7
Area (sq. cm.)	101.6	137.6	36.0	95.7	134.1	38.4
Ovarian activity (no. calves)						
Follicles 5 mm. or larger	6	24	18	5	24	19
Corpora lutea	0	1	1	0	3	3
Estrus	0	0	---	0	2	2

[a]All values are averages.
[b]Sum of length, width and height of ovary.

Data at the end of the wintering phase (April 15, 1963) are summarized in Table 3. It will be noted that there has not been a great deal of difference in body or reproductive tract growth on the two rations. Heifers on the high level supplement gained 0.96 pounds daily while those on the low gained 0.88

pounds. Heifers were given a condition score at the end of the wintering period, ranging from 0 (thinnest) to 10 (fattest). The average score for the high level heifers was 4.9 and for the low level 4.1.

It is too early to draw any conclusions as to feed effects on reproductive activity. There may possibly be a trend indicated in the number of heifers that have come in heat (estrus) and have shown corpora lutea in the ovaries (Table 3) but this remains to be seen.

In another study age at puberty is being determined in straight-bred Hereford, Angus and Charolais heifers. Crossbred heifers resulting from interbreed crossing of these three breeds as well as those from matings of Hereford, Angus and Charolais bulls on Brown Swiss cows are also being studied.

Eighty-three weaned heifer calves were assigned to this study which started December 17, 1963. From the start of the study all animals were fed grass-alfalfa hay free choice plus two pounds of grain daily. Hay feeding was stopped April 19 and grain feeding was stopped April 30, 1963. Average daily gain during this period was 0.77 pounds.

A sterile bull whose brisket is painted daily with a multipurpose grease containing green cement pigment is run with the heifers to detect estrus. Heifers with grease on the tail head or observed standing to be mounted by other heifers are considered to have been in heat. From seven to fourteen days after heat, marked heifers are weighed and the ovaries palpated rectally to confirm ovulation.

Data showing age and weight of puberal heifers are shown in Table 4.

Table 4. Age and weight of puberal heifers summarized April 15, 1963.

Breed of Sire		Breed of Dam: Hereford	Angus	Charolais	Brown Swiss
Hereford	No. heifers	8	8	7	4
	No. heifers in heat by 4/15/63	2	4	3	3
	Avg. age (days)	346	336	339	314
	Avg. wt. (lb.)	530	558	645	585
Angus	No. heifers	8	7	9	2
	No. heifers in heat by 4/15/63	6	4	6	2
	Avg. age (days)	353	343	320	322
	Avg. wt. (lb.)	552	571	573	600
Charolais	No. heifers	7	9	10	4
	No. heifers in heat by 4/15/63	5	5	6	3
	Avg. age (days)	348	330	288	305
	Avg. wt. (lb.)	597	625	625	625

Summary:	Straight-breds	Crossbreds
% in heat	48.0	63.8
Avg. age first heat (days)	326	330
Avg. wt. first heat (lb.)	575	596

Bull puberty study

A study is also underway to determine age at puberty in straight and crossbred bulls. The study involves 21 head of bulls and the experiment was started November 1, 1962. Numbers and breeds represented are shown in Table 5. During the study bulls have been group fed alfalfa hay free choice plus five pounds of grain mix daily.

Table 5. Age at puberty data in straight and crossbred bulls summarized 4/18/63.

			Electroejaculation data Age (days) at first:				Breeding ability data		
Breed	No. bulls	Weight on test (Nov.1)	Ejaculation	Appearance of sperm	Appearance of motile sperm	Sperm no. sufficient for classification	Puberty age	Puberty wt.	Avg. libido score
HXH[a]	2	428	371	259	329	329	---[b]	---	3.4
AXA	2	438	266	212	240	240	354	758	3.0
CXC	2	603	299	259	287	259	380[c]	858[c]	2.6
HXA	2	466	346	238	250	264	341[c]	790[c]	3.1
AXH	2	500	290	250	250	250	338	758	3.0
HXC	2	520	268	244	256	256	359	800	2.6
CXH	2	488	279	241	241	241	377	850	2.4
AXC	2	492	267[c]	231	247	261	358[c]	733[c]	2.7
CXA	2	450	306	226	226	226	362	796	3.1
HXBS	1	554	---	219	---	299	313	834	2.9
AXBS	1	428	246	190	190	246	358	910	3.3
CXBS	1	690	298	214	326	298	340	966	4.9
Avg. all straight-breds		490	312	243	285	276	367	808	3.0
Avg. all crossbreds		510	288	228	248	260	350	826	3.1

[a]Sire X Dam: H = Hereford; A = Angus; C = Charolais; BS = Brown Swiss.
[b]Dash indicates not obtained as of 4/18/63.
[c]Value represents one bull.

All bulls are subjected to collection with an electroejaculator at 28-day intervals. Observations made include the occurrence of an ejaculation, voltage required, ejaculate volume collected, color of fluid, and concentration and motility of sperm. The collected fluids are then stained and the sperm classified as to percent normals: abnormals and type of abnormals.

Fourteen days after electroejaculation, and again at 28-day intervals, all bulls are exposed to a heifer that has been treated with estrogen to artificially induce heat. Breeding ability is determined and a libido (breeding activity) score ranging from 0-no interest to 5-mounting and service, is given. When a bull breeds a heifer, samples of the ejaculate are obtained and examined microscopically for the presence of sperm. For purposes of the experiment puberty is defined as the ability to breed a heifer and the ejaculation of sperm in potentially fertilizing numbers.

Data are summarized as of April 18, 1963, in Table 5. It must be remembered that there are only two bulls represented in the genetic subgroups except the Brown Swiss crossbreds which have only one. Thus, caution must be used in drawing conclusions. However, it is interesting to note that when comparing all the straightbreds with all the crossbreds, the crossbred bulls reached the classification criteria earlier than straight-breds and the age at puberty, to date, has averaged 17 days sooner in crossbred bulls.

