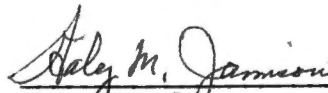


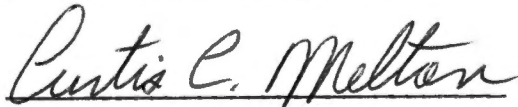
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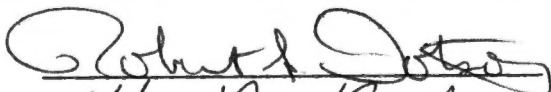
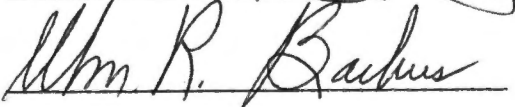
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I am submitting herewith a thesis written by Thomas Eugene Fortune entitled "Factors Affecting Carcass Traits of Beef." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.


Major Professor

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145

FACTORS AFFECTING CARCASS TRAITS OF BEEF

A Thesis

Presented to

the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by

Thomas Eugene Fortune

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ABSTRACT

Seven-hundred-thirty-six carcasses from Shorthorn, Angus, Hereford, and Charolais-cross (XB) steers were utilized in a three-year study of breed variation in beef carcass quality and yield traits. These steers were entries in the 1970, 1971, and 1972 Knoxville Finished Cattle Show.

Data collected relative to performance (carcass weight and carcass weight per day of age) indicated a significant ($P < .01$) advantage for crossbreds over the three British breeds. The carcass weight per day of age for crossbred carcasses was 1.31 pounds compared to hot carcass weights of 561.09 pounds for the British breeds.

A least squares (ANOV) indicated that breed means, with respect to hot carcass weight, were significantly different ($P < .01$) between (XB) and British breeds. No significant differences were indicated by a (DMR) test in mean hot carcass weights of the three British breeds; however, the (XB) steers produced carcasses heavier than the British breeds on an age-constant basis.

Angus carcasses had the highest mean carcass grade (Choice -) of the four breed groups. Shorthorn carcasses ranked next with a mean carcass grade of Good (+). A significant ($P < .01$) difference existed between these two breeds. The Hereford carcasses were not significantly different from Shorthorn carcasses; however, the (XB) carcasses had the lowest average carcass quality grade of the four breeds. No significant difference due to year existed in the mean carcass grades during the three-year study.

Age of steers had a significant ($P < .01$) positive effect on carcass quality grade and marbling score. Analysis of variance of carcass quality traits indicated a significant ($P < .01$) difference in breed effect on carcass quality grade.

Carcasses from the three British breeds averaged 0.45 inch and (XB) carcasses averaged 0.32 inch carcass fat thickness. This variation was significant at the ($P < .01$) level. A significant ($P < .01$) negative correlation ($r = -0.87$) existed between carcass fat thickness and percent retail cuts. Variation in overall carcass fat thickness due to year was not significant.

Carcasses from (XB) steers averaged 12.57 square inches (REA) and were more desirable ($P < .05$) than the British breed with respect to (REA). Angus carcasses averaged 11.27 square inches (REA) and were more desirable ($P < .05$) than (S) and (H) carcasses which were not different with respect to (REA). Year had a significant ($P < .05$) influence on mean (REA).

Crossbred carcasses were estimated to yield a significantly ($P < .05$) higher percent retail cuts than (A), (H), or (S) carcasses. The three British breeds were not different with respect to predicted percent retail cuts. Angus carcasses were superior in retail cuts to carcasses from (S) and (H) steers, but this difference was not significant.

A regression of percent retail cuts on age-in-days resulted in a significant ($P < .01$) negative coefficient.

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CHAPTER I

INTRODUCTION

Measurement of carcass yield and quality traits are now used by beef producers as selection and management tools. Producers are aware that these criteria provide important benefits to their own operations and also to the total beef industry.

Beef cattle evaluation using objective measurements began in the early 1930's. Research indicated early that several economically important traits could be measured objectively. Traits that are economically important have sufficiently high heritability to provide a sound foundation for selection.

With the world population rapidly increasing and the per capita consumption of beef increasing, it is of even greater necessity that the maximum pounds of beef be produced with a minimum of high protein feeds. Therefore, it is imperative that efficient beef producing animals for slaughter and reproduction purposes be utilized.

During the past nine years a 4-H and Future Farmers of America (FFA) steer show and sale has been held at the Union Livestock Yard in Knoxville, Tennessee. A carcass show is held in conjunction with the live animal show to more completely evaluate the animals shown. Participants, performing an outstanding job of producing beef, receive proper recognition and awards. With these two educational activities complementing each other, it is possible to compare subjective decision making with the objective results of the carcass show. This type of comparison

may reveal that the steer with the best conformation, as defined by the judge, may not always have superior carcass characteristics. The carcass data presented at the carcass show gives the youthful competitors a chance to see the actual results of their efforts and helps them to understand the characteristics which constitute beef carcass excellence.

Carcass shows or contests have traditionally been designed to highlight desirable as well as undesirable traits, especially the economically important ones with respect to beef production. The primary objective of the Knoxville Carcass Show is to assist 4-H and FFA members, parents, and interested breeders in becoming familiar with beef carcass characteristics that affect overall economic value.

Carcass show data should be disseminated in a manner to maximize its usefulness to those utilizing it. Carcass data may be used in a number of ways. Purebred producers need components of both the carcass and production traits. Commercial beef producers can utilize carcass data effectively for evaluating herd sires they are using. Packers can utilize carcass information to more precisely evaluate differences in value among meat-type animals.

During the past few years the number of "exotic" breed crosses participating in the Knoxville Finished Cattle Show has been increasing.

Therefore, the objectives of this study were:

1. To study breed differences in carcass yield and quality traits.
2. To summarize data from three previous carcass shows and make this information available to interested individuals.

