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To the Graduate Council:

I am submitting herewith a thesis written by Dugald E. Brown entitled "Relationships Between Type Scores and Live Animal Measurements in Beef Cattle." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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RELATIONSHIPS BETWEEN TYPE SCORES AND LIVE ANIMAL MEASUREMENTS IN BEEF CATTLE

A THESIS

Submitted to
The Graduate Council
of
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in
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for the degree of
Master of Science

by

Dugald E. Brown

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CHAPTER I

INTRODUCTION

The determination of the type score is a visual evaluation of an animal. In scoring beef cattle, no grader can indicate exactly the criteria he used to determine the type grade, nor the degree to which he used them. For this reason, the method of obtaining such an evaluation would seem to be intangible. This indicates that an objective method of determining type, such as live animal measurements, would be useful. An objective method, if it is possible to determine type score by such a method, would make type grading more uniform and remove some of the human element involved.

This investigation was therefore initiated to evaluate the usefulness of certain live animal measurements as objective criteria in determining type. This study may indicate the degree to which the grader uses the various criteria in the evaluation of type, such as height at withers, depth of chest, height of chest, and length of body.

CHAPTER II

REVIEW OF LITERATURE

There have been limited investigations reported on the relationship between type scores and live animal measurements in beef cattle. This relationship has been included in a few investigations on type and its affects on the economic factors in beef cattle production. In all but a few cases, the investigations reported were studies on the relationship between body measurements and factors associated with type, such as carcass characteristics and comparisons between beef and dual-purpose cattle. In general, the results of these investigations indicate that the linear measurements, height of withers, chest depth, and length of body are skeletal measurements and are related to the concept of type grade.

In studying the relationship between market type and body measurements made on calves, Hultz (1927) obtained a correlation coefficient between initial weight and initial type of .259 + .148, indicating no significant association between initial weight and initial type. The study showed the most important body measurements influencing the determination of low-setness (type) were: Depth of chest, paunch circumference, and height at withers. When the proportions of depth of chest and circumference of paunch to the height at withers were large, a calf had the appearance of low-setness.

Hultz and Wheeler (1927), in studying the relationship between market type of two-year-old steers and body measurements made on these steers, concluded that the appearance of low-setness was exemplified in the two-year-old steer when the proportions of his heart girth, chest depth and paunch to withers height were great.

Lush (1928) observed that the height at withers, depth of chest, and length of body changed very little due to fattening. Depth of chest and length of body were important components in the concept of low-setness, blockiness, and compactness of form in contrast to ranginess of type.

In a study of the nature of size factors in domestic cattle, Gregory (1933) found that the genetic factors which control muscular diameter are different from those that control skeletal development. He concluded, therefore, that the general conformation of an animal could be expressed in statistical units by taking the ratio of $\frac{\text{round measurement}}{\text{height at withers}}$. The muscle-skeletal index figure was obtained by this formula. In this study, the index figure of approximately .735 separated the beef cattle from the dairy cattle. The beef cattle were above this figure.

In a comparison of body measurements of beef and dual-purpose cattle, Knapp et al. (1933) divided growth data into three groups: Increase in weight; increase in skeletal structure which involves only increase in framework on which the meat is laid; and increase in volume of flesh due to fattening as well as growth.

They selected height at withers, length of body, depth of chest, and height of chest floor as measures of skeletal growth, and heart girth, width of chest, and weight as indicative of fleshing. The difference between beef and dual-purpose cattle in relation to height at withers, length of body, heart girth and width of chest were significant. The weight differences were significant until one year of age if height at withers was held constant.

From correlations of nine body measurements with rate and economy of gain and slaughter data, Black et al. (1938) found that the ratios of certain body measurements were more highly correlated with efficiency and carcass characteristics than previous research had shown. They concluded that live animal measurements should be complementary to eye appraisal and slaughter grading, and not substituted for them.

