THE RELATIONSHIP OF CERTAIN BODY MEASUREMENTS OF FEEDER CALVES TO THEIR PERFORMANCE IN THE FEED LOT

Thesis for the Degree of M. S.

George J. Propp

1937

THESIS

Cattle

This is to certify that the

thesis entitled

NON UNIFORMITIES IN THE SIZE DISTRIBUTION
OF THE NASCENT CHAINS OF GLOBIN
FROM RABBIT RETICULOCYTES

presented by

Alberto Protzel

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Biochemistry

Major professor

Date February 22, 1977

O-7639

animal husbandry

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Thesis for the Degree of Master of Science

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A THESIS

SUBMITTED TO THE FACULTY

OF

MICHIGAN STATE COLLEGE

OF

AGRICULTURE AND APPLIED SCIENCE

By

George J. Propp

IN

PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE

DEGREE OF MASTER OF SCIENCE

IN

ANIMAL HUSBANDRY

East Lansing

June 1937

THESIS

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to Professor G. A. Brown, Head of the Department of Animal Husbandry, for his advice and guidance and to Professor G. A. Branaman, Assistant in Animal Husbandry, for his helpful assistance and constructive criticism which were invaluable in the preparation of this manuscript. Appreciation is also due Dr. W. A. Baten, Associate in Mathematics, for his helpful advice in the statistical computations.

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THE RELATIONSHIP OF CERTAIN BODY MEASUREMENTS OF FEEDER CALVES TO THEIR PERFORMANCE IN THE FEED LOT

INTRODUCTION

The idea that body shape or conformation is intimately related to the subsequent performance of the individual is as old as the breeds themselves. If such a relationship significantly exists it should be possible by carefully studying and observing the outward appearance of the animals to successfully select those individuals which would most nearly fulfill the desired purpose. This relation is embodied in the one-word expression "type" which Vaughan (3) defines as being "an ideal or a standard of perfection, combining all the characters which contribute to the animal's value and efficiency for the purpose specified." It is upon this doctrine that stock shows and stock judging are based. Just what constitutes the ideal type has been the result of agreements reached through an exchange of opinions and experiences of the breeders themselves. Though there was no systematic study made of the performances of this correct type, the type was quite universally accepted and selected for. However, from time to time such factors as "fads" and differences of opinion caused the judging standard to change and with these changes taking place one cannot often be sure whether the change was an actual improvement or the reverse. As particularly vivid illustrations of such changes one may cite the radical type changes that have taken place in swine during the period of 1910 to 1925, and to a lesser degree, the changes that have taken place in the modern draft horse. Beef cattle, however, have been bred and selected since the earliest work of Bakewell with the same objective in mind. Their type has gradually approached perfection without the infusion of any radical "fads" or opinions.

Because this type has met with the approval of breeders and judges over such a long period of time, it has certainly been subject to a most severe test, yet there is no specific evidence which would give this type any advantage.

This study brings together data in an effort to determine more accurately the extent of the relation, if any, that the present body shape has to the future performance of the animal in the feed lot and also to determine the value of the mechanical measurements.

REVIEW OF LITERATURE

The study of body measurements and their relation to the ultimate performance of the animal is not an extensive one. The literature is quite lacking and of a varied nature. Most of the work that has been done in their field has not been done with beef cattle. Rather extensive work has, however, been done with dairy cattle and to a lesser degree of draft horses and lambs. The greater part of the available data does not attempt to relate the future outcome of an animal with its present shape. The studies have followed the nature of a change in measurements of growing or fattening animals. None of this work that has been done has attempted in any way to determine the efficiency of the animal in regard to the variety of type that may be present, nor has an extensive survey been made of the average daily gain and the feed required to produce 100 pounds of gain and their relation to body shape. A considerable amount of work has been done with dairy cattle but none of this material has any relation or bears any facts that might assist one in determining the value of shape so far as fattening animals are concerned. There has also been a small amount of work done with draft horses, but here again this work has no bearing on the fattening of cattle, consequently, this field is quite wanting for information.

Hultz (1), working with range-bred Hereford calves, observed the changes in the individuals during the fattening period. He did not mechanically measure any of the animals. He selected them to fit into a type series ranging from low set to very rangy. The results of this experiment indicate that the low set calves tend to become more rangy and that the rangy calves tend to improve in type during the fattening period. This study did not classify the efficiency of the different types during the fattening period and the results obtained from this experiment seemed to be more or less contrary to the present belief that the low set individuals are potentially the good doers.

Severson and Garlaugh (2) used linear measurements and obtained rather low correlations, and since body shape depends upon a proportion of measurements, higher correlations might have been obtained by calculating the multiple correlation or by using a proportion of measurements. Their work dealt with the change in measurements as the animal fattened and does not represent a study of efficiency or performance.

Lush (5) has undoubtedly done more work in the measurement of beef cattle than any other investigator. He worked with a large number of range-bred Hereford steers. He made a large number of body measurements and calculated the multiple correlation of these measurements with the rate of gain, dressing per cent, and the value of the dressed carcass. He found that in spite of the accuracy of measurements and weights that the size and the shape of the feeder steers only slightly indicated the extent of this desirability at the end of the feeding period. The data also indicated that the long-bodied tall steers with large middles, small flank girth, and thin loins made the faster gain. Here again the results obtained by measurements are contrary to the belief that we have of the present type steer, Lush states "that no score card or standard based on conformation could ever be so accurate that the future performance of the individual steer could be predicted from it with but few mistakes." His conclusions were that form and function were not closely enough correlated, which simply means that we have been placing too much weight or emphasis on the shape of our fattening cattle. No attempt was made in this study to correlate type of body or body shape with the efficiency of the gain.

EXPERIMENTAL MATERIAL

This study was started in the fall of 1932 and 1933 and was continued through a period of three consecutive years. The data studied consists of various measurements and performances of thirty-five head of Hereford heifers. The data were collected incidental to the major objective of a fattening experiment being carried on by the Michigan Agricultural Experiment Station and the Bureau of Animal Industry of the United States Department of Agriculture. Three experiments were conducted, one each in 1932-33, 1933-34, and 1934-35. In each experiment twelve purebred Hereford heifers from the United States Range Live Stock Experiment Station, Miles City, Montana, were used. Periodic killings were made at intervals of about 49 days, with the first kill starting at about 121 days. The purpose of these samplings was for the major objective and not necessarily planned to fit the measurement and performance study. There were four such samplings which resulted in nine individuals for each kill. The last, or fourth, kill is represented by only eight animals. The data on heifer No. 7 of 1934-35 was found to be incomplete and she was necessarily eliminated.

