CARCASS CHARACTERISTICS OF CROSSBRED STEERS GROWN UNDER TWO DIFFERENT MANAGEMENT SYSTEMS AND PRODUCED BY HEREFORD, ANGUS, SIMMENTAL, BROWN SWISS AND JERSEY SIRES AND HEREFORD AND ANGUS DAMS

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MICHAEL EDWARD BOYD

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New Mexico State University

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Thesis Approved:

Richard R Frahm
Thesis Adviser

Rodger K. Johnson

E. J. Turman

Norman N. Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

During the past 20 years there has been a tremendous increase in the use of crossbreeding to improve productivity of commercial beef herds. This shift to crossbreeding systems has resulted primarily from 1) the overwhelming research evidence that crossbreeding increases cow productivity and 2) economic conditions in the cattle industry that have forced cattlemen to strive for maximum production efficiency. There are two distinct ways that crossbreeding improves production levels; first, by combining the desirable characteristics of two or more breeds and second, by increased performance due to heterosis. Cundiff (1970) summarized the results of several good experiments involving heterosis in beef cattle. These studies indicated that the major benefit of crossbreeding was the result of increased fertility and maternal ability of the crossbred cow and liveability and early growth rate of the crossbred calf. Production per cow exposed to breeding can be increased 20 to 25 percent by use of systematic crossbreeding systems. Approximately half of the increase is dependent upon the use of crossbred cows.

Reproductive traits have low heritabilities and usually exhibit more heterosis than do carcass traits which are moderately to highly heritable. Heterosis estimates for carcass traits are very low, ranging from 0.8 percent for dressing percent to 4.1 percent for carcass weight at a constant age. Thus, any improvement for carcass traits as a result of crossbreeding would be expected to be largely due to additive gene effects from the breeds crossed.

Extensive crossbreeding studies involving primarily Hereford, Angus and Shorthorn breeds have clearly shown the traits of economic importance that will increase most due to heterosis. In general there is an inverse relationship between heritability for a trait and the level of heterosis exhibited in crossbreeding. Although less extensive, crossbreeding studies that also involve breeds such as Brahman or Charolais show similar patterns of heterosis with some indication that the actual magnitude of heterosis may be increased due to the possible increased genetic diversity between these breeds and the British breeds. Research studies are needed to more clearly evaluate the biological characteristics of breeds available for beef production in the U.S. and how they will complement each other in planned crossbreeding systems to maximize production efficiency under various climatic and management conditions. This evaluation must be based on the total beef production cycle.

The objective of this study was to characterize carcass traits of crossbred steers produced by mating Hereford,

Angus, Jersey, Simmental and Brown Swiss sires to Hereford and Angus dams. The resulting information provides the producers with information necessary to develop cross-breeding programs that best fit their individual needs.

CHAPTER II

REVIEW OF LITERATURE

This review of literature is divided into sections that deal with 1) crossbreeding for improved carcass traits, 2) carcass composition of young (less than 15 months) cattle versus those of older cattle (more than 15 months), 3) estimates of carcass composition.

Crossbreeding for Improved Carcass Traits

Cundiff (1970), in an excellent review of many crossbreeding studies conducted at several different research stations, reported that some improvement was observed for carcass traits as a result of crossbreeding. Crossbred cattle produced from crossing Hereford, Angus and Shorthorns showed significant improvement for carcass traits associated with growth such as carcass weight, ribeye area, weight of boneless closely trimmed retail product adjusted for age, and net merit computed as the value of the boneless, closely trimmed retail product minus feed costs from weaning to slaughter. Improvements for traits not directly related to growth such as boneless, closely trimmed retail product adjusted for carcass weight, cutability, grade and

palatability have been very small. Studies in which Charolais were included as a sire breed indicate that the primary benefit of using Charolais in crossbreeding with British breeds is increased growth and proportion of retail product and decreased fat trim of the British breeds. Carcass grade was generally lowered by the use of Charolais sires in crossbreeding programs. When Brown Swiss cows were mated to Charolais, Angus and Hereford bulls it was observed that the Brown Swiss crossbred calves were graded about 1/6 of a grade lower in carcass grade than the beef crossbreds. It was also noted that the Brown Swiss crosses sired by British breeds graded more favorably.

Gregory et al. (1966) reported the carcass traits of 191 crossbred and 183 purebred steers produced by mating Angus, Hereford and Shorthorn breeds. Steers were weaned at approximately 200 days of age and placed in the feedlot for a postweaning feeding period of 252 days. Thus the steers were slaughtered at an average age of approximately 454 days. The crossbred steers had significantly ($P<.05$) higher carcass grade and percent fat trim. Differences between crossbred and purebred steers for carcass weight per day, ribeye area, dressing percent and percent bone were all in favor of the crossbreds ($P<.01$). Actual cutability adjusted for carcass weight was identical for crossbred and purebred steers. Unadjusted actual cutability was slightly in favor of the purebreds but the difference was not significant.

Gaines et al. (1967) reported carcass data on 105 crossbred and purebred steers and 105 heifers from mating Angus, Hereford and Shorthorn cattle. The heifers were placed on feed at weaning for about 200 days and the steers were fed as long yearlings for about 130 days. In steers, traits directly associated with growth such as carcass weight, ribeye area and carcass length were significantly larger for the crossbreds than for purebreds. Only carcass weight was significantly ($P<.05$) larger for the crossbreds in the heifer group. None of the other traits measured showed significant differences in the steer group. However, crossbred heifers had significantly more marbling ($P<.05$) than the purebreds.

Lasley et al. (1971) reported on a study involving 112 short-fed and 106 long-fed heifer carcasses from Angus, Hereford and Charolais breeds and all reciprocal crosses. All heifers in a feed group were slaughtered on the same day. Feed periods averaged 190 days for the short-fed group and 260 days for the long-fed group. No significant differences were found between the purebreds and crossbreds for carcass conformation grade, marbling score, shear value or carcass quality grade. The Angus-Charolais combination was superior to all other combinations for the traits studied.

In an attempt to gather carcass information on Angus, Hereford and Charolais as sires, Urick et al. (1974) mated the above sires to cows of the same breeds as well as to

Brown Swiss cows. Carcass data were collected from 202 steers. Steers were slaughtered as they reached a predetermined average weight of 465 $\pm$ 10 kg. A comparison of crossbreds of the three beef breeds with the straightbreds indicated little or no heterosis for carcass quantity and quality traits. Steers from Brown Swiss dams and from Hereford and Angus sires were better than the straightbreds and other crossbred steers for carcass growth traits and percent cutability. Means for the above steers were as follows: carcass weight per day of age, 0.64 kg; ribeye area, 75.8 cm^2; fat thickness, 14.2 mm; carcass grade, high good; marbling score, slight, and percent cutability (Murphey's), 49.7 percent.

Newman et al. (1974) compared 98 bull carcasses from South Devon (SD), Maine-Anjou (MA) and Simmental (S) sires and commercial Hereford cows. Bulls were slaughtered when they reached an estimated "Good" carcass grade (old Canadian grading system). Average slaughter age of the bulls was 440 days. Slaughter weight and carcass weight did not differ significantly among sire breeds. Significance was found for average daily gain on test with MA>S>SD, ($P<.001$); average fat depth per 100 kg carcass weight, SD>MA=S, ($P<.05$); trimmed, deboned, defatted primal cuts per day of age, MA>S>SD, ($P<.01$), and meat marbling with SD>S<MA, ($P<.05$).

Adams et al. (1973) reported one of the earliest studies in the U.S. that involved "exotic" breeds as sires

in an evaluation study. Carcass data were collected on 80 steers produced by Hereford dams and Simmental, Limousin, Maine-Anjou, Lincoln Red, Brown Swiss, Charolais, Angus and Hereford bulls. Steers were slaughtered when they reached an estimated low choice grade (evaluated subjectively). Carcasses grouped by breed origin exhibited similar characteristics. British breeds (Angus, Hereford and Lincoln Red) had similar quality carcasses, more fat thickness, higher fat percentage and lower cutabilities. Breeds of French origin (Charolais, Limousin and Maine-Anjou) were similar and had higher cutability, less fat thickness, lower fat percentage and lower carcass quality scores. The Swiss breeds (Brown Swiss and Simmental) were intermediate in cutability, fat thickness and fat percentage. The Brown Swiss sired crossbreds exceeded all groups for carcass quality and Simmental crossbreds were intermediate.

Currently there is a study in progress at the U.S. Meat Animal Research Center (USMARC) to characterize different breeds for economic traits such as growth, feed efficiency, reproduction, maternal ability, carcass and meat traits. In the first cycle Hereford (H) and Angus (A) cows were bred by artificial insemination (AI) to H, A, Jersey (J), South Devon (SD), Limousin (L), Simmental (S) and Charolais (C) bulls. Cycle II of the program added Brown Swiss (B) and Red Poll (RP) cows to the cows from Cycle I. In Cycle II the H and A cows were bred AI to H, A, B, RP, Maine-Anjou (MA), Gelbvieh (G) and Chianina (Ch) bulls.

The B and RP cows were bred AI to H, A, RP and B bulls. Carcass data were gathered on 785 steers from Cycle I and 380 steers from Cycle II. Those breeds of particular interest are H, A, S, B and J. Hereford x Angus and reciprocal crosses (HA) had the most external fat and the highest dressing percent. J steers had the most internal fat and the highest marbling score, indicating that they were the most mature at slaughter. There was no apparent difference for HA and J steers for percent fat trim. S steers had the heaviest carcass weight, lowest yield grade, largest ribeye area, highest cutability and percent lean and bone and the lowest percent fat trim. There were no apparent differences for quality grade or tenderness. B steers tended to be intermediate for all traits.

Crouse et al. (1975) in a report on the Cycle I steers grouped the breeds in such a manner that cutabilities between the breeds would be similar. The groups are as follows: (1) Angus, Hereford and reciprocal crosses; (2) Charolais, Limousin and Simmental crosses; (3) South Devon crosses; (4) Jersey crosses. The Hereford and Angus were grouped together because they were British breeds. Charolais, Limousin and Simmental crosses represent the Continental breeds and have rapid growth and a thin subcutaneous fat layer. South Devon were intermediate to British and Continental breeds. The Jersey crosses had the lowest growth rates.

Effect of Management on Carcass Composition of Young Versus Older Animals

Determining the effect on carcass characteristics of different management systems, such as full feed at weaning age versus full feed at yearling age, is of importance not only to this study but also to the industry. Wellington et al. (1954) compared the effect of different nutrition levels on carcass changes of young cattle. They found that increasing TDN intake resulted in higher dressing percent, increased length and thickness of carcass and a larger ratio of edible meat to bone. As age increased there was also a significant increase in ratio of edible meat to bone. Age did not significantly influence dressing percent or percentage weight of muscles in the carcass.

Tuma et al. (1962) showed that shear values in Hereford females differed significantly from 18 months to 42 months, 10.56 to 18.18 pounds, respectively. Although these values are significantly different they are within the range of consumer acceptability for tender meat.

Berg and Butterfield (1968), Guenther et al. (1965) and Hedrick (1968) have illustrated the effect of age on bone, muscle and fat growth. At 12 months of age most animals are just beginning the increased fat deposition stage. Prior to this time fat deposition is approximately equal to bone deposition. Muscle deposition from 0 to 24 months is almost linear and shows no period of rapid

deposition. The growth curves indicate that an animal beginning full feed at yearling age would have a greater percentage of fat at slaughter than an animal on full feed at weaning age, although this is highly dependent on breed type and nutrition level.

Hiner and Bond (1971) studied growth of individual muscles in 51 Angus steers from 6 to 36 months of age under different feeding regimes. They found that within a feeding regime psoas major, biceps femoris and triceps brachii increased their proportion of total lean as the animal aged. The longissimus dorsi, semimembranosus, rectus femoris and adductor decreased in their proportion of total lean. Significant ($P<.05$) differences were found for seperable lean and fat within a slaughter age between feeding regimes.

Estimators of Carcass Composition

Yield grade is an estimator of cutability of a carcass while carcass grade is essentially an estimator of carcass quality based on fat content and maturity. Kropf and Graf (1959) in a study of the effect of carcass grade on yield of retail cuts found that boneless beef yield and percentage of bone decreased and fat percentage increased as grade increased when Commercial, Good and Choice beef carcasses were compared. Percent fat was increased and percent bone decreased as carcass weight increased.

Murphey et al. (1960) computed an equation whereby cutability, the yield of closely trimmed partially boned

or boneless retail cuts from the round, loin, rib and chuck could be computed using simple carcass measurements. He used approximately 450 beef carcasses and 300 live animals. The equation as originally developed was

> Yield = 51.34 - 5.784 (fat thickness over ribeye, inches) - .0093 (carcass weight, lb.) - .462 (kidney fat, percent of carcass) + .740 (area of ribeye, sq. inches).

It is this study which eventually led to the development of yield grade.

Butler (1957), Pierce (1957) and Goll et al. (1961) all found that Choice carcasses generally have more loin and rib and less round and chuck than did Standard carcasses. The loin eye area and length of loin were less for the Choice than for Standard carcasses indicating that differences in yield of loin must have been due to the extra untrimmed fat in the Choice carcasses. Also it was noted that as grade increases, yields of round and chuck decrease and those of the loin and rib increase.

Ramsey et al. (1962) evaluated the relationship of USDA beef carcass grades, proposed USDA yield grades and fat thickness over the ribeye with percent physically separable lean, fat and bone in beef carcasses. Neither carcass grade nor yield grade was superior to the fat thickness measurement over the ribeye as an estimator of percent separable lean and fat. When ribeye area was

omitted from yield grade calculations the resulting yield grades were more highly related to separable lean and fat than when ribeye area was included. This study used 133 animals from different breeds including some Brahman x British crosses and when the correlation coefficients were calculated on a within breed basis the coefficients were reduced indicating less variation within breed than in the pooled sample.

Hedrick and Krause (1975) compared the actual retail yields of 590 steers and 240 heifer carcasses to the predicted yields as determined by the present USDA yield grade equation. In this study, the only significant ($P<.05$) difference found was in the cattle with a retail yield of more than 55 percent. Yields from steers and heifers were underestimated by 1.23 and 2.99 percent, respectively. All other groups were also underestimated but differences between predicted and actual values were not significant.

Crouse et al. (1975) studied the relationship of independent variables in the USDA yield grade equation in breed groups that differ in growth and fattening characteristics. Carcasses of 786 steers derived from crosses of Hereford or Angus cows bred to Hereford, Angus, Charolais, Limousin, Simmental, South Devon and Jersey sires were used. Correlations analysis indicated that carcass weight was a good predictor of cutability within a breed group but a poor indicator over all breed groups. Ribeye area had the lowest predictive value of the four variables while fat

thickness at the 12th rib and percent kidney and pelvic fat were useful within or over all breed groups. Partial regression coefficients computed within each breed group were relatively similar though there were significant ($P<.05$) differences in intercept values for the different breed groups. The conclusion of most importance, however, was that use of a single prediction equation for all breed groups would rank animals well within a breed group but would, on the average, underestimate or overestimate animals of a breed group by 0.1% to over 1% relative to actual cutability.