CHAPTER II

REVIEW OF LITERATURE

During the past few years many studies have been made relative to breed differences. It is apparent from the information available that each breed or crossbreed has some merits. Therefore, it is easy to understand the variation in data presented about breeds. There can be little doubt that efficiency of producing beef can be increased more by utilizing existing variation among breeds than by selecting within breeds for many generations (Cartwright, 1969). Related literature will be reviewed under the following topics: performance traits, carcass quality traits, and carcass retail yield traits.

I. PERFORMANCE TRAITS

Factors Related to Preweaning Performance

The month of birth effects the average daily gain (ADG) from birth to weaning. Calves born between January and May consistently gained at a higher rate than those born in the other months according to Barker (1964). He also found that calves from cows ranging in age from five to eleven years would be approximately 5 pounds heavier at birth than calves from two, three, four, and twelve year old cows. The lightest calves at weaning were from two and three year old cows. Calf weight was also influenced by the sex of the calf; bull calves were as much as 5 pounds heavier than heifer calves at birth. Bulls generally are superior to both steers and heifers with respect to preweaning performance (BIF, 1972).

These data revealed that the (ADG) of a calf was influenced by the age of his dam. Little variation was noted in (ADG) of calves from dams four through eleven years old (Barker, 1964). A difference of 0.23 pounds per head per day was noted in average daily gain between calves from two and ten year old dams. Average daily gain was also effected by the sex of the calf. Bull calves had 0.12 pounds (ADG) above the average, heifers 0.11 pounds (ADG) below the average, and steers were intermediate with respect to (ADG).

Age of dam was highly related to preweaning (ADG) for both creep and non-creep fed calves. Calves from two, three, four, and twelve year old cows had the lowest performance for the non-creep fed group. In the creep fed group, the two and three year old dams had calves with the lowest weaning average daily gains. The study also revealed that age of dam had a small but significant effect on type score of non-creep fed calves. The maximum type score was obtained when the calf's dam was between three and eight years of age (Austin, 1968).

Breed Effects on Preweaning Performance

In a study involving 121 calves, 55 Hereford calves averaged 80 pounds at birth and the 66 Angus calves averages 72 pounds (USDA, 1972).

Ohio's Agricultural Research and Development Center completed a comparison of lifetime performance of calves from the Hereford, Charolais, and Hereford X Charolais breeds. A total of 212 calves were evaluated. Birth weights averaged 70 pounds for the Hereford, 83.3 pounds for the Charolais, and 77.4 pounds for the Hereford X Charolais cross (Klosterman, Cahill, and Parker, 1968).

Traditionally, weaning performance has been used as a criteria for evaluating breed differences in preweaning performance. According to Jamison (1970) the average weaning weight for purebred and crossbred calves was 449 pounds for Angus calves, 420 pounds for Hereford calves, 441 pounds for Shorthorn, 465 for Angus X Hereford, 470 pounds for Shorthorn X Hereford, and 465 pounds for Angus X Shorthorn calves. Mean weaning weights of 518 pounds for Hereford, 645 pounds for Charolais, and 602 pounds for Hereford X Charolais crosses at 260 days were reported by Klosterman, Cahill, and Parker (1968).

A study by Sellers, Willham, and DeBaca (1970) indicated that Angus calves from very young cows (up to 33 months) weaned heavier calves than Herefords of the same age. It was also shown that steer calves from 12 year old Angus cows gained slower than calves from Hereford cows of the same age. The estimated repeatability of weaning weight was 0.186 ± 0.002 for Angus and 0.265 ± 0.003 for Herefords.

Only limited research can be found related to the interaction of factors influencing weaning weight (Cundiff, Willham, and Pratt, 1966; Harwin, Brinks, and Stonaker, 1966). Christian, Hauser, and Chapman (1965) found that (ADG) during the later stages of the postweaning feeding period and the amount of trimmed lean cuts in the carcass significantly increased with increased weaning weight. Fat thickness over the twelfth rib and carcass quality grade were not significantly related to weaning weight. Jamison (1966) indicated that age of dam had little effect on type score of the calf at weaning.

Postweaning Performance

Weight per day of age. Chapman, Utley, and McCormick (1971), at the Georgia Coastal Plain Experiment Station, found Hereford calves to be lighter than three crossbred groups with respect to final weight, final weight per day of age (WDA), hot carcass weight and hot carcass (WDA). The three crossbred groups were not significantly different from each other with respect to those traits. No breed differences were noted in total gain, 204-day (ADG), marbling score, carcass conformation score, carcass retail yield, or carcass quality grade.

Feed efficiency. Butler et al. (1962) conducted a study involving 53 Angus steers and 53 Hereford steers to evaluate feed efficiency of two breeds. Calves were purchased from a local feeder sale and had originated from several different farms. Identical feeding lots were designed and calves were allotted to pens by breed. Hereford calves consumed 952 pounds of feed per hundred pounds gained, and the Angus calves consumed 1,035 pounds of feed per hundred pounds gained. Hereford calves consumed 22.58 pounds of feed per head per day compared to 23.32 pounds for Angus calves. Hereford calves gained 2.37 pounds per day and Angus calves gained 2.25 pounds per day. Research findings indicated that Hereford steers had significantly higher gains and a somewhat more desirable feed efficiency than Angus steers.

Cole et al. (1963) studied growth and performance of 154 steers of seven breeds. Hereford steers were 455 days of age at slaughter and had consumed 869 pounds of feed per hundred pounds of gain. Angus steers were 474 days old and averaged 909 pounds of feed consumed per hundred

pounds of gain. Holstein steers in this study were most efficient with respect to feed efficiency (776 lb.) and the Jerseys were least efficient (959 lb.). Brahman calves required 936 pounds feed per hundred pounds of gain.

