ASSOCIATION OF BEEF CARCASS CONFORMATION WITH CARCASS COMPOSITION

By

Everett L. Martin

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1963

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1965

Submitted to the Faculty of the
Graduate College
of the Oklahoma State University in
partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
May, 1968

ASSOCIATION OF BEEF CARCASS CONFORMATION

WITH CARCASS COMPOSITION

Thesis Approved:

Lowell E. Walters
Thesis Adviser

Joe Whiteman

Robert L. Henrickson

George V. Odell

D. R. Peterson

N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The author expresses his sincere appreciation to Dr. Lowell E. Walters, Professor of Animal Science, for his assistance and guidance during the course of this investigation and in the preparation of this thesis.

Grateful acknowledgment is also extended to Dr. J. V. Whiteman, Professor of Animal Science, and Dr. R. D. Morrison, Professor of Mathematics, for their assistance concerning the analyses and interpretation of the data.

Further appreciation is due Dr. R. L. Henrickson, Professor of Animal Science, Dr. George V. Odell, Professor of Biochemistry and Dr. D. R. Peterson, Professor of Veterinary Anatomy, for serving on the author's adivsory committee.

Appreciation is also extended to Mr. Dwight F. Stephens, Superintendent, Fort Reno Livestock Research Station, for his cooperation in caring for experimental animals.

In addition, the author thanks Mr. Forrest Little, the late Mr. H. Clay Potts and Mr. James R. Fleming for their encouragement and help during his stay at Oklahoma State University. Jim, I will miss the breakfast club.

The writer also wishes to express his appreciation to his parents, Mr. and Mrs. Ernest L. Martin, wife, Gloria, son, Mark and daughter Erin for their interest and encouragement throughout this course of study.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Beef carcass conformation is an extremely difficult subject to study. Many techniques have been employed and many conclusions have been reached regarding this subject. A great many of these general type conclusions should be viewed very carefully, taking into consideration the experimental conditions, type of cattle studied, evaluation technique used etc. An experimental design that would elucidate all the questions pertaining to beef carcass conformation has not been developed. This necessitates the bringing together of data from different sources, the composite evaluation of these data and the assessment of the value of these data to a particular situation or set of conditions. For example, workers have drawn conclusions from groups of British bred cattle that differ tremendously in level of fatness. It could not be expected that conclusions and relationships drawn from a sample of so called "thin cattle" would apply to fatter cattle, even of the same breed. Callow (1948) reported that the ratio between weight of muscular tissue and bone increased during fattening up to a certain level of carcass fatness. He concluded that when carcasses contained over twenty percent fatty tissue the percentage of muscular tissue, bone tissue, tendons, etc., all decreased as the percentage of fatty tissue increased from this twenty percent level. Thus, level of fatness and type of analysis (percent versus absolute) may have a marked influence on the conclusions from an experiment. Therefore, all factors should be evaluated carefully when interpreting beef carcass conformation data.

With the preceding comments in mind statements such as: "weight of muscle can be determined within one percent if the weight of the cannon bones are known"; "finish exerts more influence on yields of wholesale and retail cuts than does conformation"; "lean and bone were observed to develop proportionately over a relatively wide range of carcass shapes"; "beef cattle breeders have considerable latitude in conformation from which to select without encountering great changes in the proportion of wholesale cuts from carcasses"; and "measures of finish are four and one-half times as important as conformation scores in predicting yields of closely trimmed boneless retail cuts", have very vague meanings. Too often these statements are seen in literature reviews or popular articles without the conditions and stipulations that go with them.

Fat, how does one control it? How does one study it? How does it affect carcass conformation and to what extent? These questions and many others are frequently asked and most so-called conformation studies have been plagued with fat problems. Fat and conformation, are they separable or are they closely related? Many workers agree that beef carcass conformation is influenced to a great extent by both external and internal fat.

How does bone relate to carcass conformation? Very little information regarding this subject appears in the literature. Some studies have shown a positive association between bone and retail yield.

The study reported herein is a continuation of the thesis entitled

The Association of Beef Carcass Conformation with Thick and Thin Meat Yields (Martin 1965). Phase I of this study was initiated to obtain information concerning the yields of thick and thin muscle from selected U.S.D.A. Prime conformation beef carcasses and to compare these data to results reported by Martin (1966) concerning U.S.D.A. Choice and Standard conformation carcasses.

