THE RELATIONSHIP OF CERTAIN LIVE-ANIMAL MEASUREMENTS TO CARCASS MUSCLING CHARACTERISTICS OF BEEF CATTLE

by

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TABLE OF CONTENTS

INTRODUCTION

Since the day in 1750 when Robert Bakewell promulgated his laws of animal breeding, fat beef cattle production has been accepted as being most desirable. Both the producer and consumer have associated eating quality of beef with quantity and distribution of fat, and the ideals of quality beef have been attributed to the amount of fat. Present consumer demand for beef has stimulated interest in a higher ratio of lean to fat. In addition, consumers continue to place considerable emphasis on quality factors, as evidenced by the increasing demand for Government graded beef. The demand for leanner beef has increased the problems of the beef producer by encouraging him to select for natural muscling characteristics.

If the breeder and feeder of beef cattle could rely upon some objective body measurements, rather than visual observations of a subjective nature to accurately ascertain carcass value, his judgment in selection programs would be more valuable. Much research has recently been directed toward measures of preformance in beef cattle in an attempt to develop live animal indices that would be useful in detecting cattle with a high proportion of lean meat per unit of body weight.

Certain live animal measurements have been employed to investigate their predictive value in estimating the major components of the carcass, that is muscle, fat, and bone. Measurements which are highly correlated with these components would assist greatly in basic livestock improvement programs without necessitating the destruction of prospective breeding animals.

With these thoughts in mind the subsequent study was undertaken in an attempt to ascertain whether certain live animal measurements were related to desirable carcass characteristics. In addition, relationships between certain carcass characteristics were also studied.

REVIEW OF LITERATURE

Numerous live body measurements have been studied in beef cattle in an attempt to obtain reliable indicators for desirable carcass characteristics which could be used in selection programs. The majority of these measurements have been correlated with feed-lot performance. Lush (43) reported that steers with large fleshy measurements but small bone measurements are those which will have the highest dressing percentage and the most valuable meat at the end of the feeding period. He also observed that the most important measurements for high dressing percent and meat value are a large heart girth accompanied by a shallow chest, wide loin, a large rear flank girth, high initial weight, small paunch girth, narrow head at the eyes, and short height at the hips.

Hankins et al. (23) found that such measurements as height at withers, heart girth, circumference of cannon bone, and width of chest were significantly correlated with muscle-bone ratio. However, the muscle-bone ratio was determined by separation of the 9-10-11 rib cut into fat, lean, and bone. None of the above measurements was significantly correlated with muscle-bone ratio. Significant correlation coefficients were observed between the muscle-bone ratio and length of hind leg, thickness of muscle and fat over the wholesale rib among dual-purpose cattle only. These data indicate that conformation as evaluated by these measurements may not be a reliable guide in selection.

Butler et al. (10) studied Hereford and Brahman-Hereford crossbred steers and reported compactness as a conformation factor in beef steers to be of doubtful significance. Dressing percentage of the Hereford steers was lower (59.9%) than for the crossbreds (62.6%). There was little difference in carcass grade or in yield of wholesale cuts, although the crossbred steers had greater carcass and leg length.

Cook et al. (14) studied the relationship of five body measurements to slaughter grade, carcass grade, and dressing percentage of milking Shorthorn steers. Height at withers, height at floor of chest, circumference of fore flank, width of shoulder, and length of body were the measurements taken prior to slaughter. The more compact steers, that is, steers of shorter height both at the withers and at the chest floor were shorter in body length, had slightly higher slaughter and carcass grades, and higher dressing percentages than more rangy steers. Circumference of fore flank, which is a measurement of both bone structure and fleshing, was significantly correlated with slaughter grade. This would tend to indicate that steers with larger heart girths will grade higher at time of slaughter. This was likewise true for steers which were wider at the shoulder. However, width of shoulder was not significantly correlated with dressing percentage. This is not in agreement with Yao, et al. (62) and Green (18). The latter reported that width at shoulder was the only linear measurement, among those taken, which was significantly correlated with dressing percentage.

Weseli (57) observed that heavier boned steers tended to have significantly lower dressing percentages than steers with lighter bone. Carcass grade was highly correlated with dressing percentage according to Cook et al. (14). This is of little value since dressing percentage is normally calculated at time of slaughter.

Yao et al. (62) studied eight meat production characters and nineteen body measurements on 101 beef and 62 milking Shorthorn steers sired by 18 and 10 sires respectively. They divided the measurements into the following groups; Height measurements: height of chest floor, height of flank, height at withers, and depth of chest; Length measurements: length of body, length of rump, and length of coupling; Head measurements: length of nose, width between the eyes, and width of muzzle; Width measurements: Width of shoulder, chest, last rib, loin, and at the hip; Circumference measurements: fore flank, navel, rear flank, and shin bone. Measurements within groups were generally well correlated with each other. All the width and circumference measurements were positively correlated with slaughter grade, carcass grade, and dressing percentage. Negative correlation coefficients were found between height and length measurements with slaughter grade. Hankins and Beard (22), observed similar results between width and grade when weight was held constant and little difference existed in age of animals. Yao et al. (62) obtained significant multiple correlations between slaughter grade, with height at floor of chest, length of rump, and circumference at navel. They also found carcass grade to be correlated with height at withers and circumference of flank. These multiple correlations were significant at the .01 level. This work parallels results reported by Black et al. (6). They found a highly significant correlation between the ratio of body measurements to slaughter grade and dressing percentage.

Yao et al. (61) described some body measurement indices, which were significantly correlated with slaughter grade and body compactness. The ratios used in this study were as follows: Height at withers / width of chest; height at withers / circumference at chest; length of body / width of chest; length of body / circumference of chest; height at withers X length of body / width at chest; height at withers X length of body / circumference at chest; and height at withers X length of body / width at chest X depth at chest.

White and Green (58) reported that live measurements of beef type steers can be used to predict, with considerable accuracy, the weight of wholesale cuts of the carcass. The highest prediction accuracy was found with the cross-cut chuck for good and choice grade steers, where 98.6 percent of the total variations (R^2) in the weights of the cuts was accounted for by use of nine measurements. The short loin and round had the lowest degree of accuracy, (87.0%). In general, width and depth measurements were more important than length measurements.

Several studies have been reported comparing live animal scores with carcass characteristics. Knapp and associates (35) analyzed the scores of seven judges and found the estimates of width, conformation of rump and straightness of back to be the most reliable. The greatest variation in scores were obtained in estimating depth of flank. Bratzler and Margerum (7) encountered the greatest difficulty in live animal scores for estimating preferred cut yield of swine. However, a closer relationship exsisted between live scores with finish and length. Brown et al. (8) noted that judges preferred heavy, deep, wide bodied cattle with full rounds.

Hetzer et al. (28) noted that certain body measurements in swine offered possibilities as valuable tools in estimating yield of wholesale cuts from the live animal. For both barrows and gilts, depth of middle was the most reliable, single measurement in determining the yield of the five cuts, ham, loin, belly, picnic, and Boston butt. Next in importance was width of middle and height at shoulder for barrows, and height at shoulder and width of shoulder for gilts. Width of ham was most highly related to the yield of lean meat in the ham for both barrows and gilts.

A number of workers have studied the relationship of live probe to fatback thickness, percentage primal cuts, and carcass leanness. Hazel and Kline (26), De'Pape and Whatley (16), and Hetzer et al. (29) found the live probe to be a slightly more accurate estimate of carcass leanness and percent primal cuts than carcass fatback thickness. Pearson and coworkers (50) observed a high correlation (0.78) between the live probe and the lean meter. Results indicated little difference in live probe and lean meter for estimating fat-back thickness and percent of lean or primal cuts. However, live probe was more highly associated with loin eye area and fat trim.

Green (18) separated preferred cuts of beef into two groups, (Group I) round, trimmed loin, and rib; (Group II) round, trimmed loin, rib, and cross-cut. In correlating live animal measurements with these groups he found live weight to be the single measurement most closely associated with weight of the cuts within each group. Width of shoulder, width of hooks, and depth of twist were more highly correlated with group I and/or II than other linear measurements. Measurements such as pin-to poll, withers, and shoulder point; or hooks-to withers or shoulder point were of little value in predicting preferred cuts for either group.

Green (18) noted the highest correlation (0.69) between the round and arm chuck than for any of the other cuts not having structural continuity. This correlation of one cut to another might prove helpful as a predictive tool for purposes of selection.

Kidwell and McCormick (32) reported that at a given weight or age the carcasses from animals of larger more mature size contains a higher proportion of bone and muscle, and a lower proportion of fat.

McMeekan (44) in establishing a satisfactory system for judging carcass beef, emphasised muscle development, blockiness and fat cover. He postulated that short, thick bones are associated with thick muscles. A short leg on a carcass is not only indicative of the conformation of the hind quarter but of blockiness throughout the carcass.

McMeekan (45) demonstrated similar results with pigs. He found growth in thickness of bones in relation to length to be correlated with greater thickness in the associated muscles. Weseli (57) observed that live cannon circumference was positively correlated with loin eye area. Among steers of similar weight, loin eye area and carcass cannon circumference were not significantly correlated. However, loin eye area was significantly correlated with fat thickness in a negative manner. Woodward _et al._ (60) recorded no significant correlation between area of eye muscle and thickness of fat at the twelfth rib. When final weight was held constant a slight negative relationship was observed, but it likewise was not significant.

Clifton and Shepherd (13) studied the relationship between various measurements of choice and good grade beef carcasses. They found weight of the dressed carcass per unit of length was closely related to grade. The thickness of fat over the longissimus dorsi muscle at the twelfth rib was highly correlated (-.72) between grades. They also found total carcass length to be the single measurement most highly correlated with carcass grade. However, according to Woodward _et al._ (60) length of body was not related to thickness of fat over the eye muscle, but is significantly related to area of eye muscle, although the correlation coefficient was not significant when final weight was adjusted. Hankins and Burk (21) stated that thickness of external fat and thickness of flesh in the carcass was closely related to carcass grade. Thickness of external fat, thickness of flesh, and uniformity of width of the carcasses were closely associated with one another.