A study conducted by Guenther et al. (1965) established that feed efficiency was greatest during the initial phase of feedlot growth. On a weight-constant basis little difference was found in efficiency of gain in Hereford steers fed similarly.

II. CARCASS QUALITY TRAITS

Conformation

Bray (1963) defines conformation as the form or outline of a carcass, relating primarily to its shape and volume of muscle excluding the fat. Until recently beef cattle improvement was based on visual appraisal, with the superior looking animals being kept for breeding purposes. It was generally believed that animals of superior beef type would be more efficient in the conversion of feed. Work done at the Iowa Experiment Station in 1893 showed that dairy steers made gains as efficiently as beef steers (Wilson and Curtiss, 1893).

Pierce (1957) found that no single objective measure of conformation was consistently better than conformation grade for predicting yields.

Carcass measurements which characterize carcass conformation were evaluated by Cole et al. (1963). Steers of British background were considered more compact and had more desirable live conformation scores than steers of Zebu and dairy breeding. Carcass measurements reinforced

these generally accepted ideas of conformation or shape. Steer carcasses from dairy breeds were longer, had longer loins and deeper chests. Dairy steer carcasses were the most narrow through the chest and had the least circumference and width of round of the three groups (British, Zebu, and dairy). This research also showed that three carcass measurements were significantly different between Hereford and Angus. Hereford carcass leg lengths were 1.2 inches longer than the Angus; Hereford carcass loins were 0.5 inch longer and were 1.2 inches greater in round circumference than Angus carcasses. Angus carcasses were slightly shorter than the Hereford but were deeper and wider through the chest.

According to Kirkpatrick (1967) carcass conformation score, in a Hereford steer study, was significantly correlated with carcass grade, pounds of retailed trimmed high priced cuts, total pounds of fat trim and carcass weight.

According to Pierce (1957) and Madamba (1965) conformation scores increase significantly as carcass weight increases, with this increase being closely related to increased carcass fatness. Carcass conformation, in a study by Backus (1968), was significantly affected by fat thickness with the fatter carcasses tending to receive higher carcass conformation grades ($r = 0.62$).

Butler et al. (1962) found a significant difference between mean USDA carcass grade for Angus and Hereford carcasses. The Angus carcasses averaged 20.57 compared to 19.85 for the Hereford carcasses. A score of 21 indicated high Choice and 19 indicated low Choice. This difference was significant ($P < .01$).

Relationship between live and carcass characteristics of beef cattle were reported by Gregory et al. (1962). Graders could not rank individual live animals with respect to either quantitative or qualitative carcass traits with enough precision to justify selecting live animals for superior carcass traits. It was concluded that more precise measurements of individual live characteristics were needed.

In a study of 1,710 animals comparing Angus, Hereford, Shorthorn, and crossbred animals, Shorthorn steers had the smallest ($P < .01$) longissimus dorsi (1. dorsi) areas, the least desirable conformation scores and the lowest percent retail yield of the four breeds evaluated (Jeremiah, Smith, and Hillers, 1970).

Marbling

Intramuscular fat, properly referred to as marbling, has been given major emphasis in the current beef grading system. Current carcass grades are based on positive relationships between beef carcass quality characteristics and eating satisfaction in the cooked meat. Carcass maturity, as indicated by the appearance of the meat and bone, also has a great influence on quality evaluation (Blumer, 1963).

Specific gravity was shown to be highly related to carcass fatness (marbling) (Orme et al., 1957). His study on the specific gravity of the 9-10-11 rib section revealed the percent fat in the 1. dorsi muscle to vary from 1.90 to 8.42, and the specific gravity ranged from 1.0714 to 1.0573.

Seventy-two beef carcasses representing three age groups and six marbling scores were selected for study by Walter et al. (1962).

Marbling did not exert a significant effect on tenderness, flavor or juiciness scores. Tenderness and juiciness decreased with advancing maturity. These results are similar to those reported by Sliger (1966).

Davis et al. (1963) utilized 72 yearling beef steers to evaluate the effect of age and feeding regime on the relative deposition of marbling, subcutaneous fat cover, and other carcass characteristics. Deferred feeding tended to increase the fat content of the l. dorsi muscle but differences were not significant. Marbling scores were highest for carcasses from the treatment which consisted of a level of energy slightly above maintenance for 221 days then a finishing ration until fat cover was comparable to previously slaughtered groups. This treatment resulted in higher carcass grades.

Angus and Shorthorns have exceeded Herefords in marbling and carcass grades (Damon et al., 1960; Butler et al., 1962; Gregory et al., 1966; Gaines et al., 1967; Pahnish et al., 1969). Hereford and Angus marbling scores were compared by Butler et al. (1962) and were significantly ($P < .01$) different. Hereford carcasses averaged 14.66 (small plus) and the Angus averaged 20.06 (typical moderate).

Research involving Angus, Hereford, Shorthorn, and crossbred steers indicated that Angus had the highest marbling scores among the breed groups compared. Carcasses from Hereford steers had the lowest percent of internal fat and the lowest average marbling score. Shorthorn carcasses possessed higher marbling scores than Herefords. Crossbred carcasses were intermediate in most of the carcass traits, although they exhibited nonsignificant advantages in fat thickness measurements. Optimum levels of fat thickness and live weight were noted in each

breed group; beyond which, increases in weight or fatness were not associated with concomitant increases in marbling score (Jeremiah, Smith, and Hillers, 1970).

The above study documented breed differences in marbling. This study also verified the inaccuracy of estimating exact marbling scores on a within breed basis. Angus carcasses met or exceeded the minimum amount of marbling required to grade U. S. Choice at the lowest weight and fat thickness levels of any breed in this study. Considering these assumptions, one can be 95 percent confident that the true mean marbling score will be sufficiently high to produce carcasses grading Choice if Angus slaughter steers weigh 750 pounds and/or possess 1.0 inch of subcutaneous fat cover; Hereford calves weighing 999 pounds and/or exhibiting 0.5 inch of fat cover over the 1. dorsi; and the crossbred or Shorthorn steers weighing 916 pounds and/or possessing 0.5 inch of fat thickness should also grade Choice.