Summary Review of Literature

The available data indicate that the gain for carcass traits of crossbreds over straightbreds in most instances is very small. Those traits related to growth such as carcass weight or ribeye area are the most favorably affected by crossbreeding. The principle advantage of crossbreeding is in the reproductive and growth traits. Crossbreds have a higher reproductive rate, grow faster to weaning, gain faster in the feedlot and are slaughtered at an earlier age than purebreds.

Growth patterns tend to indicate that as an animal ages the animals deposit more fat and less muscle and bone. This growth pattern is well documented, although some studies have indicated that the deposition rates are dependent on diet and genetic makeup. If deposition rates are

constant then an animal started on full feed at yearling age should have more fat and approximately equal bone and muscle as does an animal started on full feed at weaning age. The data also indicate that as a steer ages, the shear values increase (muscle becomes less tender).

There are several estimators of muscling and fat content of carcasses that are in use today. Carcass grade and kidney, heart and pelvic fat are both estimators of fat content while yield grade is an estimator of muscling. Data tend to indicate that these estimators are not very accurate. When the formula for estimating cutability was developed in 1960, it was developed for use with straightbred British cattle. Conformation and breed types have changed so much in the past years that this formula may no longer be as accurate for predicting yield grade as it was once.

CHAPTER III

MATERIALS AND METHODS

The objectives of this study were to 1) compare carcass characteristics among crossbred groups representing different biological types of cattle and 2) measure the effect on carcass characteristics of grazing steers on wheat pasture to yearling age before being placed on feed versus feeding steers immediately post weaning. The experiment was conducted at the Oklahoma Agricultural Experiment Station in cooperation with the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma.

The data used in this study were the carcass measurements on 269 crossbred steers. The crossbred steers were produced by mating Angus (A) and Hereford (H) cows to Angus, Hereford, Simmental (S), Brown Swiss (B) and Jersey (J) bulls. HA and AH steers were combined and treated as one breed group throughout this study (HA). Thus, there were seven crossbred groups: HA, SA, SH, BA, BH, JA and JH (first letter designates sire breed and second letter designates dam breeds). Four bulls of each of the breeds were used. Different sets of bulls were used each year. Cows were bred by natural service to H, A, J and two of four B bulls in 1973 and 1974. All of the S bulls as well as two of the

four B bulls were bred by artificial insemination to the cows.

The steers were born at the Lake Carl Blackwell Research Range west of Stillwater from January through May, 1973 and 1974. Most of the calves were born in February and March. The calves remained with their dams on native range without creep feed until they were weaned in September at an average of 205 days. All of the steers were trucked to the Southwestern Livestock and Forage Research Station the day they were weaned. In 1973 the oldest half of the steers from each crossbred group were placed in the feedlot one week after weaning. The remaining steers were grazed on wheat pasture and placed in the feedlot as yearlings on March 7, 1974. The 1974 steers were treated identically to those in 1973 except the yearling steers were not placed in the feedlot until May 22, 1975.

Steers from each of the crossbred groups were randomly divided in two pens and allowed access to self feeders. Shrunk weights (off feed and water 12 hours) were obtained on each steer at the beginning and end of the finishing phase. Unshrunk weights were obtained each month during the finishing phase and pencil shrunk 4% prior to recording. All feed was carefully weighed and recorded for each pen of steers. Table I contains the ration fed to the steers. The same ration was fed each year and to each group. TDN consumed was calculated and from this efficiency estimates of carcass weight/TDN and kg of lean/TDN consumed were

TABLE I

CONTENT AND CHEMICAL ANALYSIS OF THE RATION FED TO THE CROSSBRED STEERS

	Percent of Ration	TDN,%	% TDN In Ration
Milo	78	71	55.38
Alfalfa	8	51	4.08
Cottonseed Hulls	4	44	1.76
Molasses	5	65	3.25
Supplement, Pellets[a]	6	52.8	2.64
		Total	67.11

CHEMICAL ANALYSIS (Dry Matter)

Drymatter, %	87.4
Crude Protein, %	14.1
A.D.F., %	7.6
A.D.L., %	3.0
Ash, %	5.1
Calcium, %	0.45
Phosphorous, %	0.33

[a]TDN source, soybean meal.

calculated.

Steers were individually slaughtered as they reached an estimated choice slaughter grade as determined by visual appraisal. Those steers selected to be slaughtered were taken off feed and water for 12 hours prior to obtaining the final slaughter weight. The steers were trucked to a commercial slaughter plant approximately 30 miles from the feedlot.

Carcass identification was maintained by transferral of the ear tag, on which the animal identification number was written, to the outer brisket before the skinning was complete. Prior to washing and shrouding, the ear tags were moved to the diaphragm muscle. Carcasses were allowed to cool for 48 hours before being graded by a federal grader. The following data were collected from the federal grader for each animal: conformation; estimated percent kidney, pelvic and heart fat; marbling score; carcass quality grade and yield grade. Final quality grade was determined to the nearest 1/3 of a USDA grade. To facilitate statistical analysis, carcass grade, conformation and marbling scores were given numerical values (Table II). A tracing of the longissimus dorsi and fat covering at the 12th rib was taken for measurement of the area of the l. dorsi and to estimate single and average fat thickness. Single fat thickness was determined by measuring the distance from the l. dorsi muscle perpendicular to the fat covering at a point 3/4 of the way down the

l. dorsi. Average fat thickness was the average of the fat thicknesses measured at the points 1/4, 1/2 and 3/4 of the way down the l. dorsi muscle. These points were determined by bisecting the longest axis of the l. dorsi muscle by a line and then by dividing this line into four equal segments. A line was drawn perpendicular to the bisecting line at each of the segments. The points at which the lines crossed the l. dorsi muscle were the locations at which the fat measurements were taken.

TABLE II

NUMERICAL VALUES ASSIGNED TO THE VARIOUS LEVELS OF CARCASS CONFORMATION, CARCASS GRADE AND MARBLING SCORE

Carcass Conformation and Grade	Marbling Score
Prime = 14	Abundant = 9
Prime- = 13	Sl. Abundant = 8
Choice+ = 12	Moderate = 7
Choice = 11	Modest = 6
Choice- = 10	Small = 5
Good+ = 9	Slight = 4
Good = 8	Traces = 3

Other carcass traits measured on all steers include: slaughter weight, hot carcass weight, carcass weight per day of age, dressing percent, estimated cutability,

(Murphey et al., 1960) and yield grade as determined from estimated cutability (USDA yield grade).

Six carcasses were randomly chosen from each breed group, three from each pen or 42 steers from each treatment group, for more detailed carcass evaluation. The right half of each of the six chosen carcasses was sent to the OSU Meat Laboratory by truck within four days of slaughter. The carcasses were kept in a 34 to 38 degree Fahrenheit cooler until the carcasses could be processed. Time in the cooler varied from one to ten days. Carcass traits measured on this group of steers include: actual percent kidney, pelvic and heart fat, percent total fat, percent total lean, percent bone, percent shortloin as a wholesale cut, percent shortloin trimmed to 0.3 inches of external fat, tenderness, hindquarter weight and forequarter weight. Percent fat and bone were determined less the amount of fat and bone on the trimmed shortloin. Percent total lean was calculated excluding the lean in the trimmed shortloin. Tenderness was determined by averaging the tenderness scores from six one-inch diameter cores taken from two two-inch thick steaks. Three cores were taken from each steak: dorsal, medial and lateral area of the steak (Hedrick et al., 1968).

Cutting Procedure

The rib and plate are removed from the chuck between the 5th and 6th ribs by a straight line cut perpendicular to the dorsal side of the forequarter. The plate was

removed from the rib at a point 62 percent of the distance from the ventral edge of the 13th thoracic vertibral spinal canal to the sternal end of the 12th rib. A straight cut bisecting all rib bones was made parallel to the spinal canal. Untrimmed weights were recorded for the rib and plate. The rib was trimmed to a 0.3 inch average external fat thickness (determined by probing) and the trimmed rib weight and waste fat weight recorded. The longissimus muscle, cap muscles and external cover were removed leaving a two-inch tail on the cut. The cut weight was recorded. Two two-inch steaks were removed, wrapped and frozen for tenderness determination using a Warner-Bratzler shear. The remaining lean was trimmed and a total lean (trimmed lean + rib cut), fat and bone weights were recorded. The plate was boned and trimmed to 25-30 percent fat and total weights of lean, fat and bone were recorded.

The brisket and shank were removed from the chuck at a point 2½ inches above the elbow and perpendicular to the 5th rib. A saw cut was made across the five ribs and the distal portion of the humerus bone. The shank was separated from the brisket at the natural seam between them. Untrimmed weights were recorded for each wholesale cut. The shank was boned and trimmed. The weights for total trimmed lean, fat and bone were recorded. The brisket was trimmed externally to an average of 0.3 inches, boned and the deckle removed. The respective weights for total lean, fat and bone were recorded. The untrimmed

square cut chuck was weighed and then trimmed to an average 0.3 inch external fat thickness (determined by probing). The trimmed chuck weight and excess fat weight was recorded.

To bone the chuck the clod was first removed by a cut made along the medial-dorsal portion of the humerus to the scapula-humerus joint. The cut was then made along the ventral side of the scapula spine and to the cartilagenous end of the scapula. The muscle systems, inferior to the scapula spine and dorsal to the natural fat seam of the blade and arm face of the chuck, were removed. The clod was trimmed of lean less than two inches thick and its weight was recorded. The scapula, humerus, rib and neck bones were removed (taking care to remove as much muscle and fat as possible), cleaned and weighed.

The inside chuck muscle system was removed by a cut parallel to the dorsal side of the chuck and even with the ventral edge of a fat pocket which was dorsal to the <u>serratus ventralis</u> muscle (located at the blade end). The anterior end of the inside chuck was removed at the point of the scapula-humerus articulation (the cut should bisect the prescapular lymph node). This weight of the cut was recorded. The remainder of the chuck was trimmed (25-30 percent fat) and total trimmed lean, total fat and total bone weights were recorded.

Hindquarter separation was initiated on the outside edge of the round to facilitate removal of the kidney knob and pelvic fats. These fats were removed to leave no more

than 0.4 inches of fat in the tail of the porterhouse steak section. Removal of the flank was completed by separating it at the point on the 13th rib corresponding to the point on the 12th rib marking separation of the rib and plate.

The round and loin were separated on a line determined between the points 5½ sacral vertebrae and the head of the femur. The aitchbone was then removed from the round, taking care to remove as much muscle as possible. Next the quadriceps were removed, following the natural seams between the semimembranosus and biceps femoris; next the patella was removed and the feather edges of the lean were trimmed. The shank was removed at the stifle, and care was taken to remove as much muscle as possible. Next removed were the semimembranosus, adductor and gracillis muscles as one complex, following natural seams. The femur was removed, tagged and placed in the freezer. The semitendinous and biceps femoris were separated at the natural seams. Muscle less than two inches thick was probed and removed. All muscles and muscle systems were trimmed of fats in excess of 0.3 inches and weights recorded.

The full loin was separated into sirloin and shortloin by cutting perpendicular to the lumbar vertebrae immediately in front of the forward edge of the ilium. The shortloin was trimmed of all fats in excess of 0.3 inches and weighed. The sirloin was boned by first removing the butt ends of

the psoas major and psoas minor. The remaining sirloin was boned, removing the ilium, last lumbar vertebrae and 5½ sacral vertebrae. The "top sirloin butt" was trimmed of fats in excess of 0.3 inches and all weights were recorded.

Data Analyses

The data were analyzed by general least squares procedures using the computer program entitled, "Statistical Analysis System (SAS)" developed by Barr and Goodnight (1972) at North Carolina State University. Carcass composition data were analyzed on 269 crossbred steers. Detailed carcass data were further analyzed on 159 of the steers. The model used to analyze carcass data measured on all 269 steers considering all seven crossbred groups was:

$$Y_{ijklm} = \mu + C_i + T_j + Y_k + CT_{ij} + CY_{ik} + TY_{jk} + CTY_{ijk} + P_{l(i)} + e_{ijklm}$$

where

Y_{ijklm} = the observed carcass traits of the mth steer from the lth pen, k^{th} year, j^{th} treatment and i^{th} crossbred group.

μ = population mean.

C_i = fixed effect of the ith crossbred group; $i = 1, 2, 3, 4, 5, 6, 7$.

T_j = fixed effect of the jth treatment; $j = 1, 2$.

Y_k = fixed effect of the kth year; $k = 1, 2$.

CT_{ij} = the interaction of the ith crossbred group and the jth treatment.

CY_{ik} = the interaction of the ith crossbred group and the kth year.

TY_{jk} = the interaction of the jth treatment and the kth year.

CTY_{ijk} = the interaction of the ith crossbred group with the jth treatment and the kth year.

$P_{l(i)}$ = the random effect of the lth pen in the ith crossbred group; l = 1, 2.

e_{ijklm} = random error associated with the $ijklm^{th}$ observation.

To examine sire breed and dam breed effects, the data were analyzed by the following model after deleting HA and AH steers from the data set:

$$Y_{ijklmn} = \mu + S_i + D_j + T_k + Y_l + SD_{ij} + ST_{ik} + SY_{il} + DT_{jk} + DY_{jl} + TY_{kl} + P_{m(ij)} + e_{ijklmn}$$

where

Y_{ijklmn} = the observed carcass traits of the nth steer from the mth pen, l^{th} year, k^{th} treatment, j^{th} dam breed and the ith sire breed.

μ = population mean.

S_i = fixed effect of the ith sire breed; i = 1, 2, 3.

D_j = fixed effect of the jth dam breed; j = 1, 2.

T_k = fixed effect of the kth treatment; k = 1, 2.

Y_l = fixed effect of the lth year; l = 1, 2.

SD_{ij} = the interaction of the ith sire breed with the jth dam breed.

ST_{ik} = the interaction of the ith sire breed with the kth treatment.

SY_{il} = the interaction of the ith sire breed with the lth year.

DT_{jk} = the interaction of the jth dam breed with the kth treatment.

DY_{jl} = the interaction of the jth dam breed with the lth year.

TY_{kl} = the interaction of the kth treatment with the lth year.

$P_{m(ij)}$ = the random effect of the mth pen in the ij^{th} crossbred group.

e_{ijklmn} = random error of the $ijklmn^{th}$ observation.

The models used to analyze the detailed carcass data were the same as those used to analyze the general carcass data but did not include the pen effects.