Investigating the relationship between five body measurements and the slaughter grade, carcass grade, and dressing percentage of steers, Cook et al. (1951) found that the steers shorter in height at the withers, height of chest floor and length of body tended to have slightly higher slaughter and carcass grades and a higher dressing percentage than rangier steers. Larger circumferences of foreflank and greater shoulder widths tended to produce slightly higher slaughter and carcass grades than those that were more narrow.

From a study of classification scores of Hereford cows, Gifford et al. (1951) found that graders agreed more closely on items that concerned the animal in general and were least able

to agree on individual items about the animals. The repeatability of score by the graders on the same animals at different dates was low, having a correlation between 0.4 and 0.5. Differences between the cows were the source of greatest variation in scores. These workers found seasonal influences upon the animal cause another source of variation in grading animals and this should be considered when making type evaluations of beef animals.

Guilbert and Gregory (1952) studied the growth and development of purebred Hereford cattle, using weights, body measurements, and grades. They found that higher grading animals were consistently heavier in weight and larger in round measurements, but observed no difference in height according to grade. They found that, in conventional grading, preference is given to weight in relation to height and to greater general muscle thickness associated with plumpness of round. They concluded that a person grading and actually using live animal measurements will probably find that there are optical illusions involved in the appraisal of cattle: The longer appearing animal may actually be shorter; the shallower bodied animal may not be less deep, but may be standing on longer legs; and the lighter appearing round may only vary in shape, but be as large.

White and Green (1952) studied the relationship between the measurements of live beef steers and the weights of major wholesale cuts in order to derive methods for use in estimating and predicting the weights of various parts of beef cattle. In predicting yields,

width and depth measurements were of more importance than the length measurements taken along the back. The correlations indicated that the actual weights of the parts of live beef-type animals from which the wholesale cuts are derived could be predicted by use of body measurements for the kind of cattle used in the experiment. Multiple correlation values between the major wholesale cuts, and the live weight, slaughter grade, and body measurements pertaining to the regions of the various wholesale cuts, were obtained as follows: Cross cut 0.99; rib 0.97; trimmed loin 0.97; short loin 0.93; sirloin butt 0.96; and round 0.93.

Using beef and Milking Shorthorn steers in determining the relationships between meat production characters and body measurements, Yao et al. (1953) found that all of the width and circumference measurements were positively correlated with slaughter grade, carcass grade and dressing percentage, and therefore, could be called fleshing measurements. They also found that all of the height and length measurements could be called skeletal measurements, because they were negatively correlated with slaughter grade.

Green (1954) observed, in using body measurements taken on live beef steers for predicting the weights of wholesale cuts, that live weight was the single measurement most closely associated with the weights of the preferred cuts, which are the round, trimmed loin, and rib. Width of shoulders and hooks and depth of twist were more highly correlated with the preferred cuts than the other linear measurements.

The width of shoulders was significantly correlated with dressing percentage.

An analysis of results obtained from a study of the relationship between body measurements and carcass traits indicated to Kidwell (1955) that much of the observed correlation among various measurements arises from their relationship to general size. The width of chest was the only exception to this. He also found that the ratios of height at withers to heart girth, and length to heart girth, and the chest-width measurement are the most important factors influencing carcass quality. From this research he concluded that the most desirable animals would be low at the withers, short of body and shallow of chest relative to heart girth, but wide through the chest, irrespective of size.

CHAPTER III

PROCEDURE

Animals

Two groups of cows and calves were used in this study. Twenty-five Hereford cows and 41 calves from the Tobacco Experiment Station, Greeneville, Tennessee, and 36 Hereford cows and 37 calves from the Middle Tennessee Experiment Station, Columbia, Tennessee, were weighed, photographed and graded. The data was collected at weaning time in the fall of 1953. The ages of the cows varied from three to nine years, and the calves were from seven to nine months of age. The grading was done by a committee of two or three qualified graders, and the final score was an average of grades by the individual graders.