Each kill was treated as one single unit in the study of average daily gain and of feed required for gains in weight. The entire group was treated as a single unit in the case of feeder grade since all calves were graded at the beginning of the experiment.

METHOD OF CALCULATION

Because these calves were selected for uniformity of type, it seemed unnecessary to compute a multiple correlation between the measurements used and the performances of the fattening animals, so for convenience the least square method of calculating was used as it is outlined by Arkin and Colton (3). The standard error of estimate is a measure of the variation or the scatter about the line of regression. One standard error will include 68% of the cases measured off plus and minus about the line of regression.

MEASUREMENTS USED

Some thirty measurements were taken and recorded in centimeters (Figure 1). To study width of the animals a group of measurements consisting of width of shoulder, width of crop, width of last rib, width of loin, width through the thurls and width at the rump were taken (Figure 2). This group of six widths were summed and an average width figure obtained with which to work. The depth measurements were made at brisket, fore flank, belly, rear flank and round (Figure 3). These were also summed and averaged to give an average depth figure. The length of body was taken from a point just ahead of the top of the shoulder to the pin bone and the fore leg length was obtained by taking the difference between the height of body at the withers and depth of chest. Besides these measurements there was for each animal an average daily gain figure, a feeder grade and the total digestible nutrients per 100 pounds gain (Table I). The animals were graded by a committee of three men, using the charts made up

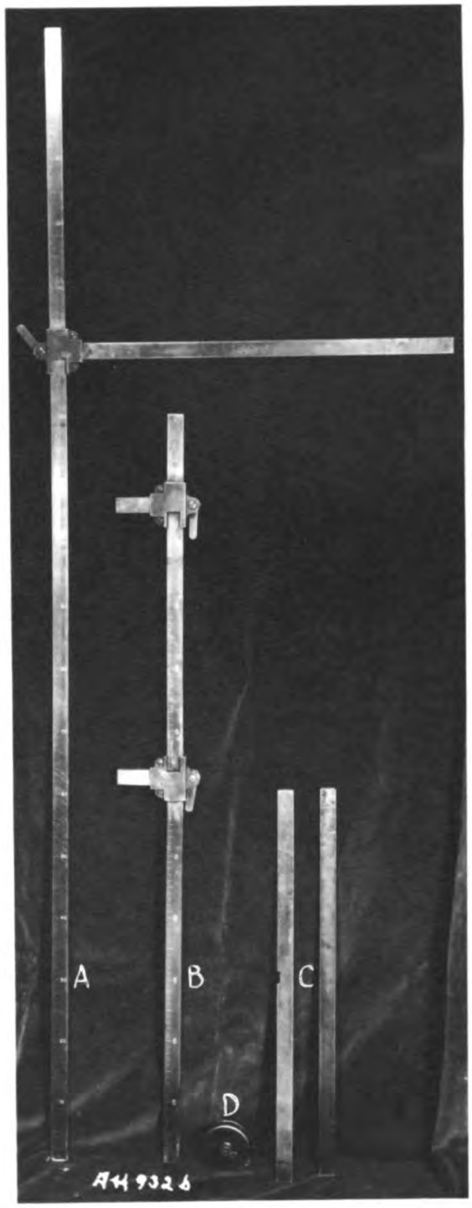

Figure 1. Measuring Instruments, Standard Equipment Obtained from the Bureau of Animal Industry, United States Department of Agriculture (A) Measuring rule for height of animal, (B) caliper for width measurements, (C) arm used to replace short caliper arms for width measurement of shoulder and thurls, (D) centimeter tape.

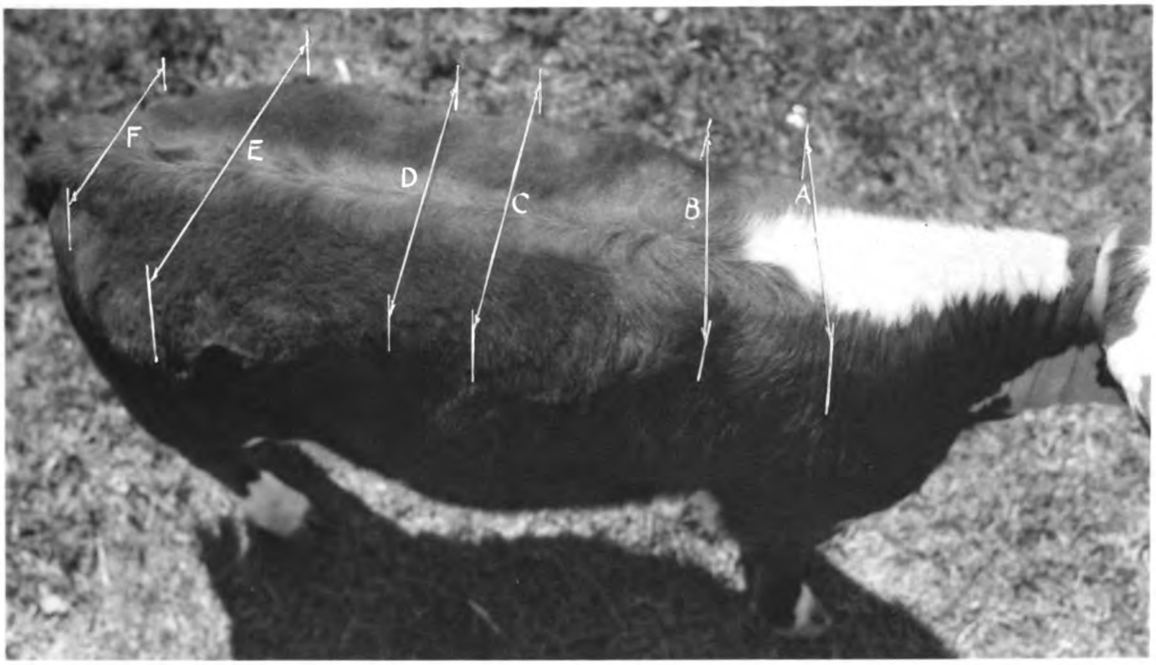

Figure 2. Measurements Taken for Width of Body

(A) Width at shoulders (long arm caliper), (B) width at crops, (C) width at last rib, (D) width at loin, (E) width at thurls. Width at rump falls on same line as (E) but was taken with short arm caliper while thurl width was taken with long arm caliper. (F) Width at pins (not used in making up average width).