Phases II and III of this investigation represent attempts to control some of the variables associated with conformation, both by field control and statistical control. It is hoped that the information, relationships and prediction equations contained herein will be of value in future beef carcass evaluation investigations and interpretations.

CHAPTER II

LITERATURE REVIEW

The following review of literature is intended to up date and in some instances expand key papers reviewed by Martin (1965). Information concerning earlier investigations with meat animal carcasses; relationships among carcass components; and some of the relationships between carcass conformation (type), U.S.D.A. grades, wholesale cut yields and carcass components may be found in the above reference.

Conformation

Information concerning beef carcass conformation and its effect on cutability is somewhat limited. Several workers agree that subjective measures of conformation are not a significant factor in determining carcass cutability (yield of boneless, closely trimmed retail cuts); Breidenstein (1962), Butler _et al_. (1957), Murphey (1960), Goll _et al_. (1961a, 1961b), Branaman _et al_. (1962) and Cole _et al_. (1960).

Tyler _et al_. (1964) demonstrated that beef carcasses having approximately the same yield grade (dual grade), but differing substantially in conformation grades, had similar retail cutability percentages. Cutability was defined as the percentage yield (carcass weight basis) of boneless, closely trimmed retail cuts from the round, loin, rib and chuck. Two groups of carcasses were selected (40 each of high Choice and low Good conformation) to be as nearly the same quality grade, yield grade and weight as possible. Average cutabilities for the two groups, 49.6 percent for the high conformation group and 49.7 percent for the low conformation group, were almost identical. Fat and bone were observed to be the major variables. High conformation Choice carcasses had 3.6 percent more fat trim than the lower conformation Good grade carcasses. However, this difference in fat was offset by a lower percentage bone. The high conformation carcasses had 13.5 percent bone while the lower conformation carcasses had 16.4 percent bone. The principle conclusion reached was that differences in conformation, among carcasses of approximately the same yield grade, do not result in differences in yields of boneless, closely trimmed retail cuts from the round, loin, rib and chuck.

Stinger et al. (1965) reported a study comparing U.S.D.A. average Choice conformation carcasses to U.S.D.A. average Good conformation carcasses with respect to cutability. An equal number of carcasses was selected from each conformation group within three different weight groups and two different fat thickness classifications. Carcasses from the two conformation groups had similar average l. dorsi area measurements. They found no significant differences in the total retail yield of the carcasses from the two conformation groups. Significant differences were found among fat thickness groups, but when the effects of internal fats were removed, no significant differences in cutability between fat groups were evident.

Martin et al. (1966) used ten pairs of U.S.D.A. Choice and Standard conformation carcasses to study thick and thin muscle yields. It should be pointed out and emphasized that the carcasses were selected and paired on carcass weight, rib eye area and fat thickness at the

12th rib. Quality grade (marbling score) did not differ significantly between the two conformation groups. Consistent and significant advantages for choice conformation carcasses were observed in the yield of thick, high value steak and roast muscle. However, this advantage for choice was small, less than one percent of the streamlined carcass weight. Total muscle yields were almost identical between the two conformation groups. Fat plus bone was observed to make up a rather constant percentage of the streamlined carcass weight, therefore, greater variation existed in fat and bone within both conformation groups as compared to variation in either thick, thin or total muscle yields. This study is in full agreement with Tyler et al. (1964).

Bell (1966) reported that differences in conformation and quality are much more obvious in live cattle than in carcasses. When Choice Hereford feeder calves and low Good "okie" feeder calves were fed to the same finish weight the resulting average carcass grades were average Choice and low Choice respectively.

Breed Differences

Rather limited information is available concerning the relative cutability (yield of boneless, closely trimmed retail cuts from the round, loin, rib and chuck) of various types and breeds of cattle. Branaman et al. (1962), comparing the cutability of beef and dairy type cattle, reported no significant difference in percentage yield of high priced wholesale cuts or trimmed retail cuts. They further reported negligible difference in separable lean between the two types of cattle. Beef breeds averaged 57.15 ± 3.72 percent lean and the dairy breeds 56.87 ± 2.66 percent lean. The authors concluded that there was little advantage for beef cattle from the standpoint of carcass cutability.

Callow (1961, 1962) working with Hereford, dairy Shorthorn and Friesian steer carcasses, found little or no significant effect of breed or level of nutrition on the distribution of muscular or fatty tissue among the joints.

