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A subjective evaluation of feeder cattle

Max F. Hawkins

To the Graduate Council:

I am submitting herewith a thesis written by Max F. Hawkins entitled "A subjective evaluation of feeder cattle." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

E. R. Lidvall, Major Professor

We have read this thesis and recommend its acceptance:

W. T. Butts Jr., W. R. Backus

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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We have read this thesis and recommend its acceptance:

Will T. Hall Jr.

Wm. R. Backus

Accepted for the Council:

L. Evans Roth

Vice Chancellor
Graduate Studies and Research

A SUBJECTIVE EVALUATION OF FEEDER CATTLE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Max F. Hawkins

December 1979

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ABSTRACT

Data from 687 steer calves of two breed groups, British (Angus, Hereford, Angus X Hereford) and Charolais crosses, formed the basis of this study. The steers were purchased through East Tennessee Graded Feeder Calf sales and represented Prime, Choice and Good grades with a mean weight of 566 lbs.

The steers were fed ad libitum corn silage for a 3-4-week period while being allowed to adjust and recover from the stresses of weaning and shipment. Following the adjustment period, the steers were weighed, photographed, sonorayed for fat thickness, measured for shoulder width and subjectively evaluated independently by committees of 10, 16 and 14 graders in 1976, 1977 and 1978, respectively. All steers were subjectively scored on a 1-15 basis for height, length, overall frame size, general trimness, head shape and muscle expression. Fat thickness was estimated in millimeters, age in months and predicted slaughter weight in pounds.

For analyses, each year the graders were divided into three categories according to their training and experience. In 1976 and 1977, approximately 30 days prior to the scoring by the committees, the steers were scored by an experienced grader who was a member of the evaluation committee.

The 1976 steers were randomly divided within breed and feeder grade into two ration groups of high and medium levels of energy. The steers were weighed and sonorayed for fat thickness at 14-day intervals until they reached 12 mm of fat thickness at which time they were slaughtered. Days on feed were calculated, and the carcass traits

of weight, yield grade and quality grade were recorded.

It was found by multiple regression analysis that models describing frame, fat and muscle accounted for 58%, 43% and 19% of the variation, respectively. Graders utilized height, depth and fat in estimating frame and fat, while width was the major factor in estimating muscle. Length and weight did not affect graders in their evaluations. There was more agreement among graders within grader category for frame and muscle, while there was greater agreement for fat among grader categories. Increases in R-squares of .01, .01 and .02 for frame, fat and muscle, respectively, were found when height-grader interactions were added to the models. Similar increases of .02, .03 and .03 in R-squares were attained when breed group-grader interactions were added to models for frame, fat and muscle, respectively. These small increases would indicate that graders handled the effects of height and breed group in a like manner.

Partial regression coefficients indicated that larger framed steers were evaluated as being taller, slightly longer, shallower, narrower and leaner. When estimated fat increased, calves were seen as being lower set, slightly shorter, deeper, wider and fatter. Steers that were scored high for muscle (muscle expression) were evaluated as being lower set, longer, shallower and wider by the graders.

Coefficients of correlation among graders were performed on a within-year and within year-breed group basis to further define agreement among graders. Coefficients for frame score ranged from .70-.95, .51-.86 and .58-.96 within year and .54-.93, .45-.89 and .56-.96 within year-breed group for 1976, 1977 and 1978, respectively. Somewhat less agreement was found for estimated fat where coefficients ranged from .45-.79, .20-.76 and .38-.85 within year and .34-.73, .14-.71 and .29-.83 within year and breed group for 1976, 1977 and 1978, respectively. Considerably less agreement was found for muscle score where coefficients ranged from .14-.58, -.07-.57 and .16-.72 within year and .13-.59, -.09-.61 and .16-.70 within year and breed group for 1976, 1977 and 1978, respectively.

Coefficients of determination between scoring times by one grader in 1976 and 1977 indicated that steers were more accurately redescribed for body dimension rather than for fat, trimness and muscle expression. The failure to accurately describe fat, trimness and muscle expression may be due, in large measure, to weight gain and environmental influences during the 30-day period between evaluations.

R-squares for grader predictions of carcass weight and days on feed were .57-.62 and .52-.56, respectively. R-squares for yield grade, .07-.14, and carcass quality grade, .06-.10, were smaller; however, the steers were slaughtered on a fat constant basis, thus reducing the total variation. Although grader experiences and the weighting of variables by the graders varied, similar variation was explained.

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CHAPTER I

INTRODUCTION

Cattle produced and available to the stocker and/or feedlot operator offer a wide variety of size, shape, breed background, weight and physiological maturing rates. However, when the initial beef package, the feeder calf, arrives at the market place, this total variation is not well defined by the present feeder calf "quality" grading system (Prime or Fancy, Choice, Good, etc.). In fact, the present grading system falls far short of placing feeder cattle into predictable outcome or uniform slaughter groups. Clouse et al. (1974) found that no combination of feeder calf traits produced a meaningful estimate of subsequent carcass quality grade.

Previous work by Montgomery (1978) has shown that grading and lotting of feeder cattle can be improved by using feeder calf sale weight, certain body dimensions and fatness as grade criteria. Utilizing this system and feeding cattle to a constant fat thickness produced more desirable beef with a minimum of over-finished carcasses yield grading 4 or 5 as compared to the present feeder calf grading system.

The need exists for a feeder and stocker cattle grading system which will uniformly describe calves and/or yearlings in such a manner that the feedlot operator can feed cattle to a uniform compositional (quality and yield grade) end point. The objectives of the research reported herein were:

1. To determine those subjective measures which, in various combinations, best describe differences in feeder calves.

2. To determine which of the subjective measures generates the greatest amount of agreement.

3. To determine the influence of training and/or experience upon graders' decisions.

4. To determine the influence of breed differences upon graders' subjective measures.

CHAPTER II

LITERATURE REVIEW

Relationship of Growth, Rate of Maturity and Performance

Considerable research demonstrates that growth curves and physiological maturity rates vary among and within breeds of cattle.

Brungardt (1971) reported marked differences within and between Angus, Hereford and Charolais cattle. Charolais and Herefords were 43% and 11%, respectively, later maturing than Angus. Significant differences ($p < .05$) in growth rate, final weight and maturity also were found within breeds when cattle were divided into five body size groups. All cattle were slaughtered at a constant compositional end point, grading choice with fat making up 30% of the carcass weight.

Brungardt (1972) stated that appraising cattle of various breeds at constant weights results in comparing cattle at different points on their growth curves.

Brown et al. (1972b) found that Hereford females continue to show an increase in body weight up to 85 months of age, while the growth in Angus females ended near 70 months. Hereford females were heavier at 40 months of age, while the reverse was true prior to 40 months. These data definitely suggest an earlier rate of maturity for Angus females. Mello et al. (1972) used 34 Hereford and 19 Angus yearling cattle of known ages to study the relationship between chronological age and physiological maturity. Overall bone maturity and final carcass maturity scores of the younger Angus cattle indicated that they attained physiological maturity earlier than Hereford cattle.

Kidwell and McCormick (1956) and Knox (1957) suggest that animals of a larger size have a longer period of linear postweaning gain. Therefore, to attain a degree of accuracy, comparisons of rate of gain and feed efficiency should be made at corresponding points on the growth curve. Large gains at young ages associated with early-maturing females and sustained growth to advanced ages associated with late-maturing females were also found by Brown et al. (1972a). The need for comparison at similar physiological ages is shown by the genetic variation in development between two fixed ages.

Rate at which different parts of the body mature is of importance because of the emphasis placed on certain body regions for evaluation. Brown et al. (1956c) found that Hereford females attained 55-58% of their mature height at 1 month of age. The order in which body regions reach maturity are height at hooks, height at withers, width at shoulders, heart girth circumference, chest depth, depth of rear flank, length of body and width at hips. With the exception of height at hooks, the forequarters mature earlier than the hindquarters. Brown et al. (1956b) reached similar conclusions for Angus females.

In a study involving 53 Hereford and 51 Angus calves fed a standard finishing ration for 186 days postweaning, Butler et al. (1962) reported slightly better feed efficiency and larger daily gains for Hereford steers and significantly better carcass quality grades for Angus steers. Carcass fat at the 12th rib was .74 and .76 inches, respectively, for Hereford and Angus.

Anderson et al. (1964) found from a 3-year study with 149 heifers and 120 steers of Choice, Good and Medium feeder grades that there was no significant difference in the gain of steers regardless of weight and grade. There was no difference in the gains of the two weight groups of heifers of the same grade. Good grade heifers of the 450-500-lb group gained significantly faster ($p < .01$) than Choice heifers of either weight group.

A study by Brinks et al. (1962) showed that within breed correlations indicated that measures of growth early in life were positively associated with measures of lean and bone and negatively associated with measures of fat in the carcass. This agrees with Hedrick (1972) who found that maximum bone growth precedes that of muscle and muscle growth precedes that of fat.

Stonaker et al. (1952) conducted a feedlot performance test with 87 Hereford steer calves of comprest, intermediate and large types. Intermediate and large types were referred to as conventional type cattle. The comprest steers reached the Low Choice grade at an average live weight of 689 lbs, whereas the conventional steers averaged 852 lbs when ready for slaughter. Although the rates of gain, total gain and feed consumption were greatly different when individually fed to a Low Choice slaughter grade, the comprest steers gained as efficiently per unit of feed consumed as did the conventional type steers.

Minish et al. (1967) using 128 Choice and Standard feeder steers tested the effects of concentrate levels added to high corn silage rations upon feedlot performance and carcass characteristics. Choice steers were significantly superior ($p < .05$) to Standard steers in conformation, marbling, quality grade, final carcass grade, rib-eye area and dressing percent. However, Standard feeders had significantly higher daily gains, a higher estimated percent of boneless, trimmed round, rib, loin and chuck and less fat at the 12th rib than Choice feeder steers.

Corrick and Hobbs (1970) found no difference in average daily gains of Good and Choice feeder heifers during 140-day roughage feeding period or full feed period. The only significant difference in carcass characteristics was .5 square inch larger rib-eye area in Good heifers.

Harrell (1971) found feeder grade to have a significant effect ($p < .05$) on average daily gain of 178 heifers through a 140-day roughage phase followed by a full feed phase. Estimated initial fat thickness affected average daily gain and overall gain on roughage but did not affect yield grade and percent retail yield. Medium-grade heifers were superior to Choice in average daily gains, but there were no differences in the gains of Good and Choice and of Medium and Good heifers.

Performance in Relation to Grade, Type, Condition and Weight

The weights, grades, types and condition of calves being fed for slaughter are not always the best indicators of expected performance or carcass desirability. Hultz (1927) selected calves to be equal in quality and similar in breeding but different in type. Calves were divided into three groups: (1) low set, (2) intermediate and (3) rangy. Rangy calves made the largest gains with intermediate and low set following, respectively. Initial feeder grade was correlated ($r = .23$) with final feeder grade, while there was a correlation coefficient ($r = .48$) for final feeder grade and carcass quality grade. This would suggest that live grade was not indicative of carcass quality.