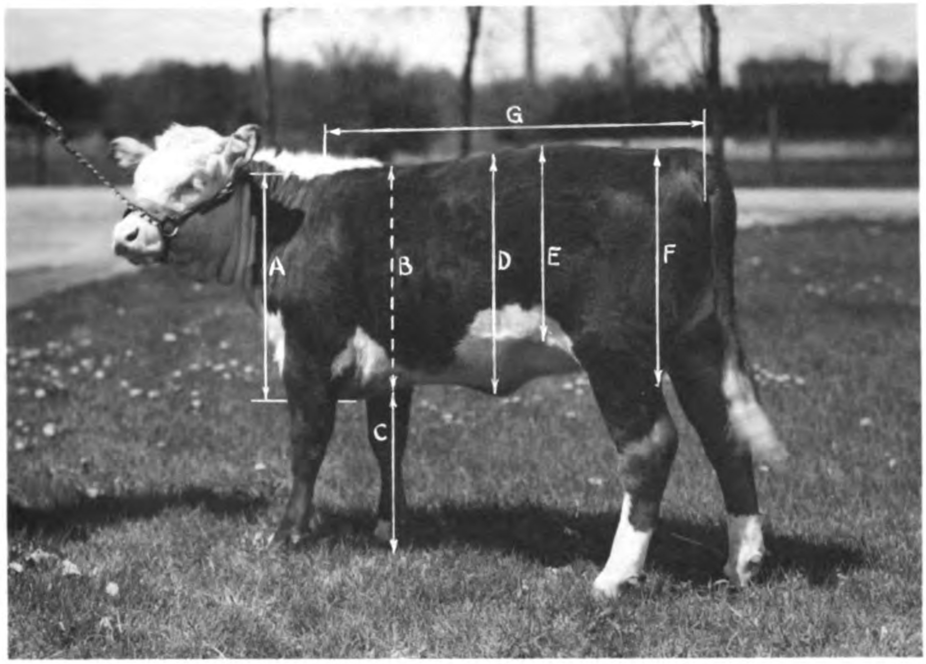

Figure 3. Measurements for Depth of Body, Length of Body and Fore Leg Length (A) Depth at brisket, (B) depth of fore flank, (C) fore leg length, (D) depth of belly, (E) depth of rear flank, (F) depth of round, (G) body length.

TABLE I. FEEDER CALF MEASUREMENTS

Cattle slaughtered in First Kill

Year	1932-33			1933-34			1934-35		
Animal No.	4	6	13	5	9	11	4	6	11
Average Width of Body*	24.75	26.08	25.25	27.5	25.9	25.2	26.0	25.42	21.83
Shoulders	22.0	22.50	21.0	24.5	23.5	24.0	21.0	22.5	19.0
Crops	19.0	20.0	19.5	23.0	21.0	21.0	22.0	20.0	17.0
Last Rib	28.5	25.5	28.0	30.0	26.5	27.0	30.0	30.5	21.0
Loin	22.5	25.0	24.0	24.5	23.5	22.5	23.5	22.0	20.0
Thurls	34.5	38.0	33.0	35.0	34.0	31.5	34.0	31.5	31.5
Rump	22.0	25.5	26.0	28.0	27.0	25.0	25.5	26.0	22.5
Average Body Depth*	46.6	50.8	47.8	49.8	46.0	46.6	47.9	42.2	46.0
Brisket	51.0	53.5	54.5	54.5	53.0	52.0	51.5	37.0	49.0
Fore Flank	48.5	54.0	50.5	52.5	50.0	50.5	49.0	46.5	48.5
Belly	46.5	54.5	50.0	54.5	48.0	49.0	51.5	46.5	48.5
Rear Flank	39.0	40.5	34.5	41.5	34.0	37.5	40.0	36.0	38.5
Round	48.0	51.5	49.5	46.0	45.0	44.0	47.5	45.0	45.5
Body Length	99.0	103.0	100.0	107.0	103.0	107.0	107.0	95.0	103.0
Fore Leg Length	49.0	46.0	46.5	45.0	47.0	46.5	48.0	46.0	48.5
Feeder Grade (%)	78.33	85.0	78.33	91.66	85.0	85.0	91.66	85.0	81.66
Average Daily Gain (lbs)	1.56	2.37	1.75	2.41	1.96	1.94	2.48	2.16	2.05
T. D. N. per 100 lbs. Gain (lbs)	501.3	490.8	496.6	428.4	495.3	454.8	420.1	443.8	425.6

*All measurements in centimeters.

TABLE I. (Con't) FEEDER CALF MEASUREMENTS

Cattle Slaughtered in Second Kill

Year	1932-33			1933-34			1934-35		
Animal No.	8	10	11	1	7	12	1	5	12
Average Width of Body*	26.83	24.83	23.33	25.40	25.10	26.0	25.25	26.08	25.08
Shoulders	23.5	23.5	23.0	23.0	21.5	23.5	21.5	21.5	23.5
Crops	19.5	18.0	19.0	21.0	19.5	22.5	21.0	19.5	20.0
Last Rib	30.5	26.5	23.0	28.0	28.0	27.5	29.5	31.0	29.5
Loin	26.0	22.0	20.0	22.5	24.5	24.0	23.0	24.0	22.5
Thurls	35.0	33.0	31.5	33.0	33.5	33.5	33.0	33.0	31.5
Rump	21.0	26.0	23.0	25.0	23.5	25.0	23.5	27.5	23.5
Average Body Depth*	47.7	47.3	46.7	45.5	48.2	47.2	45.3	48.0	46.6
Brisket	54.0	51.0	51.5	49.5	53.5	51.5	49.0	52.0	50.0
Fore Flank	51.0	49.5	49.0	48.0	50.5	48.5	46.5	49.0	47.5
Belly	48.0	49.0	49.0	50.0	52.0	50.5	48.5	50.0	48.5
Rear Flank	35.5	37.0	37.0	36.0	39.5	39.5	38.0	41.0	40.0
Round	50.0	50.0	47.0	44.0	45.5	46.0	44.5	48.0	47.5
Body Length	104.0	103.0	101.0	101.0	108.0	109.0	99.0	103.0	103.0
Fore Leg Length	47.0	48.0	48.0	45.0	48.5	48.0	51.5	50.0	53.0
Feeder Grade (%)	85.0	78.33	85.0	88.33	81.66	85.0	91.66	91.66	81.66
Average Daily Gain (lbs)	1.75	1.74	1.97	2.19	2.23	1.84	2.05	2.36	1.62
T. D. N. per 100 lbs. Gain (lbs.)	547.0	483.0	481.9	476.4	501.9	533.5	510.6	446.9	522.8

*All measurements in centimeters.