Weseli (57) reported no significant correlation between fat thickness and marbling score. Hankins and Burk (21) found fat thickness to be highly correlated with marbling. In addition, marbling and color of lean were significantly correlated (.82). This would indicate that extensive marbling had a tendency to make the lean appear brighter. In contrast, Hankins and Ellis (24) using ether extract, indicated that an increase in fatness contributed little to changes in color of lean for cattle and lambs. They reported a high correlation between the fat content of the edible portion of the 9-10-11 rib cut and fat of the edible portion of the dressed carcass. Hopper (30) found a high correlation coefficient (.987) between ether extract in the edible portion of the 9-10-11 rib cut and the fat of the edible carcass. The ether extract of the eye muscle, and the separable fat of the 9-10-11 rib cut are not as reliable an indicator of fatness as the separable fat and ether extract of the wholesale rib cut. In addition the ether extract in the bone of the 9-10-11 rib cut was not reliable as a fatness indicator because the standard error of estimate is too high for satisfactory prediction.

An accurate measurement of both muscle and fat development can be obtained in quartered beef carcasses by measuring loin eye area and fat thickness (McMeekan 44). Cahill et al. (11) observed a high correlation coefficient (.853) between the percentage of edible portion and area of longissimus dorsi muscle at the twelfth rib.

Aunan and Winters (1) used a sampling technique for estimating the proportion of fat and lean tissue in swine carcasses. Samples were taken from the carcass with a coring device. The best index of the lean tissue of the carcass was offered by the 5-6 rib sample. All sample locations were significant at the .01 level. The lean to fat ratio in the 5-6 rib sample was found to be highly associated with that of the carcass. Similar observations in lamb carcasses were noted by Hankins (20). The wholesale rib and leg offered the highest correlations with the carcass for degree of muscling. The relationship between the muscle content of the rib and the other cuts was low and of doubtful value for estimating that of the neck, shoulder, and breast.

Using the specific gravity method, Kraybill et al. (38) calculated body fat content. They found a significant correlation of (.956) between body specific gravity and fat content. The correlation coefficient of specific gravity of the

9-10-11 rib cut and that of the carcass was highly significant (.950).

Lofgreen and Garrett (41) determined the creatinine excretion per unit of body weight and found it was significantly correlated (.67) with the percent separable lean in the rib sample. The separable fat of the rib sample can be predicted accurately from the specific gravity of the whole sample by use of the equation $F = \frac{1.115 - Gw}{0.261}$ where F is the proportion of separable fat in the rib cut and Gw is the specific gravity of the whole cut. Results by Pearson et al. (47, 48), Price et al. (52), and Whiteman et al. (59) reveal that specific gravity of the ham or carcass was more highly related to carcass leanness or muscling than was live probe or fatback thickness. Specific gravity of the ham was more highly associated with the specific gravity of the carcass than any of the other cuts.

Kline et al. (33) investigated the effect of chilling time on specific gravity. They recorded the highest values at 24 hours; nevertheless, correlations between specific gravity and live probe, fatback thickness, and lean cuts were significant at all chilling times from 0 to 72 hours.

Using the antipyrine-dilution technique in swine, Clawson et al. (12) noted a high correlation between carcass specific gravity and moisture content of the carcass. They observed that if the water content of the body is known, the body composition may be predicted. This corresponds closely with the work of Skinner et al. (55) who found the correlation between percent fat and percent water in the various wholesale cuts of pork to exceed (0.917).

Butler et al. (9) conducted studies to determine the accuracy of the information obtained, when cutting only one side of a carcass. There was a small mean difference in the weight of the left hind quarter and left kidney knob attributed to the hanging tender. The slight differences were attributed to technique, instead of any difference in muscular development. They concluded that cutting data obtained from the left side of a carcass were sufficiently accurate for most purposes. Lasley and Kline (40) reported the importance of using the same side if only one side of a pork carcass is to be evaluated. The reliability of using only one side is reduced by cutting and splitting errors. They found that the left side yielded heavier loin, ham, picnic, total lean, and primal cuts; but lighter weight belly and Boston butt. Ham weight is the most reliable wholesale cut for predicting total lean cuts.

Kline and Hazel (34) studied loin eye area measured at the tenth and last rib and found little difference in the accuracy for predicting lean cuts. The area at the last rib was more highly related to percent loin than the tenth rib area. No differences were found between the two sides of the carcass.

Pearson <u>et al.</u> (49) obtained a correlation a correlation coefficient of (-.60) between the lean-fat ratio with percent lean cuts, (-.59) with specific gravity of the carcass and (-.53) with loin eye area. Fredeen <u>et al.</u> (17) reported that the area of lean in the approximal face of the ham was a more reliable index in estimating carcass leanness than loin eye area at the last rib.

These same workers also noted that gilts were superior to barrows in carcass leanness. Similar results were obtained by Herbert and Crown (27). They observed that gilt carcasses yielded a higher percentage of ham, loin, larger loin eye area and a higher percentage of separable lean in the hams than barrows.

Knapp and Nordskag (36) reported that grade and certain carcass characteristics are inherited. They estimated the heritability of slaughter grade to be 63 percent, carcass grade 84 percent, dressing percentage 1 percent, and area of loin eye 59 percent.

Schott <u>et al.</u> (53) recorded somewhat different estimates for inherited characteristics. In their work with beef type and milking Shorthorn steers the heritability percentages of slaughter grade was 38 percent, carcass grade 52 percent, and dressing percentage 39 percent. In addition Schott and coworkers found height at withers to be 100 percent, height at floor of chest 83 percent, circumference of foreflank 58 percent, width of shoulder and length of body, each 0. These workers observed heritability estimates for length of body to be in agreement with Dawson et al. (15), who found slaughter grade to be 58.3 percent, carcass grade 66.7 percent, dressing percentage 69.1 percent, and circumference at foreflank 32.3 percent inheritable. They also estimated the heritability of the width between the eyes to be 63.1 percent, width of muzzle 50 percent, and circumference of shin bone 33.5 percent. Knapp and Nordskag (36) concluded that although there seems to be less heritability in the measures of quality than in measures of growth there is an indication of ample opportunity for selection on the basis of these measurements.

Black et al. (6) found the height at withers to be one of the best measures of performance. The highest correlation was obtained between a ratio of weight to height at withers with performance factors. This was higher than any of the other ratios studied. He found the correlation coefficient between length of body and efficiency of gain or average daily gain to be higher than height at withers.

Black et al. (6) found slaughter grade to have a higher association with beef type than any other ratio of measurements.

Steers which had large increases in circumference of chest during the feeding period were those which made the greatest daily gains, as shown by Severson and Gerlough (54). A correlation coefficient of (.221) was found between the circumference at the rear flank, which was taken at the beginning of the feeding period, and the gain which individual steers made during the feeding period. The circumference of chest and height of withers was significantly correlated

(.621) with feed-lot gains. Cook et al. (14) stated that steers which made higher average daily gains, tended to produce higher carcass grades than those with lower average daily gains.

Yao et al. (62) found birth weights to have a positive correlation with most of the height and length measurements. A high birth weight resulted in a younger weaning age and less days to final weight. The correlation coefficient between head measurements, width between eyes, length of nose and width of muzzle; width and circumference of body measurements; were negative with efficiency of feed utilization and average daily gains.

With milking Shorthorn steers Kohli et al. (37) found the circumference of fore flank gave the best relationship to the measures of performance for the selection of breeding animals.

Lush (42) measured 185 steers at the beginning and close of the feeding period to determine objectively how an animal's conformation may change during intense fatting. He found chest width to have the highest percent increase (9.29%) in relation to live weight. Height over withers changed in a negative manner (-5.68%) in relation to live weight. In general animals increased more in width of body than in either length or depth.

EXPERIMENTAL PROCEDURE

The data in this study were obtained from 30 Hereford steers and 53 Hereford heifers. The steer data were collected at the termination of an experiment designed to study the effects of stilbestrol implants in calves fed a wintering-type ration, while the heifer data were collected after removing them from an experiment designed to study the effects of stilbestrol fed to spayed and non-spayed calves on roughage rations. The age of the steers ranged from approximately 18 to 20 months and the heifers from 16 to 18 months. Live weight of the heifers varied from 685 to 880 pounds, and from 800 to 1100 pounds for the steers.

The day prior to termination of the experiment the cattle were subjected to nine live-animal measurements. Linear measurements were obtained by placing the animal in a portable restraining chute. Although closely confined, the cattle stood in a normal position. Measurements were obtained with large outside measuring calipers and a hard mason-like cord. The cord measurements were transferred and read from a flexible steel tape. All measurements were read to the nearest one-tenth inch.

The linear measurements were obtained as follows: The eye to eye measurement was taken from the outside of each eye socket with the calipers held parallel to the ground. The length from poll to muzzle measurement was obtained by measuring along the midline from the highest point of the poll to the anterior end of the muzzle parallel to the long axis of the front of the head. Width of the muzzle was measured at the hair line with the calipers held parallel to the ground. Circumference of the right metacarpus was taken midway between the knee and pastern by placing the cord tightly around the cannon. The point of intersection of the cord was marked with a finger and this length was transposed to a flexible steel tape. Circumference of the forearm was taken midway between the elbow and the knee in a similar manner. Width of round was measured while standing directly behind the animal at the widest point with the calipers held parallel to the ground. In length of round measurements the distal termenius of the fleshy part of the biceps femoris muscle shall be referred to as the bottom of the round. Length from the top of the tail head to bottom of the round was measured with the calipers while standing behind the animal. The cord was used to measure from the pin bone to the bottom of the round. This is essentially a measure of the bulge of the round. Circumference of the round was obtained by placing one end of the cord on the point of the pin bone and passing the other end between the legs going over the flank and back to the orginal point on the pin bone.