In addition to the above analysis simple correlations (product-moment) were determined between estimated and actual cutability; estimated and actual kidney, pelvic and heart fat; and yield grade (as determined by the federal grader) and yield grade from estimated cutability (USDA yield grade). The data were also subjected to the maximum

R^2 procedure using single fat, actual kidney, pelvic and heart fat, ribeye area and hot carcass weight to predict constants for use in the formula to estimate cutability. Constants using the above four traits were predicted.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter will be divided into six main sections comparing carcass composition among steers: 1) of seven crossbreed groups; 2) of three sire groups; 3) of two dam groups; 4) at two different ages for entering the finishing phase; 5) for two efficiency traits and 6) an evaluation of several different estimators of carcass composition. Least squares means were adjusted for the seven crossbred groups, the three sire groups, the two dam groups and the two different ages for entering the finishing phase. Crossbred groups (CG) were adjusted for treatment (T), year (Y), CGxT, CGxY, TxY and CGxTxY. Sire breed (SB) was adjusted for dam breed (DB), T, Y, SBxDB, SBxY, SBxY, DBxT, DBxY, and TxY. Dam breed was adjusted for SB, T, Y, SBxT, SBxY, SBxDB, DBxT, DBxY and TxY. Age on test was adjusted for CG, Y, CGxT, CGxY, TxY and CGxTxY. Unless otherwise stated, all significance levels are at $P<.05$.

It must be noted here that wheat pasture for the 1973 group was of very poor quality due to insufficient rainfall. The 1974 group had sufficient rainfall during its grazing period and therefore high quality pasture. Average daily gains for the 1973 yearling steers were very low and often

negative, whereas the 1974 yearling steer gains were all positive. This observation was a factor in many of the interactions observed in this study.

Carcass Composition of the Seven Crossbred Steer Groups

Table III presents the mean squares from the analysis of variance for all carcass traits obtained at the slaughter facility on all steers. Crossbred groups were a significant source of variation for nearly all traits. There were four crossbred group by treatment interactions and seven crossbred group by year interactions. The crossbred group by treatment interactions included slaughter and carcass weight, estimated KPH fat and carcass conformation. The crossbred group by year interactions included slaughter age, average and single fat thickness, estimated KPH fat, marbling, estimated cutability and U.S.D.A. yield grade. Most of the interactions were a change in magnitude rather than a change in rank. It is likely that the interactions were primarily the result of a managerial decision to withhold the 1974 yearling steers from being placed on feed until May 22, 1975, and picking these same steers for slaughter at an earlier age. Most of the interactions were small and therefore considered negligible. Thus comparisons among crossbred groups will be based on least squares means over treatments and years.

Table IV presents the mean squares for analysis of

TABLE III

MEAN SQUARES FOR CARCASS TRAITS MEASURED ON ALL STEERS

		Mean Squares				
		Slaughter		Carcass		
Source	d.f.	Age	Weight,kg	Weight kg	Weight per Day of Age,kg	Dressing Percent
Crossbred Group (CG)	6	4602**	102383**	49213**	0.135**	20.69**
Treatment (T)	1	401661**	10572	17389**	1.761**	58.85**
Year (Y)	1	252	6472	624	0	11.48
CGxT	6	315	4592*	2540*	0.010	6.94
CGxY	6	2164**	2612	1242	0.008	2.71
TxY	1	9548**	5201	11438**	0.001	76.39**
CGxTxY	6	1494*	4345	1909	0.008	2.01
Pen (CG T Y)	28	460	2264	841	0.004	3.85
Error	216	610	2076	1023	0.006	4.61

TABLE III (Continued)

Source	Mean Squares					
	Fat Thickness, mm		Estimated KPH Fat, %	Carcass		
	Average	Single		Conformation	Grade	Marbling
Crossbred Group (CG)	6.88**	5.41**	1.40**	60.15**	2.16*	1.39
Treatment (T)	3.96*	6.50	3.49**	8.43**	40.05**	14.51**
Year (Y)	0.74	0.77	0.16	0.08	0.89	0.48
CGxT	0.74	0.66	1.06**	3.33**	1.02	1.14
CGxY	2.26*	5.44*	0.99**	1.23	1.34	2.58**
TxY	0.13	0.08	2.44**	0	37.70**	16.96**
CGxTxY	0.76	2.64	0.53	0.98	1.07	0.90
Pen (CG T Y)	1.04	1.80	0.34	1.13	1.09	1.01
Error	0.84	1.75	0.30	0.89	0.91	0.68

TABLE III (Continued)

Source	Mean Squares		
	Ribeye Area, cm^2	Estimated Cutability	U.S.D.A. Yield Grade
Crossbred Group (CG)	152.9**	8.21*	1.42
Treatment (T)	23.9	16.62*	3.01
Year (Y)	84.3**	13.21	2.17
CGxT	2.1	2.44	0.51
CGxY	6.0	12.09**	2.15**
TxY	0.2	3.61	0.60
CGxTxY	8.2	3.45	0.71
Pen (CG T Y)	7.9	4.26	0.78
Error	8.2	3.75	0.70

*P<.05

**P<.01

TABLE IV

MEAN SQUARES FOR CARCASS TRAITS MEASURED ON STEERS RANDOMLY SELECTED FOR CARCASS SEPARATION

		Mean Squares					
		Slaughter		Carcass			
Source	d.f.	Age	Weight(kg)	Weight(kg)	Conformation	Grade	Marbling
Crossbred Group (CG)	6	2910**	81119**	36688**	38.97**	2.68*	1.37
Treatment (T)	1	251499**	19443**	16903**	11.04**	18.52**	8.61**
Year (Y)	1	100	223	639	1.57	0.02	0.73
CGxT	6	267	1649	1089	1.44	0.85	0.98
CGxY	6	1160	4186*	1930*	0.90	1.18	1.82*
TxY	1	6543**	13379**	14798**	1.87	25.37**	13.65**
CGxTxY	6	1198	2204	1255	1.13	1.28	1.29
Error	131	577	1707	776	0.87	0.97	0.76

TABLE IV (Continued)

Source	Mean Squares						
		Percent					
	Ribeye Area, cm^2	Fat	Lean	Trimmed Shortloin	Bone	Wholesale Shortloin	Tenderness, kg
Crossbred Group (CG)	107.1**	63.5**	26.9**	0.21	3.74**	0.25	14.1**
Treatment (T)	32.3*	162.2**	84.7*	3.02**	8.38**	0.29	20.9*
Year (Y)	27.7	18.7	45.0	0.02	1.55	0	10.1
CGxT	0.6	4.2	2.5	0.07	1.00*	0.09	4.5
CGxY	7.7	21.7*	15.5*	0.03	0.36	0.12	2.4
TxY	3.2	300.5**	213.7**	1.35**	18.76**	0.05	81.5**
CGxTxY	12.9	5.3	5.1	0.11	0.72	0.15	1.1
Error	7.7	7.4	5.4	0.11	0.44	0.15	3.1

TABLE IV (Continued)

Source	Mean Squares						
	Weight,kg		Single Fat Thickness	Estimated		Actual	
	Forequarter	Hindquarter	mm	KPH Fat,%	Cutability %	KPH Fat,%	Cutability %
Crossbred Group (CG)	2398**	1886**	3.23*	1.36**	4.2	15.72**	24.7**
Treatment (T)	1297**	720**	1.30	2.52**	4.5	3.06*	140.2**
Year	0	18	0.41	0.04	7.7	1.88	31.8**
CGxT	55	70	0.81	1.01**	2.8	1.60*	4.5
CGxY	151*	130**	3.99*	0.74**	8.8*	0.65	12.4*
TxY	596**	1077**	0.94	1.13	7.0	8.74**	232.7**
CGxTxY	80	70	1.75	0.23	1.4	0.66	4.0
Error	59	36	1.42	0.29	3.1	0.68	4.6

*P<.05.
**P<.01.

variance for the carcass traits obtained from carcass separation and some of the traits also obtained on all steers. Thus those traits from Table III repeated in Table IV are a random sample of all steers. Interactions observed in Table III were also observed in Table IV. There were, in addition to the repeated interactions, two crossbred group by treatment and five crossbred group by year interactions. The crossbred group by treatment interactions included actual KPH fat and percent bone. The additional crossbred group by year interactions included actual cutability, percent fat and lean and forequarter weight.

Table V presents least squares means for the traits slaughter age and weight, hot carcass weight and carcass weight per day of age for the seven crossbred steer groups. SH, BA and BH steers were the oldest steers at slaughter, averaging 518 days of age. SA, JH and HA steers were intermediate in age, averaging 501 days, and the JA steers were the youngest, going to slaughter at 492 days of age. The difference between youngest and oldest can easily be attributed to age at maturity of the various crossbred groups. Steers from breeds with relatively large mature size tend to mature at a slower rate than do breeds of smaller mature size. Thus, it generally requires a longer feeding period for steers from larger breeds to obtain choice carcass grade.

SA steers were heaviest at slaughter (511.9 kg) but

TABLE V

MEANS AND STANDARD ERRORS FOR SLAUGHTER AGE, SLAUGHTER WEIGHT, HOT CARCASS WEIGHT AND CARCASS WEIGHT PER DAY OF AGE BY CROSSBRED GROUP

Crossbred Group[e]	No. Steers	Slaughter		Carcass Weight	
		Age	Weight	Hot, kg	Per day of age, kg
HA	61	498.4±3.17[c,d]	469.3±3.96[c]	286.3±2.83[c]	0.58±0.0069[b]
SA	35	504.3±4.41[b,c]	511.9±5.42[a]	314.3±3.88[a]	0.63±0.0095[a]
SH	38	518.4±4.41[a]	503.3±4.94[a,b]	306.5±3.54[a,b]	0.59±0.0086[b]
BA	43	515.3±3.90[a,b]	497.2±4.79[b]	303.9±3.43[b]	0.59±0.0083[b]
BH	33	521.0±3.83[a]	501.3±5.49[a,b]	308.7±3.93[a,b]	0.60±0.0096[b]
JA	35	492.1±4.32[d]	425.6±5.31[d]	253.0±3.81[d]	0.52±0.0093[c]
JH	27	502.7±4.75[b,c]	412.6±5.83[d]	246.8±4.18[d]	0.50±0.0102[c]

[a,b,c,d]Means in the same column that do not share at least one superscript differ significantly at P<.05 or less.

[e]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

were not significantly heavier than SH and BH steers (503.3 and 501.3 kg, respectively). The HA steers were the next heaviest steers (469.3 kg) with the JA and JH steers being the lightest (425.6 and 412.6 kg, respectively). Koch et al. (1976) reported the slaughter weights of several different crossbred groups. Although the ranking of the crossbred groups were different (SH was the heaviest, 490 kg, and JA the lightest, 429 kg) the range in weights was similar, 429 to 490 kg when adjusted to 457 days.

Dressing percent was similar across all breed groups (Table VI). The HA, SA, SH, BA and BH steers had significantly higher dressing percents (1.5%) than the JA or JH steers. Dressing percents reported by Koch et al. (1976) ranged from 58.5 for BH to 61.7 for HA steers. Their study showed B crosses to have the lowest dressing percent whereas this study showed J crosses to be the lowest.

Differences in carcass weight (Table V) were similar to differences in slaughter weight, with a slightly larger difference in magnitude between the J crosses and the other groups because of the lower dressing percents of the J crosses. J crosses had significantly lighter carcasses than all other crossbred groups. This is in agreement with Koch et al. (1976) who also found that J crosses had significantly lighter carcasses than other steer groups tested.

Carcass weight per day of age, a very important trait

TABLE VI

MEANS AND STANDARD ERRORS FOR DRESSING PERCENT, AVERAGE FAT THICKNESS, SINGLE FAT THICKNESS AND ESTIMATED KIDNEY, PELVIC AND HEART FAT THICKNESS BY CROSSBRED GROUP

Crossbred Group[e]	No. Steers	Dressing Percent	Fat Thickness		Estimated KPH Fat
			Average, mm	Single, mm	
HA	61	61.1±0.31[a]	23.7±0.61[a]	29.0±0.97[a]	3.05±0.07[b,c]
SA	35	61.4±0.42[a]	20.3±0.84[b]	26.0±1.19[b,c]	2.84±0.10[c,d]
SH	38	60.9±0.39[a]	18.9±0.74[b,c]	25.9±1.08[b,c]	2.77±0.09[d]
BA	43	61.2±0.37[a]	19.6±0.74[b]	24.3±1.05[b,c]	2.89±0.09[c,d]
BH	33	61.3±0.43[a]	20.1±0.84[b]	27.3±1.20[a,b]	2.88±0.10[c,d]
JA	35	59.5±0.41[b]	19.5±0.82[b,c]	26.0±1.17[b,c]	3.31±0.10[a]
JH	27	59.7±0.41[b]	17.0±0.90[c]	23.3±1.28[c]	3.28±0.11[a,b]

[a,b,c,d]Means in the same column that do not share at least one superscript differ significantly at $P<.05$ or less.

[e]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

to consider when selecting a meat type animal, was significantly heavier for the SA steers, 0.63 kg/day, than for any of the other crossbred groups. The intermediage groups of steers, BH, BA, SH and HA had carcass weights per day of age ranging from 0.58 to 0.60 kg/day. The low gaining steers were from the JA and JH groups (.51 kg/day average). Urick et al. (1974) found cattle from Brown Swiss cows bred to Hereford or Angus bulls had carcass weights per day of age very similar to those produced by the BH and BA steers of this study, 0.60 kg/day for steers from this study versus 0.63 for steers from his study.

Average and single fat thicknesses (Table VI) were significantly higher for HA steers than all other groups except the BH which did not differ for single fat thickness from the HA steers. S crosses, B crosses and JA steers were intermediate for fat cover, averaging 19.6 mm for average fat thickness and 25.9 mm for single fat thickness. JH steers had the least amount of fat, 17.0 mm for average fat and 23.3 mm for single fat. Fat thicknesses tended to be much higher in this study than for those studies reported by Crouse et al. (1975), Urick et al. (1974) and Adams et al. (1973). The difference may be partly due to the different measurement techniques used by each researcher.

Estimated percent kidney, pelvic and heart fat was highest for J crosses (3.29). The HA steers had the next highest amount, 3.05 percent, followed by the B and S

cross steers averaging 2.85 percent. Crouse et al. (1975) also observed that the J sired steers had more internal fat than was observed in the other crossbred groups.

Table VII presents the adjusted means for ribeye area, marbling, carcass conformation and grade. All traits except marbling were significant among crossbred groups. The SH steers had the largest ribeye area, 84.0 cm^2, but was not significantly larger than the SA and BH steer groups. The BA steers and HA steers were intermediate, averaging 78.9 cm^2, and the JA and JH steers had the smallest ribeyes, averaging 70.7 cm^2. These means are in close agreement with those presented by Koch et al. (1976).

Marbling, which was not significant among crossbred groups, ranged from 4.66 (high slight) for SH steers to 5.31 (low small) for BH steers. Adams et al. (1973) found no significant differences for marbling among BH, SH and AH steers, although BH steers had the highest marbling scores. Data from USMARC (1975) in which steers were on test for designated feed periods, yielded different results. In their study JA steers had the highest amount of marbling and the BH steers the lowest. This indicates that the JA steers were more mature at slaughter than the BH steers.