TABLE I. (Con't) FEEDER CALF MEASUREMENTS

Cattle Slaughtered in Third Kill

Year	1932-33			1933-34			1934-35		
Animal No.	3	5	7	3	4	15	0	3	9
Average Width of Body*	25.5	26.42	26.75	25.7	25.0	24.1	24.5	24.25	26.67
Shoulders	24.0	23.0	23.5	22.0	23.0	22.0	20.0	21.0	21.5
Crops	21.0	20.0	21.0	20.0	20.0	20.5	18.5	20.0	22.0
Last Rib	26.5	30.0	29.0	28.0	27.5	26.5	29.5	28.5	32.5
Loin	23.0	24.0	25.0	24.5	24.5	22.5	22.5	20.0	24.0
Thurls	33.5	34.0	36.0	33.0	32.0	31.0	31.0	33.0	34.0
Rump	25.0	27.5	26.0	26.5	23.0	22.0	25.5	23.0	26.0
Average Body Depth*	48.5	46.4	46.6	46.3	47.2	44.6	45.1	45.5	47.3
Brisket	52.5	50.5	49.5	51.0	52.0	49.0	49.5	50.0	49.5
Fore Flank	50.5	48.0	50.0	49.0	48.5	46.5	47.5	47.5	48.0
Belly	52.5	48.5	48.0	50.0	49.5	48.0	48.0	47.0	50.0
Rear Flank	40.0	37.0	36.0	37.5	38.0	37.0	36.0	39.0	41.0
Round	47.0	48.0	49.5	44.0	48.0	42.5	44.5	44.0	48.0
Body Length	104.0	103.0	102.0	102.0	109.0	99.0	96.0	103.0	107.0
Fore Leg Length	45.5	46.0	48.0	48.0	50.0	47.0	48.0	49.0	46.0
Feeder Grade (%)	81.66	91.66	78.33	95.0	81.66	81.66	81.66	75.0	88.33
Average Daily Gain (lbs)	1.62	1.96	1.96	1.94	2.02	2.03	1.51	1.94	1.97
T. D. N. per 100 lbs. Gain (lbs)	587.2	578.7	507.4	547.7	533.9	503.9	557.2	529.9	502.6

* All measurements in centimeters.

TABLE I. (Con't) FEEDER CALF MEASUREMENTS

Cattle Slaughtered in Fourth Kill

Year	1932-33			1933-34			1934-5	
Animal No.	1	2	9	6	10	13	2	8
Average Width of Body*	26.0	26.0	24.75	24.3	24.6	24.8	25.42	25.5
Shoulders	24.5	24.0	23.5	20.0	21.0	21.5	21.0	21.0
Crops	17.5	22.5	19.0	19.0	19.0	20.0	18.5	20.0
Last Rib	30.5	27.5	27.5	26.5	26.0	28.5	36.5	28.5
Loin	23.5	22.5	22.0	24.0	23.5	22.5	21.0	23.0
Thurls	34.0	33.5	32.5	31.5	33.5	32.0	31.0	32.0
Rump	26.0	26.0	24.0	25.0	24.5	24.5	24.5	24.5
Average Body Depth*	45.0	46.4	44.2	46.1	47.9	45.1	45.8	47.5
Brisket	50.0	51.0	50.0	52.5	52.5	50.0	49.0	53.0
Fore Flank	45.0	47.5	47.0	50.0	48.0	46.5	48.0	48.0
Belly	49.5	49.5	46.0	48.0	50.5	47.5	49.0	49.0
Rear Flank	34.5	39.0	35.0	36.0	41.5	37.5	38.0	40.5
Round	46.0	45.0	43.0	44.0	47.0	44.0	45.0	47.0
Body Length	103.0	105.0	103.0	100.0	110.0	104.0	96.0	101.0
Fore Leg Length	49.5	48.0	49.0	44.0	48.0	48.0	47.5	49.0
Feeder Grade (%)	81.66	81.66	81.66	88.33	81.66	81.66	81.66	88.33
Average Daily Gain (lbs)	1.57	1.32	1.68	1.93	2.39	1.76	1.94	1.45
T. D. N. per 100 lbs. Gain (lbs)	615.6	686.7	591.1	506.1	522.0	560.0	549.3	616.0

*All measurements in centimeters.

and used by the Bureau of Animal Industry of the United States Department of Agriculture. An average of these three decisions determined the animal's feeder grade. The chart is so arranged as to divide each given grade into three parts; namely, top, middle and bottom. In order to use such an arrangement in these computations, it was necessary to assign a per cent value to each of the grades. The same scheme of percentage was used here that has been used by the Bureau of Animal Industry (chart).

The figure of total digestible nutrients was rather easily computed because these calves were all individually fed and the number of pounds of feed that they required during the feeding period was at hand. The therms of net energy per 100 pounds of gain were also computed but were not used in these calculations because of their similarity to the figure of total digestible nutrients.

PLAN OF EXPERIMENT

The first or major objective of this study was to determine what relation existed between the mechanical measurement and the actual grade value that was assigned to the animals by averaging the decisions of the three judges and the performance of the animals in the feed lot. If no relationship exists, then we have been kidding ourselves as to what type is most efficient. The other objective was to determine, if possible, which of the individual measurements was of greatest importance in the eyes of the judges in reaching their decision and whether or not various proportions between these measurements were not more important than the individual measurements themselves. As has been stated before, these animals were selected for uniformity of type. It seemed, therefore, unnecessary to compute multiple correlations, so for simplicity the standard error of estimate has been computed in these results.