Equipment

The equipment for photographing the cattle consisted of a "Bovine Photographic Chute" (Figure 1) and a Speed Graphic "45" camera. The photographic chute served two purposes. One was to hold the cattle for photographing and the other was to facilitate taking the body measurements from the pictures, as the chute formed a grid between the animal and the camera. Smith et al. (1950) found that slightly higher estimates of repeatability for photographic measurements were obtained as compared to live animal measurements. Since natural lighting is irregular and undependable, the photographs

were taken with artificial lighting, in order to eliminate shadows and make the animals in the pictures more distinct for measurement.

Method of Obtaining Photographs and Measurements

The camera was set up on a tripod 13 feet from the chute grid. The lens was focused on a point of the grid where the horizontal 36-inch bar crossed the vertical 48-inch bar. The animal was held snugly between the grid and the adjustable back of the chute. Two photographs were taken of each animal. In this procedure, the animal should be standing squarely on his feet with his head up.

The photographs were enlarged from the four by five inch size to eight by ten inches to facilitate taking the detailed measurements. Conversion factors for vertical and horizontal measurements were used to eliminate the photographic and enlargement distortion and to convert the photographic animal measurements to actual animal measurements. The conversion factors, expressed in centimeters, were derived by the equation:

$$\frac{\text{Actual grid distance}}{\text{Photographic grid distance (32nd of an inch)}} \times 2.54 \text{ centimeters.}$$

The photographic animal measurements were taken in 32nds of an inch. These measurements were then multiplied by the conversion factor, which gave the actual animal measurement in centimeters.

Weight, type grade, and four body measurements were used in the statistical analyses. The body measurements used were: Height at withers, depth of chest, height of chest, and length of

body from the shoulders to pins. (See Figure 1)

Statistical Methods

In order to calculate the simple correlations, partial regressions and multiple correlations involving weight, body measurements and type score, the animals were grouped according to station of origin and then subdivided into cows, heifer calves, and bull calves. Two different analyses were used in calculating the standard partial regressions. One analysis involved the following measurements: Weight, height at withers, length of body and type grade. The other analysis included: Weight, height of chest, depth of chest, length of body and type grade. The data was analyzed in this way because height at withers, depth of chest and height of chest are dependent variables and should not be used in the same partial regression. Partial regressions were tested for significance and the multiple correlations were calculated. Correlation, partial regression and multiple correlation methods described by Goulden (1952) were used in the analysis of the data.