Cole et al. (1964) reported on a study involving British, Zebu and dairy type cattle. Among the breeds studied, the short shanked, blocky, thick fleshed Angus steer carcasses had the lowest percentage separable muscle and separable bone, but the highest percentage separable fat, ether extract, flank and brisket. The long shanked, long bodied, angular Holstein carcasses produced the highest percentage separable muscle, separable bone and the highest percentage separable muscle and bone within all except two wholesale cuts.

Martin, T. G. et al. (1965) reported on a study involving Hereford and Charolais-Hereford crossbred heifers. Significant differences were observed between the means of Hereford and crossbred groups, respectively, as follows: fat cover, 1.42 cm. and 0.86 cm.; 9-10-11 th rib percent edible portion, 57.5 and 62.2; 9-10-11 th rib percent bone, 15.0 and 17.2; and 9-10-11 th rib percent excess fat, 27.5 and 20.6. Ninth-10-11 th rib separation technique was followed as outlined by Hankins and Howe (1946).

Bradley et al. (1966) found no significant differences in lean and fat between Herefords and Hereford-Red Poll crosses. Abraham (1967) reported cutability data on 835 steers representing a wide range in breeding and management. Angus carcasses had the lowest percentage of hind quarter and of boneless roast and steak meat. Both Charolais and Charbray carcasses had significantly higher U.S.D.A. cutabilities than

Angus and Herefords. Similar results were reported by Carroll and Rollins (1965).

Barton (1967), in a review of literature, reported that conformation and size of cattle have been changed, over the years, by selection. He further stated that modern beef animals are generally smaller and more compact than formerly, but this trend has not increased the proportion of lean in the carcass or changed its distribution. One of the authors principle conclusions was that emphasis on conformation in the showyard has been largely misdirected.

Symmetry

Since carcass cutout procedures are usually quite time consuming and expensive to perform, the feasibility of cutting only one side is self evident. Several papers have been reported in which the symmetry of the beef carcass has been studied.

Butler et al. (1956) reported significant differences in numerous carcass measurements between left and right sides. However, their final conclusion attributed most of these differences to cutting technique. Brungardt and Bray (1963), Butler et al. (1956) and Goll et al. (1961a) found left sides significantly heavier due to the presence of diaphram muscle (hanging tender) and the increased weight of the kidney and pelvic fat in this side. These authors agree that differences between left and right sides were non-significant for the calculated percentages of carcass fat, muscle and bone.

Martin et al. (1965), in a study involving 20 carcasses, reported correlation coefficients between thick muscle, thin muscle, fat and bone of the left and right sides of .97, .87, .98 and .94 respectively.

Butterfield (1963) concluded that the greatest error which may occur in processing is the faulty sawing of the spinal column in the separation of the two sides of the carcass.

This brief review of literature, relative to symmetry in the beef carcass, indicates that either the left or right side of a beef carcass may be assumed to be representative of the entire carcass and therefore it is doubtful that the increased accuracy that would be gained by processing both sides and taking the average is justified.

Relationships Among Muscles

Strong relationships between the weight of certain muscles and total carcass muscle have been suggested by several authors. Working with 43 mature Hereford cows, Orme et al. (1960), found that they could account for 64 to 92 percent of the variation in total separable lean by knowing the weight of certain muscles. Of the muscles studied the Biceps femoris exhibited the strongest relationship to total lean (r = .96). When separable carcass lean was regressed on the weight of the Biceps femoris the resulting standard error of estimate was 5.52 pounds. Simple correlations between certain groups of muscles and total carcass lean were high, ranging from .88 to .97. It was determined that 90 percent of the variation in total separable lean was associated with the combined weight of the Psoas major, Semitendinosus and Infraspinatus muscles. High relationships were found among the weights of all muscles studied.

McMeekan (1941) reported the weight of the Psoas major muscle in swine to have a correlation coefficient of .81 with the weight of total carcass lean.

Butterfield (1963) reported on the use of the weights of individual muscles and groups of muscles for the prediction of the weight of total muscle in beef carcasses. Several breeds and age groups were included in this study. Correlation coefficients between the 17 muscles studied and total side muscle weight ranged from .93 to .98. These results indicated that weights of the large muscles can be used in predicting total carcass muscle weight. It is of interest to note that the best equation to predict total muscle involved the Biceps femoris. This same conclusion was reached by Orme et al. (1960).