Klosterman, Cahill, and Parker (1968) studied growth and carcass characteristics of Hereford and Charolais cattle and their crosses. Charolais calves had less fat trim than Herefords. Hereford carcasses had higher marbling scores and carcass grades than Charolais. There was no significant difference between the two breeds with respect to tenderness of broiled loin steaks.

Composite USDA Quality Grade

Butler et al. (1962) found that within the British type, Angus carcasses graded significantly higher than Hereford carcasses. Increased marbling was the primary reason for the higher grade. Carcasses of

Brahman crossbreds and straight Brahman breeding graded lower and had lower marbling scores than carcasses of British breeding (Cole et al., 1963).

Research findings by Gaines et al. (1967) showed that both crossbred and straightbred steer carcasses graded high Good. No appreciable differences were noted in four systems of mating. Mean carcass grades for four systems follow: 11.3 straightbred, 11.4 for the two-breed cross and 11.1 for the backcross. There appeared to be little heterosis for carcass grade in these steers.

British type steers produced carcasses grading higher than steer carcasses from dairy breeds. Dairy type steers came off feed at lighter weights and produced carcasses grading lower than British bred calves (Cole et al., 1964). Angus carcasses graded approximately two-thirds of a grade higher than Hereford and dairy carcasses due to increased marbling and a combination of other factors.

Angus and Shorthorns have been shown superior to Herefords with respect to marbling and carcass grade (Damon et al., 1960; Pahnish et al., 1969). Research by Zinn, Durham, and Hedrick (1970) indicated steers required 120 days on feed to attain an increase of one full grade from average Standard (14.4) to average Good (17.2). Ninety additional days (120 to 210) were required for steers to attain sufficient marbling to grade low Choice.

III. RETAIL YIELD TRAITS

Fat Thickness

Murphy et al. (1960) reported significant negative correlation coefficients of $(r) = (-).68$ $(-).85$ and $(-).81$ between fat thickness over the 1. dorsi muscle at the twelfth rib and percent of wholesale cuts, percent bone-in retail cuts, and percent boneless retail cuts, respectively. Ramsey, Cole, and Hobbs (1962) advocated the use of a single carcass fat thickness measurement for estimating fat trim. Live fat thickness measurements from this anatomical region are useful in predicting carcass fatness (Backus, 1968).

Gaines et al. (1967) found the adjusted fat thickness on British (Angus, Hereford, and Shorthorn) crossbred steer carcasses to be 0.02 inch thicker than the mean of straightbreds. This difference was negligible in practical terms. Gregory et al. (1966) found a difference of three times this amount which was highly significant ($P < .01$). In another study, carcasses from Angus had a slightly thicker fat covering (0.77) than Hereford steers and heifers (0.74), respectively (Butler et al., 1962).

Research by Klosterman, Cahill, and Parker (1968) indicated differences in fat thickness between breeds. Hereford carcasses had an average carcass fat thickness of 0.51 inch, Charolais averaged 0.30 inch, and Hereford X Charolais crosses averaged 0.40 of an inch.

Brackelsberg, Willham, and Walters (1967) reported the following average fat thicknesses from carcasses of different breeds. The averages for several groups are stated herein: 77 Hereford steers,

0.63 (in.); 61 Angus steers, 0.75 (in.); 12 4-H and FFA steers—Angus, Shorthorn, Hereford, 1.0 (in.); 79 Hereford steers, 0.67 (in.), and 31 Angus steers, 0.70 (in.).

Carcass cutability varies within USDA grades and is affected by conformation and fatness. Cutability increases with superior carcass conformation and decreases with additional carcass finish (Pierce, 1958).

Carcass Weight

Allen et al. (1968) found that carcass weight was more highly correlated with separable fat and fat trim than with separable muscle, separable bone or yield of retail cuts. It was also found that negative correlations existed between carcass weight and measures of muscling and bone, whether stated as a weight or percent. These data were reported on a within weight-group basis.

Butler et al. (1962) reported mean chilled carcass weights of 563 pounds and 554 pounds for Hereford and Angus steers, respectively, from the same management system. This difference was not significant. The Angus were slightly heavier initially; however, the mean (ADG) favored Herefords. The 16-pound heavier Hereford hide weight accounted for enough of the live weight difference to explain a significant reduction in dressing percent in the Hereford steers.

Martin, Walters, and Whiteman (1966) found that when carcass weight and fat thickness were held constant, cattle with higher conformation scores had a higher cutability. Carcass weight was also the most important variable in multiple regression equations for predicting total weight of boneless steak and roast meat.

Rib-Eye Area

Klosterman, Cahill, and Parker (1968) found in a comparison between Herefords, Charolais, and their crosses that Charolais carcasses had the larger rib-eye areas (REA) (11.97 square inch) than Hereford carcasses (9.29 square inches). Crossbred carcasses were intermediate with respect to rib-eye area (10.97 square inch). It was also established that management system caused significant differences for all carcass ~~yield~~ traits except rib-eye area. A significant ($P < .01$) simple correlation coefficient between retail yield and 1. dorsi area per hundred pounds of carcass was reported by Stringer (1963).

A study by Guenther et al. (1965), on growth and development of tissues in beef, revealed the following facts about the 1. dorsi muscle. This muscle matured faster at the sixth and ninth thoracic vertebrae than at the twelfth and had attained 87 percent of its mature size midway through the postweaning feedlot period. The 1. dorsi muscle developed in a curvilinear fashion with increasing animal age.

Matthews and Bennett (1962) found that rib-eye areas were negatively related to fat thickness measurements. The area of the rib-eye was also negatively related to quality attributes.