FEEDER CATTLE GRADING CHART

Lot Number — Date — Where Graded

Animal Number — Station — Grader

	1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
CONFORMATION Compactness			Very Compact			Compact			Moderately Compact			Slightly Rangy			Rangy			Very Rangy	
Legs			Very Short			Short			Moderately Short			Slightly Short			Long			Very Long	
Head			Very Short and Wide			Short and Wide			Moderately Short & Wide			Slightly Long & Narrow			Long and Narrow			Very Long & Narrow	
Width of Body			Wide			Moderately Wide			Slightly Narrow			Narrow			Very Narrow			Extremely Narrow	
Crops			Full			Moderately Full			Slightly Deficient			Deficient			Very Deficient			Extremely Deficient	
Loin			Thick			Moderately Thick			Slightly Thin			Thin			Very Thin			Extremely Thin	
Rump			Full			Moderately Full			Slightly Deficient			Deficient			Very Deficient			Extremely Deficient	
Round			Full			Moderately Full			Slightly Deficient			Deficient			Very Deficient			Extremely Deficient	
Thickness of Flesh (Lean)			Very Thick			Thick			Moderately Thick			Slightly Thin			Thin			Very Thin	
CONDITION Thickness of Fat			Thick			Moderately Thick			Slightly Thin			Thin			Very Thin			Extremely Thin	
QUALITY Refinement			Very Refined			Refined			Moderately Refined			Slightly Coarse			Coarse			Staggy	
Grade			Fancy			Choice			Good			Medium			Common			Inferior	
	100%	98.33%	95.00%	91.66%	88.33%	85.00%	81.66%	78.33%	75.00%	71.66%	68.33%	65.00%	61.66%	58.33%	55.00%	51.66%	48.33%	45.00%	41.66%

The proportions used in this study were arrived at after considering the contributions of each single measurement toward the ideal type. Some measurements contribute more to the ideal type because of their greatness, while others are more valuable because of their smallness. It would be a mistake to multiply such two figures together because the values of the two would cancel each other. On the other hand, to multiply two of these measurements of the same nature would tend to bring out the point that is being emphasized. Because of this logic, the proportion body length times fore leg length divided by average body width times average body depth or $\frac{L.l}{W.D}$ was used. The measurements multiplied by each other here are of the same nature, that is, L.l improve the animal's type as they become smaller. The W and D measurements improve the animal's type as they get larger. The proportions of body length times the fore leg length divided by average width, and also fore leg length divided by average width were used because of the results which were obtained in the standard errors of the single measurements.

EXPERIMENTAL RESULTS

In computing the standard error for estimating feeder grade, it will be noticed that the proportions of $\frac{l}{W}$ had the smallest error of all the measurements and proportions used in this study. This error of 4.17% is quite significant in view of the fact that each grade occupies the space of 10%. Among the single measurements fore leg length was most important with an error of 4.52%, while average body depth with a standard error of 4.60% was possibly regarded as the least valuable measurement in the eyes of the grading committee in arriving at their decision. Average body width, which is often considered to be the most important dimension had a standard error of 4.55% which is practically the same as the standard error of average body depth. Body length has a standard error of 4.59% and is only .01% smaller than the largest error of single measurement.

The proportion of $\frac{L.l}{W}$ was used to compute the standard error after average body depth was found to have the largest error of the single measurement. In comparing this proportion with that of $\frac{Ll}{WD}$, it will be noticed that the average body depth had a different effect when used in the proportion than when used alone. The standard error of the proportion $\frac{L.l}{W}$ is significant and is only .15 of a per cent larger than the smallest standard error among the single measurements. Because the width of the animal and low setness are often regarded as the greatest assets to ideal type, the proportion $\frac{l}{W}$ was also computed. This error of 4.18% is .01% smaller than the proportion $\frac{L.l}{W.D}$ (Table II). A statistical test was made to determine the significance of the differences between the standard errors of the various measurements in estimating feeder grade. The computations show that the standard error of $\frac{Ll}{WD}$ and $\frac{l}{W}$ is significantly smaller than the standard error of average body width, average body depth, body length and fore leg length. It is not significantly smaller than the error of the proportions $\frac{L.l}{W}$ and $\frac{l}{W}$. The proportion $\frac{L.l}{W}$ is significantly smaller than the standard error of average body width, average body depth, and body length. It does not differ significantly from the standard error of fore leg length, the proportion $\frac{L.l}{W.D}$ and the proportion $\frac{l}{W}$. The single measurements do not differ statistically from each other.

According to these data, the measurements given most consideration by the members of this grading committee in arriving at the feeder grade of the animal would be that of a proportion $\frac{Ll}{WD}$ or $\frac{l}{W}$. In other words, the body balance or the symmetry of the body would be the most valuable index. A proportion of body length and fore leg length over body width, or $\frac{L.l}{W}$ would also be an accurate index for the prediction of feeder grades,

TABLE II. STANDARD ERROR OF ESTIMATE IN PER CENT OF FEEDER GRADE

	Average Body Width (W)	Average Body Depth (D)	Body Length (L)	Fore Leg Length l	$\frac{L.l}{W.D}$	$\frac{L.l}{W}$	$\frac{l}{W}$
Feeder Grade	4.549	4.596	4.587	4.522	4.199	4.372	4.167

TABLE III. STANDARD ERRORS OF ESTIMATE IN POUNDS OF AVERAGE DAILY GAIN AND TOTAL DIGESTIBLE NUTRIENTS

	Kills	Feeder Grade	Average Body Width (W)	Average Body Depth (D)	Body Length (L)	Fore Leg Length (l)	$\frac{L.l}{W.D}$	$\frac{L.l}{W}$	$\frac{l}{W}$
Average Daily Gain	1	.14	.28	.27	.26	.26	.51	.29	.39
	2	.21	.24	.28	.24	.25	.24	.23	.15
	3	.17	.17	.17	.15	.17	.17	.17	.11
	4	.31	.28	.32	.31	.29	.32	.30	.30
	Average	.21	.24	.26	.24	.24	.31	.25	.24
Total Digestible Nutrients per 100 pounds Gain	1	24.0	38.2	31.9	29.5	32.0	24.6	36.7	32.6
	2	28.5	27.7	29.7	27.7	29.6	29.6	29.7	30.9
	3	28.6	29.8	28.6	30.8	24.6	28.1	29.2	29.4
	4	56.3	47.2	54.8	54.8	44.8	49.1	55.0	54.9
	Average	34.4	35.7	36.2	35.7	32.7	32.8	37.7	36.9

while in the single measurements the fore leg length would be most valuable. Body width is a more significant single index than is body length, and body length in turn is more significant than body depth. The poorest measurement to use in predicting feeder grade would be body depth.