Pelvic measurement study

Based on the previously cited information gained in the study of causes of stillbirths, a project has been initiated to relate size of the pelvic opening to calving difficulties and stillbirths. Measurement of both height and width of the opening is taken rectally with a set of sliding calipers. These two measurements are then multiplied together to give an estimate of the area.

Table 6. Pelvic and body measurement summary of first-calf heifers in 1963 calving herd.

	Breed of heifer							
	Hereford		Angus		Charolais		Brown Swiss	
Age	2-yr. old	3-yr. old	2-yr. old	3-yr. old	2-yr. old	3-yr. old	2-yr. old	3-yr. old
No. heifers	11	85	1	---	1	8	2	3
Avg. pelvic area (sq.cm.)	228.3	289.9	243.4	---	267.0	328.0	269.6	316.5
Range	181.7 to 304.9	216.1 to 325.5	---	---	---	285.1 to 360.8	265.4 to 273.8	290.7 to 329.4
Avg. hip width (in.)	17.2	20.4	17.5	---	18.0	21.6	19.2	21.2
Range	16.0 to 18.0	18.2 to 21.8	---	---	---	21.0 to 22.2	18.8 to 19.8	20.8 to 21.5
Avg. rump length (in.)	17.3	19.6	17.8	---	18.0	20.7	18.8	20.5
Range	16.0 to 18.2	18.0 to 21.5	---	---	---	18.5 to 22.0	18.5 to 19.0	20.2 to 20.8
Avg. condition score	5.0	5.8	6.0	---	5.0	6.6	4.0	4.3
Range	4 to 6	4 to 8	---	---	---	6 to 8	3 to 5	4 to 5
Avg. body wt.	786	1049	804	---	844	1213	1071	1211
Range	702 to 992	812 to 1180	---	---	---	1074 to 1400	1064 to 1078	1172 to 1232

In addition to pelvic measurements, hip widths and rump lengths were also taken and will be related to pelvic opening and calving difficulties. In this way the association between internal and external measurements can be studied. A condition score ranging from 0 to 10 was given each animal and will be used to study the relationship between fatness and calving difficulties. This information has been obtained from all pregnant first calf heifers on the Station and the data are summarized in Table 6.

Calves from first calf heifers are being measured to determine width of head, shoulders, and hips and depth of chest. These measurements will be used to study breed differences in calf size and to establish more clearly what might be considered a "minimum" pelvic area.

Summary

Physiology work now underway at the U. S. Range Livestock Experiment Station is directed primarily toward increasing the percent calf crop. Age at puberty is being studied in straight-bred bulls and heifers of the Hereford, Angus and Charolais breeds. Crossbred bulls and heifers resulting from interbreed crossing of these three breeds as well as from matings of Hereford, Angus and Charolais bulls on Brown Swiss cows are also being studied. The effects of ration energy level on age at puberty and subsequent reproductive performance is being studied in Hereford heifers.

In an attempt to reduce the number of stillborn calves the area of the pelvic opening and various external measurements have been taken in an effort to predict dams likely to have calving difficulties.

PERFORMANCE TESTING AS IT AFFECTS THE BEEF CATTLE INDUSTRY

by
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The beef cattle industry has made great strides in recent years. As compared to the five year period 1936 to 1940, we are now consuming approximately 50 percent more beef per capita (about 90 pounds per person in 1962) and consumers are expending approximately the same fraction of their disposable income for beef as during the earlier period. Progress of this kind in accomplishing the two basic purposes of any industry, namely, the ability to produce a product consumers like and secondly, to produce it at a price consumers are ready and willing to pay, is an accomplishment of which any industry might well be proud.

Many things have undoubtedly had a part in this accomplishment, among which might be mentioned improvements in feeding and management, improvements in disease control, and improvements in processing and merchandising methods. Looking at the situation over a much longer period of time, it appears that breeding has probably played a part in improving the beef cattle industry, particularly from the standpoint of producing a quality product of the kind demanded by consumers. The improvement of beef cattle themselves in efficiency of production is somewhat questionable. We have compared records made in experiment stations by cattle on standard rations (i.e., such rations as corn and legume hay, or corn, corn silage, mixed hay and a protein supplement, all the rations being without any fortification, such as stilbestrol or antibiotics) and find there is little or no evidence of an improvement in efficiency in recent years as compared to the general period 1900 to 1920. This would tend to indicate that improvements in efficiency have probably been largely due to improved feeding methods rather than to improvements in the inherent efficiency of the cattle themselves.

If true, this is not a surprising situation since beef cattle breeding to date has largely been on an empirical basis and it was only a little over 30 years ago that research was initiated here at the Miles City Station by the U. S. Department of Agriculture and the Montana Agricultural Experiment Station and at Beltsville, Maryland, by the U. S. Department of Agriculture, in order to develop new methods which might have a potential for improving the overall efficiency of the industry. In terms of generation length and reproductive rate of beef cattle, this is a relatively short period of time. During the more than thirty years which have passed since this research was initiated, it has been expanded by the Department of Agriculture to other stations and many other State experiment stations have developed active research programs in the general area of beef cattle breeding.

This research has resulted in (1) identification of economically important characters and methods of measuring them, (2) the development of breeding methods which appear to have a real potential for improving the overall efficiency of the beef cattle industry, and (3) the accumulation of large amounts of information on the heritability and genetic relationships among traits which provide the basic information on which it is possible to estimate the potential contributions of the new techniques to improvement of the industry. Without going into detail, it appears from information developed to date that if beef cattle producers in the United States adopted comprehensive programs of performance testing, average improvements, over a ten-year period, of something over 20 pounds in weaning weight per calf, of about .22 pounds in average daily gaining ability, and appreciable although relatively smaller improvements in carcass composition and palatability.