Carcass conformation was highest for the beef type steers. The SA, SH and HA steers had the highest conformation score, 12.0 (high choice), BA and BH were intermediate, 11.2 (average choice) and JA and JH steers

TABLE VII

MEANS AND STANDARD ERRORS FOR RIBEYE AREA, MARBLING, CARCASS CONFORMATION AND FINAL CARCASS GRADE BY CROSSBRED GROUP

Crossbred Group[g]	No. Steers	Ribeye Area, cm^2	Marbling[e]	Carcass[f] Conformation	Carcass[f] Grade
HA	61	77.6±0.97[c]	4.83±0.11	11.84±0.12[a]	9.96±0.12[a]
SA	35	83.4±1.29[a,b]	4.80±0.15	12.23±0.17[a]	9.95±0.17[a]
SH	38	84.0±1.16[a]	4.66±0.14	12.01±0.15[a]	9.55±0.16[a,b]
BA	43	80.1±1.16[b,c]	4.94±0.13	11.32±0.15[b]	9.75±0.15[a,b]
BH	33	82.6±1.29[a,b]	5.31±0.15	11.12±0.17[b]	10.04±0.17[a]
JA	35	70.5±1.29[d]	5.05±0.15	8.94±0.17[c]	9.48±0.17[b]
JH	27	70.8±1.42[d]	4.89±0.16	9.00±0.18[c]	9.34±0.18[b]

[a,b,c,d]Means in the same column that do not share at least one superscript differ significantly at P<.05 or less.

[e]Abundant=9, Sl. Abundant=8, Moderate=7, Modest=6, Small=5, Slight=4, Traces=3.

[f]Choice+ = 12, Choice = 11, Choice- = 10, Good+ = 9, Good = 8, Good- = 7.

[g]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

were lowest, scoring only 9.0 (high good).

Table VIII presents the adjusted means for estimated cutability and USDA yield grade (1965). USDA yield grade was computed from estimated cutability and therefore should have reflected the significance found in estimated cutability. However, yield grade was not significant and estimated cutability was. Estimated cutability was lowest for the HA steers, 46.4 percent, intermediate for the BH and JA, 46.9 percent and best for the SA, SH, BA and JH groups, 47.4 percent. USDA yield grade ranged from 4.5 for the HA steers to 4.0 for the JH steers. Crouse et al. (1975) evaluated the carcasses of 786 crossbred steers and found that Murphey's equation for cutability estimated his HA steers at 48.8 percent, J steers at 49.4 percent and S steers at 51.0 percent. Although the J and HA steers agree quite closely the S steers in his study tended to have higher estimated cutabilities than S steers in this study.

Carcass Separation Data

Detailed carcass data consisted of the data collected from the processing and separation of the right sides of the six randomly selected carcasses from each crossbred group at the OSU Meat Laboratory. Actual percent kidney, pelvic and heart fat and actual cutability are presented in Table IX. JA and JH steers had significantly higher percent KPH fat (averaging 5.73 percent) than any of the

TABLE VIII

MEANS AND STANDARD ERRORS FOR ESTIMATED CUTABILITY AND U.S.D.A. YIELD GRADE BY CROSSBRED GROUP

Crossbred Group[c]	Steers	Estimated Cutability	U.S.D.A. Yield Grade
HA	61	46.4±0.25[b]	4.5±0.11
SA	35	47.2±0.35[a]	4.2±0.15
SH	38	47.5±0.32[a]	4.1±0.14
BA	43	47.4±0.31[a]	4.1±0.13
BH	33	46.9±0.35[a,b]	4.4±0.15
JA	35	46.8±0.34[a,b]	4.4±0.15
JH	27	47.6±0.37[a]	4.0±0.16

[a,b]Means in the same column that do not share at least one superscript differ significantly at $P<.05$ or less.

[c]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

TABLE IX

MEANS AND STANDARD ERRORS FOR ACTUAL PERCENT KIDNEY, PELVIC AND HEART FAT AND ACTUAL CUTABILITY BY CROSSBRED GROUP

Crossbred Group[e]	No. Steers	Actual Percent KPH Fat	Actual Cutability,%
HA	25	3.87 ± 0.15^{c}	49.0 ± 0.44^{d}
SA	21	$4.10 \pm 0.19^{b,c}$	50.0 ± 0.49^{bcd}
SH	24	3.69 ± 0.18^{c}	51.9 ± 0.47^{a}
BA	23	4.45 ± 0.19^{b}	50.2 ± 0.47^{bc}
BH	23	$4.16 \pm 0.19^{b,c}$	50.8 ± 0.47^{ab}
JA	22	5.84 ± 0.19^{a}	49.4 ± 0.48^{cd}
JH	21	5.62 ± 0.18^{a}	49.4 ± 0.46^{cd}

[a,b,c,d]Means in the same column that do not share at least one superscript differ significantly at $P<.05$ or less.

[e]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

other breed groups. The BA steers were intermediate for this trait while the rest of the steer groups were lower, ranging from 3.69 percent for the SH steers to 4.16 percent for the BH steers. Adams et al. (1973) observed that dairy cattle tend to have more internal fat than beef breeds. Crouse et al. (1975) reported that J sired steers had more internal fat than any of the other breed groups tested. Berg (1969) observed that B sired steers had a higher percent KPH fat, but not significantly, than Angus or Charolais crossbreds.

Actual cutability was similar for all breed groups varying by 2.9 percent from high to low. The SH steers had the highest cutability (51.9 percent), but not significantly higher than the BH steers. All other steer groups had lower and quite similar cutabilities ranging from 50.2 percent for the BA steers to 49.0 percent for the HA steers. Actual cutabilities were higher than estimated cutabilities for all breed groups. Actual cutabilities as observed by Crouse et al. (1975) tended to be higher for all groups with the J steers having the lowest cutability and preceded by HA steers. Since cutability is expressed as a compositional percent (percent high valued lean) then those animals that are exceptionally fat will usually have proportionally lower cutabilities. The HA steers were very fat and hence the lower cutability.

Table X contains adjusted means for percent fat, lean, trimmed shortloin, bone and lean to bone ratio. All of the

TABLE X

MEANS AND STANDARD ERRORS FOR PERCENT FAT, LEAN, TRIMMED SHORTLOIN AND BONE AND LEAN TO BONE RATIO BY CROSSBRED GROUP

Crossbred Group[h]	No. Steers	Percent				Lean to Bone Ratio[f]
		Fat	Lean[e]	Trimmed Shortloin[g]	Bone	
HA	25	26.3±0.56[a]	54.6±0.48[c]	5.8±0.07	11.4±0.13[d]	4.79±0.06[a]
SA	21	23.8±0.63[b,c]	55.8±0.54[b,c]	5.9±0.08	11.8±0.16[c,d]	4.75±0.06[a]
SH	24	21.9±0.60[d]	57.4±0.51[a]	6.1±0.07	12.4±0.15[a,b]	4.65±0.06[a,b,c]
BA	23	24.2±0.61[b]	55.7±0.52[b,c]	5.8±0.07	11.9±0.15[c]	4.70±0.06[a,b]
BH	23	22.3±0.61[c,d]	56.0±0.52[b]	5.9±0.07	12.4±0.15[a,b]	4.52±0.06[c]
JA	22	25.3±0.62[a,b]	54.7±0.53[b,c]	5.9±0.07	12.0±0.15[b,c]	4.56±0.06[b,c]
JH	21	25.0±0.59[a,b]	54.5±0.51[c]	5.9±0.07	12.5±0.15[a]	4.34±0.06[d]

[a,b,c,d]Means in the same column that do not share at least one superscript differ significantly at $P<.05$ or less.

[e,f]Does not include percent trimmed shortloin

[g]Includes small amount of fat and bone left on the closely trimmed shortloin.

[h]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

traits except trimmed shortloin were significant among crossbred groups. Percent fat was highest for the HA steers (26.3 percent) although not significantly higher than for the JA or JH steers. The leanest steers were those of the SH breed group (21.9 percent). The rest of the breed groups were intermediate, ranging from 24.2 percent for the BA steers to 22.3 percent for the BH steers. Means from USMARC were ranked in the same order as those in this study.

Percent total lean can be obtained from Table X by adding percent lean and percent trimmed shortloin (percent trimmed shortloin includes the amount of fat and bone on a closely trimmed shortloin). Percent trimmed shortloin was not significant among crossbred groups and ranged only 0.3 percent. Percent lean, however, did vary significantly. The SH steers had a significantly higher percent lean than did any of the other steer groups, 57.4 percent. BH, BA, SA and JA steers were intermediate (averaging 55.6 percent) and HA and JH steers had the least amount of lean on a percent basis with 54.5 percent. Data from USMARC (1975) ranks the breed groups in the same order as found in this study.

Percent bone was similar across breed groups. Percent bone was highest for JH, SH and BH (averaging 11.9 percent) and lowest for the HA steers.

A meat type steer is the result of selection to produce as much meat on its skeleton as possible.

The ability to produce large portions of muscle on its skeleton can be expressed by the lean to bone ration. The HA, SA and BA best displayed the ability to deposit muscle on bone with an average ratio of 4.65. The SH, JA and BH steers were intermediate in ability to put lean on bone with an average ratio of 4.58. The JH steers had the lowest lean to bone ratio of 4.34. The H and A breeds were developed as beef breeds and therefore should have a higher lean to bone ratio. The S and B breeds are primarily dual purpose and therefore have intermediate values. The J breed is a dairy breed and thus has not had previous selection to increase muscle. Consequently, it would be expected to have a low lean to bone ratio.

Presented in Table XI are the means for tenderness as evaluated by a Warner-Bratzler device, forequarter and hindquarter weight and percent. Percent forequarter and hindquarter weight were not analyzed but crossbred groups were significantly different for the other traits. Tenderness values were all in the acceptable range, even though there were significant differences. The SH, BA and BH steers had the highest tenderness values averaging 8.41 kg of shear force. The intermediate steers were SA, HA and the JH steers with scores averaging 7.74 kg. The most tender group with an average tenderness value of 7.10 kg of shear force were the JA steers. USMARC results were similar to those of this study. They found that the BA group had the highest mean followed by SH, BH, SA, HA and

TABLE XI

MEANS AND STANDARD ERRORS FOR TENDERNESS AND FOREQUARTER AND HINDQUARTER WEIGHT AND PERCENT BY CROSSBRED GROUP

Crossbred Group[f]	No. Steers	Tenderness[e] (kg)	Forequarter		Hindquarter	
			Weight (kg)	Percent	Weight (kg)	Percent
HA	25	7.79±0.34[b]	73.2±1.08[b]	50.7	66.7±0.86[c]	46.2
SA	21	7.85±0.28[b]	79.7±1.18[a]	50.3	74.0±0.93[a]	46.7
SH	24	8.75±0.26[a]	77.6±1.12[a]	49.8	72.3±0.89[a,b]	46.4
BA	23	8.26±0.26[a,b]	77.7±1.13[a]	50.6	70.2±0.89[b]	45.7
BH	23	8.22±0.26[a,b]	77.9±1.13[a]	49.8	72.6±0.89[a]	46.4
JA	22	7.10±0.27[c]	65.2±1.15[c]	50.2	60.2±0.91[d]	46.4
JH	21	7.57±0.26[b,c]	61.2±1.11[d]	49.4	57.9±0.86[d]	46.8

[a,b,c,d]Means in the same column that do not share at least one superscript differ significantly at $P < .05$ or less.

[e]Kilograms of shear force.

[f]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

J sired steers.

Forequarter weight was heaviest for SA, SH, BA and BH steers (78.2 kg); next heaviest were HA (73.2 kg) followed by JA steers (65.2 kg) and lastly, JH (61.2 kg). Percent forequarter was very similar across all breed groups ranging from 50.7 percent for HA steers to 49.4 percent for JH steers. Hindquarter weight followed much the same pattern. SA, BH and SH were the heaviest (73.0 kg), next heaviest for the BA steers (70.2 kg) and followed by the HA steers (66.7 kg), the lightest were the JA and JH steers (59.1 kg). Percent hindquarter was also very similar among crossbred groups. The highest percent (46.7 percent) was for the SA steers and the lowest percent hindquarter (45.7 percent) was the BA steers.

Evaluation of the Sire Breeds Used in This Study

Mean squares for all traits considered in this section are presented in Table XII and Table XIII. Table XII contains the carcass traits measured on all steers. Table XIII contains the traits obtained from carcass separation in addition to some of the traits measured on all steers. Sire breed by dam breed interactions were generally not significant. Sire breed by treatment and sire breed by year interactions occurred more often than would be expected by chance alone. Sire breed was a significant source of variation for all traits except estimated

TABLE XII

MEAN SQUARES FOR CARCASS TRAITS MEASURED ON STEERS SIRED BY SIMMENTAL, BROWN SWISS AND JERSEY BULLS

		Mean Squares				
		Slaughter		Carcass		
Source	d.f.	Age	Weight,kg	Weight (kg)	Weight per Day of Age, kg	Dressing Percent
Sire Breed (SB)	2	8179**	322909**	155244**	0.414**	56.0**
Dam Breed (DB)	1	6320**	4444	2097	0.047*	0.2
Treatment (T)	1	324404**	13249*	14983**	1.432**	56.8**
Year (Y)	1	140	3838	176	0	9.8
SBxDB	2	371	1454	852	0.008	2.8
SBxT	2	151	5937	3813*	0.013	20.9**
SBxY	2	39533**	3704	1643	0.002	6.4
DBxT	1	837	456	244	0	0
DBxY	1	2735	157	139	0.015	0.4
TxY	1	7403*	1851	7788*	0	75.0
Pen (SB DB T Y)	24	298	2263	849	0.004	2.8
Error	172	705	2423	1242	0.007	4.4

TABLE XII (Continued)

Source	Mean Squares						
	Fat Thickness, mm		Estimated KPH Fat, %	Carcass		Marbling	Ribeye Area, cm^2
	Average	Single		Conformation	Grade		
Sire Breed (SB)	1.80	1.60	3.66**	168.23**	4.70**	2.56*	459.87**
Dam Breed (DB)	2.08	0.15	0.11	0.92	1.16	0.17	5.47
Treatment (T)	4.85*	7.29*	1.97*	10.00**	28.64**	10.51**	17.55
Year (Y)	0.94	0.08	0.41	0	0.33	1.97	74.52**
SBxDB	0.94	3.51	0.03	0.42	1.54	1.52	3.68
SBxT	1.27	1.73	0.63	7.26**	0.89	0.17	2.26
SBxY	5.49**	14.97**	2.27**	2.43	0.79	2.80*	9.74
DBxT	0	0.36	0.65	0.84	1.03	3.69*	5.16
DBxY	0.66	0.03	0.08	0.06	0.12	0.10	5.35
TxY	0	0.25	1.22*	0.11	38.40**	19.35**	0.06
Pen (SB DB T Y)	0.97	1.60	0.37	1.12	1.19	1.05	7.16
Error	0.84	1.70	0.31	0.91	0.99	0.79	8.84

TABLE XII (Continued)

Source	Mean Squares	
	Estimated Cutability	U.S.D.A. Yield Grade
Sire Breed (SB)	1.07	0.19
Dam Breed (DB)	0.84	0.17
Treatment (T)	16.89*	2.76
Year (Y)	9.22	1.41
SBxDB	4.11	0.96
SBxT	4.95	1.00
SBxY	33.22**	5.92
DBxT	1.17	0.49
DBxY	0.53	0.04
TxY	1.39	0.34
Pen (SB DB T Y)	3.90	0.76
Error	3.69	0.71

*P<.05.
**P<.01.