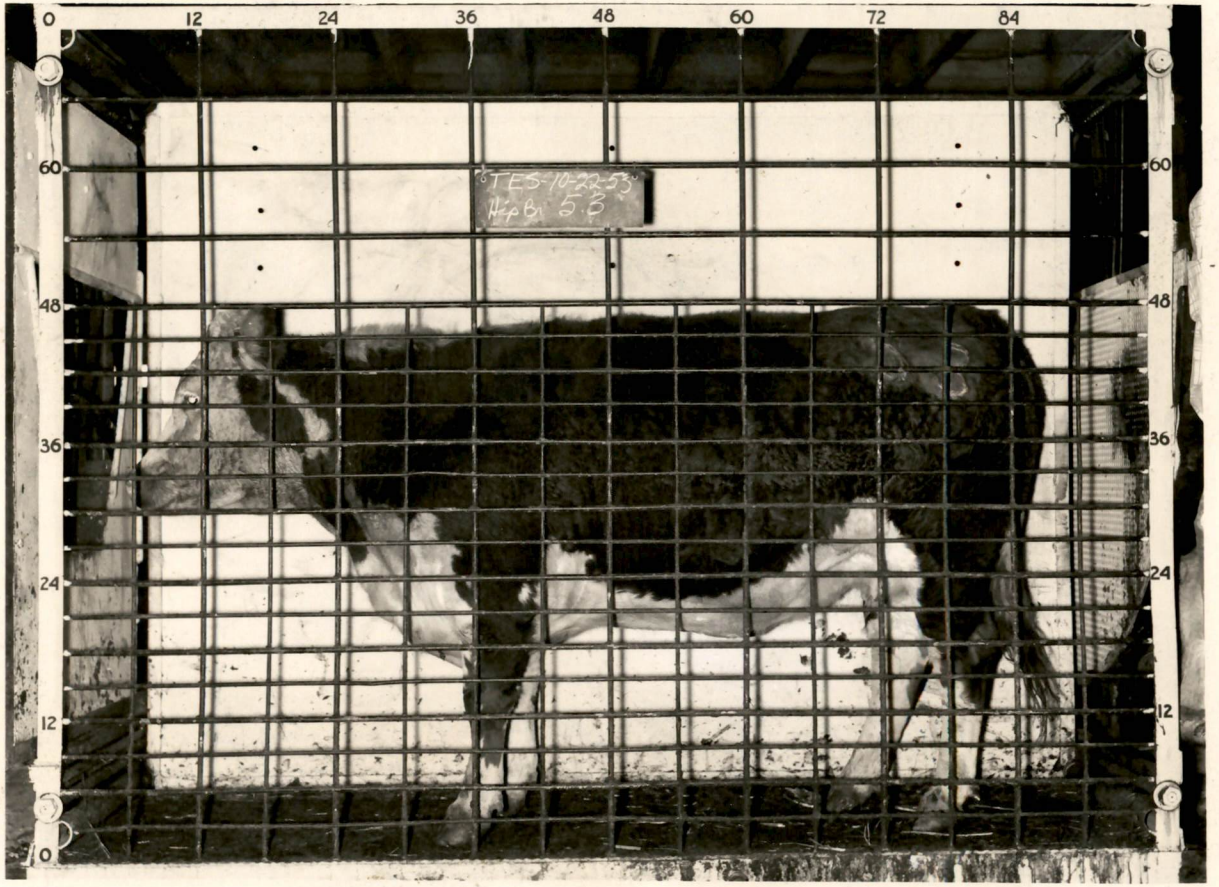

Figure 1. Photographic chute and location of body measurements.

CHAPTER IV

RESULTS AND DISCUSSION

The simple correlation coefficients between weight, body measurements and type score for the various groups of cattle are presented in Tables I, II and III. A study of Tables I and II shows that the simple correlations between weight and depth of chest and type score are highly positively significant. The type scores of the Greeneville cows seemed to be influenced largely by weight, depth of chest, height of chest and length of body, as indicated by the significantly positive correlations in Table I. However, in the Columbia cows, weight and depth of chest seemed to be the only measurements related to type score to any degree. Weight entered into the scoring of the Greeneville cows to a greater degree than the Columbia cows. This probably results from the fact that the Greeneville cows were in higher condition at the time of scoring than the Columbia cows. Height of withers did not appear to influence grades in either group of cows.

A study of Table II, showing the simple correlations pertaining to the Columbia calves, indicates that the graders seemed to favor the calves that had greater depth of chest, and then considered weight and length of body in their classification. Although the correlations between height at withers and score were not significant in the Columbia calves, this measurement apparently received more attention in scoring as compared to its importance

in scoring the Greeneville and Columbia cows.

The correlation between height of chest and type was negatively significant in the Greeneville calves, as shown in Table III. This is, in general, consistent with correlations between height of chest and type grade in the Greeneville and Columbia cows and Columbia calves (Tables I and II) but the correlations between other body measurements and type score were all negative and lacked significance. These correlations are inconsistent with similar correlations in the Columbia calves (Table II). It appears that height of chest was an important factor in grading these calves.

In both the cows and calves, height at withers was not significantly correlated with type score. However, data showed that graders consistently seemed to give lower type grades, and in some cases significantly lower scores, to cattle that were higher at the chest floor.