An improvement of 20 pounds in average weaning weight would be an increase of about five percent over present levels. If, as seems likely, this could be accomplished at little or no additional production cost, it is of obvious importance to the cow-calf operator. This is true regardless of whether he sold his calves at weaning for either slaughter or feeding purposes, or whether he, himself, carried them further and sold them for slaughter at a later age or sold them as yearlings or 2-year-olds for feeder purposes. Similarly, the improvement in average daily gain would be of obvious importance to the feeder, since it has been generally found in research that faster gaining cattle make their gains more efficiently. In research herds, an improvement of .25 of a pound per day in average daily gain has generally been associated with a 7 to 8 percent saving in feed required per 100 pounds of gain. With today's narrow feeding margins, this could well spell the difference between profit and loss in a feeding operation. In addition to its relationship to efficiency of feed utilization, rapid gain is important to the feedlot operator since he has rapid gaining animals on feed fewer days permitting more rapid turnover and a lower overhead in labor, interest, taxes, etc. Concurrent with this, if a careful program of progeny testing sires were followed, it would be possible to make improvement in average area of ribeye. I have used this character here merely as an illustration since it does have some relationship with total leanness or meatiness of the carcass. The pounds of shear force required could also be reduced. This is a test used to indicate tenderness of beef. Since most consumers want tender beef this would be an improvement from a consumers standpoint.

It should be noted that relative to existing variability, improvement in a carcass trait would be at a much slower rate than the performance traits. This will inevitably be true until such time as we have reliable means of estimating carcass quality from live animals. As you know, and as is being demonstrated here today, there are various techniques under investigation, including photogrammetry and the use of ultra-sound devices, to aid in estimating what is under the skin of beef cattle. If and when these new techniques reach the practical application stage, we will be in a much better condition to make more rapid progress in carcass characteristics.

I am also hopeful that we may train our eyes to look for those things which will lead to carcass improvements. I believe it is a fair statement to say that, over the past 200 years, our judging standards with beef cattle have been largely aimed at characteristics associated with the ability to fatten at early ages and ability to lay on fat smoothly. These are important traits in modern beef production and, as compared to the progenitors of our modern beef breeds, we undoubtedly have cattle today which are greatly superior. On the other hand, there is evidence that we have just about reached the end of the road in this regard and, as you know, complaints among consumers about over-fat beef and beef with too low percentages of lean have become widespread in recent years. Research work is going on in this area and there are indications that, if properly trained judges know what to look for, they can with a degree of accuracy better than guessing although still lower than we would like to see, pick out those animals which have the inherent ability to produce carcasses with a high cut-out of the lean cuts.

Improvements in efficiency of an industry benefit everyone, including the producer, the processor, and the consumer. Benefits to the producer are rather obvious in that, if he can produce more pounds of calf per cow carried in his herd, or if he can increase rate of gain and thereby attain greater efficiency of feed utilization in the feedlot, he automatically reaps a greater profit. This will always be true for the individual who makes these improvements ahead of his competitors. Once such improvements become universal in an industry, competition may result in profit margins shrinking back to about the original level on a percentage basis. The industry will tend to expand if efficiency improves and this is usually a healthy situation.

It is sometimes said that marketing agencies and processors have no interest in quality since they can sell anything at a price and that their income is based on taking a certain percentage from each sales dollar. There is, of course, an element of truth in this, as long as an industry is on an even keel. However, looking at the situation from a long range standpoint all segments of an industry must be healthy if any one segment is to have a reasonable income. It is only with a healthy industry that volume increases. Profits of the processor depend to a large extent upon volume. He is interested in handling a product of the kind that consumers want to purchase in increasing quantities and which producers can provide at prices consumers are able to pay. Thus, marketing agencies and processors indirectly have a vital interest in performance testing insofar as it has the potential of improving the efficiency of production and quality of product.

For many of the same reasons, the retailer also has an interest in performance testing. It is generally recognized that beef is the king pin in a retail grocery store. People go to a given store to buy beef and tend to buy their other groceries at the same place. Thus, the retailer has an interest in selling large volumes of beef both from the standpoint of the trade in beef, itself, and for its indirect effect on merchandising other items in a store.

As with any new technique, there have naturally been differences of opinion on the whole idea of performance testing. There have also been differences of opinion on the exact ways in which it should be applied. This is natural with anything as young as performance testing and we must realize that it is still in developmental stages. The methods used in practice may change rather greatly with the passing of time. An analogy might be made with Dairy Herd Improvement Association procedures. These programs have been underway in most parts of the United States for well over 50 years but, even so and even with a character as simply measured as milk production, these techniques are continually being changed to better adapt them to present day situations. I think we can look for the same thing to happen with beef cattle performance testing procedures.

Much has been made about the antagonism between performance testing procedures and selection on the basis of conformation or type. To me, this is a straw man. There is no real conflict. A comprehensive program of performance testing, including both those factors which contribute to economy of production and to quality of product is the best possible guide to conformation or type standards. It is only when over-enthusiastic representatives of certain segments of the industry develop and propagandize certain phases of performance testing to the exclusion of other phases that such a conflict sometimes seems to exist.

If conformation or type were perfectly related to productivity and quality of product, we would have no need for performance testing programs since we could look at an animal and determine accurately what his potential would be. However, all research indicates that these relationships at best are rather low and that type evaluation must be supplemented with performance records. Due to the fact that we cannot slaughter all animals for carcass evaluation in performance testing, it is inevitable that we will continue to use type or conformation evaluation in performance testing programs. I am hopeful that standards by which this can be done will be improved so that the correlation between conformation and carcass quality, in particular, can be improved.

In summary, performance testing techniques developed to date offer a real opportunity for the entire industry to produce cattle more efficiently and develop cattle producing a product which will increase the demand of the consumer for beef even over and above the high levels which now exist in this regard.