In computing standard error for the average daily gain, a somewhat different arrangement was necessary. Due to the fact that these animals were killed in four different periods, it was necessary to compute standard errors for each individual kill. The number of days on feed for the first kill for the three year average was 121 days. This lapse of time was determined by the degree of finish that the animal attained. The other kills followed at intervals of approximately forty-nine days. Each single measurement; namely, average body width, average body depth, body length and fore leg length and the proportion $\frac{Ll}{WD}$, $\frac{Ll}{W}$, and $\frac{l}{W}$ were used in computing standard errors for average daily gain. With this group of measurements feeder grade was also used. It will be noticed in Table III that there is a tendency for the standard error to become smaller toward the third kill and larger for the fourth kill. In one case out of eight measurements this is not true. The standard error of feeder grade is smallest for the first kill instead of the third kill. The fourth kill in this case is the largest, as is found to be true of the other measurements used.

In computing the standard error of the feeder grade the standard error for the first kill animals was approximately .14 of a pound. With these calves gaining from one and one-half to two and one-half pounds daily, a standard error of this size in predicting the gain is highly significant. The standard error for the second kill forty-nine days later was .21 of a pound, while the standard error for the third kill another forty-nine days later is .17 of a pound. The fourth kill has a standard error of .31 of a pound. These figures are all small in view of the fact that only nine individuals were used to compute the errors for each of the first, second and third kills and only eight animals in the fourth kill.

The average body width measurement was not as accurate an index in predicting the average daily gain of these calves as was the feeder grade. In this particular case the standard errors of the first and second kills were both higher than the standard errors of the respective kills when feeder grade was used. The first kill standard error of .28 of a pound and the second kill standard error of .24 of a pound are not necessarily large but are significantly larger than the standard errors of the first and second kills of the feeder grade. The third kill standard error of .17 of a pound is identical to that of the feeder grade, while the fourth kill standard error of .28 of a pound is approximately .03 of a pound smaller than the fourth kill standard error of the feeder grade.

The computed standard errors of the four kills using average body depth follow the same trend as is noticeable in all the measurements. The first kill has a standard error of .27 of a pound and the second kill .28 of a pound and the third kill .17 of a pound. The standard error of this third kill again is the smallest of this particular measurement and is approximately the same as that of the feeder grade and the average body width. The standard error of the fourth kill is .32 of a pound and is larger than either of the respective standard errors of the feeder grade and average body width.

Body length has a standard error of .26 of a pound for the first kill, .24 of a pound for the second kill and .15 of a pound for the third kill. The fourth kill again has the larger standard error. The third kill of .15 of a pound is more significant than any of the standard errors of the above mentioned kills and is .02 of a pound smaller than any error of the individual measurement and feeder grade.

The fore leg length runs similar in standard errors of the four kills as the previous results show. The first kill standard error is .26 of a pound, the second .25 of a pound, and the third .17 of a pound. The fourth kill standard error of .29 of a pound is smaller than all standard errors of the single measurements except average body width.

Of the proportions that were used as measurements, $\frac{L.1}{W.D}$ had the largest standard error in each of the four kills. This result is rather strange in view of the fact that this proportion had one of the smallest standard errors when computed with the feeder grade. The first kill had an error of .51 of a pound. This error is too large, especially for those calves that had an average daily gain of about one and one-half pounds. The standard error for the second kill is similar to the respective kills of the single measurement. The third kill also has a standard error of approximately .17 of a pound, and the fourth kill a standard error of .32 of a pound which is also similar to the single measurement results. In the proportion $\frac{L.1}{W}$ all kills but the first are similar to the results of the proportion $\frac{L.1}{W.D}$. The first kill is approximately .2 of a pound smaller for the mentioned proportion $\frac{L.1}{W.D}$. The proportion $\frac{1}{W}$ has a standard error of .11 of a pound in the third kill, which is smaller than any standard error regardless of kill. It is smaller than the standard errors of the respective kills of all measurements by .06 of a pound. The standard errors of the other three kills do not differ greatly from the computed standard errors with the other measurements.

The individual standard errors of each kill were averaged for each of the eight measurements. The feeder grade average is .21 of a pound and is the smallest standard error of the entire group. This means that feeder grade is a better index to the animal's performance so far as average daily gain is concerned than any of the remaining single measurements or proportions. The other measurements and proportions have a standard error ranging from .24 of a pound for body length to .31 of a pound for the proportion $\frac{L.1.}{W.D}$.

There is a certain amount of doubt cast upon the value of these measurements when the results of the computations are tested statistically. The measurements which were smallest in error when correlated with the feeder grade should also be the smallest in error when correlated with the average daily gain. This, however, does not prove to be the case in these measurements. There are possibly two explanations for the smaller standard errors for the third kill and the largest standard error for the fourth kill. According to Morrison (8), as cattle become fatter, there is a tendency for their daily gains to become smaller. This fact might account for the larger errors in the fourth kill animals. It does not account, however, for the third kill animals having the lowest standard error in all cases. The other possibility for this general trend lies in the effect of experimental error. The selection of the animals for each kill was made chiefly on degree of finish. There perhaps was an unconscious tendency to eliminate the less desirable animals in the first kill and then by a process of elimination, the poorer animals that remained were again left until the final or fourth kill.

In order to determine which of the eight measurements expresses the efficiency of the animal most accurately, they were computed with the total digestible nutrients required per 100 pounds gain. The total digestible nutrients per 100 pounds gain were computed from the pounds of feed consumed by the individual, using the Morrison feeding standard. The total digestible nutrients were used because it was thought they would be more accurate in determining the animal's efficiency than the actual pounds of feed consumed.