Stonaker et al. (1952) classified 87 Hereford steers of comprest, intermediate and large type into two groups--comprest and conventional (large and intermediate). Feed consumption, rates of gain and total gain were greatly different for the groups, and they seemed to be functions of size. Shapes and sizes of live steers and carcasses were considerably different, but when fed to grade Low Choice, the comprest steers gained as efficiently as conventional steers, and the percentage of major cuts was almost identical. Differences were found in rate of gain and slaughter weight, while efficiency of gain, days on feed and slaughter ages were similar.

Butler (1957) stated that the animal breeder has considerable latitude in selecting animals of different shapes without encountering great changes in the proportion of wholesale cuts.

Accuracy and Repeatability of Linear Body Measurements

Various techniques for determining linear body measurements and their accuracy and repeatability have been studied.

Lush and Copeland (1930) took 25 separate body measurements on Jersey cows and yearling heifers. They found close agreement for repeatability in the two groups, although larger errors were associated with larger animals. The error associated with obtaining the measurements is comparable with that associated with weighing where the standard error was found to be near 1% of the mean weight.

Touchberry and Lush (1950) obtained measurements of wither height, chest depth, body length and paunch girth of Holstein cattle three times at each of the ages of 6 months, 1, 2, 3, 4, 5 and 7 years.

Except for body length, it was found that a single measurement of each body characteristic was accurate.

Smith et al. (1950) compared live animal measurements with photographic measurements from 10 cows, 23 yearlings and 10 calves. Photographic measurements produced somewhat higher estimates of repeatability. Differences in repeatability for the three groups ranged from .726 to .844 for photographic body length, .546 to .898 for live animal length, .807 to .908 for photographic wither height and .784 to .914 for live animal wither height. Repeatabilities for chest depth were similar for photographic and live animal measurements. Variation due to time during the day measured, operator and size of animal were negligible.

The Relationship of Linear Body Measurements and Performance

Lush (1928) stated, "In a geometrical sense the animal body is of such a complicated shape that any one of a few measurements could approximate a description of it only in the crudest way." Lush and Copeland (1930) reported that measurements in addition to measure of height, length and/or total size involves the law of diminishing returns. The advantage of linear body measurements is that they are an objective measure and will remain constant over time, independent of human judgment (Lush, 1928). Black et al. (1938), Guilbert and Gregory (1952) and Lush (1932) summarized and agreed that linear body measurements are useful as a supplement to subjective measures of type.

Research that has dealt with performance and carcass traits of various types of cattle (skeletal size, conformation and fatness) has shown conflicting results. Black et al. (1938) reported that when ratios of linear body measures are used to estimate performance and carcass traits fat, weight and age factors must be corrected. When cattle of varying types are finished to a standard fat composition, performance and carcass trait measures tend to become similar.

Linear body measurements, when used to describe performance and carcass measurements, fall into two categories: (1) those that increase with fattening more rapidly than weight, such as chest width, loin width, heart girth and flank girth, and (2) those that increase with fattening less rapidly than weight, such as pelvis, head, height and trunk measurements. These measurements describe fatness either positively or negatively, respectively.

Lush (1928) found that height at withers and height at hooks were equal in repeatability and near identical to each other. Kidwell (1955) concluded that height at hooks was more highly associated with carcass traits than height at withers, while little association was found between height at hooks and performance. Kohli et al. (1951) found no significant relationship between height at withers and feed efficiency.

Lush (1932), Black et al. (1938) and Yao et al. (1953) were all in agreement that height at withers was the best measure of height. Negative correlations between height of withers and performance traits were found by Black et al. (1938) and Hultz and Wheeler (1927). However, Lush (1932) reported height at withers was associated with higher gains based on linear measurements of steers at weaning.

Cook et al. (1951), Kidwell (1955) and Ternan et al. (1959) found no relationship between body length and performance traits. Kidwell et al. (1959) reported no significant increase in body length during the last 60 days of the feeding period. Lush (1932) reported a positive association of gains to longer bodied steers. Negative correlations for body length and average daily gain and feed efficiency, respectively, were found by Black et al. (1938) and Kohli et al. (1951).

Lush (1932) and Black et al. (1938) found shallow-bodied animals to produce a higher yield of edible beef and to be more efficient in converting feed when compared to deeper bodied steers. Yao et al. (1953) reported that length and height are measures of overall skeletal size and that width, chest depth, paunch girth and heart girth or foreshank circumference are measures of thickness, fleshiness or heaviness.

The Relationship of Linear Body Measurements to Feeder, Slaughter and Carcass Grade

Significant relationships were found between some body measurements and feeder, slaughter and carcass quality grades by Cook et al. (1951) and Ternan et al. (1959). However, both agreed that the correlations were too low to be of predictive value.

Studies where cattle were fed to a constant weight or for a constant length of time, a negative association between wither height and either carcass quality grade, slaughter grade, feeder grade or all of these variables were found by Kidwell (1955), Cook et al. (1951), Black et al. (1938), Kidwell et al. (1959), Ternan et al. (1959) and Yao et al. (1953). Being of an earlier maturing type, shorter cattle fattened more quickly than taller cattle.

A nonsignificant relationship for the effect of length of body on live slaughter grade or carcass quality grade was found by Lush

(1928), Cook et al. (1951) and Kidwell (1955). However, Black et al. (1938), Brown et al. (1956a) and Yao et al. (1953) reported a negative correlation between body length at slaughter and carcass grade. Kidwell et al. (1959) stated that a body measurement or combination of measurements might be found that would reasonably predict carcass grade.

In studies using ratios, Klosterman et al. (1968) found weight: height ratios helpful in describing type and size of cows. Lush (1928) reported an association ($\underline{r}$ = .56) of heart girth:wither height with fatness. Black et al. (1938) found correlations between slaughter grade and body weight:wither height ($\underline{r}$ = .84) and an index of height, length and weight (Yapp's index) ($\underline{r}$ = -.89). Round measurement:wither height was found to be highly correlated with carcass grade by Guilbert and Gregory (1952).

Many researchers have studied skeletal height and length and found them to be highly correlated with body weight and with each other--Lush (1932), Brown et al. (1956a), Brown et al. (1956b), Brown et al. (1956c) and Brown and Shrode (1971).

Kidwell (1955) found the desirable proportion of a feeder steer to be low at withers, short of body, shallow of chest relative to heart girth but wide chested regardless of total size when steers were fed to constant weights and carcass quality grade was the major consideration. However, Guilbert and Hart (1946) found ideal size to be the largest size, under practical conditions, where desired carcass composition is met at the age demanded by the market.

Principal Component Analysis as a Means of Describing Size and Shape

The principal component analysis is a technique that has recently been applied to body measurements. Carpenter et al. (1971) used the body measurements of 38 Hereford cows to study the principle of principal component analysis. Three body measurements (chest depth, hook width and body length along with body height) were used. General size was the component that accounted for 75% of the generalized variance. A second component seemed to be a contrast of hook width with body length but may also indicate a reflection of condition. However, the first and second components together accounted for 90% of the generalized variance.

Brown et al. (1973a) used nine skeletal measurements and body weight of 267 Angus and Hereford bulls, taken at ages of 4, 8 and 12 months, to obtain six principal component analyses, one for each breed at each age. The body measurements consisted of height at hips, shoulder width, pelvic width, loin width, foregirth body depth, flank depth, heart girth and length from point of shoulder to pins. The principal components estimated not only gave a better understanding of the dependent relation among skeletal dimensions but also measured differences in size and shape. The first principal component at each of the three ages accounted for 56-68% of the variation in all ten measurements with near equal emphasis on all ten standardized traits. The second component indicated, at all three ages, that tall, narrow-bodied and short, wide-bodied bulls represented the extremes in shape. Correlations among second principal components indicated that body shape will remain relatively unchanged. Components 1 and 2 accounted for 75%

of the variation and covariation. Body length did not consistently receive weighting equal to height or width in the second component indicating that there may be more phenotypic latitude for length in cattle of different heights and widths than there is in width for different heights. Approximately 40% of the variation in the covariance structure of ten body measurements was explained by contrasting body shapes in which the relationship among body dimensions was not always positive. Therefore, extreme length was offset by decreases in depth and height. Extreme height was counteracted by a decrease in width, and width was frequently attained by sacrificing body depth.

Brown et al. (1973b) identified more than one shape which was positively associated with efficiency and rate of gain. Bulls that were larger in all measurements at 4 and 8 months grew well on test. Bulls that were taller and narrower at 4 and 8 months consumed more feed, weighed more at the end of test and gained more weight but were less efficient gainers than shorter, wider bodied bulls. Several immature shapes were identified which had acceptable performance on test.

Subjective Evaluation as a Means of Describing Cattle

Brown et al. (1956a) found from work conducted at the Georgia and Arkansas stations that 75% of the variation in the average scores of a group of competent evaluators was attributed to animal component of variance, but when repeated at intervals of several months, this was reduced to 50%. This indicated that the evaluators tended to be in agreement at a given time but were more or less influenced by temporary factors, such as age, degree of finish, etc.

Gifford et al. (1951) reported that judges tend to agree more closely on characteristics in which they must consider the entire animal. The correlations between repeated scores of a cow by the same judge were generally between .4 to .5. Ternan (1959) conlcuded that a single total score was more useful in describing an animal's conformation than is a detailed score card.

Marlowe and Benyshek (1974) reported same-day repeatability values of .8 for frame and conformation, .7 for condition, .65 for general appearance and muscle and .5 for masculinity and soundness of yearling beef type bulls.

Lewis et al. (1969) compared experienced and inexperienced evaluators in predicting carcass traits of finished cattle 3 days prior to slaughter. The experienced evaluators were more accurate in their estimations but were more aware of the size and weight relationships on carcass traits and evidently used one or both in their estimations.

Wilson et al. (1964) used six judges to estimate carcass traits of 135 Hereford steers 31 days prior to slaughter. The correlation between live estimate and tracing fat thickness and single adjusted fat thickness was 0.38 and 0.51, respectively, suggesting that fatness of the entire carcass may be predicted with moderate accuracy. Estimates of rib-eye area and percent kidney fat were less reliable as predictors of the corresponding actual carcass trait. The correlation between live estimated fat thickness and carcass cutability was 0.65, suggesting that a single estimate for fat thickness is of substantial value in predicting carcass cutability. Generally, there seemed to be little relationship between the judges' amount of experience and their proficiency at evaluating individual differences for the carcass traits.

Gregory et al. (1962) had four graders estimate the carcass traits of steers that were from similar and varying management systems. It was concluced that graders are reasonably accurate in predicting the group means for carcass traits, providing that the cattle have been fed similar and the graders have knowledge of the feeding and management program and live weight.

Crouse et al. (1974) evaluated 449 weaned calves using six experienced appraisers. Three of the appraisers independently evaluated seven live traits (disposition, condition, overall muscling, length of rump, size of bone, width between legs and growth potential). The remaining three evaluated hair coat, feeder grade, round muscling, length, depth, height and trimness. Subclass means for breeds of sire, breeds of dam and slaughter groups contributed to variation in carcass and growth traits accounted for by regression equations. This indicated that appraisers had more difficulty detecting animal-to-animal differences within a breed type under similar management conditions than in population of diverse breed types and management conditions. Correlations among appraisers were high for the characteristics evaluated except hair coat and length of rump.