PRELIMINARY RESULTS FROM THE CROSSING OF HEREFORD INBRED LINES AT THE U. S. RANGE LIVESTOCK EXPERIMENT STATION

by
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Miles City, Montana

For the past 29 years at the United States Range Livestock Experiment Station, experiments have been in progress to develop lines or strains of Hereford cattle particularly adapted to the Northern Great Plains, and to measure their combining or "nicking" ability with other inbred lines and unrelated outbred cattle. Since 1934, 14 different lines of Hereford cattle have been developed, or are in the process of being developed. Six of these lines have been culled because of genetic deficiencies affecting production. The lines that have been retained have become genetically distinct from each other, and five of these lines are currently being crossed with each other in order to evaluate their general and specific combining abilities for traits of economic importance.

Table 1. Current inbred lines at the U. S. Range Livestock Experiment Station.

Line No.	Date Line Closed	Blood Line	Source of Foundation Stock
1	1934	Advance Domino	Colorado & Montana
4	1946	Husker Mischief	New Mexico
6	1947	Real Prince Domino	Nebraska
9	1949	King Domino (Polled)	Montana
10	1948	Errol Domino	Montana
11	1960	Advance Domino & Young Mischief	Lines 1 & 5
12	1952	Errol Domino & Advance Domino	Lines 10 & 1
14	1957	Combination of several inbred lines	Lines 1, 9, 13, 10, 5, 6, 4, 8

Table 1 lists the current inbred lines at this Station while Table 2 shows average birth weights, weaning weights and body scores for these lines for the years since the initiation of the lines through 1959.

Table 2. Average birth weight, weaning weight, and body scores of calves from eight inbred lines.

Line No.	No. Years	No. Calves	Birth Wt. (lb.)	180-day Wt.(lb.)	Body Score
1	25	2027	76.8	405	76.8 1/
4	13	332	74.3	371	75.3
6	11	208	67.0	382	77.5
9	9	257	73.3	397	76.2
10	11	212	78.4	394	75.9
11	8	142	78.8	419	78.8
12	5	97	84.7	431	78.9
14	2	68	78.1	408	81.3

1/ Body scores taken over a 21 year period on 1815 calves.

All calves were dropped during March, April and May and were weaned in the latter part of October each year. Management practices were similar for all lines and all calves were sired by performance tested bulls with the exception of foundation bulls used during the early development of certain lines. Since inbreeding tends to have a depressing effect on most performance traits, a part of the difference in the birth and weaning weights of the calves in Table 2 may have been due to differences in the level of inbreeding of the various lines. Although inbreeding coefficients are not presently available on all lines the average level of inbreeding of the 1961 calves in Line 1, 6, and 10 was 21, 28 and 22 percent respectively.

The average post-weaning performance of the bulls from the various inbred lines for 196 day post-weaning gain tests in certain years is shown in Table 3.

Table 3. Post-weaning performance of Hereford inbred bulls on 196-day gain tests.

Line	Years	No. Bulls	Initial Wt. On Test	A.D.G.	Final Wt.
1	1955-62	255	456	2.44	934
4	1955-62	50	419	2.42	893
6	1955-62	46	406	2.22	841
9	1955-62	40	445	2.21	879
10	1955-62	49	417	2.37	881
11	1955-62	43	464	2.45	944
12	1957-62	36	471	2.53	966
14	1957-62	52	443	2.49	930

All bulls were fed the same ration for a 196-day period following weaning in late October of each year. Year after year, Line 1 and Line 12 bulls have consistently been the best gaining cattle of all lines tested. Since Line 1 is the oldest line on the Station, selection for post-weaning gaining ability has been practiced over a longer period of time than for the other lines. Also, selection pressure has been greater in Line 1 than in the other lines because of the larger size of the line in comparison with the other lines.

Beginning with the breeding season in 1961, reciprocal crosses were made among Lines 1, 4, 6, 9 and 10. Table 4 depicts the plan of matings for these linecrosses.

Table 4. Linecrossing mating plan.

Line of Bull	Line of Cow 1	4	6	9	10
	(No. Cows)	(No. Cows)	(No. Cows)	(No. Cows)	(No. Cows)
1	6	6	6	6	6
4	6	6	6	6	6
6	6	6	6	6	6
9	6	6	6	6	6
10	6	6	6	6	6

As is shown in the above table, 30 cows from each line have been assigned to the experiment. These cows typify the line from which they came in regard to level of inbreeding, weight, production potential, and age distribution. The cows from the same line are distributed among the bulls from the different lines so that they are as nearly comparable as possible for producing ability, level of inbreeding, weight and age. The best bull available in each line as evaluated by performance and progeny test when available, is used each year. A different bull from each line is being used each of the three years the experiment is in progress.

Table 5 presents a comparison of average birth and weaning weights and pre-weaning gains of straightline and crossline Hereford calves.

Table 5. Comparison of average birth and weaning weights and pre-weaning gains of straightline and crossline Hereford calves.

	Straightline	Crossline
Bulls:		
No.	15	50
Birth Wt. (lbs.)	75.1	78.3
A.D.G. Birth to Wn. (lbs.) 1/	1.84	1.93
Weaning Wt. (lbs.) 2/	406	425
Heifers:		
No.	8	46
Birth Wt. (lbs.)	71.2	73.2
A.D.G. Birth to Wn. (lbs.)	1.66	1.81
Weaning Wt. (lbs.)	371	400

1/ Adjusted for age of dam.
2/ Adjusted for age of dam and to 180 days of age.

The crossline bull calves were 19 pounds heavier at weaning than the straightline bulls, whereas, the crossline heifers were 29 pounds heavier at weaning than the straightline heifers. This amounts to a 4.7 percent increase in weaning weight for the crossline bulls over the straightline bulls and an increase of 7.8 percent in weaning weight for the crossline heifers over the straightline heifers.