In spite of many significant relationships between weight, body measurements and type score, only a few were of sufficient magnitude to account for much of the variance in type score. The values of the coefficients of determination (r^2), indicating the percentage of variance in type scores accounted for by a single measurement, are in general quite low. These coefficients were greatest for weight and depth of chest in the Greeneville and Columbia cows and Columbia calves. The highest value for a coefficient of determination was .593 ($.77^2$), indicating that

59.3 per cent of the variance in type scores in the Columbia calves was accounted for by differences in chest depth. This value in itself is relatively high, but r^2 for depth of chest and type score varied from .16 per cent in the Greeneville calves to 59.3 per cent in the Columbia calves. This variability in predictive value as shown by the coefficients of determination was also evident in the other measurements. It thus seems that the various measurements, when considered alone, can be of only slight predictive value.

The averages and the standard errors, the partial regression coefficients between the items and grade, and the multiple correlations are given in Tables IV, V, and VI. The standard partial regression is the fractional unit of standard deviation that the dependent variable (score in this case) changes for every unit of standard deviation change in the independent variable. The multiple correlation (R) measures the effect of the combined items on the type score. The square of the multiple correlation (R^2) indicates the amount of variance in type score accounted for by a knowledge of all of the other items. The figure ($1 - R^2$) is the amount of variance in type score not accounted for by the measurements.

The values of the standard partial regression coefficients proved to be very variable between groups of animals. The standard partial regressions of score on weight were positive in all cases (significant in five out of 12 cases) and indicate that most graders consciously or unconsciously gave weight considerable emphasis in

arriving at a type score. In partial regressions using depth of chest and height of chest instead of height at withers, the partial regression coefficients of score on weight were considerably smaller than partial regressions obtained when height at withers was used in the analysis. This suggests that the grader is favoring depth of chest and penalizing the animal for height of chest and giving less emphasis to weight. However, both weight and depth of chest are related to the size of the animal and to each other to a considerable extent. When the Greeneville cows were graded, a large amount of emphasis seemed to have been placed on the weight, as indicated by the highly positively significant partial regression coefficients for score on weight.

Standard partial regressions of score on height at withers was negative in all groups, but significant in only two out of six cases. Partial regressions of score on height of chest were negative in all groups, but significant in only one out of six cases. This indicates that scorers gave some consideration to these factors independently of others in arriving at type scores. However, both height of chest and height of withers seems to have been used variably in obtaining type scores between groups, as shown by the variability in the standard partial regression coefficients for these measurements in the different groups of cattle. Height of chest tended to be used more consistently in grading the animals, as indicated by the partial regression coefficients for this measurement. The regression coefficients for score on length of body were variable and inconsistent between groups.

The multiple correlations were calculated from the partial regressions to determine the combined effect of the measurements on score. Significantly high correlations were obtained in the Columbia and Greeneville cows, the Columbia calves, and the Greeneville bull calves. The square of these coefficients (R^2) shows that, in general, a considerable portion of the variance in type score was accounted for by the measurements studied, except in the Greeneville heifer calves where the measurements considered accounted for only 15 - 20 per cent of the variance in type score. The relatively low values for the multiple correlation coefficients in the Greeneville heifer calves as compared to other groups of cattle showed that the graders must have introduced factors not considered in the present analysis in scoring the calves. The generally high and significant multiple correlations in all other groups indicate that the graders were taking into account the combined effects of the measurements on type score.

CHAPTER V

SUMMARY

The relationship of body measurements to type score was investigated to determine the degree to which body measurements are correlated with type score.

In this investigation, body measurements on 61 cows and 78 calves were studied in relation to type score. Simple correlations were obtained to determine the effect of the individual measurement upon type score. With the exception of the Greeneville calves, correlations between measurements and type score were highly positively significant for weight and depth of chest. The correlations between body length and type score were significant in some data and not in others. Height of chest proved to be negatively correlated with type score in all simple correlations, and in some instances the correlations were significant. Height at withers was not significantly correlated with type score.

The standard partial regressions calculated from the data gave the relationship of an item to type score, independent of other items. The standard partial regression of score on weight, independent of height at withers and body length, was significant at the five per cent level and above, but independent of depth of chest, height of chest and body length, the relationship of score to weight was not significant. The standard partial regressions of score on height at withers and height of chest, independent of other

measurements, were negative and lacked significance in a majority of the groups. Standard partial regression coefficients for score on depth of chest and length of body were variable and inconsistent.