Ultrasonic Technique for Estimating Subcutaneous Fat Thickness

The ultrasonic technique has proven to be a useful tool for researchers to predict composition and value of the live animal. Meyer et al. (1966), Watkins et al. (1967), Backus (1968) and McReynolds and Arthaud (1970) have reported substantial accuracy in the application of the ultrasonic technique.

Subcutaneous fat thickness at the 12th rib is of great importance to the beef producer and researcher, since as percentage of fat increases there is an almost proportional decrease in percent lean according to Hedrick (1968).

CHAPTER III

EXPERIMENTAL PROCEDURE

Data for this study were collected from September 1976 through July 1977, September 1977 through December 1977 and September 1977 through December 1978 from experiments conducted at The University of Tennessee Blount Farm, Knoxville, Tennessee.

Experimental Animals

In the fall of 1976, 1977 and 1978, 176, 207 and 304 steer calves were purchases, respectively. The cattle were purchased from East Tennessee Graded Feeder Calf Sales and represented Prime, Choice and Good steers of British breeds (Angus, Hereford and Angus X Hereford) and Charolais crosses as designated by the State Grading Service.

Feeding and Management

Upon arrival at the experimental barn, the cattle were allowed to adjust and recover from the stresses of weaning and shipment for a period of 3-4 weeks while being fed ad libitum a ration of corn silage.

Following the adjustment period, the cattle were weighed, photographed, sonorayed for fat thickness, measured for shoulder width and identified. They were then subjectively scored by the committee within 7-10 days.

The steers from 1976 were randomly divided within breed and feeder grade into two ration groups. Within each ration group, animals were randomly assigned to one of 15 feeding groups of six animals each.

Feeding groups were randomly assigned to pens within the barn.

Ration treatments represented high and medium levels of energy. The high-level treatment was fed ad libitum a ration composed of: 59% corn, 10% cottonseed meal, 20% cottonseed hulls, 5% molasses, 3% dehydrated alfalfa meal, 2% animal fat, .5% ground limestone and .5% salt. The medium-level ration was composed of corn silage, ad libitum, and a concentrate mixture composed of 86% corn and 14% cottonseed meal. Concentrate mixture was fed initially at the rate of 1.25% of body weight (pen mean) daily and increased to 1.4% and 1.55%, when animals reached a pen average of 8 and 10 mm of subcutaneous fat, respectively. It was fed daily in two feedings. Salt and dicalcium phosphate mixture was offered free choice.

Animals were weighed and fat was measured ultrasonically at 28-day intervals until approximately February 1 and at 14-day intervals thereafter. First-order polynomials were fitted to the fat measurements of individual calves from initiation of the trial to each biweekly measurement date and evaluated at 12 mm of fat. Animals that were projected to reach 12 mm of fat before the next biweekly measurement date were slaughtered on the Friday nearest their predicted date. Carcass data were collected on the following Monday. The carcass traits evaluated were hot carcass weight (carcass weight), carcass fat, rib-eye area, percent KPH, yield grade, marbling score and carcass quality grade. Days on feed were also calculated.

Objective Measures

Fat thickness was ultrasonically measured in millimeters, with a Branson Model 12 Sonoray, over the l. dorsi. at the 12th and 13th rib junction three-fourths the distance between the dorsal midline and distal edge of the l. dorsi. The process was repeated at 2-week intervals until slaughter in 1976.

Shoulder width measurements were obtained by using body calipers to measure from point of shoulder to point of shoulder and were recorded in centimeters.

Photographs of each calf were made in a specially designed grid chute. Points of measurements were accomplished by paint branding the steers on the point of the shoulder, hook bone and pin bone immediately prior to entering the grid chute. Linear body measurements were obtained from life-size projections of 35 mm transparencies at a later date for the following measurements (Figure 1):

1. Height at withers (HW)--from the base of the grid chute to the dorsal top line of the withers.

2. Length of body (LB)--from the superior point of the shoulders to the posterior ischium.

3. Depth of body (DB)--from the chest floor, posterior to the forearm, to the shortest distance to the dorsal top line.

Subjective Evaluation

Cattle were independently scored by the graders without knowledge of the objective measures on a scale of 1 to 5 for height, length, overall frame size, fat, general trimness, age, head shape, predicted slaughter weight and muscle expression. Each numeral was subdivided into three scores, i.e., 1-, 1, 1+, 2-, 2, 2+, etc., resulting in 15 possible scores. Scores were transcribed, analyzed and reported in this

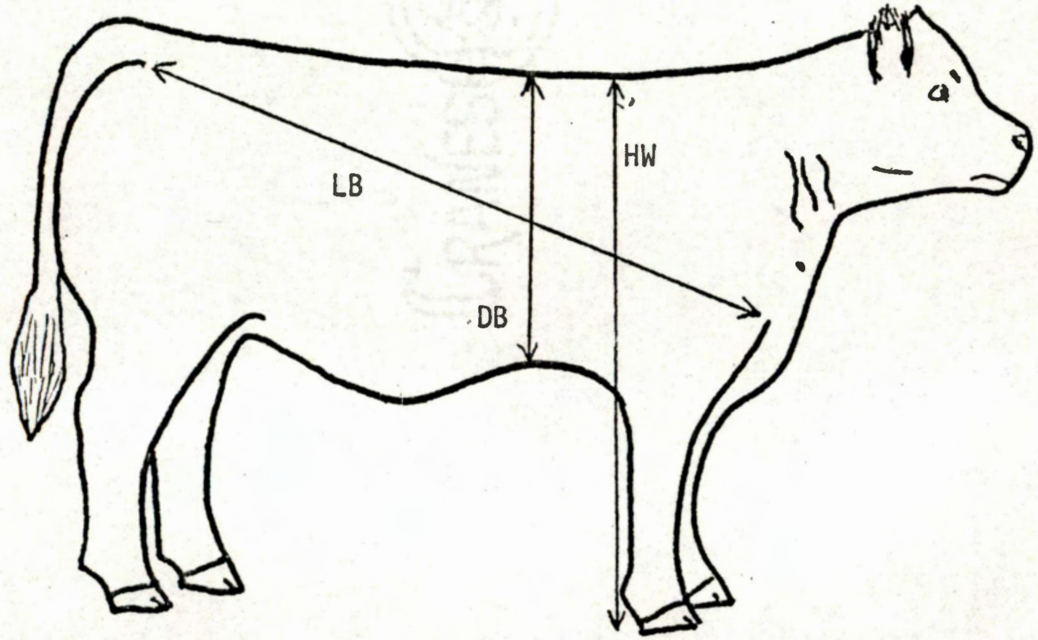

Figure 1. Location of objective body measurements on the feeder calf.

thesis on a 1 to 15 basis. Age was estimated in months. Fat was a subjective estimate of fat thickness as measured at the 12th rib location in millimeters and predicted slaughter weight was an estimate of the live weight at which the cattle would acquire 12 mm of external fat thickness.

The steers were evaluated by a committee of 10, 16 and 14 graders in 1976, 1977 and 1978, respectively. For analyses, each year the graders were divided into the following categories: (1) those having experience in the grading of feeder cattle for experimental purposes of market reporting, (2) order buyers and State Agriculture Department graders of varying levels of experience and training, (3) graduate students and/or junior staff members in Animal Science with similar educational backgrounds but with varied levels of cattle evaluation experience. The graders scored the feeder steers independently.

In 1976 and 1977, approximately 30 days prior to the scoring by the committees, the steers were scored by an experienced grader who was a member of the evaluation committee. These scores were used to determine the agreement of subjective scores on the same set of steers over time. All steers were scored one at a time in a 16-by-40-foot pen.

Description of Traits Evaluated

Height was an evaluation of overall tallness of the steer in relation to weight and/or age. A score of 3 was average. Steers appearing to be lower set and shorter in the cannon were scored 2 and 1. On the other hand, steers that appeared to be taller than average, longer legged and higher at the withers were scored above 3. An extremely short-legged steer received a score of 1-.

Length was an estimation of overall length of the steer in relation to weight and/or age. A score of 3 was average. Steers that appeared to be shorter bodied with less distance from head to tail were scored 1s and 2s, while steers that were stretchier and longer sided than average were scored 4s and 5s. An extremely short-bodied calf received a score of 1-, with a very long-sided calf having a score of 5+.

Cattle that appeared to be well balanced, symmetrical and proportionate in height and length received identical scores for height and length. However, some cattle appeared to be longer and stretchier than they were tall, or taller and more upstanding than they were long. An example of a longer-than-tall score might be described as a 3+ for length and 3- for height. An extremely short-bodied animal might be scored 4 for height and 3 for body length. Overall frame size was a combination of height and length scores. This variable allowed for compromises between the height and length scores leaving a description that neither height nor length accounted for by themselves. For instance, if a calf were scored 3 for height and 3- for length, the grader would probably score the calf a 3 for overall frame size. Figure 2 depicts the five frame sizes (body types) utilized in describing differences in height, length and overall frame size in this study.

In addition to illustrating the various frame-size scores, Figure 2 also depicts the weight ranges at which cattle of varying frame sizes might be expected to reach 12 mm of fat cover at the 12th rib location. Using this chart as a general outline, predicted slaughter weight was estimated in pounds. A frame score 1 steer was estimated to reach 12 mm of fat cover before reaching a live weight of 850 lbs, frame