Percent Kidney Fat

Cole et al. (1963) found that Angus carcasses were significantly fatter internally than other breeds evaluated. The following average percentages were recorded for percent kidney fat for five breeds: Hereford 4.1 percent, Angus 5.0 percent, Brahman 3.7 percent, Holstein 4.5 percent, and Jersey 6.5 percent.

Percent Lean Cuts

Kline and Taylor (1967) found that variations in body form reflected variations in carcass composition. Body composition of heavily muscled steers averaged 66 percent lean, 18 percent fat, and 16 percent bone, while fatter steers in the study averaged 43 percent lean, 44 percent fat, and 13 percent bone. The research indicated retail yield advantages for modern, muscular, beef-type steers.

Gregory et al. (1966) reported that Hereford and Angus carcasses yielded higher percents of retail product and less fat trim than Shorthorn carcasses. Results reported by Damon et al. (1960) indicated that Herefords contain a higher percent lean and less fat than Angus or Shorthorns. According to Butler et al. (1962), Hereford carcasses contained a higher percent of retail product in the round and loin than Angus but a lower percent of cuts from the chuck.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE OF INFORMATION

Seven-hundred-thirty-six steers and their carcasses were included in a three-year study. The steers used were the entries in the Knoxville Finished Cattle Show and Sale during 1970, 1971, and 1972. Four primary breed divisions were identified. These divisions were Shorthorn, Angus, Hereford, and crossbreds. During the three-year period 131 Shorthorns, 250 Angus, 214 Herefords, and 141 crossbreds were evaluated. Steers entered in the show ranged in age from approximately 350 to 575 days of age. All calves entered in the Knoxville Finished Cattle Show were fitted and shown by 4-H and FFA members. The calves were entered on Thursday, shown on Friday, and sold on Saturday during the week of the show. Most of the calves were sold locally and slaughtered locally. Therefore, most of the calves entered could also be evaluated in the carcass show which was conducted by The University of Tennessee Extension Service. The carcass show was in cooperation with slaughter plants in the Knoxville area.

The steers were weighed immediately after the sale on Saturday and most were slaughtered on Monday with the remainder on Tuesday, following the sale. Each steer was identified with a tag which remained with the carcass.

Animals involved in the study were representative of different types of management practices and were apparently representative of each

breed. Animals involved came from a 38-county area of East Tennessee.

II. PACKING PLANT DATA

Individual hot carcass weights were recorded after dressing and before shrouding. The carcasses were chilled for about 24 hours at approximately 37° F. After chilling, the left side was ribbed by packing plant personnel between the twelfth and thirteenth ribs, exposing a cross section of the l. dorsi muscle. This muscle and the surrounding tissue was measured to the nearest 0.1 square inch with plastic overlay grid and recorded in square inches (REA). Fat thickness was measured over the l. dorsi muscle between the twelfth and thirteenth rib three-fourths distal to the chine as described by Ramsey, Cole, and Hobbs (1962). Carcass quality estimates and estimated kidney fat were obtained by a USDA grader. Estimates of retail yield were made by procedures described by Murphy et al. (1960).

III. METHOD OF ANALYSIS

The data were analyzed statistically using the method of least-squares analysis as described by Harvey (1960). Constants were fitted for breed, year, and age in days. If significant main effects were observed, the means were tested with Duncan's (1955) Multiple Range Test. Simple correlation coefficients were computed on live animal statistics and measures of carcass composition.

The primary model used in the least-squares analysis was:

$$Y = \mu + \text{breed} + \text{year} + b_1 (\text{age in days}).$$

In this model Y was hot carcass

weight; carcass weight per day of age; USDA quality grade; USDA marbling score; carcass fat thickness; (REA); predicted percent trimmed boneless retail cuts from the round, loin, rib and chuck, and USDA yield grade. With this model, Y was the dependent variable. The method of analysis also included fitting fat thickness and carcass weight with the primary model.

CHAPTER IV

RESULTS AND DISCUSSION

Objective and subjective measures for evaluating carcass merits have been used extensively in animal research. These criteria are useful to producers, feeders, and packers for improving the marketability of carcass beef.

Overall means and standard deviations of carcass data used in this study are reported in Table 1. Simple coefficients (r) of correlation between all carcass data were calculated and are reported in Table 2.

I. ESTIMATES OF PERFORMANCE

Hot Carcass Weight

Hot carcass weight and carcass weight per day (CWDA) are valid estimates of live performance of animals similar in age. In this study mean carcass weight and (CWDA) are reported on an age-constant basis to remove some variation due to age differences.

Overall mean hot carcass weight was 546.53 pounds. Breed group means were 538.17, 522.98, 538.26, and 586.72 pounds for Shorthorn (S), Angus (A), Hereford (H), and crossbreed (XB), respectively (Table 3). A least-squares analysis of variance (ANOV) indicated that breed means, with respect to hot carcass weight, were significantly different ($P < .01$) (Table 4). Shorthorn and (H) carcasses were not different with respect to mean hot carcass weight and were intermediate between (A) carcasses

TABLE 1
MEANS AND STANDARD DEVIATIONS OF CARCASS QUALITY
AND RETAIL YIELD TRAITS

Variable	Mean	Standard Deviation
Number in sample	736	-
Hot carcass weight (lb.)	543.5	76.8
Hot carcass weight per day of age	1.20	0.17
USDA carcass quality grade ¹	11.0	1.2
USDA marbling score ²	4.40	1.10
Carcass fat thickness (in.)	0.42	0.17
Area of <u>1. dorsi</u> (sq. in.)	11.3	1.4
Percent retail cuts ³	50.9	1.7
USDA yield grade ³	2.6	0.8

¹11 = Good (+), 12 = Choice (-).

²4 = "Slight," 4.3 = "Slight (+)," 4.7 = "Small (-)."

³As described by Murphy et al. (1960).