The following day the animals were weighted to the nearest five pounds. Immediately following weighing a visual estimation of bone size, degree of muscling, and visual grade were independently assigned each individual by a committee of six appraisers. The average of these scores was used for the analysis.

The scoring card was composed of 7 divisions for appraising. For example, the bone scores were: 1, very fine, 2, fine, 3, slightly fine, 4, medium, 5, slightly rugged, 6, rugged, and 7 very rugged. The visual estimation of muscling was recorded in a similar manner ranging from 1 to 7 with very light muscling scored as 1, and animals with greater degrees of muscling receiving higher numerical scores. Live grade was estimated to the nearest one-third of the grade. Numerical values were assigned to each one-third of a grade in accordance with the standards established by the Beef Evaluation Committee of the Reciprocal Meats Conference (5) 1957 for purposes of statistical analysis.

The cattle were shipped to a nearby Packing Company and slaughtered in accordance with standard packing plant procedure. After the carcasses had chilled 48 hours the right side of each carcass was ribbed between the 12th and 13th rib and the U.S.D.A. grade was assigned to each carcass by the area supervisor of the Federal grading service. A marbling and color score were obtained together with a pencil tracing of the longissimus-dorsi muscle and fat thickness at the 12th rib. Area of the longissimus-dorsi muscle was determined from the pencil tracing with a compensating polar planimeter. Fat thickness at the twelfth rib was measured as outlined by the Beef Evaluation Committee of the Reciprocal Meat Conference (3).

The carcasses were separated into the wholesale cuts as described by the Beef Evaluation Committee at the Reciprocal Meat Conference (4) with the following modifications. The rib was removed from the plate on a line parallel to and ten inches from the backbone. The brisket was removed parallel with the back on the same line as the shank. The shortloin was not separated from the sirloin. The rump was removed from the commercial round and the exposed semimembranosus, semitendinosus, and biceps femoris muscles were traced on the round portion. Area of these muscles was measured with the planimeter.

These data were statistically analyzed in accordance with the procedures for simple and partial correlations coefficients as outlined by Snedecor (56). Simple and partial correlations were calculated between all live-animal measurements, live-animal measurements with carcass characteristics and between all characteristics measured in the carcass. Partial correlations coefficients were calculated to determine the relationship between two characteristics independent of live weight. In the statistical analysis all coefficients were recorded to four digits, but were rounded to two places in the subsequent results and discussion in accordance with the rule suggested by Kelly (31).

RESULTS AND DISCUSSION

Correlations Between Live-Animal Measurements

Simple and partial correlation coefficients between live-animal measurements of steers and heifers are presented in Tables 1 and 2 respectively. In general, correlations between live-animal measurements were lower for steers than for heifers. Simple correlations, (.45) and (.34), between eye to eye and poll to muzzle measurements were the only head measurements, among those taken, which were significant in steers and heifers respectively. This relationship

Table 1. Simple and partial correlation coefficients between live-animal characteristics of steers.

	E. - E.	P. - M.	W.M.	C.F.C.	C.F.	W.Rd.	L.TH.-B.Rd.	L.PB.-B.Rd.	C.Rd.	B.A.	M.A.	L.Wt.
P. - M.	.45 * (.31)											
W.M.	.36 * (.35)	.26 (.24)										
C.F.C.	-.18 (-.96)**	.29 (-.02)	.10 (.04)									
C.F.	.28 (-.16)	.14 (-.01)	.45 * (.44)*	.30 (.16)								
W.Rd.	.42 * (.23)	.34 (.17)	.20 (.17)	.24 (.25)	.12 (-.07)							
L.TH.-B.Rd.	.24 (-.04)	.22 (-.02)	-.06 (-.14)	-.17 (-.18)	.08 (.19)	.29 (-.01)						
L.PB.-B.Rd.	.31 (-.07)	.26 (-.05)	.19 (.16)	.06 (.05)	.36 * (.15)	.33 (-.03)	.78 ** (.64)**					
C.Rd.	.19 (-.04)	.10 (-.10)	.02 (-.03)	-.30 (-.36)	.28 (.01)	.12 (-.13)	.58 ** (.44)*	.60 ** (.46)*				
B.A.	-.004 (.02)	-.07 (-.05)	.02 (.02)	.32 (.32)	-.01 (.004)	.32 (.39)*	-.06 (-.04)	.02 (.08)	.09 (.12)			
M.A.	.04 (-.06)	-.39 * (-.52)**	.05 (.04)	.17 (.12)	.21 (.14)	.17 (.10)	.06 (.06)	.12 (.004)	.21 (.15)	.57 ** (.60)**		
L.G.	.05 (.03)	-.14 (-.14)	.06 (.06)	-.07 (.001)	-.06 (-.09)	-.10 (-.14)	.22 (.02)	.09 (.01)	.18 (.29)	.25 (.27)	.44 * (.44)*	.06
L.Wt.	.50 **	.41 *	.10	.04	.36 *	.50 **	.58 **	.71 **	.44 *	-.05	.18	

Simple correlation coefficients not in parenthesis
Partial correlation coefficients are in parenthesis
** $P < 0.01$
* $P < 0.05$

Codes for live-animal measurements

E. - E.	-----	Eye to eye (head, measurement of width)
P. - M.	-----	Poll to muzzle (head, measurement of length)
W.M.	-----	Width of muzzle
C.F.C.	-----	Circumference of forecannon
C.F.	-----	Circumference of forearm
W.Rd.	-----	Width of round
L.TH.-B.Rd.	-----	Length from tailhead to bottom of round
L.PB.- B.Rd.	-----	Length from pinbone to bottom of round
C.Rd.	-----	Circumference of round
B.A.	-----	Bone appraisal
M.A.	-----	Muscling appraisal
L.G.	-----	Live grade
L.Wt.	-----	Live weight

Table 2. Simple and partial correlation coefficients between live-animal characteristics of heifers.

	E. - E.	P. - M.	W.M.	C.F.C.	C.F.	W.Rd.	L.TH.-B.Rd.	L.PB.-B.Rd.	C.Rd.	B.A.	M.A.	L.Wt.
P. - M.	.34 * (.23)											
W.M.	.11 (.01)	.15 (-.01)										
C.F.C.	.26 (.14)	.31 * (.08)	.46 ** (.36)**									
C.F.	.37 ** (.27)*	.37 ** (.16)	-.06 (-.29)*	.31 * (.10)								
W.Rd.	.09 (.05)	-.06 (-.21)	.12 (.08)	.05 (-.03)	.21 (.14)							
L.TH.-B.Rd.	.43 ** (.34)*	.26 (-.03)	-.13 (-.34)*	.15 (-.10)	.47 ** (.29)*	.28 * (.01)						
L.PB.-B.Rd.	.46 ** (.42)**	.28 * (.21)	-.09 (-.17)	.17 (.08)	.38 ** (.33)*	.24 (.21)	.59 ** (.54)**					
C.Rd.	.37 ** (.29)*	.19 (.01)	-.01 (-.09)	.25 (.09)	.42 ** (.30)*	.27 * (.23)	.54 ** (.59)**	.76 ** (.75)**				
B.A.	.15 (.02)	.28 * (.08)	.17 (.03)	.61 ** (.51)**	.28 * (.08)	-.04 (-.12)	.14 (-.08)	.15 (.07)	.19 (.04)			
M.A.	.14 (-.06)	.15 (-.23)	.14 (-.06)	.34 * (.04)	.32 * (.05)	.05 (-.07)	.29 * (.01)	.20 (.10)	.31 * (.13)	.18 (.09)		
L.G.	.16 (.02)	.10 (-.18)	.06 (-.10)	.13 (-.12)	.35 ** (.16)	.05 (-.02)	.25 (.04)	.16 (.07)	.24 (.09)	.46 ** (.32)*	.81 ** (.75)**	.46 **
L.Wt.	.30 *	.51 **	.32 *	.50 **	.48 **	.16	.46 **	.21	.35 **	.44 **	.61 **	

Simple correlation coefficients not in parenthesis
Partial correlation coefficients are in parenthesis
** $P < 0.01$
* $P < 0.05$

<u>Codes for live-animal measurements</u>

E. - E. ----- Eye to eye (head, measurement of width)
P. - M. ----- Poll to muzzle (head, measurement of length)
W.M. ----- Width of muzzle
C.F.C. ----- Circumference of forecannon
C.F. ----- Circumference of forearm
W.Rd. ----- Width of round
L.TH.-B.Rd. ----- Length from tailhead to bottom of round
L.PB.-B.Rd. ----- Length from pinbone to bottom of round
C.Rd. ----- Circumference of round
B.A. ----- Bone appraisal
M.A. ----- Muscling appraisal
L.G. ----- Live Grade
L.Wt. ----- Live weight

indicated that longer headed animals were also wider between the eyes. The eye to eye measurement was significantly correlated (.36) with width of muzzle in steers, but the partial correlation (.35) only approached statistical significance. Other simple and partial correlation coefficients between head measurements were positive, but low. Among heifers of similar weight, eye to eye measurement, correlated with such measurements as circumference of round (.37), tailhead to bottom of the round (.43), and pinbone to bottom of the round (.46) were highly significant. The partial correlation (.42) between eye to eye with length from pinbone to bottom of round was highly significant; length from tailhead to bottom of round (.34) and circumference of round (.29) were significant. This would tend to indicate that heifers which were wide between the eyes also possessed large round measurements. Lush (43) stated that a narrow head at the eyes was one of the important measurements for high dressing percent and meat value. In steers, only the width of the round was significantly correlated (.42) with width between the eyes before the effect of weight was removed. In contrast to heifers, partial correlations between these measurements for steers were negative except for width of the round. There were no significant correlations in steers, between poll to muzzle and circumference of forecannon, forearm, and all round measurements. In heifers, the simple correlation coefficient between poll to muzzle and circumference of forearm was highly significant (.37). Also, poll to muzzle was significantly correlated with circumference of forecannon (.31) and length from pinbone to bottom of the round (.28). Simple (.46) and partial (.36) correlation coefficients between width of muzzle and circumference of forecannon in heifers were highly significant. Significant, negative, partial correlations were found between width of muzzle and circumference of forearm (-.29) and length from tailhead to bottom of the round (-.34), for heifers. Among steers, only the simple (.45) and partial (.44) correlations between width of muzzle and circumference of forearm were significant. A significant, negative, coefficient (-.39) was found between the length from poll to muzzle and muscle appraisal for steers. When the effect of weight was removed the correlation was highly significant (-.52). In general, head measurements had a very low predictive value for other live-animal measurements. However, the eye to eye measurement indicated some promise as a tool for selection in heifers, particularly for round measurements.