TABLE XIII

MEAN SQUARES FOR CARCASS TRAITS MEASURED ON STEERS RANDOMLY SELECTED FOR CARCASS SEPARATION AND SIRED BY SIMMENTAL, BROWN SWISS AND JERSEY BULLS

		Mean Squares					
		Slaughter		Carcass			
Source	d.f.	Age	Weight(kg)	Weight(kg)	Conformation	Grade	Marbling
Sire Breed (SB)	2	6174**	247756**	113997**	107**	7.09**	3.65*
Dam Breed (DB)	1	5141**	3129	968	0.17	1.34	0.74
Treatment (T)	1	208424**	14479**	15042**	10.14**	15.30**	8.30**
Year (Y)	1	32	16	1362	0.43	0	1.80
SBxDB	2	207	5239	1801	1.02	0.26	0.28
SBxT	2	394	2406	1758	3.57*	0.70	0.04
SBxY	2	1681	5593*	2243	1.77	1.44	1.59
DBxT	1	394	1011	932	0.25	1.19	1.65
DBxY	1	1705	535	510	0.05	0.02	0.04
TxY	1	5398**	6680	9053**	0.26	24.35**	14.79**
Error	119	589	1735	842	0.81	1.05	0.90

TABLE XIII (Continued)

Source	Mean Squares						
			Estimated		Actual		
	Ribeye Area, cm^2	Single Fat Thickness, mm	KPH Fat, %	Cutability %	KPH Fat, %	Cutability %	Fat
Sire Breed (SB)	313.2**	3.55	3.14**	1.17	37.99**	23.18**	64.83**
Dam Breed (DB)	19.0	1.55	0.19	11.38	2.80	20.41*	59.99**
Treatment (T)	22.1	1.73	1.69*	5.65	1.72	98.11**	127.51**
Year (Y)	17.7	0.12	0.39	6.24	1.67	30.29*	22.65
SBxDB	8.3	2.79	0.54	2.24	0.22	10.44	9.66
SBxT	1.5	1.93	1.12*	5.41	2.37*	7.45	10.69
SBxY	4.7	12.10**	1.13*	24.49**	1.33	21.47*	43.77**
DBxT	0.3	0.06	0.77	0.20	0.53	0.15	0.92
DBxY	5.0	0.19	0.27	1.02	0.03	10.12	15.32
TxY	0	0.27	0.43	4.18	6.18**	202.92**	275.49**
Error	8.7	1.45	0.29	3.10	0.76	4.52	7.05

TABLE XIII (Continued)

Source	Mean Squares						
	Lean	Trimmed Shortloin	Bone	Wholesale Shortloin	Tenderness kg	Weight, kg Forequarter	Weight, kg Hindquarter
Sire Breed (SB)	41.13**	0.26	0.37	0.10	27.49**	7389.3**	5811.9**
Dam Breed (DB)	9.05	0.27	9.47**	0.22	14.51*	263.9*	19.8
Treatment (T)	53.65**	2.79**	8.27**	0.31	26.19**	1209.0**	582.0**
Year (Y)	46.92**	0	1.79	0.05	3.84	7.1	64.7
SBxDB	10.97	0.09	0	0.02	5.34	96.8	155.3*
SBxT	1.19	0.09	0.74	0.05	2.02	60.7	106.0
SBxY	26.10**	0.05	0.17	0.04	1.99	202.7*	175.2*
DBxT	2.13	0.01	3.05*	0.20	14.20*	35.8	28.6
DBxY	9.96	0.03	0.29	0.01	1.23	14.5	1.2
TxY	209.22**	0.83**	13.36**	0.09	58.38**	379.7*	637.3**
Error	5.32	0.10	0.47	0.13	3.01	62.7	39.9

*P<.05

**P<.01

cutability and yield grade. Most of the interactions were small and involved a change in magnitude rather than rank. Hence, sire breeds were compared over dam breeds, treatment and years.

Simmental (S), Brown Swiss (B) and Jersey (J) sires were used on Hereford (H) and Angus (A) cows whereas A bulls were used only on H cows and H bulls on A cows. Since the analysis was conducted on steers from S, B and J sires on A and H cows, the HA mean will be presented in the tables only as a reference point.

Table XIV gives the means for slaughter age and weight, hot carcass weight, carcass weight per day of age and dressing percent. B sired steers were significantly older at slaughter than the J sired steers, 518 days versus 497 days. S sired steers did not differ from either B or J sires but were intermediate at 512 days of age. B and S sires are large, late maturing breeds whereas the J breed is a small early maturing breed; thus, the differences in age at a fixed stage of maturity.

Slaughter weight displayed much the same pattern as slaughter age only the S sired steers were the heaviest at slaughter but not significantly heavier than the B sired steers (502 and 495 kg, respectively). Steers from J sires were the lightest (414 kg), HA steers were intermediate to the B and J sired steers. Adams et al. (1973) observed the same ranking for S and B sire breeds. Means reported by USMARC (1975) also indicate the same ranking for the

TABLE XIV

MEANS AND STANDARD ERRORS FOR SLAUGHTER AGE, SLAUGHTER WEIGHT, HOT CARCASS WEIGHT, CARCASS WEIGHT PER DAY OF AGE AND DRESSING PERCENT BY SIRE BREED

Sire Breed[c,d]	No. Steers	Slaughter Age	Slaughter Weight, kg	Carcass Weight Hot, kg	Carcass Weight Per Day of Age, kg	Dressing Percent
S	73	511.9±3.15[a,b]	502.6±2.63[a]	310.1±2.83[a]	0.61±0.0068[a]	61.7±0.28[a]
B	76	518.4±3.16[a]	495.3±3.82[a]	306.9±2.78[a]	0.60±0.0066[a]	61.8±0.28[a]
J	62	497.2±3.38[b]	414.7±4.17[b]	249.5±3.04[b]	0.51±0.0073[b]	60.0±0.30[b]
HA	61	498.4±3.17	463.3±3.96	286.3±2.83	0.58±0.0069	61.1±0.31

[a,b]Means in the same column that do not share at least one superscript differ significantly at P<.05 or less.

[c]S=Simmental, B=Brown Swiss, J=Jersey, H=Hereford, A=Angus.

[d]HA included only as a reference point.

sires as this study.

Hot carcass weight is a reflection of slaughter weight. S sired steers were heaviest (310 kg) but not significantly heavier than B sired steers (307 kg). The J sired steers were significantly lighter (249 kg) than S or B groups. Again the HA steers were intermediate to the B and J sired steers.

Carcass weight per day of age did not differ significantly among the S and B steers, averaging 0.60 kg/day of age. The J sired steers, however, gained at a significantly slower rate, 0.51 kg/day, than did the other breed groups. Carcass weight/day of age was mainly a function of maturity and ability to gain. An animal that matures slowly and gains poorly will have a very poor carcass weight per day of age. However, as was the case with B and S sired steers which mature late and gain well relative to J sired steers, the carcass weight/day of age was very good.

The means for average and single fat thickness as well as ribeye area, marbling score, carcass conformation and final grade are presented in Table XV. Fat thickness, average and single, were not significantly different among sire breeds. HA steers had the highest fat thicknesses. S, B and J sired steers had 19.3 mm of average fat and 25.5 mm of single fat. Adams et al. (1973) and USMARC (1975) both reported higher fat thicknesses in the HA group than in any of the other groups.

TABLE XV

MEANS AND STANDARD ERRORS FOR AVERAGE AND SINGLE FAT THICKNESS, RIBEYE AREA, MARBLING, CARCASS CONFORMATION AND GRADE BY SIRE BREED

Sire Breed[g,h]	No. Steers	Fat Thickness Average, mm	Fat Thickness Single, mm	REA, cm^2	Marbling[d]	Carcass[e,f] Conformation	Carcass[e,f] Grade
S	73	19.6±0.55	25.8±0.78	83.6±0.90[a]	4.7±0.11[b]	12.1±0.11[a]	9.75±0.12[a]
B	76	20.0±0.54	26.0±0.77	81.5±0.90[a]	5.1±0.10[a]	11.2±0.11[b]	9.89±0.12[a]
J	62	18.4±0.59	24.8±0.84	70.5±0.97[b]	4.9±0.11[a,b]	8.9±0.12[c]	9.34±0.13[b]
HA	61	23.7±0.61	29.0±0.97	77.6±0.97	4.8±0.11	11.8±0.12	9.96±0.12

[a,b,c]Means in the same column that do not share at least one superscript differ significantly at P<.05 or less.

[d]Abundant=9, Sl. Abundant=8, Moderate=7, Modest=6, Small=5, Slight=4, Traces=3.

[e,f]Choice+=12, Choice=11, Choice-=10, Good+=9, Good=8, Good-=7.

[g]S=Simmental, B=Brown Swiss, J=Jersey, A=Angus, H=Hereford.

[h]HA included only as a reference point.

As would be expected, the S and B sired steers had the largest ribeye areas (83.6 and 81.5 cm^2), significantly larger than the J sired steers (70.5 cm^2). HA steers had smaller ribeye areas than did the B steers and a larger ribeye area than the J steers.

Marbling was highest for the B sired steers, 5.1 (low small), but not significantly higher than the marbling score for J and HA steers, which both graded 4.9 (high slight). Simmental sired steers had the least amount of marbling, 4.7 (high slight). Adams et al. (1973) found that B sired steers also had the highest marbling score, although not significantly higher than S or AH steers.

Carcass conformation was significantly higher for S sired steers than B sired steers which were significantly better than J sired steers. The HA steers were intermediate to the S and B sired steers. S sired steers scored high choice as did the HA steers. B sired steers scored choice and J sired steers scored high good. Adams et al. (1973) found no differences for carcass conformation for B, S and AH steers. However, in his study AH had the highest conformation followed by S then B sired steers.

Carcass grade was higher for HA steers than for S and B sired steers, all of which essentially graded low choice. J sired steers had significantly lower grades than S or B steers. The J steers had a final grade of high good. The J steers failed to grade because of their poorer conformation (this study was conducted under the old grading

system). Based on the new grading system the J sired steers would have graded low choice. Adams et al. (1973) found that since conformation was not significant then marbling was the factor determining final grade. In this study marbling was essentially the same and conformation was the deciding factor. Means presented by USMARC (1975) show no differences for HA, S and J steers with B steers grading 2/3 of a grade higher.

Estimated percent kidney, pelvic and heart fat was significantly higher for J sired steers than for S or B sired steers. J steers had 3.3 percent KPH fat while S, B and HA steers had 2.9 percent. As was previously observed dairy breeds have a larger amount of internal fat than the beef breeds. The means for estimated KPH fat are presented in Table XVI. Adams et al. (1973) found that the B sired steers had significantly more KPH fat than the S sired steers; HA steers were intermediate. USMARC means indicate that the J sired steers had more KPH fat than HA, S or B steers.

Sire breeds did not differ significantly for estimated cutability and USDA yield grade (Table XVI). Means were very similar, ranging from 47.2 to 47.4 for cutability and 4.2 to 4.3 for USDA yield grade. Adams et al. (1973) found no difference for estimated cutability or USDA yield grade in the S, B and AH steers. However, they used actual components in estimation of yield grade instead of estimated components. USMARC (1975) means for USDA yield

TABLE XVI

MEANS AND STANDARD ERRORS FOR ESTIMATED PERCENT KIDNEY, PELVIC AND HEART FAT, ESTIMATED CUTABILITY AND U.S.D.A. YIELD GRADE BY SIRE BREED

Sire Breed[c,d]	No. Steers	Estimated KPH Fat, %	Estimated Cutability	U.S.D.A. Yield Grade
S	73	2.8±0.07[b]	47.4±0.23	4.2±0.10
B	76	2.9±0.07[b]	47.2±0.22	4.3±0.10
J	62	3.3±0.07[a]	47.2±0.24	4.2±0.11
HA	61	3.1±0.07	46.4±0.25	4.5±0.11

[a,b]Means in the same column that do not share at least one superscript differ at P<.05 or less.

[c]S=Simmental, B=Brown Swiss, J=Jersey, A=Angus, H=Hereford.

[d]HA included only as a reference point.

grade tended to be lower for S sired steers but the difference between high and low yield grade was only 0.6.

Carcass Separation Data

Actual percent kidney, pelvic and heart fat means are presented in Table XVII. As in the estimated percent KPH fat, the J sired steers had significantly more actual KPH fat, 5.7 percent than the B sired steers which had 4.3 percent. The S sired steers had significantly less KPH fat than the B steers, 0.4 percent less. HA steers had the same amount of KPH fat as the S sired steers, 3.9 percent. Data from Adams et al. (1973) and USMARC are in agreement on the ranking of the breed groups for actual KPH.

Also in Table XVII are the means for actual cutability, tenderness, percent fat, lean, trimmed shortloin and bone and lean to bone ratio. Sire breed was significant for all traits except percent trimmed shortloin and percent bone.

Actual cutability did not differ significantly for S and B sired steers (50.8 percent). The J steers had significantly lower cutabilities (49.5 percent). HA steers had the lowest cutabilities (49.0 percent) but not significantly lower than the J steers. Crouse et al. (1975) reported that the J steers had the lowest actual cutabilities followed by HA steers and then by S steers. Adams et al. (1973) could not find any differences for B,

TABLE XVII

MEANS AND STANDARD ERRORS FOR PERCENT ACTUAL KIDNEY, PELVIC AND HEART FAT ACTUAL CUTABILITY, TENDERNESS, PERCENT FAT, LEAN TRIMMED SHORTLOIN, BONE AND LEAN TO BONE RATIO BY SIRE BREED

Sire Breed[f,g]	No. Steers	Actual		Tenderness, kg	Percent		
		KPH Fat,%	Cutability		Fat	Lean[d]	Trimmed Shortloin[e]
S	45	3.9±0.13[c]	51.0±0.32[a]	8.2±0.18[a]	22.7±0.40[b]	56.7±0.35[a]	6.01±0.05
B	46	4.3±0.13[b]	50.5±0.32[a]	8.2±0.18[a]	23.3±0.41[b]	55.8±0.35[a]	5.87±0.05
J	43	5.7±0.13[a]	49.5±0.32[b]	7.3±0.18[b]	25.1±0.41[a]	54.7±0.35[b]	5.89±0.05
HA	25	3.9±0.15	49.0±0.44	7.8±0.34	26.3±0.56	54.6±0.48	5.80±0.07

TABLE XVII (Continued)

Sire Breed[f,g]	Bone	Lean to Bone Ratio
S	12.1±0.10	4.69±0.04[a]
B	12.1±0.10	4.61±0.04[a]
J	12.3±0.10	4.54±0.04[b]
HA	11.4±0.13	4.79±0.06

[a,b,c]Means in the same column that do not share at least one superscript differ at P<.05 or less.

[d]Does not include percent trimmed shortloin.