Table 6 gives the birth and weaning weight of crossline and contemporary straightline Hereford calves for 1962. In addition, average daily gains of the bull calves for the first 168 days of their 196 day post-weaning gain tests is shown.

Table 6. Birth and weaning weights of contemporary straightline and crossline Hereford calves.

Line or Line Cross	Heifers No.	Heifers Birth Wt.	Heifers Weaning Wt.1/	Bulls No.	Bulls Birth Wt.	Bulls Weaning Wt.1/	168-day ADG on Feed
1	2	70	373	3	85	453	3.13
4	2	75	358	2	79	422	2.82(1)
6	1	56	329	3	67	393	2.58
9	1	68	352	4	68	378	2.38
10	2	78	414	3	81	396	2.91
1X4 & 4X1	7	78	444	5	93	468	3.12
1X6 & 6X1	5	69	378	5	79	451	2.87
1X9 & 9X1	4	73	401	5	73	432	2.83
1X10 & 10X1	2	79	386	7	79	413	3.01
4X6 & 6X4	5	71	416	5	73	411	2.81
4X9 & 9X4	3	74	377	7	77	421	2.89
4X10 & 10X4	3	85	409	5	83	408	3.08
6X9 & 9X6	5	65	391	3	71	412	2.69
6X10 & 10X6	5	70	370	5	71	402	2.60
9X10 & 10X9	7	74	396	3	83	437	2.75

1/ Adjusted for age of dam and to 180-days of age.

The limited amount of data available at the present time precludes making any definite statements as to which of the above lines offers the most promise of increasing calf weights and gains when they are intercrossed with each other. These lines will be intercrossed with each other for at least two more years, and as more data becomes available from the testing of several bulls from each line in the various line crosses, the results should become more meaningful.

SUMMARY

From the research conducted at the U. S. Range Livestock Experiment Station over the past several years in the development and crossing of inbred lines of Hereford cattle, it would appear that hybrid vigor in significant amounts for certain traits may be obtained within purebreeds of beef cattle. Other possibilities include the establishment of new lines of cattle from the crossing of established lines. Through careful selection, new peaks of performance for certain traits may be obtained in the newly established lines not otherwise obtainable in the parental lines.

PRELIMINARY RESULTS FROM BREED CROSSING FOR INCREASED BEEF PRODUCTION AT THE U. S. RANGE LIVESTOCK EXPERIMENT STATION

by
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Miles City, Montana

Breed crossing as a means of producing market animals is a practice well established in the swine industry. It is estimated that approximately 92 percent of all hogs marketed in the United States are crossbreds. Crossbreeding for beef production has been particularly successful in the Gulf Coast region of the United States where adaptation to sub-tropical environmental conditions has favored extensive crossing of Brahman cattle with the various British breeds.

Data from a limited number of Charolais X Hereford crosses made at this Station prior to 1961, showed that the crossbreds were 62 pounds heavier at weaning than the straight Herefords and gained .30 of a pound more per day in the feedlot than did the straight Hereford calves. The carcass grades of the Herefords at the end of the feedlot period was Low Choice, whereas the Charolais X Hereford crossbreds graded High Good. Tenderness tests showed that the straight Herefords were slightly more tender than the crossbreds. Based on physical separation of the 9-10-11 rib, the Hereford steers had the smallest amount of lean and the largest amount of total edible fat.

Matings involving a Brown Swiss bull on Hereford cows also made prior to 1961, showed a weaning weight advantage of 69 pounds for the Brown Swiss X Hereford crossbreds over the straight Hereford calves. The crossbreds also gained .28 of a pound more per day in the feedlot than did the Hereford calves. The Brown Swiss X Hereford calves were more tender than the Herefords and had an average carcass grade of High Good. Based on physical separation of the 9-10-11 rib, the Brown Swiss X Hereford steers had approximately five percent more lean and six percent less fat than did the Hereford steers.

In the spring of 1961, a comprehensive breed crossing project involving four breeds of cows and three breeds of bulls was initiated at this Station. Table 1 depicts the plan of matings for this project.

Table 1. Crossbreeding project mating plan.

Breed of Bull	Breed of Dam: Hereford	Charolais	Angus	Brown Swiss
	(No. Cows)	(No. Cows)	(No. Cows)	(No. Cows)
Hereford				
1	6	6	6	4
2	6	6	6	4
3	6	6	6	4
Charolais				
1	6	6	6	4
2	6	6	6	4
3	6	6	6	4
Angus				
1	6	6	6	4
2	6	6	6	4
3	6	6	6	4

Fifty-four cows from each of the Hereford, Angus, and Charolais breeds have been assigned to this experiment. Thirty-six cows of the Brown Swiss breed which were available from a preliminary crossing trial are also being utilized but are not actually an integral part of the program since reciprocal crosses involving Brown Swiss bulls are not being made. As is shown in Table 1, the Hereford, Angus, and Charolais cows have been divided into nine groups of six cows each, and the Brown Swiss cows have been divided into nine groups of four cows each. Three different bulls of the Hereford, Angus, and Charolais breeds are being used each year of the experiment and each bull of the same breed has been, or will be obtained from a different herd during all years the experiment is in progress. No attempt has been made to use performance tested bulls to the exclusion of non-performance tested bulls and no bulls produced at the U. S. Range Livestock Experiment Station will be used.

The first calves from this project were weaned in the fall of 1962. Tables 2 and 3 show the birth and weaning weights and scores of the steer and heifer calves respectively.

Table 2. Birth and weaning weights and scores of straight-bred and crossbred steer calves.