There were no significant correlations between circumference of forecannon and any of the other live-animal characteristics of steers. However, the partial correlation between circumference of the forecannon and circumference of the round was approaching statistical significance (-.36). In addition, length from pinbone to bottom of the round was the only measurement in steers significantly correlated with circumference of forearm (.36). Among heifers, circumference of forearm was significantly correlated (.31) with circumference of forecannon before the effect of weight was removed. The partial coefficient was low (.10). Although heifers were significant, in general, these results do not agree with those of Weseli (57). He found that a large live cannon circumference was highly correlated with a large forearm measurement even among steers of similar weight. This is in accord with McMeekan (44), who suggested that shorter, thicker boned steers tended to be heavier muscled. Highly significant simple correlation coefficients were obtained between circumference of forearm and length from tailhead to bottom of the round (.47), length from pinbone to bottom of the round (.38), and circumference of the round (.42) in heifers. When the effect of weight was removed the coefficients were lowered to (.29), (.33), and (.30) for the respective muscles, but remained significant. Highly significant correlation coefficients (.61 and .51, simple and partial respectively) were obtained between bone appraisal and forecannon circumference for heifers. The same relationships were approaching statistical significance in steers, (.32 for both correlations). These data would indicate that large cannon circumference was associated with the appraisers estimations of large bone.

Round measurements were highly correlated with each other, among both steers and heifers, except width of round. Among steers, round width was not significantly correlated with any of the other round measurements. Simple correlation coefficients between width of round with length from tailhead to bottom of the round (.28) and circumference of the round (.27) were significant in heifers. The correlations independent of live weight were not significant. Among heifers, simple correlation coefficients between length of tailhead to bottom of the round with length from pinbone to bottom of the round (.59) and circumference of the round (.54) were highly significant. Correlations independent of live weight .54 and .59 respectively were likewise highly significant for these measurements. Simple correlations among steers, between length from pinbone to bottom of the round, length from tailhead to bottom of the round (.78), and circumference of the round (.58) were highly significant. The partial correlation (.64) was highly significant between length from pinbone to bottom of the round and significant (.44) with circumference of the round. Simple (.76) and partial (.75) correlation coefficients were highly significant between length from pinbone to bottom of the round and circumference of the round for heifers. The same correlations for measurements among steers were also highly significant. The simple .60 and partial .46. These high coefficients among round measurements would be expected since they are essentially measuring the same muscles.

Highly significant simple (.57) and partial (.60) correlation coefficients were found between bone and muscle appraisal in steers. Steers which had high bone scores tended to be scored high in muscling. Similar correlations for heifers were low.

Among heifers, the correlation coefficient (.46) between bone appraisal and live grade was highly significant (.46) and significant (.32) when the effect of weight was removed. Live grade among steers was significantly correlated (.44) with muscling appraisal. There were no differences between the simple and partial (.44) correlations. Simple (.81) and partial (.75) correlations between live grade and muscle appraisal were highly significant for heifers. These results indicate that judges place considerable emphasis upon muscling when estimating live cattle grades.

Simple correlations between live weight, bone (.44) and muscle (.61) appraisal were highly significant for heifers, but not significant (-.05) and (.18) for steers. This would indicate that judges were more accurate in their estimation of bone and muscle as live weight increased in heifers, but that weight was not as an important a factor for steers. Live weight was generally well correlated with live measurements in both steers and heifers. This seems logical since it would be expected that as live weight increased the live measurements would also increase.

Correlations Between Live-Animal Measurements And Carcass Characteristics

The simple and partial correlation coefficients between live-animal measurements and carcass characteristics of steers and heifers are presented in Tables 3 and 4, respectively. In general, correlations between head measurements and carcass characteristics in both steers and heifers were low and not significant. The simple correlation between the eye to eye measurement and the area of biceps femoris muscle (.27) was significant in heifers. The area of the semimembranosus muscle was the only carcass characteristic significantly correlated

Table 3. Simple and partial correlation coefficients between live-animal and carcass characteristics of steers.

	E. - E.	P. - M.	W.M.	C.F.C.	C.F.	W.Rd.	L.T.H.-B.Rd.	L.P.B.-B.Rd.	C.Rd.	B.A.	M.A.	L.Wt.
C.G.	.03 (-.04)	-.08 (-.15)	.02 (.01)	-.04 (-.04)	-.08 (-.14)	.24 (.20)	-.06 (-.16)	-.09 (-.18)	.20 (.16)	.28 (.29)	.30 (.29)	.13
M.S.	.09 (.04)	-.07 (-.13)	-.01 (-.02)	-.01 (-.02)	-.06 (-.11)	.21 (.18)	-.06 (-.15)	-.12 (-.29)	.18 (.15)	.27 (.27)	.27 (.26)	.11
A.L.D.	.38 * (.32)	-.02 (-.13)	.20 (.18)	-.14 (-.15)	.35 (.30)	.15 (.04)	-.15 (-.34)	.04 (-.18)	.18 (.09)	-.02 (-.01)	.48 ** (.46)**	.23
F.T.	-.11 (-.39)*	.04 (-.15)	-.11 (-.17)	-.06 (-.08)	.02 (-.15)	.23 (.04)	.24 (.02)	.29 (.02)	.08 (-.11)	-.02 (-.05)	.21 (.16)	.40*
A.S.M.	-.02 (-.02)	-.19 (-.20)	.09 (.09)	-.03 (-.03)	-.14 (-.16)	.15 (.17)	.09 (.11)	-.17 (-.23)	-.04 (-.05)	-.28 (-.30)	-.18 (-.18)	-.01
A.S.T.	.08 (.02)	-.20 (-.28)	.35 (.34)	.10 (.09)	.12 (.09)	.07 (.01)	.28 (.25)	.21 (.17)	.15 (.12)	.07 (.001)	.40 * (.38)*	.13
A.B.F.	.35 (.07)	.30 (.08)	.15 (.10)	.03 (.01)	.54 ** (.44)*	.11 (-.27)	.35 (.02)	.50 ** (.14)	.37 * (.14)	-.18 (-.19)	.12 (.007)	.60**
% In.	.02 (-.12)	.13 (.03)	.03 (-.01)	-.22 (-.24)	.37 * (.26)	-.007 (.14)	.06 (-.11)	.31 (.19)	.23 (.14)	-.14 (-.13)	.02 (-.03)	.26
% Rb.	-.06 (-.09)	-.25 (-.30)	-.18 (-.18)	.17 (.17)	-.11 (-.13)	.16 (.16)	-.25 (-.33)	-.34 (-.53)**	-.13 (-.12)	.13 (.13)	.24 (.24)	.04
% Ck.	.31 (.39)*	.15 (.19)	.19 (.20)	.11 (.11)	-.14 (-.14)	.07 (.04)	.11 (.10)	-.001 (.08)	-.17 (-.22)	.06 (.06)	-.15 (-.15)	-.05
% Rp.	-.05 (.04)	-.20 (-.14)	.05 (.07)	.06 (.07)	-.01 (-.08)	-.21 (-.35)	-.01 (-.13)	.004 (-.17)	-.20 (-.33)	-.38 * (-.39)*	-.15 (-.12)	-.17
% C.Rd.	-.19 (.09)	-.02 (.24)	.24 (.34)	-.06 (-.05)	.07 (-.13)	-.38 * (-.35)	-.01 (.001)	-.12 (.15)	-.11 (.14)	-.12 (-.11)	-.26 (.19)	-.51**
% T.WS.C.	.03 (.25)	.06 (.24)	.48 ** (.59)**	.07 (.09)	.25 (.38)*	-.15 (.02)	-.16 (.04)	-.16 (.18)	-.17 (-.003)	-.20 (-.24)	-.22 (-.17)	-.34

Simple correlation coefficients not in parenthesis
Partial correlation coefficients are in parenthesis
** $P < 0.01$
* $P < 0.05$

Codes for live-animal and carcass characteristics appear on page 24

Table 4. Simple and partial correlation coefficients between live-animal and carcass characteristics of heifers.