TABLE 2
COEFFICIENTS OF CORRELATION (r) BETWEEN ALL VARIABLES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) USDA Quality Grade	1.0000	0.1867	0.0079	0.3879	0.0327	0.8729	-0.3340	0.3304	0.1901
(2) Hot carcass weight (lb.)		1.0000	0.6563	0.3906	0.5067	0.2041	-0.3391	0.3372	0.4280
(3) Weight/day of age			1.0000	0.2019	0.4057	0.0167	-0.1466	0.1457	-0.3780
(4) Carcass fat thickness				1.0000	-0.1414	0.3957	-0.8698	0.8647	0.2200
(5) Area of <u>l. dorsi</u> (sq. in.)					1.0000	0.0728	0.4866	-0.4889	0.1362
(6) USDA marbling score						1.0000	-0.3114	0.3076	0.2126
(7) Percent retail cuts							1.0000	-0.9967	-0.2249
(8) USDA yield grade								1.0000	0.2235
(9) Age-in-days									1.0000

TABLE 3
 LEAST-SQUARES MEANS¹ AND COEFFICIENTS OF REGRESSION^b
 EFFECT OF BREED, YEAR AND AGE-IN-DAYS
 ON ESTIMATES OF PERFORMANCE

Breed	Number in Sample	Hot Carcass Weight lb.	Carcass Wt./Day of Age lb.
Overall	736	546.53	1.21
Shorthorn	131	538.17 ^b	1.19
Angus	250	522.98 ^b	1.15
Hereford	214	538.26 ^b	1.19
Other breeds	141	586.72 ^a	1.31
1970	226	539.25 ^b	1.19
1971	224	539.26 ^b	1.19
1972	286	561.09 ^a	1.24
Age-in-days ^{b1}		0.66	-0.001

¹Means in the same column bearing similar superscripts are not significantly different ($P < .05$).

TABLE 4
ANALYSIS OF VARIANCE OF CARCASS WEIGHT AND
CARCASS WEIGHT PER DAY OF AGE

	d.f.	Mean Squares**	
		Carcass Weight	Carcass Weight per Day of Age
Breed	3	121,185.9**	0.71**
Year	2	39,565.7**	0.20**
Age-in-days ^{b**}	1	882,332.3**	2.30**
Residual	729	4,191.6	0.02

** (P < .01).

and (XB) carcasses. A Duncan's Multiple Range Test (DMR) indicated there were no significant differences in mean hot carcass weight of the three British breeds; however, the (XB) steers produced carcasses heavier than the British breeds on an age-constant basis.

There was no significant difference in mean hot carcass weights of all animals for the years 1970 and 1971. The mean hot carcass weight for 1972 was 561.09 pounds and was significantly ($P < .01$) higher than the means for hot carcass weight from the two previous years. This difference can be attributed to a greater number of (XB) steer carcasses in the 1972 group. During the three-year period there were 131 Short-horns, 250 Angus, 214 Herefords, and 141 crossbreds. Linear regression of age-in-days on hot carcass weight resulted in a significant ($P < .01$) regression coefficient of $b = 0.66$.

When variation in hot carcass weight was analyzed on an age- and fat thickness-constant basis the (XB) carcasses were predicted to weigh 613 pounds compared to 518 for (A), 530 for (S), and 536 for (H) carcasses. Trends in breed differences based on this analysis are similar to those when analyzed on an age-constant basis; however, the magnitude of difference in hot carcass weights between British and (XB) carcasses was larger and greater than when age was held constant. This may reflect some difference in the ratio of rate of fattening to body weight between British and (XB) steers.

Carcass Weight Per Day of Age

Carcass weight per day of age ranged from 1.15 to 1.31 pounds for the (A) and (XB) steers, respectively. Shorthorn and Hereford steers

averaged 1.19 pounds carcass weight per day of age and were intermediate between (A) and (XB) carcasses. These data indicate identical trends in breed mean hot carcass weight and breed mean carcass weight per day of age. This should be expected since breed group variation in carcass weight per day of age was analyzed on an age-constant basis (Table 3, page 23).

II. CARCASS QUALITY TRAITS

USDA Carcass Quality Grade

Data reported in Table 5 illustrate (A) carcasses had a mean carcass grade of 11.57 or low Choice. This mean was the highest ($P < .01$) average carcass grade of the four breed groups. Shorthorn carcasses ranked next with an average carcass quality of 10.90 or high Good. A significant ($P < .01$) difference existed between these two breeds. Carcasses from the Hereford group had a mean grade of 10.78 which was not significantly different from Shorthorn. Carcasses from crossbred steers had the lowest average carcass quality grade of the four breeds. Crossbred steer carcasses graded significantly ($P < .05$) lower than (A) and (S) carcasses but were similar to (H) steer carcasses with respect to carcass quality grade.

Angus steer carcasses had an average marbling score of 4.89 Small (-). Damon et al. (1960), Butler et al. (1962), and Pahnish et al. (1969) indicated the primary reason for Angus carcasses grading higher was increased marbling. Hereford carcasses had a mean marbling score of 4.09 and the crossbreds had a mean marbling score of 4.03. Trends and magnitudes of significant differences in overall carcass quality

TABLE 5
LEAST-SQUARES MEANS¹ AND THE COEFFICIENT OF REGRESSION^b
FOR THE EFFECT OF BREED, YEAR, AND AGE-IN-DAYS
ON CARCASS QUALITY TRAITS

Breed	Number in Sample	USDA ³ Carcass Quality Grade	USDA ⁴ Marbling Score
Overall	736	10.94	4.36
Shorthorn	131	10.90 ^b	4.41 ^b
Angus	250	11.57 ^a	4.89 ^a
Hereford	214	10.78 ^{bc}	4.09 ^{bc}
Other breeds ²	141	10.52 ^c	4.03 ^c
1970	226	11.09	4.46
1971	224	10.80	4.38
1972	286	10.94	4.23
Age-in-days ^{b₁}		0.004	0.004

¹Means in the same column with similar superscripts are not significantly different ($P < .01$).