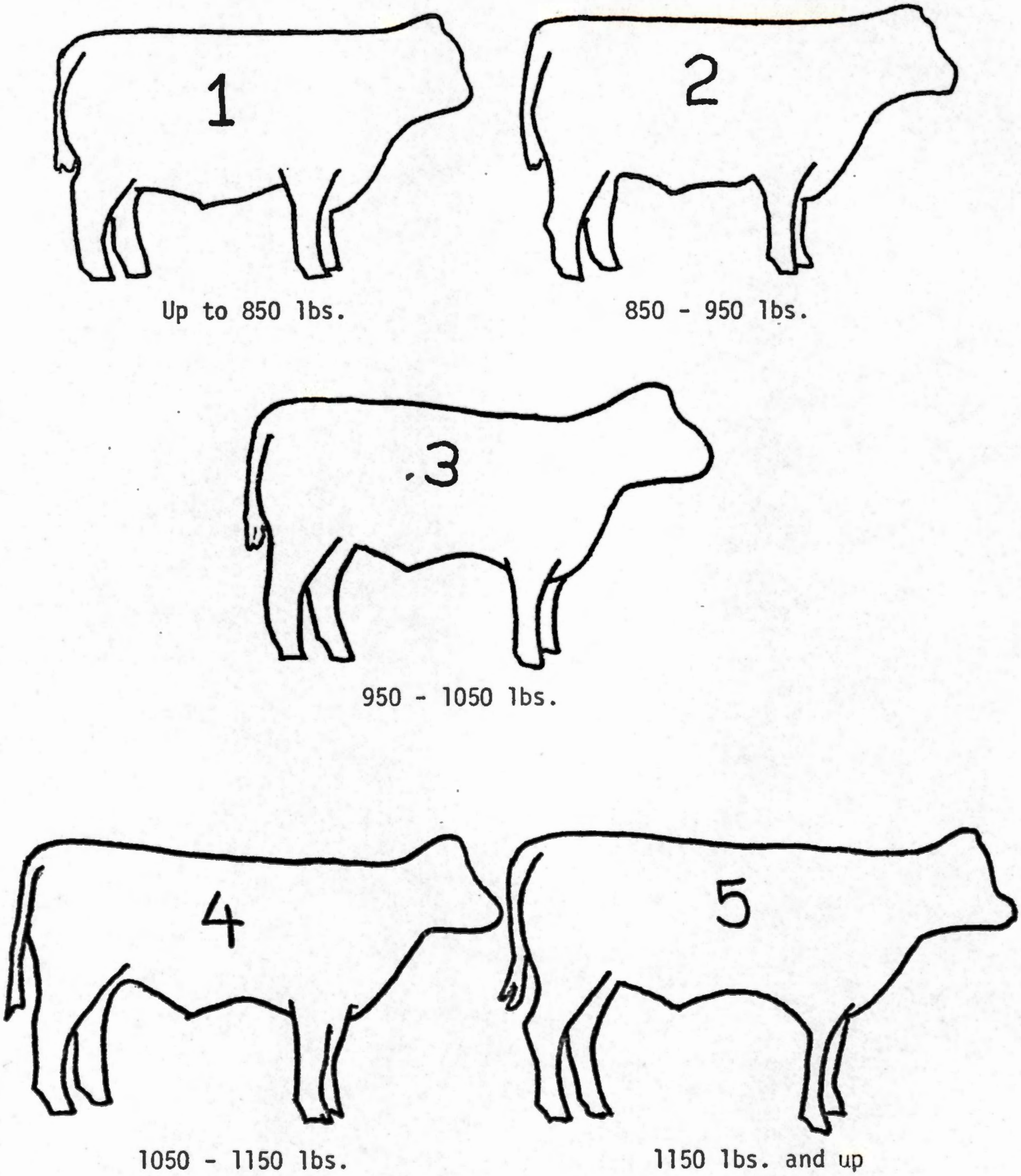

Figure 2. General appearance of cattle at various frame scores and the approximate weights at which they would be expected to have 12 mm of fat cover at the 12th rib.

score 2 between 850 and 950 lbs, up to a frame score 5 from 1150 lbs and over. A factor that affected predicted slaughter weight in addition to frame score was fat. If an animal appeared to be early maturing (or late maturing) and predisposed toward fatness (or leanness), the grader made adjustments in predicted slaughter weight accordingly.

General trimness score described the overall "trim" look of a steer from a side view. A score of 3 was considered to be average. A wasty-fronted, loose-made, deep-middled steer was scored in the 2s and 1s. Those cattle that were neater fronted, tighter middled than average and displayed an overall clean appearance irrespective of fat cover were scored in the 4s and 5s. A steer that was extremely leathery in the dewlap and brisket and excessively loose and deep middled was scored a low 1, while the extremely clean-fronted, neat, tight-middled, meaty-appearing steer was scored in the high 5s.

Muscle expression was a measure of general thickness and body shape. The term "muscle expression" became desirable for use as a result of a study conducted by Butterfield (1970) in which he found that holding fat constant and bone being a relative constant muscle mass remained the same, taken as a percent of carcass weight when contrasting conventional beef cattle against angular, flatter muscled cattle. A flat-quartered, close fronted, narrow-moving calf was scored in the 2s and 1s, while a moderately thick calf received a score in the 3s and 4s, with a very thick, wide-moving, grooved-top calf being scored in the high 4s and 5s. Factors influencing muscle expression were thickness and shape of the quarter, "expression" down the top, prominence of muscle in the stifle and forearm and width of walk.

Head shape was a score describing the general proportions of the head. A head that was moderately wide and slightly longer from the eye to the muzzle than from the eye to the poll was considered to be normal and was scored a 3. A head that was narrow and much longer from the eye to the muzzle than from the eye to the poll was scored in the 4s and 5s.

Estimated age was recorded in months. Factors considered when scoring for this trait were a youthful or mature look of the head, haircoat, length of body, length of tail, substance of bone, foot size and overall general appearance. On the average, as cattle mature, their heads appear to increase in size in relation to their body; their ears decrease in size in relation to the size of their heads; the muzzle becomes proportionately wider; the head becomes longer in relation to its width; the haircoat becomes coarser; the feet become larger in relation to the size of the bone and the tail increases in length and exhibits a more prominent switch.

Methods of Analysis

Using the statistical analysis system developed by Barr and Goodnight (1976), multiple regression analyses were performed on selected criteria variables for the feeder steers. The analyses related subjective scores to their respective objective measures.

Multiple Regression Analysis

Multiple regression analysis, calculated by using least squares analysis, is a means of predicting a dependent variable through the use of a number of independent variables.

The general form of the model was as follows:

$$Y = \mu + \text{height}_i + \text{length}_j + \text{depth}_k + \text{width}_l + \text{weight}_m + \text{fat}_n + \text{grader category}_o + \text{year}_p + \text{group}_q + \text{grader (grader category)} + \text{error}_{ijklmnopq},$$

where Y is the subjective height, length, frame, fat, trimness, muscle expression, head shape and predicted slaughter weight.

The analysis was used in order to determine grader effects on subjective evaluations by regressing the subjective scores on the objective measures.

It was shown by preliminary analyses that many of the dependent variables were synonymous with each other. Height, length and frame were highly related, and it was decided to use frame because of its combination description of frame size and because of its industry use. Head shape was synonymous with the body dimension scores, while predicted slaughter weight was associated with frame and fat. It was also shown that grader interactions with objective measures were significant ($\underline{p} < .001$) but explained less than 2% of the variation.

CHAPTER IV

RESULTS AND DISCUSSION

Description of the Feeder Steers

Simple Description

Table 1 contains the means and standard deviations for the subjective scores and objective measures of the feeder steers. The coefficients of correlation for the objective measures are shown in Table 2 on a within-year, year-breed and year-breed group basis.

Multiple Regression Analysis

R-square values (Table 3) show that models describing frame, fat and muscle account for 58%, 43% and 19% of the variation, respectively. Variables in the model estimating frame were all significant ($p < .001$); however, the graders placed more emphasis on height, depth and fat in arriving at a final frame score. Height, fat and depth were the variables that graders emphasized in estimating fat. Width ($p < .001$) was the main trait used by graders in describing muscle. This may be somewhat confounded in that an overall width measurement will also include fat. Width was of little value to the graders in describing frame and fat. Length, although significant ($p < .001$) for frame and fat and for muscle ($p < .05$), did not influence the graders in their estimations. Weight was significant ($p < .001$) in all models but did not greatly affect the graders in their decisions.

There was more agreement between grader-within-grader category than among grader categories for frame and muscle, while there was more

Table 1. Means and standard deviations of subjective scores and objective measures.

Subjective Variables	
Height[a]	8.0 ± 2.74
Length	8.2 ± 2.63
Frame	8.1 ± 2.68
Estimated fat (mm)	3.4 ± 1.38
General trimness	8.1 ± 1.98
Muscle expression	8.2 ± 1.60
Head shape	8.2 ± 1.96
Estimated age (months)	11 ± 1.56
Predicted slaughter weight (lbs)	1028 ± 116.21
Objective Variables	
Weight (lbs)	566 ± 89.44
Fat thickness (mm)	3.0 ± 1.41
Shoulder width (cm)	37.1 ± 2.26
Length (cm)	109.3 ± 5.74
Depth (cm)	56.9 ± 4.42
Height (cm)	103.7 ± 4.08

[a]Subjective scores are based on a 1-to-15 scoring system.

Table 2. Coefficients of correlation for objective measures within year, year, breed and year, group.

	Height	Length	Depth	Shoulder Width	Weight	Fat
Height						
Year		.42	.51	-.02 NS	.35	-.25
Year, breed		.41	.57	.01 NS	.33	-.13***
Year, group		.41	.56	.01 NS	.33	-.12***
Length			.36	.08*	.32	-.06 NS
			.37	.09*	.32	-.03 NS
			.38	.09*	.32	-.02 NS
Depth				.21	.43	.12***
				.19	.42	.10**
				.21	.43	.11**
Shoulder width					.38	.23
					.38	.20
					.40	.21
Fat						.10**
						.15
						.16

*p < .05 **p < .01 ***p < .001

Table 3. Analyses of variance for subjective frame, fat and muscle.

Source	Frame		Fat		Muscle	
	df	MS	df	MS	df	MS
Height	1	8471.93***	1	1007.98***	1	44.04***
Length	1	421.16***	1	30.45***	1	9.44*
Depth	1	2733.61***	1	393.64***	1	126.29***
Width	1	191.52***	1	177.70***	1	1139.25***
Weight	1	571.94***	1	74.49***	1	39.29***
Fat	1	764.49***	1	439.47***	1	.09
Grader category	2	1298.25***	2	13.73***	2	138.14***
Year	2	94.40***	2	95.42***	2	5.55
Breed group	1	2284.70***	1	214.26***	1	837.58***
Grader Grader category	18	150.98***	18	58.65***	18	66.19***
Residual	1298	3.03***	9298	1.08***	9298	2.07***
R-square	.58		.43		.19	

*p < .05

***p < .001

agreement among grader categories for fat.

R-square values (Table 4) increased .01, .01 and .02 for frame, fat and muscle, respectively, when the interactions height-grader category and height-grader-within-grader category were included in the model. Similar increases in R-square values of .02, .03 and .03 were found when the interactions breed group-grader category and breed group-grader-within-grader category were added to the model. However, these small increases would indicate that the graders were in agreement and handled the effects of height and breed group in a similar fashion.

Partial regression coefficients (Table 4) were all significant ($p < .001$) when the objective variables were regressed on frame and fat. Partial regression coefficients for frame showed that for each 1 cm increase in height, frame increased approximately about one-third of a frame score on a 1-15 basis. Coefficients for both depth and fat indicate that for each centimeter increase in depth or each millimeter increase in fat, frame score decreased approximately one-third for each. The equation for fat showed that for each centimeter increase in height estimated fat decreased .12, while as depth increased, estimated fat increased .11 mm per centimeter. Each increase of 1 mm of fat resulted in an increase of .22 mm in estimated fat.

Partial regression coefficients for muscle indicated that width was responsible for the greatest increase in the graders' estimate of muscle. One centimeter increase in width resulted in an increase of approximately one-fourth of a muscle score on a 1-15 basis. Length and width had virtually no effect on the graders' decision.

In general, as the calves were frame scored larger, they were taller, slightly longer, shallower, narrower and leaner. Calves became

Table 4. Partial regression coefficients and least squares means for subjective frame, fat and muscle.