Breed Cross 1/	No.	Birth Wt. (lb.)	180-day Wt. (lb.)	Weaning Score
H X H	5	79.8	400	77.8
H X C	4	80.8	484	78.0
H X BS	4	87.2	523	77.7
H X A	6	74.0	437	79.3
C X C	6	91.8	462	75.8
C X H	2	99.5	501	82.5
C X BS	5	106.2	518	77.8
C X A	4	98.0	491	81.5
A X A	9	75.7	432	79.4
A X H	5	81.0	436	79.8
A X C	2	76.5	432	80.5
A X BS	7	87.0	495	79.3

1/ H = Hereford; C = Charolais; A = Angus; and BS = Brown Swiss.

Table 3. Birth and weaning weights and scores of straight-bred and crossbred heifer calves.

Breed Cross	No.	Birth Wt. (lb.)	180-day Wt. (lb.)	Weaning Score
H X H	8	71.8	399	78.5
H X C	7	77.7	470	81.3
H X BS	4	83.0	494	80.8
H X A	8	68.3	408	79.0
C X C	10	92.5	504	80.3
C X H	7	86.1	447	79.7
C X BS	4	104.3	530	80.8
C X A	9	82.9	442	79.7
A X A	7	72.6	412	80.9
A X H	8	70.1	392	78.4
A X C	9	76.9	446	81.2
A X BS	2	84.0	470	78.0

The Hereford calves were the lightest at weaning, and those calves having Brown Swiss mothers, regardless of breed of sire, were the heaviest at weaning time. The largest calves at birth were those out of Brown Swiss cows by Charolais bulls. Calves by Charolais bulls had the heaviest weaning weights when averaged over all breeds of dam. Steer calves out of Hereford cows by Charolais bulls and heifer calves by Hereford bulls out of Charolais cows received the highest scores at weaning. This would indicate that these calves had desirable conformation and were in good condition at weaning time.

The initial weight on feed and the average daily feedlot gain for each kind of cross, up through 140 days on feed is shown in Table 4.

Table 4. 140-day post-weaning feedlot weights and gains of straight-bred and crossbred steers.

Breed Cross	No.	Initial Wt. on Feed (lb.)	Wt. after 140-days on feed (lb.)	140-day A.D.G. (lb.)
H X H	5	405	716	2.23
H X C	4	505	837	2.36
H X BS	4	474	835	2.58
H X A	6	462	793	2.36
C X C	6	485	834	2.49
C X H	2	516	907	2.79
C X BS	5	533	879	2.34
C X A	4	504	872	2.78
A X A	9	407	760	2.29
A X H	5	452	787	2.40
A X C	2	450	753	2.16
A X BS	7	516	842	2.33

All steers will be taken off feed and slaughtered when they reach a feedlot weight of between 1,000 and 1,050 pounds. At this writing, three steers have reached the desired weight and have been slaughtered. All three of these steers were sired by Charolais bulls and were out of Hereford, Angus, and Brown Swiss cows, respectively. All three steers had been on feed 159 days, made an average daily feedlot gain of 2.83 pounds, and had a carcass grade of Good.

At the end of 140 days on feed, the average daily gains by breed of sire were 2.60, 2.30, and 2.38 for steers sired by Charolais, Angus, and Hereford bulls respectively.

Summary

Data has been presented on a limited number of steer and heifer calves sired by three different breeds of bulls and out of four different breeds of cows. Calves by Charolais bulls were the heaviest at weaning and after 140 days on feed, steers sired by Charolais bulls had made the most rapid gains. The data presented in this paper represent only one calf crop and the numbers are necessarily limited. Thus, no definite conclusions can be reached at the present time in regard to the relative merit of the various breed crosses for the traits studied. A total of three calf crops will be obtained for each breed cross. A sufficient number of calves should be available after the third calf crop to properly evaluate each kind of cross for the traits studied.

SOME METHODS OF RANGE IMPROVEMENT

by
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Investigations at this station over the past 5 years have shown several ways of increasing the quantity of total range herbage and the desirable grass species.

Many millions of acres of northern plains rangelands are producing far less than their potential, occasionally as little as 30-40 percent.

In 1957 a series of range improvement practices were emplaced on some of the major range sites on the station. The improvement practices were as follows: 1. Protection from grazing. 2. Reseeding with western wheatgrass (Agropyron smithii Rydb.) and alfalfa mixture (Ladak cultivar) after complete seedbed preparation. 3. Range pitting. 4. Range pitting with alfalfa seeded in pits. 5. Range pitting followed by one application of 30 pounds of nitrogen per acre. 6. One application of 30 pounds of nitrogen. 7. One application of 90 pounds of nitrogen.

Precipitation

The 4 years since 1957 were successively drier, culminating in a severe drought in 1961 with considerable loss of desirable perennial grasses (Table 1). In 1962, the last year of study, precipitation was 25-40 percent above average.

Treatments

The reseeding treatment nearly doubled the production of total vegetation over the control treatment (Table 2). Perennial grasses were reduced about 30 percent and annuals increased 2½ times. Western wheatgrass was increased 40 percent on this treatment and blue grama (Bouteloua gracilis (H.B.K.) Lag.) reduced to almost nothing.

The 90 pounds of nitrogen treatment increased perennial grasses 50 percent and annuals 20 percent. Both western wheatgrass and blue grama were increased about 50 percent.

The pitting plus alfalfa seeded in pits treatment increased total vegetation 22 percent, perennial grasses 29 percent, western wheatgrass 34 percent, and blue grama 29 percent. Production of annuals was not affected by the treatment.

The pitting, pitting plus 30N, and 30N treatments were about equally effective, and all increased production 21-28 percent.

By protection from grazing average production of annuals was increased 25 percent. No other components were affected.

Effect of Years

Production was greatly influenced by the yearly precipitation (Table 3). Total production reached the lowest level in 1961 and the highest in 1962. Annuals were most abundant in 1962. Blue grama was drastically reduced in 1959.

Table 1. Spring, growing-season, and total annual precipitation for the period 1958-62 at the U. S. Range Livestock Experiment Station, Miles City, Montana.