	E. - E.	P. - M.	W.M.	C.F.C.	C.F.	W.Rd.	L.T.H.-B.Rd.	L.P.B.-B.Rd.	C.Rd.	B.A.	M.A.	L.Wt.
C.G.	-.04	-.16	-.09	-.20	-.11	.03	-.11	-.19	-.04	-.26	.15	-.01
	(-.04)	(-.19)	(-.09)	(-.22)	(-.12)	(.03)	(-.12)	(.20)	(-.04)	(-.28)	(.20)	
M.S.	.03	-.13	-.07	-.18	-.02	.08	.01	.10	.002	-.25	.19	.05
	(.01)	(-.18)	(-.09)	(-.24)	(-.05)	(.08)	(-.02)	(.09)	(-.02)	(-.28)*	(.20)	
A.L.D.	.13	.08	.04	.20	.17	.39 **	.42 **	.33 *	.37 **	.07	.26	.24
	(.06)	(-.04)	(-.03)	(.10)	(.07)	(.37)**	(.36)**	(.29)*	(.32)*	(-.04)	(.15)	
F.T.	-.04	.09	-.14	-.21	.09	-.05	-.02	-.10	-.06	-.15	.27 *	.20
	(-.13)	(-.01)	(-.22)	(-.37)**	(-.01)	(-.09)	(-.14)	(-.14)	(-.14)	(-.07)	(.19)	
A.S.M.	.01	.22	.29 *	.12	-.06	.20	.02	.20	.22	-.17	.03	.07
	(-.01)	(.22)	(.28)*	(.10)	(-.11)	(-.10)	(-.01)	(.19)	(.21)	(-.22)	(-.02)	
A.S.T.	.14	.38 **	.14	.28 *	.27 *	.24	.26	.33 *	.42 **	.16	.37 **	.40**
	(.02)	(.23)	(.02)	(.11)	(.10)	(.19)	(.09)	(.30)*	(.32)*	(-.02)	(.18)	
A.B.F.	.27 *	.31 *	.19	.27 *	.46 **	.17	.46 **	.37 **	.42 **	.36 **	.47 **	.62**
	(.11)	(.002)	(-.01)	(-.10)	(.24)	(.10)	(.25)	(.35)**	(.28)*	(.12)	(.16)	
% In.	-.14	-.18	-.19	-.27 *	-.02	-.08	.12	-.09	-.004	-.27 *	-.10	-.06
	(-.12)	(-.25)	(-.18)	(-.27)*	(.01)	(-.07)	(.17)	(-.12)	(.02)	(-.27)*	(-.08)	
% Rb.	-.16	-.29 *	.01	-.03	-.25	-.20	-.20	-.24	-.17	.07	.01	-.15
	(-.12)	(-.43)**	(.06)	(.06)	(-.21)	(-.18)	(-.15)	(-.24)	(-.13)	(.16)	(.13)	
% Ck.	.25	.34 *	.01	.26	.22	-.04	.08	-.01	-.07	.08	.08	.14
	(.22)	(.31)*	(-.04)	(.22)	(.18)	(-.06)	(.01)	(.02)	(-.13)	(.02)	(.01)	
% Rp.	.20	.31 *	.14	.41 **	.18	.25	.37 **	.47 **	.52 **	.14	.14	.27*
	(.12)	(.21)	(.06)	(.33)*	(.06)	(.22)	(.29)*	(.44)**	(.47)**	(.03)	(-.03)	
% C.Rd.	.14	.14	-.03	.38 **	-.01	.14	.24	.29 *	.34 *	.46 **	.10	.12
	(.07)	(.09)	(-.08)	(.37)**	(-.07)	(-.12)	(.21)	(.27)*	(.32)*	(.46)**	(.03)	
% T.WS.C.	.15	.13	-.12	.34 *	.03	-.04	.23	.09	.17	.44 **	.09	.11
	(.12)	(.08)	(-.16)	(.34)*	(-.03)	(-.06)	(.21)	(.07)	(.14)	(.44)**	(.03)	

Simple correlation coefficients not in parenthesis
Partial correlation coefficients are in parenthesis
** P $<$ 0.01
* P $<$ 0.05

Codes for live-animal and carcass characteristics appear on page 24

Codes for live-animal and carcass characteristics

1.	E.-- E.	-----	Eye to eye (head, measurement of width)
2.	P.-- M.	-----	Poll to muzzle (head, measurement of length)
3.	W.M.	-----	Width of muzzle
4.	C.F.C.	-----	Circumference of forecannon
5.	C.F.	-----	Circumference of forearm
6.	W. Rd.	-----	Width of round
7.	L.TH.-B.Rd.	-----	Length from tailhead to bottom of round
8.	L.PB.-B.Rd.	-----	Length from pinbone to bottom of round
9.	C.Rd.	-----	Circumference of round
10.	B.A.	-----	Bone appraisal
11.	M.A.	-----	Muscling appraisal
12.	L.G.	-----	Live grade
13.	L.Wt.	-----	Live weight
14.	C.G.	-----	Carcass grade
15.	M.S.	-----	Marbling score
16.	A.L.D.	-----	Area of longissimus dorsi muscle
17.	F.T.	-----	Fat at twelfth rib
18.	A.S.M.	-----	Area of semimembranosus muscle
19.	A.S.T.	-----	Area of semitendinosus muscle
20.	A.B.F.	-----	Area of biceps femoris muscle
21.	% Ln.	-----	Percent loin
22.	% Rb.	-----	Percent rib
23.	% Ck.	-----	Percent chuck
24.	% Rp.	-----	Percent rump
25.	% C.Rd.	-----	Percent commercial round
26.	% T.WS.C.	-----	Percent total wholesale cuts

with width of muzzle in heifers. The simple (.29) and partial (.28) correlations were significant. For heifers, the simple correlation coefficients between the poll to muzzle measurement with area of semitendinosus and biceps femoris muscles were highly significant (.38) and significant (.31) respectively. However, the partial correlations (.23) (.002) were low and for the biceps femoris muscle was essentially zero. In steers there were no significant correlations between the poll to muzzle measurement and any of the carcass characteristics studied. The simple correlation (.38) for steers, between the eye to eye measurement and area of longissimus dorsi muscle was significant. Also significant was the correlation between the eye to eye measurement and fat at the twelfth rib (-.39). The percentage wholesale cuts except percent chuck either individually or combined were not significantly correlated with the eye to eye and width of muzzle measurements in steers. In heifers, the poll to muzzle measurement was significantly correlated with the percentages rib (-.29), chuck (.34), and rump (.31). The partial correlation between poll to muzzle and percentage rib (-.43) was highly significant, but only significant (.31) with percentage chuck. The percentage chuck was the only wholesale cut significantly correlated (.39) with the eye to eye measurement in steers. Simple (.48) and partial (.59) correlations between width of muzzle and percentage total wholesale cuts were highly significant in steers. The same coefficients for heifers were negative and low. It may be concluded from these data that head measurements had little value as a predictive measure for muscling characteristics or percentage wholesale cuts either individually or combined.

Circumference of forecannon and forearm were not significantly correlated with area of the longissimus dorsi muscle in either steers or heifers. Weseli (57) obtained highly significant correlations between these same measurements and area of the longissimus dorsi muscle; however, among steers of similar weight the coefficients were not significant. The simple and partial correlations between fat thickness at the twelfth rib with forecannon and forearm circumference in steers, were not significant. These results concur with correlations obtained by Weseli (57). Only the partial correlation between forecannon circumference and fat at the twelfth rib of heifers was significant (-.37). In heifers, area of the semitendinosus muscle was also significantly correlated with circumference of forearm and forecannon. However, the partial correlations for the same measurements were not significant. In heifers the simple correlations between area of the biceps femoris muscle and circumference of the forearm (.46) and forecannon (.27) were highly significant and significant respectively. For steers, simple and partial correlations coefficients were highly significant (.54) and significant (.44) respectively, between forearm circumference and area of the biceps femoris muscle.

None of the wholesale cut percentages were significantly correlated with circumference of forecannon in steers, nor with circumference of forearm in heifers. Forecannon circumference was significantly, negatively, correlated (-.27) with percentage loin among heifers. Weight did not effect the coefficient. The simple (-.22) and partial (-.24) correlations for the same measurements in s teers were not significant. The correlation coefficient (.37) between circumference of forearm and percentage loin was also significant for steers prior to correcting for weight difference. The same measurements for heifers were essentially zero. Simple correlation coefficients for heifers between circumference of the forecannon, with percentage rump (.41) and with percentage commercial round (.38) were highly significant. The partial correlation (.37) between forecannon circumference with percentage commercial round was highly significant, but the coefficient with percentage rump was only (.33) significant at the 5 percent level. The simple and partial correlations between percentage total wholesale cuts and forecannon circumference among heifers were identical (.34) and significant. These results indicate that as size of forecannon increased in heifers the percentage rump and round, as well as total wholesale cuts increased. Live weight had little or no effect upon the coefficients.

Carcass grade and marbling score were not significantly correlated either simple or partial, with any live steer measurements. Bone appraisal independent of live weight was the only significant correlation with carcass grade and marbling score, both coefficients were (-.28). For heifers, highly significant simple correlation coefficients were obtained between area of the longissimus dorsi muscle and width of round (.39) length from tailhead to bottom of the round (.42), and circumference of the round (.37). Correlations between width of round (.37), length from tailhead to bottom of the round (.36), with area of the longissimus dorsi muscle independent of live weight were highly significant. Simple (.33) and partial (.29) correlations between area of the longissimus dorsi muscle and length from pinbone to bottom of the round were significant. In contrast to heifers, correlation coefficients between area of the longissimus dorsi muscle and all round measurements for steers were low and not significant. In general, correlation coefficients between round measurements of steers and all carcass characteristics were low and not significant. Width of round had the least predictive value of any of the live measurements taken in both steers and heifers for percentage wholesale cuts. Among the wholesale cuts only percentage commercial round was significantly correlated (-.38) with width of round for steers. The partial correlation also negative was approaching statistical significance, but in heifers both the simple and partial coefficients were low and not significant. These data indicate, at least for steers, that percentage round decreased as round width increased. Therefore, percentage round is probably influenced to a greater degree by length rather than width. This will become evident when the correlation between percentage round and length from the tailhead to the bottom of round is discussed. These results are not in agreement with the findings of White and Green (58). They stated that for predicting weight of wholesale cuts of carcasses, width and depth measurements were more important than length measurements. In the present study round measurements other than width, indicated some possibilities for predicting muscling and percentage wholesale cuts, especially in heifers.