Topel et al. (1965) conducted a study, involving 89 slaughter barrows and gilts, to determine relationships of size of certain whole porcine muscles to carcass muscling. Partial correlation coefficients between the five muscles studied and weight of lean cuts holding carcass weight constant were as follows: L. dorsi .70, Psoas major .62, Semimembranosus .64, Biceps femoris .63 and Rectus femoris .66.

Prediction

Predicting carcass composition, either from live animal or carcass measurements, has been the objective of numerous research efforts. Many of these studies have proved successful from the standpoint of statistics, but their findings, in general, have not been widely accepted by the livestock industry; an exception is the so called U.S.D.A. cutability equation (Murphey et al. 1960). The U.S.D.A. regression equation to predict percentage boneless retail yield from the four major wholesale cuts has met with wide acceptance because it is easy to use and does not require that the carcass be broken down. The equation was developed from cattle differing widely in grade and weight.

Variables used in the equation were as follows: fat thickness at the 12th rib, estimated percentage kidney fat, carcass weight and area of the ribeye. Murphey reported a correlation coefficient of 0.923 between predicted and actual cutout yield with a standard error of the estimate of 1.9 percent. Therefore, a combination of the four variables accounted for over 80 percent of the variation in boneless retail yield.

Since the U.S.D.A. equation has met with such wide acceptance several workers have investigated the accuracy of the equation. Palmer et al. (1961), working with 138 carcasses, found the correlation between predicted and actual U.S.D.A cutability yields to be 0.76, indicating that slightly under 60 percent of the variation in retail yield was accounted for.

Ramsey et al. (1962) working with 133 steers representing 8 breeds, reported that when U.S.D.A. yield grades were recorded as whole numbers, simple correlation coefficients between yield grade and percentage separable lean, fat and bone were -0.75, 0.63 and -0.51 respectively.

Brungardt and Bray (1963) in studies with 99 Choice grade carcasses, using the same four variables as used in the U.S.D.A. equation, could account for 44.9 percent of the variation in retail yield. The multiple correlation coefficient (R^2) among the independent variables was 0.67 and the standard error of estimate for the multiple regression equation was 2.0 percent.

Research relating to the accuracy of the U.S.D.A. equation indicates that 35 to 80 percent of the variation in retail yield can be accounted for. However, it should be pointed out that the U.S.D.A. yield grade equation was developed using both steers and heifers, involving several grades and weight ranges.

Gottsch *et al.* (1961) reported a study involving 38 Hereford steer carcasses. Highly significant correlations were observed between boneless trimmed lean from the round and chuck with total carcass lean, 0.78 and 0.77 respectively, accounting for 61 and 59 percent of the variation in total carcass lean. A highly significant negative correlation of -0.91 was found between total carcass lean and total carcass fat. A multiple correlation coefficient of 0.72 was obtained between fat thickness at the 12th rib, percentage kidney knob, five fat probes and total carcass fat.

Elliot *et al.* (1961) investigated the use of streamlined hind quarters as an indicator of carcass cutability. The flank, kidney and suet were removed from the hind quarter and the outside fat was trimmed to a desired specified thickness. Since three primal cuts of the hind quarter remained after trimming, the streamlined hind quarter constituted a major part of the high priced cuts of the carcass. A correlation coefficient Of 0.89 was obtained between streamlined hind quarter and percentage yield of primal cuts on 101 steer carcasses. This procedure was developed to fit into a packing-house type of operation and does not require extensive cutting techniques.

Goll *et al.* (1961b) working with 90 steers, 30 each from the Standard, Good and Choice grades, reported that wider, thicker, deeper carcasses yielded a higher percentage of the thick cuts. Cole *et al.* (1962) reported a study involving 132 steer carcasses representing a wide range in breed, conformation and degree of fatness. With carcass weight held constant, fat thickness at the rib eye was associated with much more of the variation in pounds of separable lean than was rib eye area. Carcass weight was more closely related to pounds of separable lean than was any other variable studied. An equation including fat thickness and carcass weight accounted for over 70 percent of the variation in separable lean.