[e]Includes the amount of fat and bone in the closely trimmed shortloin.

[f]S=Simmental, B=Brown Swiss, J=Jersey, A=Angus, H=Hereford.

[g]HA included only as a reference point.

S and AH steers, although the ranking of sire breeds was the same.

Tenderness, kg of shear force, was within acceptable limits for all sires but did differ significantly among sire breeds. S and B sired steers had the worst tenderness value, 8.3 kg of shear force. J sired steers were the most tender (7.3 kg) while the HA steers were intermediate to B and J steers. USMARC (1975), which measures tenderness on half inch cores, versus one inch cores used in this study, showed the same means for HA, B and S breeds with the J breeds being slightly lower, 7.4 versus 6.4 kg.

The HA and J steers had significantly more total fat than either S or B sired steers, 25.7 versus 23.0 percent. A possible explanation for the high amount of fat in the HA steers is the fact that H and A cattle were once selected in this country for their ability to put on fat. At one point a highly desirable animal was one in which fat in the brisket came well down below the knee. There was also at this time simultaneous selection for short, compact bodies. The change back to a lean, muscular animal is slow and is probably not yet complete. J steers probably had such a high percent fat due to their very high percent KPH fat. Data from USMARC (1975) indicated that HA were the fattest followed by the J, S and B steers.

Percent lean was calculated without the lean from the

closely trimmed shortloin. The percent closely trimmed shortloin did not differ significantly among sire breeds and ranged from 5.83 percent for HA steers to 6.01 percent for S sired steers. Percent lean was the inverse of percent fat with S and B steers having significantly more lean than the J or HA steers, 56.3 percent versus 54.7 percent.

Percent bone did not differ among the sire breeds. Steers from the HA group had less bone on a carcass weight basis than did the other sire breeds, 11.4 versus 12.2 percent. As can be noticed in Table X, steers from A dams averaged 11.9 % bone while steers from H dams averaged 12.4% bone. However, the HA steers had only 11.4% bone indicating the S, B and J breeds have a higher percent bone than do H or A breeds.

The above differences can be observed in the lean to bone ratio. The S and B steers did not differ significantly for this trait. The HA steers had the highest ratio, 4.79, S steers had a ratio of 4.69 and B steers a ratio of 4.61. J sired steers had a significantly lower lean to bone ratio of 4.45. To be a good beef animal, the animal must carry as much lean on the skeleton as possible. S and B breeds are principally dual purpose breeds with little emphasis on the ability of the breed to carry meat on the given sized skeleton. The same reasoning applies to the J sires, a dairy breed.

Table XVIII presents the means for weight and percent of forequarter and hindquarter. Percent forequarter and hindquarter were not analyzed, hence no significance was found. Forequarter and hindquarter weight did differ significantly among sire breeds. Forequarter weight was similar for S and B sired steers. Percent forequarter was also very similar for S and B steers (50.0 and 50.1 percent, respectively). However, hindquarter weight did differ among S and B sired steers, 73.2 kg for the S steers versus 71.4 kg for the B steers. Percent hindquarter was slightly higher for the S steers (46.4 percent) than for B steers (46.1 percent). The difference between the two sire groups is essentially a measure of conformation. The J sired steers had the heaviest hindquarter and also the highest conformation score. Berg (1969) reported that conformation was the factor that kept the B crossbreds from grading as well as the AH or Charolais x Angus crossbreds. J sired steers had significantly lower weights than the HA steers which were significantly lower than the B sired steers. Percent forequarter and hindquarter were both very similar to those of the S and B groups.

Evaluation of the Two Dam Breeds Used in This Study

Dam breed x treatment and sire breed by dam breed interactions were generally not significant, therefore traits were compared among dam breeds averaged over sirebreeds,

TABLE XVIII

MEANS AND STANDARD ERRORS FOR FOREQUARTER AND HINDQUARTER WEIGHT AND PERCENT BY SIRE BREED

Sire Breed[d,e]	No. Steers	Forequarter Weight(kg)	Forequarter Percent	Hindquarter Weight(kg)	Hindquarter Percent
S	45	78.7±0.79[a]	50.0	73.2±0.63[a]	46.4
B	46	77.7±0.79[a]	50.1	71.4±0.63[b]	46.1
J	43	63.2±0.80[b]	49.9	59.0±0.63[c]	46.5
HA	25	73.2±0.34	50.7	66.7±0.86	46.2

[a,b,c]Means in the same column that do not share at least one superscript differ at P<.05 or less.

[d]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

[e]HA included only as a reference point.

treatments and years. Means for traits measured on all steers are presented in Table XIX. Only two of these traits differed significantly among dam breeds.

Slaughter age differed significantly among dam breeds. Steers from A dams were significantly younger, P<.01 at slaughter than were steers from H dams, 504 days versus 515 days. This was probably due to the ability of the A breed to mature more rapidly. Lasley et al. (1971) evaluated A, H and Charolais (C) heifers and all reciprocal crosses and found no significant differences in A and H dam comparisons. However, the A dams did have the youngest age at slaughter and the highest marbling score.

Carcass weight per day of age was significantly higher, P<.05, for steers from A cows. The difference, 0.02 kg/day was a function of slaughter age since neither carcass weight nor dressing percent differed significantly for dam breed.

Table XX contains the means for the data collected from the processing and separation of the right sides of the randomly selected carcasses from each dam breed. Actual cutability was significantly, P<.05, larger for steers from H cows than for steers from A cows, 50.7 versus 49.9 percent. This difference was due to the difference in percent fat between the breeds which was significantly, P<.01, higher for steers from A dams, 24.4 versus 23.1 percent. Lasley et al. (1971), Gregory et al. (1966) and USMARC (1975) all report similar results. However,

TABLE XIX

MEANS, STANDARD ERRORS AND DIFFERENCES FOR TRAITS MEASURED ON ALL STEERS, BY DAM BREED

	Angus	Hereford	Difference
No. Steers	113	98	
Slaughter Age	503.8±2.58	514.6±2.68	-10.8**
Slaughter Weight (kg)	478.9±3.24	471.4±3.35	7.5
Carcass Weight (kg)	291.2±2.32	286.2±2.40	5.0
Carcass Weight/ Day of Age (kg)	0.58±0.006	0.56±0.006	0.02*
Dressing Percent	60.7±0.20	60.6±0.21	0.1
Average Fat Thickness (mm)	19.9±0.45	18.8±0.46	1.1
Single Fat Thickness (mm)	25.4±0.64	25.6±0.66	-0.2
Estimated KPH fat, %	3.03±0.05	2.97±0.06	0.06
Carcass Conformation[a]	10.8±0.09	10.7±0.10	0.1
Carcass Grade[b]	9.7±0.10	9.6±0.10	0.1
Marbling[c]	5.0±0.09	4.9±0.09	0.1
Ribeye Area, cm^2	78.1±0.74	78.9±0.76	-0.8
Estimated Cutability, %	47.1±0.19	47.3±0.19	-0.2
U.S.D.A. Yield Grade	4.3±0.08	4.2±0.08	0.1

*P<.05
**P<.01

[a,b]high choice = 12, choice = 11, low choice = 10, high good = 9, good = 8, low good = 7.

[c]Modest = 6, Small = 5, Slight = 4, Traces = 3.

TABLE XX

MEANS, STANDARD ERRORS AND DIFFERENCES FOR THE RANDOM SAMPLE OF STEER SELECTED FOR CARCASS SEPARATION, BY DAM BREED

Trait	Dam Breed		Difference
	Angus	Hereford	
No. Steers	66	68	
KPH Fat, Estimated%	3.0±0.07	3.0±0.06	0.0
Actual%	4.8±0.11	4.5±0.11	0.3
Cutability, Estimated%	46.7±0.22	47.3±0.22	-0.6
Actual%	49.9±0.26	50.7±0.26	-0.8*
Percent Fat	24.4±0.33	23.1±0.32	1.3**
Lean[a]	55.5±0.29	56.0±0.28	-0.5
Trimmed Shortloin[b]	5.9±0.04	6.0±0.04	-0.1
Bone	11.9±0.09	12.4±0.08	-0.5***
Wholesale Shortloin	6.8±0.05	6.9±0.04	-0.1
Tenderness (kg of shear force)	7.7±0.15	8.2±0.14	-0.5*
Forequarter Weight, kg	74.2±0.65	72.3±0.63	1.9*
Percent	50.3	49.7	0.6
Hindquarter Weight, kg	68.1±0.52	67.6±0.50	0.5
Percent	46.2	46.5	-0.3

*P<.05 **P<.01 ***P<.001

[a]Does not include lean in the closely trimmed shortloin.

[b]Includes amount of fat and bone on the closely trimmed shortloin.

differences reported by Lasley are not significant.

Percent bone was significantly, P<.001, higher for steers from H cows than for steers from A cows, 12.4 versus 11.9 percent. This difference was also observed by Lasley et al. (1971), Gregory et al. (1966) and USMARC and may be due to a greater amount of cortical and dense bone in the H breeds (J. J. Guenther, personal communication).

Tenderness, kg of shear force, was significantly (P<.05) higher for steers from H dams (8.2 kg) than for those from A dams (7.7 kg). Again this difference was supported by data from Lasley et al. (1971) and USMARC.

Forequarter weight was 1.9 kg heavier for steers from H dams (P<.05). Percent forequarter was higher for A steers than H steers indicating that the difference is not a function of carcass weight. This difference is possibly due to a greater amount of fat in the forequarter area as percent fat was significantly higher for A steers.

Treatment Differences for Carcass Composition of the Crossbred Groups

For many of the carcass traits evaluated there were highly significant treatment by year interactions. Most of the interactions were probably the result of two management changes. First was the change in the selection committee for slaughter determination. The author of this paper was the principle change in the committee and was

responsible for selecting steers for slaughter for the weaning group steers in 1974. The criteria for selection was not changed but only the members of the selection committee. Second was the decision to hold the 1974 steers on pasture an additional 76 days. This extra period caused the on-test weights to be higher for the 1974 group. Traits with interactions were primarily those most affected by fat quantity, such as marbling, dressing percent, kidney, pelvic and heart fat, etc. These traits will be evaluated by year. Traits with no significant treatment by year interactions will be evaluated over years.

Table XXI presents the means for treatments by year for slaughter age, hot carcass weight, dressing percent, estimated kidney, pelvic and heart fat, marbling and final grade. As would be expected, slaughter age was highly significant, $P<.001$ with the 1973 yearling group 95 days older than the weaning group. In 1974 the yearling steers were only 70 days older than the weaning group. The 25 day reduction in age between years can be attributed to the change in the slaughter selection committee, as the committee returned to its original makeup for the 1974 yearling group. Slaughter age is also indirectly affected by fat quantity since a steer will not marble until a certain degree of maturity is reached. Therefore, the older the animal the fatter it will be when on full feed.

Hot carcass weight was not significantly, $P<.05$,

TABLE XXI

MEANS AND STANDARD ERRORS FOR SLAUGHTER AGE, HOT CARCASS WEIGHT, DRESSING PERCENT, ESTIMATED KIDNEY, PELVIC AND HEART FAT, MARBLING, AND CARCASS FINAL GRADE BY TREATMENT GROUP FOR BOTH YEARS OF THE TEST

	1973			1974		
	Age on Test			Age on Test		
Trait	Weaning	Yearling	Difference	Weaning	Yearling	Difference
No. Steers	71	73		57	71	
Slaughter Age	461.2±2.93	556.3±3.03	-95.1***	471.1±3.27	541.3±2.93	-70.2***
Hot Carcass Weight, kg	290.1±2.56	288.2±2.64	1.9	298.8±2.85	276.8±2.56	22.0***
Dressing Percent	60.4±0.25	60.6±0.26	-0.2	62.1±0.28	59.9±0.25	2.2***
Estimated KPH, %	2.99±0.06	2.97±0.07	0.02	3.25±0.07	2.81±0.06	0.44***
Marbling[a]	4.8±0.10	4.9±0.10	-0.1	5.5±0.11	4.5±0.10	1.0***
Carcass Final Grade[b]	9.8±0.11	9.8±0.12	0.0	10.5±0.13	8.8±0.11	1.7***

***$P<.001$

[a]Abundant = 9, Sl. Abundant = 8, Moderate = 7, Modest = 6, Small = 5, Slight = 4, Trace = 3.

[b]Choice+ = 12, Choice = 11, Choice- = 10, Good+ = 9, Good = 8, Good- = 7.

different for the 1973 steers but differences were highly significant, P<.001, for the 1974 steers. Carcass weight for the 1973 weaning steers was only 1.9 kg heavier than the yearling steers. However, in 1974 the yearling steers were 22.0 kg lighter than the weaning steers.

Dressing percent, which is directly related to fat quantity, showed no significant differences for 1973 while again in 1974 the difference between treatment groups was highly significant, P<.001. The 1973 group had 60.4 and 60.6 percent for the weaning and yearling groups while the 1974 group had 62.1 and 59.9 percent for the weaning and yearling group, respectively. The difference was probably due to the 1974 weaning steers being fatter at slaughter while the 1974 yearling group tended to have less fat than the comparable group from 1973.

Estimated kidney, pelvic and heart fat, marbling and final grade were not significantly different for the 1973 group whereas in the 1974 group all the differences were highly significant. As fat increased in the 1974 weaning group, estimated KPH fat, marbling and grade, all of which are directly related to fat, correspondingly increased. Estimated KPH fat averaged 2.9 percent in 1973 while in 1974 it ranged from 3.3 percent for the weaning steers to 2.8 percent for the yearling steers. Marbling in 1973 averaged 4.85 or essentially a small amount of marbling. In 1974 marbling ranged a whole score apart, 5.5 (typical small) to 4.5 (typical slight) for weaning and yearling

groups, respectively. Final grade was the mirror image of marbling. The 1973 steers had a final grade of low choice while the 1974 steers graded from low choice for the weaning group to high good.

Another possible reason the 1974 yearling steers failed to grade low choice was an observation of a federal grader at the commercial slaughter plant where the steers in this study were slaughtered. It was the grader's observation that steers that had been on wheat pasture during the winter and spring of 1975 had adequate external fat thicknesses to grade low choice yet were still failing to grade.

None of the other traits associated with general carcass traits were affected significantly by the treatment by year interactions and hence were averaged over years. Slaughter weight was significantly, $P<.01$, heavier for the weaning steers than for the yearling steers, 480.1 kg versus 469.0 kg. This difference can partly be explained by the fact that the weaning steers tended to have slightly more fat than was observed in average and single fat thickness. Average fat was 1.33 mm thicker and single fat was 1.8 mm thicker for the weaning steers. The means for the above traits are presented in Table XXII.