Source	Frame	Fat	Muscle
Height	.35***	-.12***	-.03***
Length	.04***	-.01***	.01*
Depth	-.29***	.11***	-.06***
Width	-.09***	.09***	.22***
Weight	.01***	.00***	.01***
Fat	-.29***	.22***	.00
Grader category 1	7.85	3.28	8.71
2	9.13	3.17	8.40
3	7.77	3.26	8.12
Year 1976	8.41	3.18	8.30
1977	8.37	2.95	8.50
1978	7.96	3.58	8.43
Breed group 1	7.59	3.43	8.02
2	8.91	3.04	8.81
Grader (Grader category)[a]			
R-square	.58	.43	.19
R-square[b]	.59	.44	.21
R-square[c]	.60	.46	.22

$^{*}p < .05$ $^{***}p < .001$

[a]Lease square means for Grader (Grader Category) have been deleted due to the large number of graders.

[b]R-square for initial model plus Height-Grader Category and Height-Grader (Grader Category).

[c]R-square for initial model plus Breed Group-Grader Category and Breed Group-Grader (Grader Category).

lower set, slightly shorter, deeper, wider and fatter as fat score increased. Steers that were muscle scored more expressively were lower set, longer, shallower and wider.

Similar trends are found (Tables 5, 6, 7, 8, 9, 10) for the models on a within-grader category basis. R-square values for all grader categories were largest for frame, somewhat less for fat and less yet for muscle.

Height, depth and fat were the influencing factors for all grader categories in estimating frame, while height, depth and fat were emphasized more in fat estimation, and width was responsible for the greatest variation in muscle.

Partial regression coefficients (Tables 8, 9, 10) within-grader category indicated similar adjustments for all grader categories. Grader category 1 was more affected by breed group than was 2 or 3 as indicated by the differences in the least squares means of breed group. Grader category 1 was the smallest ($\underline{n} = 3$) and did see a wider distribution in the feeder steers. Grader category 2 was least influenced by breed group but did have the narrowest distribution. Small or no increase in R-square values when the interaction grader-breed group was added to the model indicated that all grader categories treated breed group similarly.

Agreement among graders, for subjective frame, fat and muscle, was further defined by coefficients of correlation (Tables 11, 12, 13) within year and within year and breed group. Coefficients among graders within year and within year and breed group were significant ($\underline{p} < .001$) for all grader relationships. Coefficients for frame ranged from .70-.95, .51-.86 and .58-.96 within year for 1976, 1977 and 1978, respectively.

Table 5. Analysis of variance for subjective frame, fat and muscle within grader category 1.

Source	Frame		Fat		Muscle	
	df	*MS*	*df*	*MS*	*df*	*MS*
Height	1	2134.46***	1	272.99***	1	36.71***
Length	1	90.72***	1	3.06	1	.12
Depth	1	576.71***	1	101.18***	1	35.83***
Width	1	123.26***	1	53.41***	1	264.27***
Weight	1	186.80***	1	13.46***	1	.26
Fat	1	324.33***	1	192.86***	1	.10
Year	2	40.65***	2	52.31***	2	16.03***
Breed group	1	967.47***	1	127.55***	1	330.75***
Grader	2	700.13***	2	9.99***	2	86.61***
Residual	1842	3.37***	1842	1.22***	1842	2.18***
R-square		.64		.46		.22

***$p < .001$

Table 6. Analysis of variance for subjective frame, fat and muscle within grader category 2.

Source	Frame		Fat		Muscle	
	df	MS	df	MS	df	MS
Height	1	3372.67***	1	391.15***	1	2.02
Length	1	247.97***	1	17.23***	1	12.56*
Depth	1	1354.09***	1	139.46***	1	50.10***
Width	1	27.86***	1	74.35***	1	478.44***
Weight	1	136.29**	1	37.30***	1	8.04*
Fat	1	238.68***	1	116.85***	1	.02
Year	2	10.55*	2	39.79***	2	5.20
Breed group	1	801.04***	1	47.84***	1	285.87***
Grader	10	21.64***	10	44.20***	10	31.68***
Residual	4402	2.83***	4402	1.09***	4402	2.05***
R-square		.51		.38		.13

*$p < .05$

**$p < .01$

***$p < .001$

Table 7. Analysis of variance for subjective frame, fat and muscle within grader category 3.

Source	Frame		Fat		Muscle	
	df	MS	df	MS	df	MS
Height	1	2919.12***	1	346.26***	1	27.16***
Length	1	98.23***	1	13.09***	1	.49
Depth	1	775.82***	1	153.73***	1	43.19***
Width	1	110.72***	1	65.00***	1	394.58***
Weight	1	328.64***	1	24.05***	1	54.34***
Fat	1	279.79***	1	173.62***	1	.01
Year	2	40.15***	2	17.09***	2	31.58***
Breed group	1	656.74***	1	74.48***	1	258.09***
Grader	6	168.07***	6	57.77***	6	107.76***
Residual	3036	2.77***	3036	.91***	3036	1.98***
R-square		.59		.51		.24

***p < .001

Table 8. Partial regression coefficients and least squares means of grader category 1 for subjective frame, fat and muscle.

Source	Frame	Fat	Muscle
Height	.39***	-.14***	-.05***
Length	.04***	-.01***	.00
Depth	-.30***	.12***	-.07***
Width	-.16***	.11***	.24***
Weight	.01***	.00***	.00
Fat	-.42***	.32***	-.01
Year 1976	8.47	2.87	8.90
1977	8.06	2.61	9.14
1978	7.55	3.77	8.53
Breed group 1	7.07	3.43	8.29
2	8.99	2.73	9.42
Grader 1	8.04	2.95	8.73
2	7.01	3.07	8.57
3	9.03	3.22	9.26
R-square	.64	.46	.22
R-square[a]	.65	.47	.22

***p < .001

[a]R-square when Grader-Breed Group is added to the model.

Table 9. Partial regression coefficients and least squares means of grader category 2 for subjective frame, fat and muscle.

Source	Frame	Fat	Muscle
Height	.32***	-.11***	-.01
Length	.05***	-.01***	.01***
Depth	-.30***	.10***	-.06***
Width	-.05**	.08***	.20**
Weight	.01***	.00***	.00*
Fat	-.23***	.16***	.00
Year 1976	9.23	3.31	8.57
1977	9.11	2.97	8.37
1978	8.85	3.52	8.34
Breed group 1	8.50	3.40	8.09
2	9.62	3.13	8.76
Grader 1	8.79	4.00	8.29
2	9.07	2.98	8.37
3	8.95	3.74	8.22
4	9.20	3.14	8.63
5	8.96	3.25	8.67
6	9.10	3.40	9.03
7	9.29	2.97	8.25
8	8.86	3.04	8.04
9	8.77	3.46	8.28
10	9.17	3.27	8.63
11	9.55	2.66	8.32
R-square	.51	.38	.13
R-square[a]	.52	.41	.16

*p < .05 **p < .01 ***p < .001

[a]R-square when Grader-Breed Group is added to the model.

Table 10. Partial regression coefficients and least squares means of grader category 3 for subjective frame, fat and muscle.

Source	Frame	Fat	Muscle
Height	.35***	-.12***	-.03***
Length	.04***	-.01***	.00
Depth	-.27***	.12***	-.06***
Width	-.12***	.09***	.23***
Weight	.01***	.00***	.01***
Fat	-.31***	.24***	-.01
Year 1976	8.06	3.08	7.74
1977	8.13	3.06	8.05
1978	7.35	3.56	8.46
Breed group 1	7.23	3.44	7.70
2	8.46	3.02	8.47
Grader 1	7.45	2.55	7.02
2	8.07	3.12	8.44
3	7.09	3.22	8.16
4	8.06	3.87	8.47
5	8.26	3.43	8.04
6	8.99	3.59	7.73
7	7.00	2.82	8.72
R-square	.59	.51	.24
R-square[a]	.60	.52	.27

***p < .001

[a]R-square when Grader-Breed Group is added to the model.

Table 11. Coefficients of correlation among graders' scores for subjective frame, fat and muscle in 1976.[a]

Graders		Graders 1	2	3	4	5	6	7	8	9	10
1	Frame		.77	.78	.78	.70	.83	.83	.74	.79	.76
	Muscle		.40	.35	.40	.42	.52	.56	.22	.51	.37
	Fat		.64	.67	.57	.68	.76	.70	.61	.59	.72
2	Frame	.68		.85	.81	.82	.87	.89	.82	.81	.79
	Muscle	.42		.38	.44	.40	.50	.39	.22	.41	.14
	Fat	.52		.68	.55	.53	.70	.65	.56	.45	.55
3	Frame	.67	.80		.73	.78	.89	.87	.90	.85	.74
	Muscle	.29	.41		.41	.33	.45	.38	.36	.38	.27
	Fat	.56	.60		.59	.60	.76	.67	.69	.53	.60
4	Frame	.69	.75	.63		.72	.81	.83	.74	.79	.84
	Muscle	.39	.45	.40		.52	.49	.55	.14	.36	.39
	Fat	.35	.40	.47		.58	.65	.59	.55	.47	.68
5	Frame	.54	.75	.69	.62		.80	.81	.76	.74	.78
	Muscle	.40	.41	.29	.51		.46	.47	.17	.36	.51
	Fat	.48	.36	.46	.35		.68	.60	.59	.55	.73
6	Frame	.73	.84	.85	.75	.71		.95	.87	.88	.82
	Muscle	.55	.50	.48	.50	.48		.58	.14	.55	.22
	Fat	.64	.60	.68	.50	.50		.79	.64	.62	.68
7	Frame	.72	.86	.81	.77	.72	.93		.83	.87	.83
	Muscle	.57	.40	.38	.55	.47	.59		.19	.36	.37
	Fat	.60	.56	.59	.46	.46	.73		.59	.62	.59
8	Frame	.62	.77	.87	.65	.66	.82	.77		.83	.73
	Muscle	.20	.23	.34	.13	.15	.14	.19		.19	.17
	Fat	.47	.45	.62	.41	.44	.53	.48		.55	.56
9	Frame	.67	.75	.78	.72	.63	.83	.81	.76		.78
	Muscle	.51	.42	.37	.36	.35	.56	.36	.18		.21
	Fat	.50	.35	.44	.34	.44	.54	.55	.47		.51
10	Frame	.64	.72	.63	.79	.67	.72	.75	.63	.68	
	Muscle	.29	.18	.16	.40	.49	.28	.40	.13	.18	
	Fat	.51	.37	.45	.48	.52	.49	.42	.38	.38	

[a]Coefficients above the diagonal are within year and coefficients below the diagonal are within year and breed group.

If coefficient is $\leq .14$, then $p > .05$
If coefficient is between .15 and .17, inclusive, then $p < .05$.
If coefficient is between .18 and .23, inclusive, then $p < .01$.
If coefficient is $\geq .24$, then $p < .001$.