Brungardt and Bray (1963) investigated the relationship between various linear measurements of beef carcasses and wholesale cuts with the yield of closely trimmed retail cuts from the round, loin, rib and chuck. Untrimmed wholesale cut yield accounted for only 11 percent of the variation in retail yield. When these same cuts were trimmed to a constant standard 3/8 inch fat trim, 74 percent of the variation in retail yield was accounted for. The largest simple correlation coefficient of any single measurement with retail yield was that of percentage trimmed round. This measurement accounted for 69 percent of the variation in retail yield and 56 percent of the variation in the predicted percentage of carcass muscle. Similarly, Cole et al. (1960) demonstrated that total lean of the round was highly associated with total carcass lean. Furthermore (Brungardt and Bray) found that each of the 14 fat probes that they made was negatively and highly correlated with percent retail yield. The simple correlations for these fat measurements with percent retail yield ranged from -0.54 to -0.90. The most useful equation developed in this study included percent trimmed round and a single fat measurement at the 12th rib. These two variables alone accounted for 81 percent of the variation in percent retail cut yield.

Hicks et al. (1965) separated 257 Angus and Hereford steer carcasses into retail cuts, fat, bone and lean trim. Carcass values were computed from average retail prices and adjustments were made for differences in year born, breed, feeding program and carcass weight. Based on adjusted values, fat trim accounted for 81 percent of the total variance in carcass value, while fat trim plus kidney fat accounted for 87 percent. The authors concluded that fat trim from the entire carcass is the important factor which influences the value of carcasses which are uniform in weight and grade. High accuracy in predicting carcass value per se cannot be achieved without direct information concerning fat trim. Kidney fat and fat depth are useful indicators, but do not reflect overall carcass differences to a satisfactory degree.

Texas workers (Fitzhugh et al. 1965) reported methods of predicting the weight of boneless roast and steak meat from easily obtained beef carcass measurements. This study involved 152 Hereford steers with an average carcass weight of 527.88±68.74 pounds. Partial correlations with carcass weight held constant disclosed significant negative relations between the measures of carcass fat, kidney fat weight and fat thickness and either L. dorsi area or roast and steak meat. Carcass weight alone accounted for more variation in roast and steak meat than any other variable. An equation containing kidney fat weight and carcass weight accounted for 90 percent of the variation in the dependent variable. Equations containing a measure of fat thickness and carcass weight accounted for 83 percent of the variation in roast and steak meat yield.

Cobb and Ovejera (1965) conducted a study involving the relationship between yield of trimmed retail cuts and certain carcass measurements. One-hundred and three steers were utilized in this study and were slaughtered at a constant weight of 462.7 Kg. Yield of trimmed retail cuts was significantly ($P<.01$) correlated with specific gravity of the whole carcass ($r = 0.72$), weight of kidney ($r = -0.65$), fat thickness at the ribeye (r = -0.36), chilled carcass weight (r = -0.32) and carcass depth (r = -0.23). The multiple correlation coefficient between yield of trimmed retail cuts and chilled carcass weight, rib eye area, fat thickness at the 12th rib and weight of kidney fat was 0.69. When specific gravity of the carcass was included with the four above traits, the multiple correlation coefficient was 0.78. Carcass specific gravity was the best single indicator of the yield of trimmed retail cut yield in the beef carcass followed by the weight of the kidney fat.

DuBose et al. (1967) evaluated 231 carcasses of various breeds in an attempt to predict boneless steak and roast meat yield. They found carcass weight to be the most accurate predictor of boneless retail cut yield (weight), r = 0.94. Length of body, length of leg, width of round and carcass weight accounted for 92 percent of the variation in weight of boneless steak and roast meat.