Year	Spring	Growing Season	Annual
		Inches	
1958	3.6	7.5	12.6
1959	4.5	7.3	10.3
1960	3.8	5.4	8.1
1961	4.4	8.5	10.7
1962	7.9	11.6	14.6
86-year average	5.7	9.2	12.8

Table 2. Average production of vegetation components by treatments for the period 1958-62.

Treatment	Total Vegetation	Perennial Grasses	Annuals	Western Wheatgrass	Blue Grama
		Pounds per Acre			
Control	375	240	131	96	77
Protection	417	250	163	87	77
Reseeded	662	166	461	136	3
Pitted	452	275	174	119	84
Pitted + alfalfa	457	306	132	129	100
Pitted + 30# N	479	288	174	121	84
30# Nitrogen	464	315	144	123	94
90# Nitrogen	523	356	158	146	121

Table 3. Average production of vegetation components by years, 1958-62.

	1958	1959	1960	1961	1962
			Pounds per Acre		
Total Vegetation	612	401	375	237	768
Perennial Grasses	495	259	275	100	243
Annuals	99	116	87	136	522
Western Wheatgrass	155	157	131	41	114
Blue Grama	233	43	49	17	58

PREDICTING LIVE ANIMAL FAT AND MUSCLE TISSUE WITH ULTRASONICS

by

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Knoxville, Tennessee

Not too many years ago, when a beef cattle judge had placed a group of steers live and was questioned about why his live animal placing had not ranked the steers the same as the ranking of the carcasses in the cooler, his comment was, "If it were not for the hide and hair on the live animal, our relationship between live animal placings and carcass placings might be considerably higher." It is not to say that the carcass placings are always the "correct" placings, because there is error involved in this method of appraisal, as well as in the live animal appraisal. But to keep the producer of one of our nation's greatest delicacies from becoming completely confused, it has been the aim of livestock research people in the past few years to try to get the live animal and the carcass placings in shows, as well as in grades, closer together. The producer of beef cattle for the consumer--the commercial beef cattle man--is interested in finding the sires that give him calves which raise the question from the packer, "Where can I get more beef like this?" More and more feedlot operators are trying to get carcass information on their steers. They have found that competition is becoming so keen that they need the kind of cattle which will demand a premium price.

Last year at the Reciprocal Meats Conference, a meeting of University and industry meats men, a producer, who represented the American National Cattlemen's Association, made the statement that carcass evaluation had not generally been discussed by producers because "by and large, we have thought our responsibility ceased when fat cattle were sold to the meat packer." He went on to say, "In recent years, we have finally come to realize that we are producing <u>beef</u>, not cattle. This is a difficult point for range producers to realize, and I doubt if very many feeders are fully aware of this basic elementary fact."

Recognizing in the live animal what makes a superior beef carcass which will demand this premium price is not an easy job. Through a tremendous amount of training, observing hundreds of heads of cattle--both live and then later in the carcass--a man can develop some degree of accuracy in picking out the "right" kind. However, this man, and there are several in our country today, quickly admits that his task would be much more accurate with additional tools. Considerable research has been aimed at this problem, going right back to the carcass and trying to find out what we really want. Consumer studies have indicated that a desirable piece of beef is one with a large amount of lean, one that is juicy, tender, tasty, and with little external fat. In the past, it has been the practice to get the juiciness, tenderness, and flavor through the fattening process. Coupled with this, of course, is the fact of good breeding. Certain kinds of cattle just don't have the ability to go to a very high rung on the acceptability ladder. Therefore, the goal is to find cattle that are high in quality, i.e., juicy, tender, and flavorful, with a large amount of lean and little fat.

One area of research which has attempted to "remove the hide and hair" has been through the use of the probing technique. In hogs, this has been a rather simple matter, consisting of merely slitting the skin and sliding a metal ruler down through the fat until it reaches lean. Since there is little bleeding in the hog, this has been successful. However, when tried in cattle, a different matter was involved. The problem was to try to get an idea of the fat thickness on the animal, along with some measure of lean. Since there are a large number of blood vessels, both in the hide and in the fat, in beef cattle some kind of a non-surgical method needed to be developed to do this probing.

In the early 1950's, medical researchers were working with a technique to try to visualize the outlines of tissue structures in the body by the use of Sonar, high-frequency sound, which was used by the Navy during the war in depth preception and the location of ships, submarines, mines, and so forth. The principle involved is one long known to scientists--that a quartz crystal will produce mechanical vibrations when an electrical charge is placed upon it, and that the reverse is also true, as a vibrating crystal will develop an electrical charge. The sound waves emitted by quartz crystal in vibration are of a high frequency nature which cannot be heard by the human ear and are at the frequency of a few million cycles per second. These sound waves can be controlled into a narrow beam by lenses or shapes of the quartz crystal. Sonar, which stands for "sound and navigational ranging", merely uses these principles of a vibrating crystal to send a high frequency sound wave to an object, which in turn returns an echo which is again received by the quartz crystal, changed into electrical energy at the rate of several thousand repetitions of this action per second, and results in a train of signals which are amplified and passed into an oscilloscope or cathode ray tube where they produce a series of light signals. By controlling these signals, one can get a representation of different layers of tissue. Medical researchers were interested in this technique for the detection of tumors, cancers, distension, and foreign materials. Much of the first work was done in the area of cancer research, and later it has developed into studies of the brain, eyes, and other organs. The question arose in the animal scientists' minds as to why this technique could not be used in the study of fat thickness and muscling of our domestic animals. The use of ultrasonics was more or less an attempt to answer the problem of non-surgical probing.