When the feeder grade measurement was computed with the total digestible nutrients per 100 pounds gain, the error for the first kill was approximately twenty-four pounds. This error is not large. It would be a great asset to a feeder to be able to predict within twenty-four pounds the feed required to produce one hundred pounds of beef. The errors of the second and third kills are approximately equal and are about four and a half pounds larger than the error of the first kill. As far as estimating feed for 100 pounds gain, these two errors are still significant in the eyes of the livestock man. The fourth kill has an error of 56.31 pounds. This error is almost twice as large as the error of the second and third kills. With the fourth kill animals consuming approximately six hundred pounds of total digestible nutrients per 100 pounds gain, an error of this size is not necessarily large. This is the largest error of all kills and all measurements.

In the average body width measurement, the first kill has an error of 38.17 pounds. This error does not compare in size with the respective error of the feeder grade measurement, while the second and third kills of the average body width measurement are in approximation of the second and third kills of the feeder grade. The error of the fourth kill is approximately nine pounds smaller than that of the same kill with the feeder grade measurement. It will be noticed that here again there is a tendency for the second and third kills to have the smaller errors, while the first and fourth kills are generally larger. The fourth kill is considerably higher in error than the first kill. In two cases out of the eight, the errors of the first kill animals are smaller than the errors of the second and third kill animals. This is true of the feeder grade and the proportion of $\frac{L.l.}{W.D}$

The results of computing average body depth with the total digestible nutrients per 100 pounds gain are similar to those obtained when average body width was used. The error of the first kill animals is smaller than the respective error of the average body width by about six pounds. The errors of the second and third kill animals are approximately the same in size and the error of the fourth kill animals is about seven pounds greater for the average body depth measurement than for average body width.

The body length errors vary a little for the different kills when compared to the average body width and the average body depth measurements, but their results indicate that there is very little difference in the choice of any of the three as to the value in estimating or predicting the requirements of total digestible nutrients per 100 pounds of gain.

Fore leg length has a standard error of thirty-two pounds for the first kill, twenty-nine and a half pounds for the second kill, 24.64 pounds for the third kill, and 44.8 pounds for the fourth kill. Although this first kill standard error was a little higher than the respective standard errors of average body depth and feeder grade, it is smaller by six pounds than the first kill error for the average body width measurement.

Because the figures here were so variable, an average of the standard errors of the four kills was made. Of the single measurement fore leg length has an average standard error of 32.74 pounds. This is the smallest error of the four single measurements in addition to the feeder grade, and would be the most accurate index in selecting animals for efficiency in utilization of feed. Feeder grade is the second most accurate of this group of measurements while body length, average body depth and average body width are nearly equal in this respect. Of the three different proportions used, $\frac{L.1}{W.D}$ is a more accurate index than either $\frac{L.1}{W}$ or $\frac{1}{W}$. The proportion $\frac{1}{W}$ is a little more accurate than is $\frac{L.1}{W}$. Fore leg length with an error of 32.7 pounds is a more accurate index than any of the proportions, but is only .09 of a pound smaller than the error of $\frac{L.1}{W.D}$. The proportion $\frac{L.1}{W.D}$ ranks second in value with an error of 32.8 pounds. Feeder grade with an error of 34.4 pounds is the third most accurate index. The greatest error and the poorest measurement as an index to efficiency in the utilization of feed is the proportion $\frac{L.1}{W}$. It has an error of thirty-seven and a half pounds. The larger errors of the four kills here again possibly have two explanations. The animals were selected for slaughter in groups of equal finish as nearly as possible. The animals of the fourth kill were left after a process of elimination. The other explanation lies in the experimental work cited by Snapp (4) and Morrison (8), et al. Experimental evidence shows that as fattening animals near a high degree of finish, more feed is necessary to produce one hundred pounds of gain than in the thin animals.

GENERAL CONSIDERATION AND DISCUSSION

The data used in this experiment were collected incidental to a major objective of a "degree of finish experiment." It is possible to suppose, had the experiment been executed to fit the requirements of the measurement and performance study, greater or lesser differences might have resulted. The fact that these animals were killed at intervals of four different periods has necessitated a separate calculation for each standard error. It has reduced the number from thirty-five individuals to nine animals in three of the four kills and eight in the other. The reduction in numbers alone has tended to depreciate the value of these standard errors. Another error introduced into the experiment was that of combining animals of a three-year period. Regardless of ability, there certainly is a difference in the way a judge will see an animal from one time to the next. With these animals being graded in three different years, it seems possible that an error could be made in the grading of the feeder animals. These animals were selected for their uniformity of type. This selection made these animals too much alike so that little or no difference existed between them. A study of the original data (Table I) will support this consideration. In many cases, especially the results of the proportions used in this study, the differences were as small as one millimeter. It is also possible to think that a greater number of measurements calculated with the performance of the animals might have been of more value and significance. This seems unlikely in the light of previous work that has been done. It is possible to suppose that there are external characters which are readily recognized by a skilled judge which are not susceptible of measurements with either tape or measuring rule. Such things as disposition, individuality, pliability of skin and others are examples of these characters. In this study mathematics assumes the position ranging from zero to one hundred, or from animals of one extreme type that do not exist to those of the other extreme which again do not exist. The animals used in this study were uniformly of a type somewhere between these two extremes. The feeder grades of these calves ranged from seventy-five per cent to ninety-five per cent. The data and results here do not express the performance of a highly varied type but of one general type. It seems, therefore, that in order to have such an experiment work out successfully, animals of the same breed should be selected but of a widely varied type. It is also wrong to assume that there is a direct improvement in efficiency of the animal as type improves. Winter (6) states that "there has been a general assumption that as type improved, there was a similar improvement in efficiency. We know this is not necessarily the case. To a certain extent we have been kidding ourselves on this point all these years." We also know that as fattening cattle become fatter, they require more pounds of feed per 100 pounds gain. Therefore, each individual kill in this experiment actually represents a different degree of finish and with that a different feed requirement per 100 pounds of gain. The data show a tendency for the typier animals to be a little the more efficient in their feed requirements per 100 pounds gain as compared to the somewhat less desirable type individual. On the whole, the animals were too nearly alike to specifically show a definite contrast in performance of the different types.