²Primarily Charolais crosses on Angus or Hereford.

³11 = Good (+), 12 = Choice (-).

⁴4 = Typical "Slight," 4.3 = "Slight (+)," 4.7 = "Small (-)."

grade were also found in USDA marbling score. A significant ($P < .01$) positive correlation of 0.87 existed between carcass quality grade and USDA marbling score.

Mean carcass quality grades for 1970, 1971, and 1972 were 11.09, 10.80, and 10.94, respectively. No significant differences existed in the mean carcass grades for the three years. The mean marbling scores for 1970, 1971, and 1972 were 4.46, 4.38, and 4.23, respectively; however, differences between year means, with respect to marbling score, were not significant. The age of the steers, expressed in days, had a significant ($P < .01$) effect on carcass quality grade and marbling score. A regression of carcass quality grade on age-in-days was found to be significant ($P < .01$). For each 100 days increase in age, carcass grade and marbling score would each increase 0.4 units. Analysis of variance of carcass quality traits indicated a significant ($P < .01$) breed effect on carcass quality grade (Table 6). A significant ($P < .01$) difference was also noted for overall breed effect on marbling score.

In work reported by Damon et al. (1960), Butler et al. (1962), and Pahnish et al. (1969) within the British breeds, Angus carcasses graded significantly higher than Hereford carcasses.

III. ESTIMATES OF CARCASS RETAIL YIELD

Carcass retail yield has been expressed as a percent or as a weight alone. One conventional way is to report cutability as the weight of trimmed, partially boneless retail cuts from the wholesale round, loin, rib, and chuck expressed as a percent of the hot carcass weight (Murphy et al., 1960). Many other estimates of retail yield have been proposed.

TABLE 6
ANALYSIS OF VARIANCE OF CARCASS QUALITY TRAITS

Source	d.f.	Mean Squares	
		USDA Quality Grade	USDA Marbling Score
Breed	3	41.5**	33.1**
Year	2	4.2	3.5
Age-in-Days ^{b**}	1	32.2**	35.1**
Residual	729	1.3	1.0

**P < .01.

Most of these procedures utilize the functions of carcass fatness, muscling (REA), interior and carcass weight in some combination to solve for individual estimates of cutability. Since ratios between the three physical carcass components (muscle, fat, and bone) are interdependent, carcass fatness has a strong influence on carcass composition. Least-square means of factors related to retail yield are shown in Table 7.

Carcass Fat Thickness

Fat thickness measured over the 1. dorsi muscle was shown to be negatively related to retail yield expressed as a percent (Murphy et al., 1960). Overall carcass fat thickness was 0.42 inch. Carcasses from the three British breeds averaged 0.45 inch and (XB) carcasses averaged 0.32 inch carcass fat thickness (Table 7). This source of variation was significant ($P < .01$) and agrees with results reported by Winfree (1973). When these data were analyzed on an age- and carcass weight-constant basis, these same trends in breed differences were apparent; however, the magnitude of difference with respect to carcass fatness between British breed carcasses and (XB) carcasses was larger (0.46 vs. 0.26 in.), respectively. Backus (1968) stated that live backfat thickness measurements are useful in predicting carcass fatness. Ramsey, Cole, and Hobbs (1962) advocated the use of a carcass fat thickness measurement to estimate carcass fat trim. Research by Klosterman, Cahill, and Parker (1968) indicated Hereford carcasses had an average carcass fat thickness of 0.51 inch, Charolais averaged 0.30 inch, and Hereford X Charolais crosses averaged 0.40 of an inch. The research data in Table 8

TABLE 7
 LEAST-SQUARES MEANS¹ AND COEFFICIENTS OF REGRESSION^b
 FOR THE EFFECT OF BREED, YEAR, AND AGE-IN-DAYS
 ON CARCASS RETAIL YIELD TRAITS

Breed	Number in Sample	Carcass Fat Thick- ness (in.)	REA (sq.in.)	Percent Retail Cuts	Yield ² Grade
Overall	736	0.42	11.39	50.39	2.61
Shorthorn	131	0.45 ^b	10.89 ^c	50.45 ^b	2.85 ^a
Angus	250	0.46 ^b	11.27 ^b	50.79 ^b	2.67 ^a
Hereford	214	0.45 ^a	10.84 ^c	50.41 ^b	2.84 ^a
Other breeds	141	0.32 ^b	12.57 ^a	52.08 ^a	2.11 ^b
1970	226	0.43 ^a	11.15 ^b	50.62 ^b	2.74 ^a
1971	224	0.41 ^a	11.57 ^a	51.31 ^a	2.45 ^b
1972	286	0.41 ^a	11.46 ^a	50.87 ^b	2.64 ^a
Age-in-Days ^{b1}		0.0006	0.01	0.005	.002

¹Means in the same column with common superscripts are not significantly different ($P < .05$).

²As described by Murphy et al. (1960).

TABLE 8
ANALYSIS OF VARIANCE OF CARCASS RETAIL YIELD TRAITS

Source	d.f.	Mean Squares			
		Fat Thickness	REA	Percent Retail Cuts	Yield Grade
Breed	3	0.67**	93.7**	87.5**	16.7**
Year	2	0.05N.S.	9.9**	24.4**	4.5**
Age-in-Days ^{b**}	1	0.63**	58.1**	59.4**	11.1**
Residual	729	0.03	1.4	2.4	0.5

** (P < .01).

are reported on an age-constant basis and show the regression of age on carcass fat thickness to be significant ($P < .01$) ($b = 0.0006$). A significant ($P < .001$) correlation of $r = -0.87$ existed between carcass fat thickness and percent retail cuts. Variation in overall carcass fat thickness due to year was not significant.