Studies on the carcasses of beef cattle have indicated that carcass weight, fat thickness, and certain measures of muscling--such as loin-eye area, weight of the round, weight of the lean cuts, and other measures--can be used in predicting the amount of lean in the carcass. Several studies have indicated that carcass weight and fat thickness account for over three-quarters of the variation in leanness in the carcass. Weight of the animal is quite easily obtained. Therefore, it may remain for us to develop a technique to measure fat thickness.

Recent research with ultrasonic devices in measuring the thickness of fat between the 12th and 13th rib on beef cattle and estimating the size of the loin area, has indicated that a fair degree of accuracy can be obtained. So far, results have shown that about 50 to 60 percent of the variation in actual fat thickness between animals, as measured either directly from the carcass or from a tracing, can be accounted for by estimates of fat thickness from the use of ultrasonics. Some researchers have done this well, or better, in estimating the size of the ribeye area, while others have reported a lesser amount of success. There is no doubt that the technique, as well as the interpretation of the results, can be improved. As one researcher has put it, the machine is wholly accurate. It gives a representation of exactly what it "hears". The problem, then, is in interpretation.

Now, let's see how data collected from beef cattle by the use of an ultrasonic scanning device may be used in an improvement program. This, of course, is qualified to mean when the results from research studies indicate that the use of the device is accurate enough to be used commercially. The Livestock Division of the Agricultural Marketing Service, USDA, developed a system for estimating the yield of closely-trimmed, boneless, retail cuts. This would be information used in addition to the conventional grading system where cattle are put into classes of "prime", "choice", "good", "standard", and so forth. Almost without exception, the research dealing with wholesale cuts of beef shows that longer carcasses with less fat produce a higher percentage of the more demanded cuts and a lower percentage of the less demanded cuts. This system of estimating the yield of boneless retail cuts would then give an idea of cutability of animals, as well as quality. The formula that they use is: Percent of carcass in boneless retail cuts in round, loin, rib, and chuck = 51.34 -5.784 (fat thickness over the ribeye, inches) -0.0093 (carcass weight, lb.) -0.462 (kidney fat, lb./100 lb. of carcass) +0.740 (area of ribeye, sq. in.). A numerical scale from 1 to 6 indicated the predicted range in yield of retail cuts. These scale numbers, each of which represents a range of 2.3 percent in yield of retail cuts, represent the "yield grades" that are used in conjunction with the quality grades. This grading system, of course, was set up for carcasses, but it gives an idea of what to look for when selecting live cattle with higher cutability. The fat thickness and the area of the ribeye are two of the traits that are used in the formula.

Research at the University of Tennessee has indicated that fat has a more definite influence on percent of separable lean than does ribeye area. In fact, using the cutability grades on 133 carcasses of seven different breeds and crosses, they found out that when ribeye area was omitted from the yield grade calculations, resulting yield grades were more highly related to separable lean and fat than when ribeye area was included. Part of the difference can be accounted for by the fact that the yield grades are based on retail cuts and not on separable lean. In addition, they pointed out that neither carcass grade nor yield grade was superior to a single fat thickness measurement or an average of three fat thickness measurements over the ribeye, as an estimator of percentage separable lean and fat. Then they constructed formulae on the basis of their data that would more accurately predict the separable lean of a carcass. The prediction equation that accounted for the most variation in separable lean of the carcass involved carcass length, ribeye area at the 5th rib, ribeye area at the 12th rib, ribeye area at the last lumbar, fat thickness at the 12th rib, and carcass weight. However, by using only fat thickness at the 12th rib and carcass weight, they found that they could come, on the average, within seven pounds of the actual pounds of lean with their predicted pounds of lean in one side. The formula they developed for prediction of pounds of lean in one side of a beef carcass for Angus and Herefords was: Lbs. of lean = 39.16 -1.40 (fat thickness, mm.) +0.2266 (carcass wt., lbs.).

As the Tennessee workers have pointed out that only 18 percent of the variation in total separable lean can be accounted for by the area of the ribeye muscle, the question as to what traits can be used to more accurately estimate the lean edible portion of a carcass arises. They have estimated that over 80 percent of the variation in separable carcass lean can be accounted for by the weight of the lean of the round wholesale cut. The chuck and foreshank were also good indicators of lean.

Wisconsin workers have recently shown that percent trimmed round made the largest contribution to the multiple correlation coefficient in predicting percent retail yield. They also pointed out that the ribeye area, when used in prediction equations with a single 12th rib fat measurement, percent kidney knob, and left side weight, made a significant improvement in the precision of the estimate. All of the fat measurements studied had highly significant relationships with percent retail yield. They indicated that two measurements--percent trimmed round and a single 12th rib fat measurement--could account for over 80 percent of the variation in percent retail cut yield. Their prediction equation for retail yield is:

Retail Yield = 16.64 +1.67 x percent trimmed round -4.94 x single fat measurement over the 12th rib.

The potential, then, of a device such as the ultrasonic scanning device is in trying to get an idea of fat thickness, area--or better yet, amount--of certain muscles in the body, and, going even further, trying to find out the relationships in the size of these muscles to the rest of the body. As pointed out earlier, estimation of fat thickness and ribeye area can be done with some degree of accuracy, even though it is not as high as it should be at present for commercial use. Present research with the use of the sonoray, or "somascope" as it is sometimes called, indicates that representation of the muscles in the round can be made. There is also a little hope that with newer developments some idea of the amount of fat within the lean may be possible.

If estimates of muscling and fatness of the live animal can be made, then these are additional traits that can be studied and selected for in breeding programs. Tools such as this device may improve our accuracy in selecting for total merit. Other research involved along the same lines deals with photogrammetry, taking three-dimensional pictures of animals so as to get an idea of the volume of various parts of the body; bio-assay techniques, a method of sampling the meat on the live animal; and so forth. These types of research may lead to some developments that will help us considerably in the future. One word that should be left is that the use of such devices as have been mentioned only supplement the eye of the master breeder--they do not replace it.