Carcass weight per day of age differences were highly significant, $P<.001$. The weaning group was highest for this trait, 0.63 kg/day versus 0.52 kg/day. This difference was a reflection of carcass weight and age at slaughter

TABLE XXII

MEANS, STANDARD ERRORS AND DIFFERENCES FOR SLAUGHTER WEIGHT, AVERAGE AND SINGLE FAT THICKNESS, CARCASS WEIGHT PER DAY OF AGE, CARCASS CONFORMATION, RIBEYE AREA, ESTIMATED CUTABILITY AND U.S.D.A. YIELD GRADE BY TREATMENT GROUP

Trait	Age on Test		Difference
	Weaning	Yearling	
No. Steers	128	144	
Slaughter Weight	480.1±2.63	469.0±2.70	11.1***
Average Fat Thickness, mm	20.5±0.41	19.2±0.40	1.3*
Single Fat Thickness, mm	26.9±0.59	25.1±0.58	1.8*
Carcass Weight/Day of Age, kg	0.63±0.005	0.52±0.005	0.11***
Carcass Conformation[a]	11.1±0.08	10.7±0.08	0.38**
Ribeye Area, cm^2	79.2±0.65	77.6±0.63	1.6
Estimated Cutability	46.8±0.17	47.4±0.17	-0.6*
U.S.D.A. Yield Grade	4.4±0.07	4.1±0.07	-0.3*

*P<.05

**P<.01

***P<.001

[a]Choice+ = 12, Choice = 11, Choice- = 10, Good+ = 9, Good = 8, Good- = 7.

which was, of course, much younger for the weaning group.

Although both groups had essentially the same conformation, average choice, they did differ significantly at the $P<.01$ level. The weaning group scored 0.38 of a grade higher than the yearling group. In addition to the means for conformation, the means for ribeye area, estimated cutability and USDA yield grade are also presented in Table XXII.

Ribeye area, which did not differ significantly, tended to be slightly larger for the weaning group. The means were 79.2 cm^2 for the weaning group and 77.6 cm^2 for the yearling group. The difference, 1.6 cm^2, was not significant but does seem to reflect conformation, since conformation is based on muscling.

Estimated cutability, Murphey et al. (1960) was significantly higher, $P<.05$, for the yearling group, 47.4 percent versus 46.8 percent for the weaning group. This difference occurred because the components of the equation were in favor of the yearling group. Percent KPH fat, single fat thickness and carcass weight were all smaller values than the corresponding values for the yearling group. Ribeye area did not differ for the two groups, therefore the yearling group was favored by the cutability equation. USDA yield grade, which was computed from estimated cutability was correspondingly and significantly, $P<.05$, in favor of the yearling group, 4.1 versus 4.4. These differences, although significant, are of small

economic value and therefore of little importance.

Carcass Separation Traits

As with the previous carcass traits, there were many treatment by year interactions for the detailed carcass composition traits. The traits showing the interactions also tended to be the traits most affected by fat quantity, the exception being tenderness. The means for all of the traits affected by the treatment by year interactions are presented in Table XXIII.

The difference between the 1974 yearling and weaning group for actual percent kidney, pelvic and heart fat, 0.9 percent, was highly significant, $P<.001$. This difference was due to the fact that the weaning steers were fatter at slaughter. The 1973 group did not differ significantly and had an average KPH fat of 4.3 percent.

Actual cutability, percent trimmed boneless retail cuts from the round, loin, rib and chuck, differed significantly in both years. In 1973 the weaning group had significantly, $P<.05$, higher cutability than did the yearling group, 50.7 percent versus 50.1 percent. In 1974 the weaning group had significantly, $P<.001$, lower cutability than did the yearling group, 47.3 percent versus 51.7 percent. The 1973 group, which did not differ for grade, was a better representative for the real difference between the two treatments. The reversal of the group positions in 1974 can be explained by the highly significant, $P<.001$,

TABLE XXIII

MEANS, STANDARD ERRORS AND DIFFERENCES FOR ACTUAL KIDNEY, PELVIC AND HEART FAT, ACTUAL CUTABILTY, TENDERNESS, PERCENT FAT, LEAN AND BONE, PERCENT TRIMMED SHORTLOIN, FOREQUARTER AND HINDQUARTER WEIGHT BY TREATMENT GROUP

	1973			1974		
	Age on Test			Age on Test		
Trait	Weaning	Yearling	Difference	Weaning	Yearling	Difference
No. Steers	41	42		39	37	
Actual KPH Fat,%	4.2±0.13	4.4±0.13	-0.2	5.0±0.13	4.1±0.14	0.9***
Actual Cutability	50.7±0.33	50.1±0.34	0.6*	47.3±0.34	51.7±0.35	-4.4***
Tenderness, kg of shear force	8.4±0.41	7.1±0.42	1.3***	7.8±0.42	8.4±0.43	-0.6*
Percent Fat	23.7±0.43	24.5±0.44	-0.8	27.1±0.44	22.3±0.45	4.8
Percent Lean	56.4±0.36	55.6±0.37	-0.8	53.0±0.37	56.8±0.38	-3.8***
Percent Bone	12.2±0.10	11.9±0.11	0.3*	11.3±0.11	12.5±0.11	-1.2***
Trimmed Shortloin,%[a]	5.9±0.05	6.0±0.05	-0.1	5.6±0.05	6.1±0.05	-0.5***
Forequarter Weight,kg	74.1±0.79	72.9±0.82	1.2	76.3±0.81	69.5±0.84	-6.8***
Percent	51.1	50.6	0.5	51.1	50.2	0.9
Hindquarter Weight,kg	67.0±0.63	68.1±0.65	-1.1	71.1±0.64	64.1±0.66	7.0***
Percent	46.2	47.2	-1.5	47.6	46.3	1.3

*P<.05 **P<.01 ***P<.001

[a] Includes percent fat and bone on the closely trimmed shortloin.

difference in percent fat, 27.1 percent for the weaning group to 22.3 percent for the yearling group. Since cutability is expressed as a percent of hot carcass weight, a lean animal would be favored over a fat animal of comparable muscling and conformation.

Percent fat and lean did not differ significantly for the 1973 group, however percent bone did differ significantly, $P<.05$, 12.2 percent for the weaning group versus 11.9 percent for the yearling group. The only explanation for the difference would be the availability of essential nutrients necessary for bone growth during the period of maximum bone growth for the weaning group steers. Difference for percent fat, lean and bone were highly significant $P<.001$, for the 1974 group. The weaning group had more fat 27.1 percent versus 22.3 percent, less lean, 53.0 percent versus 12.5 percent. The reversal of the groups for percent bone was probably due to the tremendous difference for percent fat, since on a composition basis as one trait increases, one or both of the other traits must decrease.

Percent trimmed shortloin, a high priced retail cut, did not differ among the 1973 steers, ranging from 5.9 to 6.0 percent for weaning and yearling steers respectively. However, the 1974 steers did differ significantly, $P<.001$, with the yearling steers having the highest percent shortloin, 6.1 versus 5.6 percent for the weaning group. This difference was due to the high percent fat for the weaning group. Since percent trimmed shortloin is a component of

total lean then as percent fat increases, percent lean and/ or bone will decrease.

Tenderness differences, kg of shear force, were significant, P<.001, for the 1973 group of steers. The weaning group was toughest, 8.4 kg versus the yearling steers, 7.0 kg of shear force. This was contrary to what was expected to occur. The weaning group should have been the most tender since most studies indicate a decrease in tenderness with increasing age. Part of the difference can probably be attributed to normal variation in the Warner-Bratzler shear machine and in cooking techniques (Hedrick, et al., 1968). The 1974 steers also varied significantly, P<.05, but in the opposite order with the weaning steers being the most tender, 7.8 kg versus 8.4 kg of shear force.

Forequarter weight and hindquarter weight did not differ in 1973 with average weights of 73.5 kg and 67.5 kg, respectively. In 1974 the weaning age group had significantly, P<.001, higher forequarter and hindquarter weights than did the yearling steers. This difference was probably due to amount of fat deposited in the quarters by the weaning group steers, since the weaning group steers had a higher percent forequarter and hindquarter and were so much fatter than the yearling steers.

The other two detailed carcass traits considered in this study were not significantly affected by treatment by year interactions. Percent wholesale shortloin did not differ among treatment groups. The weaning age group

had 6.83 percent shortloin and the yearling group had 6.93 percent shortloin. The difference in lean to bone ratio was also not significant between groups, 4.67 for the weaning group versus 4.61 for the yearling group. The failure of lean to bone ratio to be different between years or treatments was evidence that the differences in percent fat, lean and bone is the result of differences in percent fat deposited. The means for percent wholesale shortloin and lean to bone ratio are presented in Table XXIV.

TABLE XXIV

MEANS, STANDARD ERRORS AND DIFFERENCES FOR PERCENT WHOLESALE SHORTLOIN AND LEAN TO BONE RATIO BY TREATMENT GROUP

	Age on Test		
	Weaning	Yearling	Difference
No. Steers	78	81	
Wholesale Shortloin, %	6.83±0.04	6.93±0.04	-0.10
Lean to Bone Ratio	4.67±0.03	4.61±0.03	0.06

Comparisons of the Crossbred Groups' Efficiency in Utilizing TDN

Table XXV presents the mean squares for the efficiency traits carcass weight per TDN consumed and lean weight per TDN consumed. TDN was based on the feed consumed during the

TABLE XXV

MEAN SQUARES FOR CARCASS WEIGHT/TDN AND LEAN WEIGHT/TDN CONSUMED

Source	d.f.	Mean Squares	
		Carcass Weight/TDN	Lean Weight/TDN
Crossbred Group (CG)	6	0.0006	0.0002
Treatment (T)	1	0.0156	0.0078
Year (Y)	1	0.0312*	0.0109*
CG x T	6	0.0004	0.0002
CG x Y	6	0.0007	0.0003
T x Y	1	0.0351**	0.0175*
CG x T x Y	6	0.0005	0.0002
Error	28	0.0062	0.0025

*P<.05
**P<.01

feedlot period. Crossbred group by treatment interactions were not significant for either trait. Carcass weight per TDN consumed was similar for all crossbred groups, ranging from 0.23 (B crosses) to 0.26 (HA) (Table XXVI). Likewise the lean produced per TDN consumed ranged from 0.14 (B and JH) to 0.16 (HA). Differences were not significant for either trait.

Although age on feed was not significant there are some observations worth noting. Table XXVII presents the means and differences for each treatment and year; treatment by year interactions were significant, $P<.05$, for both traits. The 1974 yearling group remained on wheat pasture 76 days longer than the 1973 yearling group. Wheat pasture for the 1973 group was of very poor quality due to insufficient rainfall. The 1974 group had sufficient rainfall durings its grazing period and therefore high quality pasture. Average daily gains for the 1973 yearling steers were very low and often negative, whereas the 1974 yearling steer gains were all positive. The effect of pasture conditions on the 1973 yearling steers was to make them less efficient than the 1973 weaning group. The opposite effect was observed for the 1974 steers, adequate pasture and higher on test weights due to a longer grazing period caused the 1974 yearling group to be more efficient overall than the weaning group. The data appears to indicate that the 1974 yearling steers were the most efficient. However what it actually indicates

TABLE XXVI

MEANS AND STANDARD ERRORS FOR CARCASS WEIGHT/TDN AND LEAN WEIGHT/TDN CONSUMED BY CROSSBRED GROUP

Crossbred Group[a]	No. Steers	Carcass Weight/TDN	No. Steers	Lean Weight/TDN
HA	61	0.26	25	0.16
SA	35	0.24	21	0.15
SH	38	0.24	24	0.15
BA	43	0.23	23	0.14
BH	33	0.23	23	0.14
JA	35	0.25	22	0.15
JH	27	0.24	21	0.14
Std. Error		0.011		0.007

[a]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

TABLE XXVII

MEANS AND DIFFERENCES FOR CARCASS WEIGHT/TDN AND LEAN WEIGHT/TDN CONSUMED BY TREATMENT GROUP AND YEAR

Trait	1973 Age on Feed		Difference	1974 Age on Feed		Difference
	Weaning	Yearling		Weaning	Yearling	
Carcass weight/ TDN	0.22	0.20	0.02	0.22	0.33	-0.11
Lean weight/ TDN	0.14	0.14	0.02	0.13	0.21	-0.08

is that regardless of the type of management, on feed at weaning or at yearling age, it is necessary to push a steer to maximum possible weight gain to achieve maximum efficiency.

Evaluation of Several Estimators of Carcass Composition

Single product-moment correlations were determined for USDA yield grade and yield grade as estimated by the federal grader; estimated and actual kidney, pelvic and heart fat; and estimated and actual cutability in order to aid in determining if the estimated values were good estimates of the actual values. Table XXVIII contains the correlation coefficients for the above traits.

TABLE XXVIII

CORRELATION COEFFICIENTS FOR ESTIMATED AND U.S.D.A. YIELD GRADE: ESTIMATED AND ACTUAL KIDNEY, PELVIC AND HEART FAT; AND ESTIMATED AND ACTUAL CUTABILITY

Trait	USDA Yield Grade	Actual KPH Fat	Actual Cutability
Estimated Yield Grade	0.57[a]	....	....
Estimated KPH Fat	....	0.54[a]	....
Estimated Cutability	....	....	0.47[a]

[a]$P<.001$ that rho = 0.

The correlation for estimated and USDA yield grade was determined to aid in determining if estimated yield grade was a good estimator of actual yield grade, as determined by the USDA, and hence a good estimator of cutability. The correlation coefficient between these traits is 0.57. The coefficient of determination (r^2) for the traits is 0.32 indicating that only 32 percent of the variation in actual yield grade is accounted for by estimated yield grade. The correlation coefficient can also be considered very low since both traits are estimates of cutability and therefore the correlation coefficient should have been much higher. This data would suggest that yield grade stamped on the carcass may not be a very good estimate of actual cutability.

The correlation coefficient of estimated and actual kidney, pelvic and heart fat, 0.54, also indicates basically the same effect as for yield grade. The failure of the estimated KPH fat to be accurate was constant across all breed groups. In all cases estimated KPH fat underestimated actual KPH fat. The underestimates ranged from -0.9 percent for SH steers to -2.4 percent for JA steers (Table XXIX). Since estimated KPH fat is an element of the equation to estimate actual cutability, therefore any error is transmitted to the yield grade.

The correlation coefficient, 0.47, for estimated and actual cutability was even lower than for the previous two traits and was a reflection of the error transmitted to the

TABLE XXIX

MEANS AND DIFFERENCES FOR ESTIMATED AND ACTUAL KIDNEY, PELVIC AND HEART FAT AND CUTABILITY BY CROSSBRED GROUP

Group[e]	No. Steers	KPH Fat, % Estimated[a]	KPH Fat, % Actual[c]	Difference	Cutability Estimated[b]	Cutability Actual[d]	Difference
HA	25	3.0	3.9	-0.9***	46.7	49.0	-2.3***
SA	21	2.7	4.1	-1.4***	46.7	50.0	-3.3***
SH	24	2.8	3.7	-0.9***	47.2	51.9	-4.7***
BA	23	3.1	4.5	-1.4***	46.7	50.2	-3.5***
BH	23	2.8	4.2	-1.4***	47.0	50.8	-3.8***
JA	22	3.4	5.8	-2.4***	46.5	49.4	-2.9***
JH	21	3.3	5.6	-2.3***	47.7	49.4	-1.7**

**$P < .01$

***$P < .001$

[a]Standard errors and significances are in Table VI

[b]Standard errors and significances are in Table VIII.