Area of the 1. dorsi Muscle (REA)

Rib-eye area has been considered to contribute positively to estimates of percent cutability (Murphy et al., 1960); however, other researchers have shown (REA) to be of little or no value in predicting percent retail cuts (Tuma et al., 1967 and Epley et al., 1970).

Breed has been shown to influence the accuracy of predicting retail yield when the USDA equation is used (Abraham et al., 1968). This phenomenon may be due to variation in linearity between the yield grade traits and actual cutability due to breed.

Carcasses from (XB) steers averaged 12.57 square inches (REA) and were more desirable ($P < .05$) than the British breeds with respect to (REA). Klosterman, Cahill, and Parker (1968) found that Charolais carcasses and their crosses had larger rib-eye areas than Herefords. Matthews and Bennett (1962) found that rib-eye areas were negatively related to fat thickness. The area of the rib-eye was also negatively related to quality attributes. Angus carcasses averaged 11.27 square inches (REA) and were more desirable ($P < .05$) than (S) and (H) carcasses which were not different with respect to (REA). Year had a significant ($P < .05$) influence on mean (REA). Carcasses shown in 1970 had a smaller average (REA) than carcasses shown in 1971 and 1972.

A regression of (REA) on age-in-days resulted in a significant ($P < .01$) coefficient of $b = 0.01$.

Predicted Percent Retail Cuts

Crossbred carcasses were estimated to yield a significantly ($P < .05$) higher percent retail cuts than (A), (H), or (S) carcasses. The three British breeds were not different with respect to predicted percent retail cuts. The overall estimated retail cuts percentage was 50.93. Crossbred carcasses were predicted to yield 52.08 percent and the British breeds 50.54. Angus carcasses were superior to carcasses from (S) and (H) steers, but this difference was not significant (Tables 7 and 8, pages 31 and 32, respectively).

A regression of percent retail cuts on age-in-days resulted in a significant ($P < .01$) negative coefficient of $b = -0.005$. This illustrated the effect of increasing carcass fatness on percent retail cuts.

Variations in USDA yield grade are identical to those reported for percent retail cuts since both variables are calculated from identical data and are based on identical functions (Tables 7 and 8).

CHAPTER V

SUMMARY

Seven-hundred-thirty-six carcasses from Shorthorn, Angus, Hereford, and Charolais-cross (XB) steers were utilized in a three-year study of breed variation in beef carcass quality and yield traits. These steers were entries in the 1970, 1971, and 1972 Knoxville Finished Cattle Show.

Data collected relative to performance (carcass weight and carcass weight per day of age) indicated a significant ($P < .01$) advantage for crossbreds over the three British breeds. The carcass weight per day of age for crossbred carcasses was 1.31 pounds compared to 1.18 pounds for the British breeds.

A least squares (ANOV) indicated that breed means, with respect to hot carcass weight, were significantly different ($P < .01$) between (XB) and British breeds. No significant differences were indicated by a (DMR) test in mean hot carcass weights of the three British breeds; however, the (XB) steers produced carcasses heavier than the British breeds on an age-constant basis.

Angus carcasses had the highest mean carcass grade (Choice -) of the four breed groups. Shorthorn carcasses ranked next with a mean carcass grade of Good (+). A significant ($P < .01$) difference existed between these two breeds. The Hereford carcasses were not significantly different from Shorthorn carcasses; however, the (XB) carcasses had the lowest average carcass quality grade of the four breeds. No significant

difference due to year existed in the mean carcass grades during the three-year study.

Age of steers had a significant ($P < .01$) positive effect on carcass quality grade and marbling score. Analysis of variance of carcass quality traits indicated a significant ($P < .01$) difference in breed effect on carcass quality grade.

Carcasses from the three British breeds averaged 0.45 inch and (XB) carcasses averaged 0.32 inch carcass fat thickness. This variation was significant at the ($P < .01$) level. A significant ($P < .01$) negative correlation ($r = -0.87$) existed between carcass fat thickness and percent retail cuts. Variation in overall carcass fat thickness due to year was not significant.

Carcasses from (XB) steers averaged 12.57 square inches (REA) and were more desirable ($P < .05$) than the British breed with respect to (REA). Angus carcasses averaged 11.27 square inches (REA) and were more desirable ($P < .05$) than (S) and (H) carcasses which were not different with respect to (REA). Year had a significant ($P < .05$) influence on mean (REA).

Crossbred carcasses were estimated to yield a significantly ($P < .05$) higher percent retail cuts than (A), (H), or (S) carcasses. The three British breeds were not different with respect to predicted percent retail cuts. Angus carcasses were superior in retail cuts to carcasses from (S) and (H) steers, but this difference was not significant.

A regression of percent retail cuts on age-in-days resulted in a significant ($P < .01$) negative coefficient.

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VITA

Thomas Eugene Fortune was born in Swannanoa, North Carolina, on September 4, 1942. He received his primary and secondary education in Swannanoa, North Carolina. In 1960 he graduated from Charles D. Owen High School in Buncombe County, North Carolina.

He attended Mars Hill College at Mars Hill, North Carolina, and was graduated from The University of Tennessee at Knoxville in March, 1967, with a major in Agricultural Education. While attending The University of Tennessee he was a member of the Society of Agricultural Education Students and was selected for membership in Alpha Zeta, honorary agricultural fraternity.

After receiving his Bachelor of Science degree, he accepted a position as Assistant County Agent of Roane County with the Tennessee Agricultural Extension Service. He became Extension Leader in Johnson County, Tennessee, in July, 1972.

In 1970 he entered Graduate School at The University of Tennessee on a part-time basis. He received the Master of Science degree with a major in Animal Husbandry and a minor in Extension Education in 1973.

In September, 1972, he was married to Sandra Hussey of Tupelo, Mississippi.