The multiple correlations between various measurements and type score were calculated and ranged from .44 to .82, showing that the combined effects of the measurements on type score accounted for 18 per cent to 68 per cent of the variance in type score. The majority of the correlations were significant.

This study indicates that the individual body measurements included in this analysis are of little predictive value in determining type score because of the variability with which the different items were related to type score by the graders. However, when the combined effects of measurements on type score were studied, they proved to be of greater predictive value than any single item, indicating that the graders obtained type score by using a combination of items.

TABLE I

SIMPLE CORRELATION COEFFICIENTS BETWEEN BODY MEASUREMENTS AND TYPE SCORES OF GREENEVILLE AND COLUMBIA COWS[1]

Cows	Height Withers	Depth Chest	Height Chest	Length	Grade
Weight					
Greeneville	.57**	.90**	-.19	.82**	.69**
Columbia	.51**	.73**	.23	.71**	.56**
Depth Chest					
Greeneville			-.16	.69**	.53**
Columbia			.23	.48**	.48**
Height Chest					
Greeneville				.02	-.47*
Columbia				.32	-.10
Height Withers					
Greeneville				.56**	.02
Columbia				.41*	.23
Length					
Greeneville					.46*
Columbia					.31

[1]Degrees of freedom are 23 for Greeneville cows and 34 for Columbia cows.

*Significant at 5% level.

**Significant at 1% level.

TABLE II

SIMPLE CORRELATION COEFFICIENTS BETWEEN BODY MEASUREMENTS AND TYPE SCORES OF COLUMBIA BULL AND HEIFER CALVES[1]

Columbia Calves	Height Withers	Depth Chest	Height Chest	Length	Grade
Weight					
Bulls	.83**	.87**	.32	.83**	.66**
Heifers	.72**	.88**	.27	.84**	.73**
Depth Chest					
Bulls			.16	.84**	.77**
Heifers			.05	.81**	.77**
Height Chest					
Bulls				.15	-.08
Heifers				.28	-.11
Height Withers					
Bulls				.66*	.46
Heifers				.72**	.33
Length					
Bulls					.59*
Heifers					.65**

[1]Degrees of freedom are 12 for bulls and 21 for heifers.

*Significant at 5% level.

**Significant at 1% level.

TABLE III

SIMPLE CORRELATION COEFFICIENTS BETWEEN BODY MEASUREMENTS AND TYPE SCORES OF GREENEVILLE BULL AND HEIFER CALVES[1]

Greeneville Calves	Height Withers	Depth Chest	Height Chest	Length	Grade
Weight					
Bulls	.89**	.82**	.53*	.87**	-.00
Heifers	.61**	.77**	.26	.81**	-.12
Depth Chest					
Bulls			.56**	.75**	-.04
Heifers			.31	.74**	-.22
Height Chest					
Bulls				.56*	-.64**
Heifers				.43	-.49*
Height Withers					
Bulls				.79**	-.29
Heifers				.74**	-.40
Length					
Bulls					-.16
Heifers					-.22

[1]Degrees of freedom are 18 for bulls and 19 for heifers.

*Significant at 5% level.

**Significant at 1% level.

TABLE IV

AVERAGES AND STANDARD ERRORS OF THE ITEMS STUDIED, STANDARD PARTIAL REGRESSION COEFFICIENTS, AND MULTIPLE CORRELATIONS RELATING MEASUREMENTS TO TYPE SCORES IN THE GREENEVILLE AND COLUMBIA COWS