SUMMARY

The investigation reported in this paper is a study of the relation of certain body measurements to the performance of fattening cattle in the feed lot. The data were collected from thirty-five head of Hereford heifers fed by the Michigan Agricultural Experiment Station during the years 1932-33, 1933-34 and 1934-35. The relation of certain body measurements and feeder grade were used to compute standard errors using feeder grades, average daily gains and total digestible nutrients in the ration per 100 pounds of gain in body weight as the variables. Because there is a change in feed requirements and average daily gains as animals become fatter, each kill was necessarily computed separately and later averaged. The data show:

The proportion $\frac{1}{W}$ is the most accurate index in estimating the feeder grades of the animal. The judges, therefore, place more emphasis on the proportion of these measurements than on any one single measurement in grading the animal.

The proportion $\frac{L.l}{W.D}$ was second most accurate in estimating the feeder grade. The grading committee gave more consideration to this proportion than any single measurement in arriving at a feeder grade.

Of the single measurement, fore leg length was given more consideration than body length, average body depth or average body width. The low setness of the animal has been considered one of its greatest assets toward ideal type.

Average body width is a more important measurement than either average body depth or body length.

Average body depth received the least consideration by the grading committee in arriving at a feeder grade.

The standard errors for all measurements were small enough to keep the animals within the assigned grade, although none of these errors kept the animal within its own third of that grade.

Average body width allowed the animal to shift 1.22% into the third of a grade above or below the assigned third of the feeder grade.

Average body depth allowed the animal to shift 1.26% above or below the third of the assigned third of the feeder grade.

The proportion $\frac{l}{W}$ is the best measurement in estimating feeder grade. It has a slight advantage over the proportion $\frac{L.l}{W.D}$, but this difference is not statistically significant. If the proportion $\frac{L.l}{W.D}$ is equally just as valuable as an index in estimating feeder grade as is the proportion $\frac{l}{W}$, then it should be in close approximation to both feeder grade and the proportion $\frac{l}{W}$ in estimating average daily gains. This, however, is not the case. The results cast suspicion on the value of the mechanical measurement as compared to the judgment of a skilled grading committee.

The proportion $\frac{l}{W}$ ranks second to feeder grade as an index to average daily gains. This proportion functioned as would be expected in estimating the average daily gains.

Of the single measurement, body length is the most accurate index of average daily gains, while fore leg length is the second most accurate index in estimating average daily gains. Here again the difference between the two errors is not statistically significant. Consequently, these two measurements have functioned approximately as would be expected.

Average body depth is the poorest single measurement to use as an index in estimating average daily gains and the proportion $\frac{L.1}{W.D}$ is the least accurate of the three proportions in estimating average daily gains. It is also the least accurate of all eight measurements used in this respect.

The single measurement, fore leg length is the best index of the group of measurements in estimating the total digestible nutrients per 100 pounds of gain.

The proportion $\frac{L.1}{W.D}$ has an error of only .09 of a pound larger than that of the fore leg length measurement and ranks second in value for estimating total digestible nutrients per 100 pounds of gain.

Feeder grade ranks third in accuracy in estimating the total digestible nutrients per 100 pounds of gain.

The largest error and the least accurate measurement is that of the proportion $\frac{L.1}{W}$. The other measurements all rank about the same in their value as an index to requirements of total digestible nutrients per 100 pounds gain.

The best measurement for estimating average daily gains and total digestible nutrients per 100 pounds of gain cannot be determined from the results that have been obtained. Each kill has its own standard error and most of them are too nearly alike to show any significant differences in their sizes. Although an average of the standard errors of the four kills was made for each measurement to assist in this discussion, it is not mathematically correct. Hence, the significance of the differences between them was not computed.

CONCLUSION

The standard errors obtained in these results indicate that there is a slight correlation between the various body measurements and the performance of the animal in the feed lot. The standard errors show very little variation between themselves, but their differences in many cases are significant in spite of their likeness. The animals used in this study were uniformly alike in type. The fact that this particular type shows a slight relation to performance does not mean that an improvement in type would also mean a corresponding improvement in efficiency or vice versa. The performance of the fattening animal does not follow the trend of a straight line. There is a general decrease in average daily gain during the fattening period and a general increase in the requirements of total digestible nutrients per 100 pounds of gain as the feed period progresses. The errors obtained are too large to predict the animal's position within the one-third of the feeder grade but are small enough to accurately predict the general feeder grade. The three proportions used in this study when statistically tested are significantly better than the single measurement in predicting feeder grade. Feeder grade is a better index than the mechanical measurements in estimating average daily gains by periods while the mechanical measurements are practically the same in their value in estimating average daily gains. All measurements are approximately equal in size of error in estimating the necessary total digestible nutrients per 100 pounds gain. Fore leg length and the proportion $\frac{L.1}{W.D}$ are a little the better index to total digestible nutrients required per 100 pounds gain than are the other measurements used. In the case of average daily gains and total digestible nutrients, the animals were killed in periods. This division in two periods has destroyed the effect of large numbers and has tended to depreciate the value of the standard error. Whether these errors statistically differ from each other is very doubtful, but they do show that there is an increase in error for the fourth kill animals and that sometime during the fattening period, there is a time when the performance of the animal is more closely related to its body shape than at any other time. The results of this study are too meager to warrant any specific decision. However, conformation is often the only basis available for judgment and should be given this consideration at all times.

BIBLIOGRAPHY

1. Hulze, Fred S.
Type in Beef Calves
Wyoming Agricultural Experiment Station Bulletin 153, 1927

2. Severson, B. O. and Gerlaugh, P.
A Statistical Study of Body Weights, Gains and Measurements of Steers During the Fattening Period.
Pennsylvania Agricultural Experiment Station Annual Report 1916-17, pp. 275-295.

3. Arkin, Herbert and Colton, Raymond R.
An Outline of Statistical Methods, 1934

4. Snapp, Roscoe R.
Beef Cattle
Second Edition 1930

5. Lush, Jay L.
The Relation of Body Shape of Feeder Stters to Rate of Gain, to Dressing Per Cent and to Value of Dressed Carcass.
Texas Agricultural Experiment Station Bulletin No. 471, 1932

6. Winters, L. M.
Breeding Market Beef Cattle
Shorthorn World, April 10, 1937

7. Vaughan, Henry W.
Breeds of Livestock in America, 1931

8. Morrison, F. B.
Feeds and Feeding
Twentieth Edition, 1936