Among steers, many of the correlations between round measurements and percentage wholesale cuts, were low and negative. For heifers, the same correlations were positive for the most part. With steers, the partial correlation (-.53) between length from the pinbone to bottom of the round and percentage rib was the only significant correlation found between round length and circumference measurements with percentages of the wholesale cuts. Among heifers, simple correlations for percentage rump with round measurements were: circumference of the round, (.52); length from tailhead to bottom of the round, (.37); and length from pinbone to bottom of the round, (.47). These coefficients were all highly significant. Highly significant partial correlations were obtained for percentage rump with length from pinbone to bottom of the round, (.44) and circumference of the round, (.47); length from tailhead to bottom of the round was significant, (.29) at the 5 percent level. The simple correlation coefficients between percentage commercial round with length from pinbone to bottom of the round, (.29) and circumference of the round, (.34) were significant for heifers. These coefficients were only slightly lower, (.27 and .32, respectively) when the effect of weight was removed. These data reveal that length had a greater influence than width upon percentage round.

Among heifers the simple correlation coefficients between area of the biceps femoris muscle with length from pinbone to bottom of the round (.37), tailhead to bottom of the round (.46), and with circumference of the round (.42) were highly significant. The simple correlation in steers between length from pinbone to bottom of the round and area of the biceps femoris muscle (.50) was highly significant. However, only the partial correlations between the area of the biceps femoris muscle with the length from pinbone to bottom of the round (.35) and circumference of round (.28) were significant for steers. Area of the semitendinosus muscle in heifers was significantly correlated with length from the pinbone to bottom of the round (.33) and highly significantly with circumference of the round (.42). The partial coefficients between area of the semitendinosus muscle with length from the pinbone to the bottom of the round and with circumference of the round were lower (.30 and .32, respectively), but likewise significant. The area of the biceps femoris muscle was more consistently significantly correlated with live-animal and carcass characteristics than any other muscle measured, including the longissimus dorsi muscle.

Green (18) found live weight to be more closely associated with weight of wholesale cuts than any other live-animal measurements. In the present study correlations were calculated between live weight and percentages of wholesale cuts instead of with the weight of the cuts. This would account for the coefficients being low and not significant. Among steers, however, the correlation coefficient between live weight and percentage commercial round -.51 was highly significant. This indicates that as live weight increased percentage commercial round decreased. The correlation between live weight and percentages total wholesale cuts was approaching statistical significance (-.34). The same coefficients for heifers were low. The correlation between percentage round and carcass weight in steers was also (-.51). These relationships concur with those of Pierce (51), who found percentage round to be inversely proportional to weight.

As live weight increased the area of the biceps femoris muscle also increased; the correlations were highly significant for both steers (.60) and heifers (.62). The correlations between live weight and other muscle areas were all low and not significant for steers; while with heifers, the area of the semitendinosus was highly significantly correlated (.40) with live weight.

Neither bone nor muscling appraisal were well correlated with carcass characteristics for either steers or heifers. Among the carcass characteristics determined in steers, only percentage rump was significantly correlated with bone appraisal either before (-.38) or after (-.39) the effect of weight was removed. Among heifers of similar weight, correlations for bone appraisal with percentage commercial round (.46), and percentage total wholesale cuts (.44) were highly significant. Percentage loin was significantly correlated (-.27) with bone appraisal. The coefficients for simple and partial correlations were the same for each of the above coefficients, indicating that weight was not a factor in the judges appraisal. The only muscle area associated with bone appraisal was the biceps femoris muscle. The simple correlation coefficient (.36) was highly significant; whereas, the partial (.12) was not significant.

Muscling appraisal was highly correlated with area of the longissimus dorsi muscle. Difference between the simple (.48) and partial (.46) correlations were small. The same coefficients were not significant for heifers. Simple (.40) and partial (.38) correlations between muscling appraisal and area of the semitendinosus muscle of steers was significant. The simple correlations between muscling appraisal and areas of the semitendinosus (.37) and biceps femoris (.47) muscles were highly significant. Partial coefficients for these measurements were low. These results indicate that subjective appraisal is not a very reliable estimate for most carcass characteristics in either steers or heifers.

Correlations Between Carcass Characteristics

Simple and partial correlation coefficients between carcass characteristics of steers and heifers are presented in Table 5 and 6 respectively. The simple correlation between the longissimus dorsi muscle and average fat thickness at the twelfth rib was not significant for carcass of steers (-.11) or heifers (-.22). In heifers the partial correlation (-.40) was negative and highly significant; however, in steers the partial correlation, also negative, was not significant (-.31). These data substantiate the findings of Clifton and Shepherd (13) and Weseli (57) who reported that animals with large "loin eye's" tended to carry less outside fat.

The correlation coefficients, independent of live weight, between the area of the longissimus dorsi muscle with the area of the semitendinosus (-.002) (.20), semimembranosus (-.13) (.25), and biceps femoris (.40) (.08) muscles of the round among steers and heifers respectively, were surprisingly low. It was anticipated that these measurements might be highly correlated to validate the general assumption that the area of the longissimus dorsi muscle is a reliable expression of muscling throughout the carcass. While this may be true, the area of the longissimus dorsi muscle was not highly correlated with the area of the round muscles measured in this study. This may possibly be attributed to the relative size of the muscles at the location of the measurement of these three round muscles, which was immediately posterior and parallel to the aitch bone. The biceps femoris was the only muscle of the round in steer carcasses which was significantly correlated with area of the longissimus dorsi muscle. Both the simple (.48) and partial (.40) correlations indicate that as area of the longissimus dorsi muscle increased, area of the biceps femoris muscle in the round also increased. In heifer carcasses, the correlation between area of the

Table 5. Simple and partial correlation coefficients between carcass characteristics of steers.

	A.L.D.	A.S.M.	A.S.T.	A.B.F.	C.G.	F.T.	% ln.	% Rb.	% Ck.	% Rp.	% C.Rd.	% T.WS.C.	M.S.
F.T.	-.11 (-.31)				.33 (.31)								
A.S.M.	-.12 (-.13)												
A.S.T.	.06 (-.002)	.20 (.20)											
A.B.F.	.48 ** (.40)*	-.26 (-.27)	-.04 (-.24)										
% ln.	.45 * (.39)*	-.36 * (-.39)*	-.28 (-.38)*	.51 ** (.40)*	-.003 (-.06)	.48 ** (.38)*							
% Rb.	.17 (.15)	-.03 (-.04)	-.18 (-.20)	-.20 (-.36)*	.49 ** (.51)**	.13 (.09)	-.05 * (-.09)*						
% Ck.	-.20 (-.16)	.29 (.30)	.11 (.14)	-.18 (-.10)	-.07 (-.05)	-.32 (-.29)	-.41 * (-.39)*	-.23 (-.22)					
% Rp.	-.29 (-.26)	.44 * (.45)*	.34 (.39)*	-.09 (.01)	-.21 (-.20)	-.001 (.09)	-.22 (-.18)	-.24 (-.23)	.15 (.13)				
% C. Rd.	-.07 (.08)	-.02 (-.01)	.09 (.22)	-.02 (.48)**	-.40 * (-.38)*	-.44 * (-.25)	-.16 (.01)	.36 * (-.35)*	.04 (.04)	.18 (.11)			
% T.WS.C.	.11 (.22)	.09 (.11)	.07 (.15)	.02 (.32)	-.14 (-.10)	-.26 (-.13)	.07 (.19)	-.05 (-.02)	.36 * (.33)	.22 (.19)	.67 ** (.62)**		
M.S.	-.01 (-.06)	.09 (.08)	.09 (.06)	-.35 (-.60)**	.95 ** (.95)**	.25 (.20)	-.03 (-.08)	.57 ** (.56)**	-.12 (-.10)	-.28 (-.27)	-.33 (-.32)	-.12 (-.08)	
S.Wt.	.29	.02	.20	.65 **	.14	.51 **	.34	.11	-.15	-.16	-.51 **	-.31	.14

Simple correlation coefficients not in parenthesis
Partial correlation coefficients are in parenthesis
** P < 0.01
* P < 0.05

<u>Codes for carcass characteristics</u>

A.L.D. ----- Area of longissimus dorsi muscle
A.S.M. ----- Area of semimembranosus muscle
A.S.T. ----- Area of semitendinosus muscle
A.B.F. ----- Area of biceps femoris muscle
C.G. ----- Carcass grade
F.T. ----- Fat at twelfth rib
% ln. ----- Percent loin
% Rb. ----- Percent rib
% Ck. ----- Percent chuck
% Rp. ----- Percent rump
% C.Rd. ----- Percent commercial round
% T.WS.C. ----- Percent total wholesale cuts
M.S. ----- Marbling score
S.Wt. ----- Side weight of carcass

Table 6. Simple and partial correlation coefficients between carcass characteristics of heifers.