[c,d]Standard errors and significances are in Table IX.

[e]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

equation for estimating KPH fat. The coefficient of variation was 0.22 or estimated cutability accounted for only 22 percent of the variation in actual cutability. As with estimated and actual KPH fat, estimated cutability underestimated actual cutability in all cases. The means for estimated and actual cutability are presented in Table XXIX.

The equation for estimating cutability was developed by Murphey et al. (1960) and is as follows (converted to metric units):

Cutability = 51.34 - 2.28 (single fat thickness, cm)
- (percent KPH fat) + .114 (ribeye area, cm^2)
- 0.021 (hot carcass weight, kg).

Since estimated cutability underestimated actual cutability for all breed groups, sire breeds and treatment groups, regression coefficients for the traits associated with cutability were calculated based on the data in this study. The regression coefficients were calculated over all breed groups and by sire breed. The generated regression coefficients are presented in Table XXX. The generated regression coefficients for KPH fat differed significantly from Murphey's equation only for the HA and S equation, ribeye area only for the overall equation. Regression coefficients for carcass weight did not differ significantly from Murphey's.

All the developed equations were used to calculate

TABLE XXX

CORRECTION FACTORS FOR ESTIMATED CUTABILITY FOR MURPHEY'S OVERALL STEERS AND BY SIRE BREED

Trait	Constants[a]					
	Murphey	Overall	HA	Simmental	Brown Swiss	Jersey
Intercept	51.34	53.18***	50.28*	55.99***	52.80***	51.47
Single Fat	-2.28	-0.82***	-0.05***	-1.23***	-0.67***	0.77***
KPH Fat	-0.462	-0.387	-0.863*	-0.102**	-0.611	-0.773*
Ribeye Area	0.115	0.084*	0.115	0.114	0.108	0.086
Carcass Weight	-0.0205	-0.0196	-0.0243	-0.0342	-0.0216	-0.0066

*P<.05 **P<.01 ***P<.001

[a]All constants tested against Murphey's.

cutabilities and the results are presented in Table XXXI. The HA prediction equation did the worst job of all the generated equations, underestimating breed groups on the average by 3.5 percent. All of the other equations overestimated cutability on the average from 0.4 percent for the overall equation to 2.6 percent for the S equation. All of the developed equations were closer predictors of cutability than was Murphey's equation.

Crouse et al. (1975) also developed prediction equations based on data collected from 786 crossbred steers. He found that the generated prediction equations overestimated HA and J breed groups, and that the poorest fit was for J steers. This is only partially in keeping with the results from this study. HA and J steers were generally overestimated and the poorest fit was for the HA steers. Crouse also found that use of a single prediction equation underestimated by 0.1 percent or overestimated by as much as 1.0 percent relative to actual cutability.

Hedrick and Krause (1975) comparing actual retail yields to estimated cutability from 590 and 240 purebred and crossbred steers and heifers found that actual yields exceeded predicted yields by 1.9 percent for steers and 1.2 percent for heifers. Although the magnitude was not as great as it was in this study, Murphey's equation again underestimated cutability. Murphey's equation was originally based on 459 beef carcasses, with the work conducted in the mid 1950's. During this period the beef

TABLE XXXI

MEANS FOR ACTUAL CUTABILITY AND ESTIMATED CUTABILITY FROM THE PREDICTION EQUATIONS FOR THE VARIOUS SIRE GROUPS, MURPHEY AND OVERALL STEERS

Breed Group	Actual Cutability %	Prediction Equation					
		HA (%)	S (%)	B (%)	J (%)	Over-All (%)	Murphey (%)
HA	49.0	48.8	51.4	50.7	51.1	50.3	46.4
S	51.0	48.7	51.0	50.8	51.5	50.3	47.0
B	50.5	48.3	50.9	50.5	51.0	50.1	46.8
J	49.5	47.2	51.8	49.9	49.6	50.0	47.1

type animal was predominantly purebred. In the last 10 years the interest in and corresponding number of crossbred animals have increased. The introduction of exotic type breeds further increased the interest in crossbreeding. It is these crossbred animals with their different conformations that have affected Murphey's equation the most. Murphey's equation as was adopted by the U.S.D.A. to determine yield grade may no longer be an adequate predictor of cutability for all cattle types.

CHAPTER V

SUMMARY

This study involved the carcass measurements on 269 crossbred steers. Carcass separation was conducted on a random sample of 159 steers. The steers were born at Lake Carl Blackwell Research Range west of Stillwater from January through May, 1973 and 1974. Most of the calves were born in February and March. The crossbred steers were produced by mating Angus (A) and Hereford (H) cows to Angus, Hereford, Simmental (S), Brown Swiss (B) and Jersey (J) bulls. Thus there were eight crossbred groups, HA, AH, SA, SH, BA, BH, JA and JH.(The first letter designates sire breed and the second letter designates dam breed.)

The steers were divided into two groups each year. In 1973 the oldest half of the steers from each crossbred group were placed in the feedlot one week after weaning. The remaining steers were grazed on wheat pasture and placed in the feedlot as yearlings on March 7, 1974. The 1974 steers were treated identically to those in 1973 except the yearling steers were not placed in the feedlot until May 22, 1975. The HA and AH steers were mixed and treated as a single crossbred group for the finishing phase (HA). Steers were individually slaughtered as they

reached an estimated choice slaughter grade as determined by visual appraisal.

Carcass traits that were obtained on all steers include live weight at slaughter, hot carcass weight, carcass weight per day of age, dressing percent, average fat (12th rib), single fat (12th rib), estimated kidney, pelvic and heart fat, carcass conformation, marbling score, carcass grade, ribeye area (12th rib), estimated cutability (Murphey et al., 1960), and yield grade as estimated from estimated cutability (U.S.D.A. yield grade). In addition to the carcass traits obtained on all steers the following traits were measured: actual percent kidney, pelvic and heart fat, percent total fat, percent lean, percent shortloin trimmed to 0.3 inches of external fat, percent bone, percent wholesale shortloin, tenderness, hindquarter weight and forequarter weight.

Slaughter age was oldest for steers from late maturing breed combinations. SH and BH steers were the oldest, 520 days versus 492 days. B sired steers were not significantly, $P<.05$, older than S sired steers but B sired steers were older ($P<.05$) than the J sired steers. S sired steers did not differ significantly from J sired steers.

Slaughter weight and hot carcass weight both had the same ranking for breed groups. SA were the heaviest, $P<.05$, 512 kg and 314 kg respectively. The JA and JH steers were the lightest, 419 kg and 250 kg for slaughter weight and hot carcass weight respectively. S and B sires did not

differ for either trait but both were were heavier, $P<.05$, than J sired steers.

Carcass weight per day of age was significantly heavier, $P<.05$, for the SA steers than for any of the other crossbred groups, 0.63 kg/day. JA and JH steers were the slowest gainers, 0.51 kg/day. S and B sired steers did not differ from each other but were heavier, $P<.05$, than the J sired steers, 0.61 kg/day versus 0.51 kg/day. Dressing percent differed only between the J sired steers and all other crossbred groups and was lower, $P<.05$, for the J sired steers, 59.6 percent and 61.2 percent.

Average and single fat thickness was highest, $P<.05$, for the HA steers and lowest for JH steers. Average fat ranged from 23.7 mm to 17.0 mm, and single fat ranged from 29.0 mm to 23.3 mm. The traits did not differ by sire breed.

Estimated kidney, pelvic and heart fat were highest, $P<.05$, for the JA and JH steers, 3.3 percent, and lowest for the SH steers which had only 2.8 percent. Like the crossbred groups the J sired steers had more internal fat than the S or B sired steers, $P<.05$.

Ribeye area was largest, $P<.05$, for steers from late maturing breed combinations. The SH had the largest ribeye area, 84.0 cm^2, while the JA and JH had the smallest ribeye area, 77.6 cm^2. The S and B sired steers did not differ significantly for ribeye area but both were larger, $P<.05$, than the steers from J sires, 82.5 cm^2 versus 70.5 cm^2.

Marbling had no effect on final grade since marbling did not differ significantly among crossbred groups. Final grade was determined by conformation which was highest, $P<.05$, for HA and S crosses, averaging high choice, and was lowest for J cross steers, high good. Final grade followed the same pattern but only J crosses failed to grade low choice, grading instead high good.

Marbling was a determining factor of final grade for sire breeds. B sired steers had the highest marbling score, average small, while the S sired steers had the lowest, $P<.05$, score, high slight. J sired steers did not differ from either B or S sired steers. Conformation was clearly divided into three distinct ranks. S sired steers had better conformation than B sired steers which had better conformation than J sired steers, high choice, average choice, and high good, respectively. Final grade did not differ for the S and B sired steers which were both better than J sired steers, low choice versus high good.

Estimated cutability was highest, $P<.05$, for SA, SH, BA and JH steers, 47.4 percent, and lowest for HA steers, 46.4 percent. U.S.D.A. yield grade was determined from estimated cutability and did not differ among crossbred groups averaging 4.2. Estimated cutability and U.S.D.A. yield grade did not differ significantly for sire breed and averaged 47.3 percent and 4.2, respectively.

Actual percent kidney, pelvic and heart fat was much greater, $P<.05$, for the JA and JH steers than for any of the

other crossbred groups, 1.28 higher than the next highest crossbred group. The crossbred group with the lowest percent KPH fat was the SH steers, 3.69 percent. J sired steers had significantly, P<.05, more KPH fat than B sired steers, P<.05, more KPH fat than S sired steers, 5.7, 4.3 and 3.9 percent, respectively.

Actual cutability ranged from 49.0 for HA steers to 51.9 for SH steers, P<.05. All of the other crossbred groups were intermediate with no distinct differences between them. S and B sired steers did not differ for actual cutability and both differed significantly, P<.05, from J steers, 50.8 percent versus 49.5 percent.

Percent fat was highest for HA steers, P<.05, 26.3 percent, and lowest for the SH steers, 21.9 percent. S and B sired steers did not differ for percent fat but both were lower than the J sired steers, 23.0 percent versus 25.1 percent.

Percent lean was divided into two parts; percent trimmed shortloin which did not differ among crossbred groups or sire breeds and percent lean which did differ among crossbred groups and sire breeds. The SH steers had the highest, P<.05, percent lean, 57.4 percent, and lowest was the HA and JH steers, 54.6 percent. S and B sired steers had 56.3 percent lean which was greater, P<.05, than the J sired steers, 54.7 percent lean. Percent trimmed shortloin averaged 5.9 percent over crossbred groups and sire breeds.

Percent bone was highest for JH, BH and SH steers, 12.4 percent, lowest for HA steers, 11.4 percent and intermediate for all other crossbred groups. Percent bone did not differ among sire breeds, indicating that percent bone is a function of dam breed, which did differ significantly, $P<.001$. Steers from A dams had 11.9 percent bone while steers from H dams had 12.4 percent bone.

Lean to bone ratio differed significantly, $P<.05$, among crossbred groups. HA and SA steers had the best ratio, 4.77 while JH steers had the worst ratio, 4.34. S and B sired steers did not differ for lean to bone ratio but they had a higher ratio than steers from J sires, 4.65 versus 4.45. Lean to bone ratio did not differ among dam breeds.

Tenderness was within acceptable limits for all crossbred groups and sire breeds, however, it did differ significantly, $P<.05$, for both. SH steers were the toughest, 8.6 kg of shear force, and JA steers the most tender, 7.10 kg of shear force. S and B sired steers did not differ for tenderness and were both tougher than steers from J sires, 8.3 kg versus 7.3 kg of shear force.

Percent forequarter and hindquarter was very similar across all breed groups and sire breeds. S and B sired steers did not differ for forequarter weight but did differ, $P<.05$, for hindquarter weight, 78.2 kg for forequarter weight and 73.2 kg and 71.4 kg for hindquarter weight, respectively. J sired steers were lighter, $P<.05$, for

both traits, 63.2 kg and 59.0 kg, respectively.

Steers from A dams were significantly better, P<.05 or less, for slaughter age, carcass weight per day of age, percent bone tenderness and forequarter weight. Steers from H dams were significantly better, P<.05 or less, for actual cutability and percent fat. Breed of dam did not differ significantly, P<.05, for any of the other traits studied.

Due to the large number of treatment by year interactions in this study, it is difficult to determine which treatment produced the most desirable type of carcass. The traits with significant, P<.05, treatment by year interactions are slaughter age, hot carcass weight, dressing percent, estimated KPH fat, marbling, final grade, actual KPH fat, actual cutability, tenderness, percent fat, lean, trimmed shortloin and bone, forequarter and hindquarter weight. The treatment group rank observed in 1973 was often reversed in the 1974 groups.

Those traits that did not have significant, P<.05, treatment by year interactions generally favored the weaning group. Slaughter weight, carcass weight per day of age, carcass conformation, estimated cutability and U.S.D.A. yield grade were all significantly better, P<.05, or less, for the weaning group of steers. Average and single fat thicknesses were significantly lower, P<.05, for the yearling group of steers. Ribeye area, percent wholesale shortloin and lean to bone ratio did not differ

significantly between treatment groups.

Efficiency traits, carcass weight per TDN consumed and lean weights per TDN consumed, were not significant among crossbred groups, treatments or years. Carcass weight per TDN consumed ranged from 0.23 (B crosses) to 0.26 (HA). Lean weight per TDN consumed ranged from 0.14 (B and JH) to 0.16 (HA).

Simple correlation (product-moment) between estimated and actual KPH fat, estimated and actual yield grade and estimated and actual cutability were calculated to aid in evaluating estimated and actual traits. The correlation coefficients indicated that the estimated values were poor estimators of the actual values. The correlation coefficients were 0.57, 0.54 and 0.47, respectively.

Estimated cutability underestimated actual cutability on the average by 6.3 percent. Cutability equations as developed in this study underestimated breed groups by as much as 3.5 percent. The equation developed for all breed groups overestimated on the average by only 0.4 percent.

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VITA

Michael Edward Boyd

Candidate for the Degree of

Master of Science

Thesis: CARCASS CHARACTERISTICS OF CROSSBREED STEERS GROWN UNDER TWO DIFFERENT MANAGEMENT SYSTEMS AND PRODUCED BY HEREFORD, ANGUS, SIMMENTAL, BROWN SWISS AND JERSEY SIRES AND HEREFORD AND ANGUS DAMS

Major Field: Animal Science

Biographical:

Personal Data: Born in Ciudad Juarez, Chihuahua, Mexico, August 30, 1951, the son of Mr. and Mrs. James E. Boyd; married Bobbie L. Jones, October 19, 1970; the father of two sons, Michael Edward and Ronald Clayton.

Education: Received the Bachelor of Science degree in Agriculture from New Mexico State University in Las Cruces, New Mexico, July, 1974, with a major in Animal Science. Completed the requirements for the Master of Science degree in December, 1976.

Experience: Graduate Research Assistant, Oklahoma State University, September, 1974 to August, 1976.

Organizations: Alpha Zeta.