	Columbia Cows		Greeneville Cows	
No. Animals	36		25	
Averages and Std. Errors:				
Weight (lbs.)	1012.89 ± 16.83		959.0 ± 19.47	
Height Withers (cm.)	116.06 ± .57		115.36 ± .67	
Depth Chest (cm.)	63.56 ± .29		62.32 ± .53	
Height Chest (cm.)	52.08 ± .43		53.48 ± .45	
Body Length (cm.)	140.64 ± .72		138.16 ± 1.00	
Gradel	10.04 ± .16		10.06 ± .69	
Std. Partial Regressions of Body Measurements on Score:				
Weight	.70**	.52	1.12**	1.26*
Height Withers	-.07	—	-.51*	—
Depth Chest	—	.19	—	-.49
Height Chest	—	-.24	—	-.31
Body Length	-.15	-.07	-.18	-.23
Multiple Correlation (R)	.57**	.62**	.82**	.80**
$(1 - R^2)$	.67	.62	.32	.35

[1]Scoring based on: 13 = Choice, 12 = Low Choice, 11 = High Good, 10 = Good, 9 = Low Good, 8 = High Medium, 7 = Medium, 6 = Low Medium.

*Significant at 5% level.

**Significant at 1% level.

TABLE V

AVERAGES AND STANDARD ERRORS OF THE ITEMS STUDIED, STANDARD PARTIAL REGRESSION COEFFICIENTS, AND MULTIPLE CORRELATIONS RELATING MEASUREMENTS TO TYPE SCORES IN THE COLUMBIA BULL AND HEIFER CALVES

	Bulls		Heifers	
No. Animals	14		23	
Averages and Std. Errors:				
Weight (lbs.)	313.93 ± 15.02		339.39 ± 9.79	
Height Withers (cm.)	89.71 ± .93		91.52 ± .68	
Depth Chest (cm.)	44.86 ± .64		46.22 ± .44	
Height Chest (cm.)	44.79 ± .58		45.78 ± .48	
Body Length (cm.)	95.64 ± 1.29		97.48 ± 1.15	
Grade[1]	9.43 ± .38		10.46 ± .23	
Std. Partial Regressions of Body Measurements on Score:				
Weight	.79	.29	.78*	.44
Height Withers	-.26	—	-.46	—
Depth Chest	—	.79	—	.31
Height Chest	—	-.26	—	-.28
Body Length	.10	-.27	.33	.11
Multiple Correlation (R)	.68	.81*	.79**	.81**
$(1 - R^2)$	.54	.35	.37	.35

[1]Scoring based on: 13 = Choice, 12 = Low Choice, 11 = High Good, 10 = Good, 9 = Low Good, 8 = High Medium, 7 = Medium, 6 = Low Medium.

*Significant at 5% level.

**Significant at 1% level.

TABLE VI

AVERAGES AND STANDARD ERRORS OF THE ITEMS STUDIED, STANDARD PARTIAL REGRESSION COEFFICIENTS, AND MULTIPLE CORRELATIONS RELATING MEASUREMENTS TO TYPE SCORES IN THE GREENEVILLE BULL AND HEIFER CALVES

	Bulls		Heifers	
No. Animals	20		21	
Averages and Std. Errors:				
Weight (lbs.)	425.75 ± 16.50		396.67 ± 9.84	
Height Withers (cm.)	96.15 ± .85		96.05 ± .73	
Depth Chest (cm.)	49.85 ± .59		49.95 ± .33	
Height Chest (cm.)	46.35 ± .47		46.52 ± .56	
Body Length (cm.)	106.65 ± 1.29		104.71 ± .98	
Grade[1]	11.44 ± .24		11.55 ± .25	
Std. Partial Regressions of Body Measurements on Score:				
Weight	1.66*	.62	.18	.14
Height Withers	-1.32*	—	-.54	—
Depth Chest	—	.23	—	-.19
Height Chest	—	-.90**	—	-.47
Body Length	- .56	-.37	.03	.00
Multiple Correlation (R)	.69*	.79**	.44	.50
$(1 - R^2)$	.53	.37	.81	.75

[1]Scoring based on: 13 = Choice, 12 = Low Choice, 11 = High Good, 10 = Good, 9 = Low Good, 8 = High Medium, 7 = Medium, 6 = Low Medium.

*Significant at 5% level.

**Significant at 1% level.

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