	A.L.D.	A.S.M.	A.S.T.	A.B.F.	C.G.	F.T.	% In.	% Rb.	% Ck.	% Rp.	% C.Rd.	% T.WS.C.	M.S.
F.T.	-.22 (-.40)				.32 * (.30)*								
A.S.M.	.32 * (.25)												
A.S.T.	.38 ** (.20)	.69 ** (.69)**											
A.B.F.	.24 (.08)	-.16 (-.03)	.12 (-.27)*										
% In.	-.03 (-.02)	-.15 (-.15)	-.06 (-.05)	.11 (.17)	-.12 (-.11)	.14 (.16)							
% Rb.	.14 (.09)	-.11 (-.14)	-.27 * (-.24)	-.24 (-.21)	.31 * (.34)*	.001 (.04)	-.22 (-.23)						
% Ck.	-.16 (-.22)	-.10 (-.001)	.02 (.06)	.05 (.12)	-.11 (-.10)	.004 (.02)	-.23 (-.23)	-.18 (-.18)					
% Rp.	.32 * (.19)	.57 ** (.54)**	.57 ** (.50)**	.21 (-.004)	-.06 (-.01)	-.08 (-.18)	-.31 * (-.32)*	-.21 (-.36)**	.10 (.13)				
% C. Rd.	.17 (.19)	-.07 (-.07)	-.002 (-.01)	.36 ** (.46)**	-.28 * (-.29)*	-.28 * (-.30)*	-.22 (-.22)	-.30 ** (-.30)**	.13 (.13)	.40 ** (.41)**			
% T.WS.C.	.08 (.03)	-.19 (-.18)	-.12 (-.08)	.18 (.32)*	-.25 (-.28)	-.17 (-.15)	.13 (.13)	-.10 (-.07)	.58 ** (.57)**	.15 (.19)	.69 ** (.69)**		
M.S.	.31 * (.24)	.18 (.14)	.07 (-.04)	.05 (-.11)	.93 ** (.93)**	.23 (.18)	-.02 (-.01)	.21 (.25)	-.12 (-.11)	-.04 (-.12)	.32 * (.32)*	-.24 (-.23)	
S.Wt.	.46 **	.22	.48 *	.63 **	.14	.26	-.03	-.13	-.06	.33 *	.02	-.10	.21

Simple correlation coefficients not in parenthesis
Partial correlation coefficients are in parenthesis
** $P < 0.01$
* $P < 0.05$

<u>Codes for carcass characteristics</u>

A.L.D. ----- Area of longissimus dorsi muscle
A.S.M. ----- Area of semimembranosus muscle
A.S.T. ----- Area of semitendinosus muscle
A.B.F. ----- Area of biceps femoris muscle
C.G. ----- Carcass grade
F.T. ----- Fat at twelfth rib
% In. ----- Percent loin
% Rb. ----- Percent rib
% Ck. ----- Percent chuck
% Rp. ----- Percent rump
% C.Rd. ----- Percent commercial round
% T.WS.C. ----- Percent total wholesale cuts
M.S. ----- Marbling score
S.Wt. ----- Side weight of carcass

longissimus dorsi muscle and area of the biceps femoris muscle was not significant (.24). However, area of the longissimus dorsi muscle was significantly correlated with area of the semimembranosus (.32) and semitendinosus (.38) muscles before the effect of carcass weight was removed.

In general, the muscles measured in the round were not closely associated with each other. Only the correlation coefficient (.69) between the semitendinosus and semimembranosus muscles of heifer carcasses was significant. Carcass weight had no effect upon the correlation. The biceps femoris muscle in steer and heifer carcasses, although not significant, was negatively correlated with the other muscles of the round, which cannot be explained from the data collected in this study. Among steers, correlations for simple and partial coefficients respectively for biceps femoris were; semitendinosus, (-.04) and (-.24); and semimembranosus, (-.26) and (-.27). The same relationships among heifers were; semitendinosus, (.12) and (-.27); and semimembranosus (-.16) and (-.03). None of these correlations were statistically significant. ~~The~~

The areas of these three round muscles per one-hundred pounds of live weight were compared between steers and heifer carcasses. These data appear in Table 7. Differences between individual round muscles of both steers and heifers were small. There was essentially no difference between steer and heifer carcasses in the total area of the three round muscles measured. These combined areas of these three muscles of the round per one-hundred pounds live weight were; steers, 4.37 square inches; and heifers, 4.35 square inches respectively. This indicates that the area of these muscles of the round in heifers and steers of the same weight are approximately equal.

The correlation coefficients between the area of the longissimus dorsi muscle and percentages of the wholesale cuts were low. In steer carcasses percentage loin was the only wholesale cut significantly correlated (.45) with

Table 7. Fat thickness and muscle areas per 100 pounds live weight.

	Steers		Heifers	
	Measurement per 100 lb. Live-Wt.	S.D.[3]	Measurement per 100 lb. Live-Wt.	S.D.[3]
Fat Thickness, in.[1]	0.057	0.013	0.076	0.013
Area of Longissimus Dorsi, sq. in.[2]	1.06	0.11	1.21	0.14
Area of Semimembranosus Muscle, sq. in.[2]	1.82	0.64	1.71	0.46
Area of Semitendinosus Muscle, sq. in.[2]	0.68	0.12	0.61	0.13
Area of Biceps Femoris Muscle, sq. in.[2]	1.87	0.15	2.05	0.38
Total area of Round Muscles, sq. in.[2]	4.37	0.70	4.35	0.54

1. Fat at 12th rib ave. of 3 measurements. (Ave. total thickness of fat divided by live weight of each steer or heifer.)
2. Muscle areas are plamineter determined areas. (Total area divided by live weight for each steer or heifer.)
3. Sample standard deviation.

area of the longissimus dorsi muscle. Among carcasses of similar weight the coefficient was also significant (.39). However, in the case of heifer carcasses the correlation between percentage loin and area of the longissimus dorsi muscle was low (-.03).

It is generally conceded that as fat thickness increases over the loin the percentage loin increases. Pierce (51) explained that fat influences the yield of most cuts considerably more than conformation. He found that higher finish grade and greater depth of fat were associated with higher yields of short loin, rib, flank, brisket, plate, and hindquarter, but with lower yields of round, loin end, chuck, and foreshank. Hankins and Titus (25) found the proportions of rib, plate, rump, flank, and short loin in steers increased with fattening, while those of foreshank, round, and loin end decreased, and chuck changed little. In the present study, heifer carcasses revealed a low, but positive correlation coefficient (.16) between fat thickness at the twelfth rib and percentage loin. On the other hand, fat thickness in steer carcasses was highly, significantly correlated (.48) with percentage loin. The partial correlation coefficient, although lower (.38), was also significant. Thus, it appears percentage loin was influenced by fat thickness as well as muscle area. These differences between steer and heifer carcasses are difficult to explain, especially since heifers were found to have a greater thickness of fat at the twelfth rib per hundred pounds live weight. These data are presented in Table 7. For every one-hundred pounds live weight heifer carcasses measured .076 inches of fat thickness at the twelfth rib compared to .057 inches for steers. This difference of .019 inches per one-hundred pound live weight while seemingly small was approximately 0.2 inches more fat for a 1,000 pound heifer than an equal weight steer. However, heifers were also found to possess a larger area of longissimus dorsi muscle per one-hundred pounds live weight than steers. The longissimus dorsi muscle areas in steer carcasses measured 1.06 square inches per one-hundred pounds live weight compared to 1.21 square inches for heifer carcasses. This was one and one-half square inch larger muscle area for a 1,000 pound heifer than for an equal weight steer. The excepted opinion that steers possess one square inch of loin muscle for every one-hundred pounds of live weight is evident from these data. However, heifers have larger loin muscles as revealed by these data. Herbert and Crown (27) explained similar results with pigs. They found that gilt carcasses yielded higher percentages of ham, loin, and possessed larger "loin eye" areas than barrows. Palsson and Verges (46) found ewe lambs had a greater amount of fat covering than wethers. They stated that the earlier maturity of the ewe lambs was the factor involved. No significant differences in size of "loin eye" area were observed between sexes.

In contrast to the loin percentage, commercial round was significantly, negatively, correlated with fat at the twelfth rib. This would seem logical since the round is one of the last areas of the beef carcass in which fat is deposited and the fat covering in relation to that of the loin is much less. Simple correlations were (-.44) and (-.28) for steer and heifer carcasses respectively. However, when the effect of weight was removed the correlation for steers (-.25) was not significant and the correlation for heifers (-.30) remained significant. Fat thickness was not significantly correlated with any of the other wholesale cuts. There was a slight but non-significant negative correlation (-.17) between fat thickness and percent total wholesale cuts.

Fat thickness was not significantly correlated with marbling score in either steer (.26) or heifer (.23) carcasses. This indicates that marbling is quite independent of fat covering. This is in agreement with Weseli (57), but is not in accord with Hankins and Burk (21) who found fat thickness to be highly correlated with marbling. However, the latter used cattle representing many grades, types, and weights with no adjustment made for these variables.

In heifer carcasses, percentage rump was highly correlated with the areas of the semimembranosus and semitendinosus muscles. The simple (.57) (.57), and partial (.54) (.50) correlations for semimembranosus and semitendinosus muscles respectively were highly significant. Simple (.44) and partial (.45) correlations between percentage rump and area of the semimembranosus muscle were significant in steer carcasses. The partial (.39) correlation b etween percentage rump and area of the semitendinosus muscle was also significant. Correlation coefficients between percentage loin and area of the semimembranosus muscle were significant, but negative for simple (-.36) and partial (-.39) among steers. The partial correlation between percentage loin and area of semitendinosus muscle was significant (-.38), but also negative. The simple correlation was not significant (-.28). The correlation coefficients between the same characteristics in heifer carcasses were also negative, but low. The simple correlation between the area of the biceps femoris muscle was highly significantly correlated (.51) with percentage loin in s teers. The coefficient decreased (.40) when the effect of weight was removed, but remained significant. These results in both steer and heifer carcasses, indicate that as percentage loin increased the area of the biceps femoris muscle increased, but the area of the semimembranosus and semitendinosus muscles decreased. These muscles comprise a large portion of the round. According to Hankins and Titus (25), round percentage decreased as percentage loin increased which they attributed to the increased fat deposited over the loin. In steer carcasses area of the biceps femoris muscle was significantly correlated (-.36) with percentage rib and highly significantly correlated (.48) with percentage commercial round. The correlation coefficients in heifer carcasses between area of biceps femoris muscle and percentage commercial round were highly significant for both simple (.36) and partial (.46) coefficients. Also among heifer carcasses the partial correlation between area of the biceps femoris muscle and percentage total wholesale cuts was significant (.32). Among steers, simple and partial coefficients were (.02) and (.32) respectively for the same correlations.