Table 12. Coefficients of correlation among graders' scores for subjective frame, muscle and fat in 1977.[a]

Graders		Graders 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Frame		.83	.77	.84	.84	.82	.67	.85	.76	.81	.67	.76	.78	.73	.65	.82
	Muscle		.55	.40	.63	.37	.45	.11	.53	.23	.55	.49	.51	.37	.42	-.01	.52
	Fat		.33	.45	.40	.38	.50	.32	.30	.44	.39	.33	.21	.49	.33	.31	.32
2	Frame	.77		.72	.80	.78	.76	.66	.82	.65	.75	.61	.73	.73	.68	.53	.78
	Muscle	.55		.31	.51	.40	.44	.04	.43	.29	.49	.42	.45	.41	.37	.07	.41
	Fat	.23		.72	.70	.61	.59	.45	.57	.69	.47	.38	.49	.58	.59	.52	.70
3	Frame	.68	.60		.78	.82	.72	.63	.73	.65	.61	.62	.57	.74	.60	.53	.75
	Muscle	.41	.32		.42	.48	.20	-.07	.43	.34	.41	.46	.38	.16	.18	-.01	.22
	Fat	.39	.67		.76	.60	.67	.50	.59	.73	.61	.51	.48	.62	.60	.58	.66
4	Frame	.77	.68	.68		.86	.80	.65	.87	.67	.75	.67	.68	.79	.73	.52	.85
	Muscle	.61	.52	.45		.45	.54	.18	.58	.36	.57	.57	.56	.50	.46	.07	.56
	Fat	.32	.61	.71		.64	.70	.37	.68	.66	.59	.51	.51	.50	.55	.49	.73
5	Frame	.79	.66	.75	.80		.79	.69	.93	.72	.74	.64	.66	.79	.70	.57	.81
	Muscle	.37	.40	.48	.46		.42	.09	.49	.32	.39	.45	.38	.27	.31	.16	.26
	Fat	.29	.50	.53	.54		.56	.24	.67	.54	.47	.44	.47	.41	.47	.41	.62
6	Frame	.78	.70	.65	.75	.74		.63	.81	.76	.80	.70	.72	.83	.70	.57	.80
	Muscle	.41	.43	.21	.48	.43		.30	.53	.17	.36	.35	.39	.44	.49	.18	.42
	Fat	.45	.52	.63	.66	.49		.46	.66	.66	.61	.56	.43	.52	.48	.52	.64
7	Frame	.57	.54	.51	.53	.58	.55		.65	.55	.63	.61	.59	.62	.60	.58	.73
	Muscle	.02	.01	-.09	.03	.07	.19		.04	-.04	.13	.09	.04	.09	.36	.29	.25
	Fat	.30	.46	.50	.37	.22	.46		.20	.42	.45	.29	.24	.52	.40	.38	.24
8	Frame	.79	.70	.61	.80	.89	.77	.53		.74	.79	.62	.79	.78	.72	.54	.83
	Muscle	.51	.43	.43	.57	.49	.51	-.02		.30	.47	.43	.49	.37	.29	-.02	.37
	Fat	.22	.49	.54	.61	.61	.62	.18		.54	.59	.56	.43	.37	.45	.44	.71
9	Frame	.70	.56	.56	.59	.66	.72	.45	.69		.72	.60	.66	.73	.63	.58	.66
	Muscle	.25	.30	.35	.42	.32	.21	-.01	.32		.25	.31	.32	.34	.09	.03	.19
	Fat	.37	.62	.69	.60	.46	.62	.45	.47		.57	.42	.53	.62	.59	.60	.65
10	Frame	.78	.72	.52	.71	.69	.76	.56	.76	.67		.64	.82	.72	.79	.63	.76
	Muscle	.56	.49	.41	.61	.39	.38	.14	.47	.25		.51	.51	.45	.44	.16	.41
	Fat	.36	.44	.59	.58	.44	.59	.44	.57	.55		.55	.37	.49	.48	.46	.52
11	Frame	.60	.51	.52	.59	.54	.64	.53	.52	.52	.58		.63	.69	.66	.52	.65
	Muscle	.47	.41	.46	.55	.45	.30	.01	.41	.33	.51		.46	.40	.36	.12	.41
	Fat	.28	.31	.47	.46	.38	.52	.28	.53	.36	.52		.31	.34	.38	.40	.53
12	Frame	.72	.69	.47	.61	.59	.67	.51	.63	.60	.79	.56		.67	.71	.60	.69
	Muscle	.51	.45	.38	.57	.37	.38	.01	.48	.33	.51	.46		.41	.27	-.04	.44
	Fat	.14	.42	.42	.44	.41	.37	.22	.50	.47	.34	.26		.40	.34	.45	.52
13	Frame	.74	.68	.69	.77	.76	.81	.54	.76	.68	.68	.63	.62		.72	.54	.77
	Muscle	.36	.41	.16	.52	.27	.44	.07	.36	.35	.45	.39	.41		.31	.20	.39
	Fat	.45	.53	.58	.46	.34	.48	.52	.31	.58	.47	.29	.35		.56	.46	.42
14	Frame	.65	.58	.47	.65	.60	.64	.50	.63	.55	.75	.58	.65	.66		.51	.72
	Muscle	.39	.37	.18	.40	.31	.44	.29	.26	.12	.45	.32	.26	.31		.29	.44
	Fat	.26	.52	.55	.47	.38	.42	.39	.38	.54	.45	.32	.27	.52		.57	.56
15	Frame	.62	.48	.48	.46	.53	.52	.54	.49	.54	.59	.47	.56	.50	.46		.55
	Muscle	-.05	.06	-.01	.01	.15	.13	.25	-.05	.05	.16	.09	-.06	.19	.25		.18
	Fat	.29	.55	.58	.51	.41	.52	.37	.44	.61	.45	.39	.44	.46	.57		.56
16	Frame	.74	.68	.65	.78	.72	.75	.64	.74	.57	.72	.57	.63	.73	.63	.50	
	Muscle	.49	.41	.24	.48	.26	.33	.10	.35	.25	.45	.37	.45	.40	.37	.12	
	Fat	.21	.60	.59	.65	.51	.59	.22	.66	.58	.51	.48	.46	.35	.48	.59	

[a]Coefficients above the diagonal are within year and coefficients below the diagonal are within year and breed group.

If coefficient is <.13, then $p > .05$.
If coefficient is between .14 and .16, inclusive, then $p < .05$.
If coefficient is between .18 and .23, inclusive, then $p < .01$.
If coefficient is $\geq .24$, then $p < .001$.

Table 13. Coefficients of correlation among graders' scores for subjective frame, muscle and fat in 1978.[a]

Graders		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Frame		.77	.79	.82	.79	.82	.83	.79	.77	.73	.74	.76	.76	.80
	Muscle		.52	.54	.60	.64	.63	.66	.39	.54	.59	.45	.41	.21	.43
	Fat		.49	.62	.65	.65	.67	.74	.50	.55	.71	.38	.65	.49	.60
2	Frame	.67		.73	.83	.76	.86	.86	.73	.74	.68	.76	.69	.72	.75
	Muscle	.48		.47	.60	.54	.54	.51	.39	.53	.49	.38	.44	.24	.48
	Fat	.44		.60	.69	.66	.65	.64	.60	.51	.59	.51	.56	.51	.63
3	Frame	.69	.61		.80	.88	.81	.83	.80	.85	.80	.75	.86	.81	.90
	Muscle	.48	.43		.41	.65	.47	.51	.26	.54	.56	.30	.53	.25	.53
	Fat	.55	.55		.65	.66	.73	.72	.47	.58	.66	.61	.66	.53	.80
4	Frame	.76	.78	.72		.81	.87	.88	.82	.81	.76	.81	.78	.79	.81
	Muscle	.60	.59	.39		.54	.58	.54	.35	.55	.47	.53	.41	.20	.47
	Fat	.61	.66	.61		.73	.70	.72	.62	.62	.63	.49	.63	.58	.66
5	Frame	.67	.64	.81	.74		.84	.86	.80	.85	.82	.79	.83	.82	.89
	Muscle	.59	.50	.60	.53		.54	.52	.38	.67	.56	.53	.50	.25	.60
	Fat	.60	.63	.61	.70		.76	.76	.70	.63	.69	.52	.73	.70	.68
6	Frame	.74	.80	.72	.83	.76		.96	.84	.83	.75	.84	.77	.80	.83
	Muscle	.60	.51	.42	.58	.50		.72	.35	.49	.47	.41	.39	.22	.41
	Fat	.60	.61	.67	.66	.73		.85	.65	.57	.70	.54	.68	.61	.76
7	Frame	.74	.80	.74	.83	.79	.94		.84	.84	.77	.85	.80	.83	.85
	Muscle	.62	.48	.46	.53	.47	.70		.35	.45	.48	.37	.45	.24	.42
	Fat	.69	.60	.67	.68	.73	.83		.62	.64	.72	.45	.71	.58	.72
8	Frame	.70	.62	.71	.76	.72	.78	.78		.83	.78	.81	.81	.79	.78
	Muscle	.38	.38	.24	.34	.37	.33	.33		.45	.30	.40	.37	.31	.39
	Fat	.42	.55	.36	.57	.66	.58	.56		.56	.59	.34	.66	.61	.56
9	Frame	.69	.65	.79	.76	.80	.76	.78	.76		.78	.80	.91	.82	.86
	Muscle	153	.52	.54	.54	.67	.47	.43	.45		.44	.60	.56	.25	.58
	Fat	.54	.49	.58	.61	.62	.57	.63	.55		.57	.49	.70	.56	.59
10	Frame	.61	.56	.70	.68	.74	.65	.67	.70	.70		.76	.79	.76	.77
	Muscle	.51	.44	.49	.47	.48	.41	.41	.30	.45		.29	.36	.30	.41
	Fat	.64	.55	.56	.57	.65	.61	.66	.49	.59		.45	.69	.52	.67
11	Frame	.66	.70	.68	.76	.74	.80	.81	.75	.75	.69		.76	.74	.77
	Muscle	.54	.43	.38	.56	.62	.47	.43	.42	.63	.43		.38	.16	.50
	Fat	.33	.48	.58	.46	.49	.50	.40	.29	.48	.41		.45	.47	.59
12	Frame	.65	.57	.80	.70	.75	.68	.72	.73	.88	.71	.68		.78	.86
	Muscle	.37	.41	.51	.40	.48	.36	.42	.36	.55	.31	.41		.34	.46
	Fat	.59	.51	.60	.58	.70	.62	.66	.61	.70	.63	.41		.61	.68
13	Frame	.65	.60	.72	.72	.74	.72	.75	.69	.75	.66	.66	.69		.84
	Muscle	.16	.20	.20	.18	.20	.18	.20	.30	.23	.24	.20	.32		.21
	Fat	.44	.47	.48	.55	.68	.58	.55	.57	.55	.49	.44	.57		.61
14	Frame	.69	.64	.84	.73	.82	.76	.77	.69	.81	.66	.71	.80	.76	
	Muscle	.51	.47	.52	.46	.60	.39	.40	.39	.58	.41	.53	.44	.19	
	Fat	.52	.58	.75	.61	.63	.69	.66	.47	.59	.56	.57	.61	.58	

[a]Coefficients above the diagonal are within year and coefficients below the diagonal are within year and breed group.

If coefficient is $\leq .17$, then $p < .01$.
If coefficient is $\geq .18$, then $p < .001$.

Slightly less agreement among graders was found when coefficients were also within breed group. Coefficients ranged from .54-.93, .45-.89 and .56-.96 for 1976, 1977 and 1978, respectively.

Somewhat less agreement was found for estimated fat where coefficients ranged from .45-.79, 120-.76 and .35-.85 within year and .34-.73, .14-.71 and .29-.83 within year and breed group for 1976, 1977 and 1978, respectively. Considerably less agreement was found for muscle expression where coefficients ranged from .14-.58, -.07-.57 and .16-.72 within year and .13-.59, -.06-.61 and .16-.70 within year and breed group for 1976, 1977 and 1978, respectively.

Coefficients of determination between scoring times of one grader (Table 14) indicated that the grader could more accurately redescribe the steers for body dimension rather than for fat, trimness and muscle expression. The inability to redescribe the steers in these subjective areas, in large measure, could be due to the steers' weight gain over the period.

R-squares (Table 15) for grader predictions estimating carcass traits and days on feed resulted in more variation being accounted for in models for carcass weight .57-.62 and days on feed .52-.56. R-squares for yield grade and carcass quality grade ranged from .07-.14 and .06-.10, respectively. However, all steers were slaughtered on a fat constant basis, therefore reducing the total variation. Although grader experience and the weighting of variables by the graders varied, similar variation was explained.

Table 14. Coefficients of correlation between scoring times of one grader for subjective scores.

	Coefficients Based on	
	Within Year	Within Year, Breed
Height	.86	.77
Length	.86	.75
Frame	.86	.77
Fat	.57	.51
Trimness	.59	.54
Muscle expression	.54	.53
Head shape	.74	.71
Predicted slaughter weight	.86	.76

For all coefficients, $p < .0001$.

Table 15. Coefficients of determination for grader predictions of carcass weight, yield grade, carcass quality grade and days on feed for the 1976 steers.

Grader	Carcass Weight[a]	Yield Grade	Carcass Quality Grade	Days on Feed
1	.58	.09	.07	.55
2	.62	.08	.08	.54
3	.57	.08	.06	.54
4	.59	.10	.09	.52
5	.59	.07	.10	.56
6	.59	.12	.07	.55
7	.59	.11	.08	.52
8	.59	.11	.06	.53
9	.57	.14	.07	.53
10	.59	.07	.09	.53

[a]All models contained $y = \mu$ + weight + frame score + muscle score + fat + breed group + ration + frame score X ration + frame score X breed group + error.

Conclusions

Results of this study led to the following conclusions:

1. Graders were more consistent in scoring traits associated with structural dimension, somewhat less so in estimating fat and quite inconsistent in scoring muscle expression of feeder calves.

2. Graders of similar training and experience were more in agreement among themselves (as a group) in estimating frame, whereas all graders, regardless of training and experience, were more in agreement on their estimation of fat thickness.

3. Breed (Angus, Hereford, Angus X Hereford versus Charolais) did not greatly affect the graders' estimation of frame, fat or muscle.

4. Feeder cattle can be accurately redescribed over a period of time for frame and somewhat less so for fat and muscle expression.

CHAPTER V

SUMMARY

Data from 687 steer calves of two breed groups, British (Angus, Hereford, Angus X Hereford) and Charolais crosses, formed the basis of this study. The steers were purchased through East Tennessee Graded Feeder Calf sales and represented Prime, Choice and Good grades with a mean weight of 566 lbs.

The steers were fed ad libitum corn silage for a 3-4-week period while being allowed to adjust and recover from the stresses of weaning and shipment. Following the adjustment period, the steers were weighed, photographed, sonorayed for fat thickness, measured for shoulder width and subjectively evaluated independently by committees of 10, 16 and 14 graders in 1976, 1977 and 1978, respectively. All steers were subjectively scored on a 1-15 basis for height, length, overall frame size, general trimness, head shape and muscle expression. Fat thickness was estimated in millimeters, age in months and predicted slaughter weight in pounds.

For analyses, each year the graders were divided into three categories according to their training and experience. In 1976 and 1977, approximately 30 days prior to the scoring by the committees, the steers were scored by an experienced grader who was a member of the evaluation committee.

The 1976 steers were randomly divided within breed and feeder grade into two ration groups of high and medium levels of energy. The steers were weighed and sonorayed for fat thickness at 14-day intervals until they reached 12 mm of fat thickness at which time they were slaughtered. Days on feed were calculated, and the carcass traits of weight, yield grade and quality grade were recorded.

It was found by multiple regression analysis that models describing frame, fat and muscle accounted for 58%, 43% and 19% of the variation, respecitvely. Graders utilized height, depth and fat in estimating frame and fat, while width was the major factor in estimating muscle. Length and weight did not affect graders in their evaluations. There was more agreement among graders within-grader category for frame and muscle, while there was greater agreement for fat among grader categories. Increases in R-squares of .01, .01 and .02 for frame, fat and muscle, respectively, were found when height-grader interactions were added to the models. Similar increases of .02, .03 and .03 in R-squares were attained when breed group-grader interactions were added to models for frame, fat and muscle, respectively. These small increases would indicate that graders handled the effects of height and breed group in a like manner.

Partial regression coefficients indicated that larger framed steers were evaluated as being taller, slightly longer, shallower, narrower and leaner. When estimated fat increased, calves were seen as being lower set, slightly shorter, deeper, wider and fatter. Steers that were scored high for muscle (muscle expression) were evaluated as being lower set, longer, shallower and wider by the graders.

Coefficients of correlation among graders were performed on a within-year and within year-breed group basis to further define agreement among graders. Coefficients for frame score ranged from .70-.95,

.51-.86 and .58-.96 within year and .54-.93, .45-.89 and .56-.96 within year-breed group for 1976, 1977 and 1978, respectively. Somewhat less agreement was found for estimated fat where coefficients ranged from .45-.79, .20-.76 and .38-.85 within year and .34-.73, .14-.71 and .29-.83 within year and breed group for 1976, 1977 and 1978, respectively. Considerably less agreement was found for muscle score where coefficients ranged from .14-.58, -.07-.57 and .16-.72 within year and .13-.59, -.09-.61 and .16-.70 within year and breed group for 1976, 1977 and 1978, respectively.

Coefficients of determination between scoring times by one grader in 1976 and 1977 indicated that steers were more accurately redescribed for body dimension rather than for fat, trimness and muscle expression. The failure to accurately describe fat, trimness and muscle expression may be due, in large measure, to weight gain and environmental influences during the 30-day period between evaluations.

R-squares for grader predictions of carcass weight and days on feed were .57-.62 and .52-.56, respectively. R-squares for yield grade, .07-.14 and carcass quality grade .06-.10 were smaller; however, the steers were slaughtered on a fat constant basis, thus reducing the total variation. Although grader experience and the weighting of variables by the graders varied, similar variation was explained.

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APPENDIX

Table A-1. Coefficients of correlation among graders' scores for subjective frame, muscle and fat in 1976.[a]

		Grader									
Grader		1	2	3	4	5	6	7	8	9	10
1	Frame		.77	.78	.78	.70	.83	.83	.74	.79	.76
	Muscle		.40	.35	.40	.42	.52	.56	.22	.51	.37
	Fat		.64	.67	.57	.68	.76	.70	.61	.59	.72
2	Frame	.71		.85	.81	.82	.87	.89	.82	.81	.79
	Muscle	.42		.38	.44	.40	.50	.39	.22	.41	.14
	Fat	.48		.68	.55	.53	.70	.65	.56	.45	.55
3	Frame	.66	.80		.73	.78	.89	.87	.90	.85	.74
	Muscle	.27	.40		.41	.33	.45	.38	.36	.38	.27
	Fat	.52	.58		.59	.60	.76	.67	.69	.53	.60
4	Frame	.70	.75	.63		.72	.81	.83	.74	.79	.84
	Muscle	.36	.44	.37		.52	.49	.55	.14	.36	.39
	Fat	.34	.40	.46		.58	.65	.59	.55	.47	.68
5	Frame	.57	.76	.70	.62		.80	.81	.76	.74	.78
	Muscle	.39	.40	.29	.50		.46	.47	.17	.36	.51
	Fat	.50	.36	.46	.36		.68	.60	.59	.55	.73
6	Frame	.72	.85	.84	.75	.72		.95	.87	.88	.82
	Muscle	.54	.51	.46	.47	.48		.58	.14	.55	.22
	Fat	.63	.59	.67	.48	.51		.79	.64	.62	.68
7	Frame	.71	.87	.80	.76	.73	.92		.83	.87	.83
	Muscle	.55	.39	.36	.52	.46	.56		.19	.36	.37
	Fat	.60	.56	.58	.46	.46	.73		.59	.62	.59
8	Frame	.62	.77	.87	.65	.67	.82	.76		.83	.73
	Muscle	.20	.23	.34	.13	.15	.15	.19		.19	.17
	Fat	.47	.44	.61	.40	.45	.51	.48		.55	.56
9	Frame	.66	.76	.78	.72	.65	.82	.80	.75		.78
	Muscle	.48	.41	.34	.30	.33	.52	.31	.19		.21
	Fat	.51	.34	.44	.33	.44	.54	.55	.46		.51
10	Frame	.66	.72	.63	.79	.68	.73	.75	.63	.69	
	Muscle	.26	.16	.14	.36	.47	.26	.37	.14	.14	
	Fat	.49	.35	.43	.49	.51	.48	.42	.38	.38	

[a]Coefficients above the diagonal are within year and coefficients below the diagonal are within year and breed.

If coefficient is ≤ .14 then P>.05.
If coefficient is between .15 and .17 inclusive then P<.05.
If coefficient is between .18 and .23 inclusive then P<.01.
If coefficient is between .24 and .27 inclusive then P<.001.
If coefficient is ≥ .28 then P<.0001.