Correlation coefficients between percentage loin and rib with other wholesale cuts and total wholesale cuts were predominately negative. This was true for steer and heifer carcasses irrespective of the effect of weight. The percentage chuck, rump, commercial round, and total wholesale cuts were all positively correlated with each other in steer and heifer carcasses. Significant simple (-.31) and partial (-.32) correlations between percentage loin and rump were found in heifers. The simple (-.22) and partial (-.18) coefficients were also negative among steers, but low. This would tend to indicate that as percentage loin increased the percentage rump decreased, which further substantiates the findings of Hankins and Titus (25). For heifers the simple and partial correlation coefficients between percentage chuck and total wholesale cuts were (.58) and (.57) respectively. Both are highly significant. Only the simple correlation between percentage chuck and total wholesale cuts for steers was significant (.36). Percentage loin in steers was negatively correlated with percentage chuck. Both the simple (-.41) and partial (-.39) coefficients were significant. The percentage rib and rump in heifer carcasses were highly correlated with commercial round. There was essentially no difference between the simple (.40) and partial (.41) correlation for the rump, and no difference between the simple and partial correlations for the rib (-.30) with percentage commercial round. The percentage commercial round was the most predictive cut for percentage total wholesale cuts. Lasley _et al._ (39), predicting lean cuts of pork, obtained a correlation coefficient of .88 between ham weight and weight of lean cuts. The correlations in the present study were highly significant for both steer and heifer carcasses. In steer carcasses the coefficients were .67 and .62 for simple and partial correlations respectively; the simple and partial coefficient for heifers was .69. Thus, weight had little or no effect on the predictive value of the percentage round for total wholesale cuts. Green (18) noted a correlation of .69 between weight of the round and arm chuck. The correlations between the round and chuck were low for both steers (.04) and heifers (.13) in this study; however, the arm was removed from the chuck.

Carcass grade was significantly, negatively correlated with percentage commercial round among both steer (-.40) and heifer (-.28) carcasses. The partial coefficients were also significant, (-.38) and (-.30) respectively for steers and heifers. This may be attributed to increased fat cover over the rib and loin region causing the percentages of these wholesale cuts to go up and the percentage round to decrease as carcass grade increased. Carcass grade was also highly correlated with percentage rib in steer carcasses (.49). Among steers of similar weight there was a slight increase in the coefficient (.51). Correlations between carcass grade with percentage rib among heifers (.31 and .34 for simple and partial respectively) were significant and again there was a slight increase in association when the effect of weight was removed. The correlation between carcass grade and fat at the twelfth rib was lower than might be expected. Significant simple (.32) and partial (.30) correlation coefficients were obtained with heifer carcasses. The correlation coefficients for steers were approaching statistical significance, these were; simple (.33) and partial (.31). These correlations indicate that carcass grade was quite independent of quantity of fat cover. Hankins and Burk (21) stated that fat thickness was closely associated with carcass grade. However, this study included several types, grades and weights of beef carcasses with no adjustment for these variables.

The correlation coefficients between carcass grade and marbling score were remarkably high. The correlations were .95 and .93 for steer and heifer carcasses respectively. There was no difference in the simple and partial coefficients. The coefficient of determination (R^2) reveals that 89 and 86 percent of the varibility in carcass grade can be attributed to marbling in steer and heifer carcasses respectively.

The correlations between carcass weight and area of longissimus dorsi (.46) semitendinosus (.48), and biceps femoris muscles (.63) were all highly significant in heifer carcasses. In steers the same correlations for longissimus dorsi (.29) and semitendinosus (.20) muscles were not significant. However, the biceps femoris muscle was highly correlated (.65) with carcass weight. As the weight of the animals increased these muscles also tended to increase. Carcass weight was highly correlated (.51) with fat at the twelfth rib in steers, but was only approaching statistical significance (.26) for heifer carcasses. This appears logical since an increase in weight of full-fed cattle is associated with an increase in fat deposition. The low correlation in heifer carcasses was somewhat surprising since it has been demonstrated that heifers have more fat per unit of live weight than steers. However, the measurement of fat at the twelfth rib in heifer carcasses may not be as reliable an indicator of fat deposition as in steers. The data in this study indicate that there was an inverse relationship between percentage of the individual wholesale cuts, total wholesale cuts and carcass weight. Coefficients for total wholesale cuts for steer and heifers were (-.31) and (-.10) respectively. The most significant correlation for an individual wholesale cut was that of the commercial round. In steers the correlation coefficient between carcass weight and commercial round was negative (-.51), while in heifer carcasses the coefficient, although positive, was essentially zero (.02). Pierce (51) found that heavier carcasses yield more chuck, rib, flank, brisket and plate than did lighter carcasses, but lower yields of other cuts. However, no distinction was made between the yields of steers and heifers in his study.

SUMMARY AND CONCLUSIONS

Data in this study were obtained from 30 Hereford steers and 53 Hereford heifers.

Linear measurements included head measurements; circumference of forearm and forecannon; and width, circumference and length measurements of the round. In addition each individual was visually appraised for grade, bone, and muscle. Carcass characteristics measured were areas of loin and round muscles, percentages of the wholesale cuts, carcass grade, fat thickness, and marbling score.

Simple and partial correlation coefficients between the measurements of the live-animal, carcass characteristics, and between the live-animal and carcass characteristics were computed.

Head measurements were of little practical value in the prediction of either carcass characteristics or other live-animal measurements. A large forearm circumference was associated with large length and circumference measurements of the round among heifers, but not with steers.

Length and circumference measurements of the round were highly associated with each other and with live weight. As expected, such measurements increased as the weight of the cattle increased.

Round measurements taken on the live animal, indicated some possibilities for estimating muscling in heifer carcasses. In general, the coefficients among steers were low. As round measurements increased, areas of loin and round muscles also increased. Length of round exerted a greater influence upon percentage commercial round than width of round.

The biceps femoris muscle was more highly correlated with measures of muscling and percentages of the wholesale cuts than any other muscle area including the longissimus dorsi muscle. While not easily obtained for practical use, these data indicate the biceps femoris muscle may be the most reliable indicator of muscling throughout the carcass.

Live weight was found to influence judges appraisal of bone and muscling in heifers more than with steers.

The correlation between carcass grade and fat thickness at the 12th rib was low, indicating that grade was not dependent upon thickness of outside fat. Likewise, 86 and 89 percent of the variability of carcass grade may be attributed to the degree of marbling for heifers and steers, respectively.

These data revealed that heifer carcasses possessed a thicker fat cover at the twelfth rib per one-hundred pounds live weight than steers. In addition, area of longissimus dorsi muscle in heifer carcasses was 0.15 square inches larger per one-hundred pounds of live weight than for the same weight steers. Little difference existed between the total area of the round muscles of steer and heifer carcasses of the same weight.

The results of this study indicate that a number of differences exist between carcass characteristics of steers and heifers. While this appears to be true for these data, they suggest a need for further investigation into the fundamental differences in steer and heifer carcasses.

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THE RELATIONSHIP OF CERTAIN LIVE-ANIMAL MEASUREMENTS
TO CARCASS MUSCLING CHARACTERISTICS OF BEEF CATTLE

by

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The demand for leanner beef has increased the problems of the beef producer in selecting for natural muscling characteristics. Research has been directed toward the development of live-animal indices that would be useful in estimating the major components of the carcass, that is muscle, fat, and bone. Live-animal measurements, useful in detecting cattle with a high proportion of lean meat per unit of body weight, would assist greatly in basic live stock improvement programs without necessitating the complete destruction of prospective breeding animals.

In conducting this study, 30 Hereford steers and 53 Hereford heifers were subjected to a number of live-animal and carcass measurements.

Linear measurements included head measurements; circumference of forearm and forecannon; and circumference and length measurements of the round. In addition each individual was visually appraised for grade, bone, and muscle. Carcass characteristics measured were areas of loin and round muscles, percentages of the wholesale cuts, carcass grade, fat thickness, and marbling score.

Simple and partial correlation coefficients between the measurements of the live-animal, carcass characteristics, and between the live-animal and characteristics were computed.

Head measurements were of little practical value in the prediction of either carcass characteristics or other live-animal measurements. A large forearm circumference was associated with large length and circumference measurements of the round among heifers, but not with steers.

Length and circumference measurements of the round were highly associated with each other and with live weight. As expected, such measurements increased as the weight of the cattle increased.

Round measurements taken on the live animal, indicated some possibilities for estimating muscling in heifer carcasses. In general, the coefficients among steers were low. As round measurements increased, areas of loin and round muscles also increased. Length of round exerted a greater influence upon percentage commercial round than width of round.

The biceps femoris muscle was more highly correlated with measures of muscling and percentages of the wholesale cuts than any other muscle area including the longissimus dorsi muscle. While not easily obtained for practical use, these data indicate the biceps femoris muscle may be the most reliable indicator of muscling throughout the carcass.

Live weight was found to influence judges appraisal of bone and muscling in heifers more than with steers.

The correlation between carcass grade and fat thickness was low, indicating that grade need not be dependent upon thickness of outside fat. Likewise, 86 and 89 percent of the variability of carcass grade may be attributed to the degree of marbling for heifers and steers respectively.

These data revealed that heifer carcasses possessed a thicker fat cover at the twelfth rib per one-hundred pounds live weight than did steers. In addition, area of longissimus dorsi muscle in heifer carcasses was 0.15 square inches larger per one-hundred pounds of live weight than for the same weight with steers. Little difference existed between the total area of the round muscles of steer and heifer carcasses of the same weight.

The results of this study suggest a number of differences exist between carcass characteristics of steers and heifers. While this appears to be true for these data, they indicate a need for further investigation into the fundamental differences in steer and heifer carcasses.