Table A-2. Coefficients of correlation among graders' scores for subjective frame, muscle and fat in 1977.[a]

Grader		Grader 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Frame		.83	.77	.84	.84	.82	.67	.85	.76	.81	.67	.76	.78	.73	.65	.82
	Muscle		.55	.40	.63	.37	.45	.11	.53	.23	.55	.49	.51	.37	.42	-.01	.52
	Fat		.33	.45	.40	.38	.50	.32	.30	.44	.39	.33	.21	.49	.33	.31	.32
2	Frame	.76		.72	.80	.78	.76	.66	.82	.65	.75	.61	.73	.73	.68	.53	.78
	Muscle	.55		.31	.51	.40	.44	.04	.43	.29	.49	.42	.45	.41	.37	.07	.41
	Fat	.23		.72	.70	.61	.59	.45	.57	.69	.47	.38	.49	.58	.59	.52	.70
3	Frame	.70	.61		.78	.82	.72	.63	.73	.65	.61	.62	.57	.74	.60	.53	.75
	Muscle	.41	.32		.42	.48	.20	-.07	.43	.34	.41	.46	.38	.16	.18	-.01	.22
	Fat	.39	.67		.76	.60	.67	.50	.59	.73	.61	.51	.48	.62	.60	.58	.66
4	Frame	.78	.68	.68		.86	.80	.65	.87	.67	.75	.67	.68	.79	.73	.52	.85
	Muscle	.61	.52	.45		.45	.54	.18	.58	.36	.57	.57	.56	.50	.46	.07	.56
	Fat	.32	.61	.71		.64	.70	.37	.68	.66	.59	.51	.51	.50	.55	.49	.73
5	Frame	.79	.67	.75	.30		.79	.69	.93	.72	.74	.64	.66	.79	.70	.57	.81
	Muscle	.38	.40	.48	.46		.42	.09	.49	.32	.39	.45	.38	.27	.31	.16	.26
	Fat	.29	.51	.53	.54		.56	.24	.67	.54	.47	.44	.47	.41	.47	.41	.62
6	Frame	.78	.70	.65	.75	.74		.63	.81	.76	.80	.70	.72	.83	.70	.57	.80
	Muscle	.41	.44	.22	.48	.44		.30	.53	.17	.36	.35	.39	.44	.49	.18	.42
	Fat	.46	.52	.63	.65	.49		.46	.66	.66	.61	.56	.43	.52	.48	.52	.54
7	Frame	.57	.54	.52	.53	.59	.55		.65	.55	.63	.61	.59	.62	.60	.58	.73
	Muscle	.01	.01	-.07	.04	.10	.18		.04	-.04	.14	.09	.04	.09	.36	.29	.25
	Fat	.30	.46	.51	.37	.23	.46		.20	.42	.45	.29	.24	.52	.40	.38	.24
8	Frame	.79	.70	.62	.80	.89	.77	.53		.74	.79	.62	.69	.78	.72	.54	.83
	Muscle	.52	.43	.43	.58	.48	.52	-.0003		.30	.47	.43	.49	.37	.29	-.02	.37
	Fat	.24	.50	.54	.62	.61	.62	.19		.54	.59	.56	.54	.37	.45	.44	.71
9	Frame	.70	.56	.56	.59	.66	.72	.46	.69		.72	.60	.66	.73	.63	.58	.66
	Muscle	.26	.30	.34	.42	.32	.22	-.001	.32		.25	.31	.32	.34	.09	.03	.19
	Fat	.38	.63	.70	.60	.45	.62	.43	.45		.57	.42	.53	.62	.59	.60	.65
10	Frame	.78	.73	.56	.72	.72	.78	.55	.77	.69		.64	.82	.72	.79	.63	.76
	Muscle	.56	.49	.41	.61	.40	.38	.14	.47	.25		.51	.51	.45	.44	.16	.41
	Fat	.37	.45	.59	.58	.43	.59	.45	.56	.54		.55	.37	.49	.48	.46	.52
11	Frame	.60	.52	.58	.61	.58	.67	.53	.52	.55	.56		.63	.69	.66	.52	.65
	Muscle	.47	.41	.47	.55	.46	.30	-.0002	.42	.33	.51		.46	.40	.36	.12	.41
	Fat	.28	.31	.46	.46	.37	.52	.29	.52	.35	.52		.31	.34	.38	.40	.53
12	Frame	.72	.70	.51	.63	.62	.69	.50	.64	.62	.78	.54		.67	.71	.60	.69
	Muscle	.51	.45	.37	.57	.37	.39	.01	.48	.33	.52	.46		.41	.27	-.04	.44
	Fat	.15	.42	.42	.44	.40	.37	.22	.50	.47	.34	.26		.40	.34	.45	.52
13	Frame	.74	.68	.69	.77	.76	.81	.55	.76	.68	.70	.66	.66		.72	.54	.77
	Muscle	.36	.41	.16	.52	.29	.44	.06	.37	.36	.45	.38	.41		.31	.20	.39
	Fat	.46	.54	.58	.44	.34	.47	.53	.30	.57	.46	.28	.35		.56	.46	.42
14	Frame	.65	.59	.51	.67	.63	.65	.49	.63	.57	.73	.55	.63	.68		.51	.72
	Muscle	.39	.38	.20	.41	.34	.43	.27	.28	.13	.46	.32	.27	.30		.29	.44
	Fat	.26	.52	.54	.47	.38	.41	.39	.37	.53	.45	.32	.27	.52		.57	.56
15	Frame	.62	.48	.50	.46	.55	.53	.53	.49	.55	.58	.45	.54	.50	.44		.55
	Muscle	-.05	.06	-.01	.01	.15	.13	.25	-.05	.05	.16	.09	-.06	.19	.26		.18
	Fat	.30	.55	.58	.51	.41	.51	.37	.44	.61	.45	.38	.44	.45	.57		.56
16	Frame	.74	.68	.66	.78	.73	.76	.64	.74	.58	.71	.57	.63	.73	.63	.50	
	Muscle	.49	.42	.25	.49	.29	.33	.08	.37	.26	.45	.37	.46	.40	.36	.12	
	Fat	.22	.61	.59	.66	.50	.59	.24	.65	.57	.50	.47	.46	.34	.48	.60	

[a]Coefficients above the diagonal are within year and coefficients below the diagonal are within year and breed.

If coefficient is $\leq$ .13 the $P>.05$.
If coefficient is between .18 and .23 inclusive then $P<.01$.
If coefficient is between .24 and .26 inclusive then $P<.001$.
If coefficient is $\geq$ .27 then $P<.0001$.

Table A-3. Coefficients of correlation among graders' scores for subjective frame, muscle and fat in 1978.[a]

Graders		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Frame		.77	.79	.82	.79	.82	.83	.79	.77	.73	.74	.76	.76	.80
	Muscle		.52	.54	.60	.64	.63	.66	.39	.54	.59	.45	.41	.21	.43
	Fat		.49	.62	.65	.65	.67	.74	.50	.55	.71	.38	.65	.49	.60
2	Frame	.67		.73	.83	.76	.86	.86	.73	.74	.68	.76	.69	.72	.75
	Muscle	.46		.47	.60	.54	.54	.51	.39	.53	.49	.38	.44	.24	.48
	Fat	.42		.60	.69	.66	.65	.64	.60	.51	.59	.51	.56	.51	.63
3	Frame	.67	.60		.80	.88	.81	.83	.80	.85	.80	.75	.86	.81	.90
	Muscle	.48	.42		.41	.65	.47	.51	.26	.54	.56	.30	.53	.25	.53
	Fat	.53	.54		.65	.66	.73	.72	.47	.58	.66	.61	.66	.53	.80
4	Frame	.75	.78	.70		.81	.87	.88	.82	.81	.76	.81	.78	.79	.81
	Muscle	.58	.58	.39		.54	.58	.54	.35	.55	.47	.53	.41	.20	.47
	Fat	.60	.65	.60		.73	.70	.72	.62	.62	.63	.49	.63	.58	.66
5	Frame	.66	.64	.79	.72		.84	.86	.80	.85	.82	.79	.83	.82	.89
	Muscle	.58	.49	.60	.52		.54	.52	.38	.67	.56	.53	.50	.25	.60
	Fat	.59	.62	.60	.70		.76	.76	.70	.63	.69	.52	.73	.70	.68
6	Frame	.73	.80	.71	.82	.74		.96	.84	.83	.75	.84	.77	.80	.83
	Muscle	.58	.49	.42	.56	.49		.72	.35	.49	.47	.41	.39	.22	.41
	Fat	.59	.60	.65	.66	.73		.85	.65	.57	.70	.54	.68	.61	.76
7	Frame	.73	.79	.72	.82	.78	.94		.84	.84	.77	.85	.80	.83	.85
	Muscle	.61	.46	.46	.52	.46	.69		.35	.45	.48	.37	.45	.24	.42
	Fat	.68	.59	.65	.67	.73	.82		.62	.64	.72	.45	.71	.58	.72
8	Frame	.69	.61	.69	.75	.70	.77	.77		.83	.78	.81	.81	.79	.78
	Muscle	.38	.38	.24	.34	.37	.34	.33		.45	.30	.40	.37	.31	.39
	Fat	.39	.54	.32	.56	.66	.56	.54		.56	.59	.34	.66	.61	.56
9	Frame	.67	.64	.77	.74	.79	.75	.77	.75		.78	.80	.91	.82	.86
	Muscle	.53	.52	.54	.54	.67	.47	.43	.46		.44	.60	.56	.25	.58
	Fat	.52	.47	.55	.60	.62	.55	.61	.52		.57	.49	.70	.56	.59
10	Frame	.59	.55	.68	.65	.71	.62	.65	.69	.68		.76	.79	.76	.77
	Muscle	.48	.41	.48	.45	.47	.36	.38	.30	.45		.29	.36	.30	.41
	Fat	.63	.54	.54	.57	.64	.60	.65	.47	.58		.45	.69	.52	.67
11	Frame	.65	.69	.67	.75	.73	.79	.80	.75	.74	.68		.76	.74	.77
	Muscle	.52	.40	.37	.54	.62	.44	.41	.42	.63	.39		.38	.16	.50
	Fat	.31	.47	.57	.45	.49	.49	.39	.27	.47	.40		.45	.47	.59
12	Frame	.63	.56	.78	.68	.73	.65	.69	.72	.88	.68	.67		.78	.86
	Muscle	.40	.44	.52	.42	.49	.40	.44	.36	.57	.36	.45		.34	.46
	Fat	.57	.50	.57	.58	.69	.60	.64	.58	.68	.62	.39		.61	.68
13	Frame	.63	.59	.69	.69	.71	.70	.73	.68	.74	.62	.65	.66		.84
	Muscle	.17	.21	.21	.18	.21	.19	.21	.30	.23	.26	.21	.32		.21
	Fat	.42	.46	.45	.54	.68	.56	.53	.55	.52	.47	.43	.55		.61
14	Frame	.68	.63	.83	.71	.80	.74	.75	.67	.80	.63	.70	.78	.74	
	Muscle	.41	.46	.52	.46	.60	.39	.40	.39	.57	.41	.53	.45	.19	
	Fat	.50	.57	.73	.61	.64	.68	.64	.42	.56	.55	.56	.58	.55	

[a]Coefficients above the diagonal are within year and coefficients below the diagonal are within year and breed.

If coefficient is ≤ .17 then P<.01.
If coefficient is between .18 and .21 inclusive then P<.001.
If coefficient is ≥ .22 then P<.0001.

VITA

Max Franklin Hawkins, son of David Horton Hawkins and Esther May (Cash) Hawkins, was born in Edgar County, Illinois, on May 17, 1952. He lived in Kansas, Illinois, where he graduated from Kansas High School in 1970. After graduation, he attended Western Illinois University at Macomb, Illinois. He graduated in June 1975 with a Bachelor of Science degree in Animal Science. He was then employed by the Illinois Cooperative Extension Service as an Assistant County Agent in Mercer County, Aledo, Illinois, until September 1977. He then attended The University of Tennessee, Knoxville, and received his Master of Science degree in Animal Science in December 1979.