Henderson et al. (1966a) reported the effects of different cattle populations on prediction equations involving the same variables. Data were collected on three different groups: 46 Angus-Hereford crossbred steers, 16 steer carcasses and 24 heifer carcasses. Groups and carcasses within groups varied considerable in carcass weight and fat thickness at the 12th rib. The regression equation for percentage separable lean or muscle was as follows: 64.832 - 22.905 (fat thickness/50 Kg. of carcass) + 0.724 (L. dorsi area/50 Kg. of carcass). The corresponding equation for percent retail yield was: 52.340 - 21.909 (fat thickness/50 Kg. of carcass) + 0.924 (rib eye area/50 Kg. of carcass weight). All multiple correlations for these estimates were above 0.70. Percentage kidney did not increase prediction accuracy. Multiple correlation and regression coefficients for equations involving the same variables in many cases differed significantly among the different cattle populations. These results along with results reported by Henderson et al. (1966b) suggest that it is important to adequately describe the population used when reporting data on beef carcasses. In this connection Berg and Butterfield (1966) reported that breed groups of diverse origins, weights and ages differed significantly in all three major carcass tissue weights. Proportion of muscle to bone ratios also differed significantly, ranging from 3.66:1 in the Brahman group to 2.92:1 in the Polled Hereford group. Correlation coefficients of muscle with bone were high (r = 0.71 to 0.99) and regression of muscle on bone was significant in each of the seven groups studied. Regression coefficients among groups also differed significantly. Older animals tended to have lower regressions of muscle on bone, indicating that the proportion of muscle to bone within the groups did not rise as rapidly with an increase in general size as it did in the younger groups. The authors found that carcass weight differences accounted for almost all of the variance associated with muscle to bone ratios and that percentage fat had no effect when carcass weight was statistically controlled. These results indicate that if adjustments for muscle to bone ratios are made for differences in carcass weights, there will be no need to make any further adjustments based on fatness. However, this conclusion must be viewed with caution with regard to fatness since only one group of the seven studied had fat in excess of 20 percent of the carcass weight. Tayler (1964) did not consider cattle to be in the fattening phase of growth until they had reached a degree of fatness equivalent to 20 percent carcass fat. Up to the 20 percent level all three major tissues, lean, fat and bone, are increasing as a percent of the carcass weight, but at or near the 20 percent level the effect of increasing fat decreases lean tissue as a percent of the carcass. This is in agreement with work published by Callow (1948).

CHAPTER III

MATERIALS AND METHODS

A total of 113 carcasses were utilized in this study. Table I contains a listing of the cattle (carcasses) involved along with a brief description. Groups 1, 2 and 3 constitute phase I of the study while groups 4, 5, 6, 7 and 8, 9, 10 represent phases II and III respectively. Phase I carcasses originated in the packers coolers, therefore no information was available as to source, breeding, feeding or management practices associated with the production of these carcasses. Unlike phase I, the carcasses in phases II and III were produced from selected feeder steers fed at the Fort Reno Livestock Research Station.

Phase I

Phase I of this study was initiated to obtain information concerning the yields of thick and thin muscle from selected U.S.D.A. Prime conformation beef carcasses and to compare these data to results reported by Martin et al. (1966) concerning thick and thin muscle yields from selected U.S.D.A. Choice and Standard conformation carcasses. The 10 Prime conformation carcasses used in this study were purchased from Dugdale Packing Company in Saint Joseph, Missouri. All 10 carcasses were selected by the same company representative, over a 10 week period, with the following restrictions as a guide: conformation grade minimum Prime or better, carcass weight 600 pounds plus or minus 10 pounds, rib

TABLE I

DESCRIPTION OF THE CARCASS GROUPS UTILIZED IN THIS STUDY

Group Number	Number Per Group	Carcass Group Description	Cold Carcass Weight (lb.) Mean ± S.D.
1	10[e]	Standard conformation[a]	600.3 ± 26.8
2	10[e]	Choice conformation[a]	599.8 ± 25.15
3	14	Prime conformation[b]	593.5 ± 23.0
4	10	100 day fed common[c]	406.4 ± 36.0
5	8	100 day fed choice[c]	520.6 ± 26.4
6	8	140 day fed common[c]	456.1 ± 47.0
7	10	140 day fed choice[c]	575.7 ± 38.2
8	15	Angus[d]	600.6 ± 12.1
9	15	Charolais X Angus[d]	597.4 ± 12.9
10	13	Ayrshire[d]	564.2 ± 35.6
Total	113		

[a]Data from M.S. Thesis Martin (1965).

[b]Carcasses processed Spring 1965.

[c]Carcasses from live animal feeding trials, Fort Reno Experiment Station (1966).

[d]Carcasses from live animal feeding trials, Fort Reno Experiment Station (1967).

[e]One carcass in each of groups 1 and 2 was omitted from the prediction equation section of this study (to be discussed later) because of incomplete intact muscle weight data.

eye area 12 square inches plus or minus one square inch and average fat thickness at the 12th rib 0.3 inch plus or minus 0.1 inch. These same specifications, with the exception of conformation grade, served as a guide for the selection of U.S.D.A. Standard and Choice conformation carcasses reported on by Martin et al. (1966).

In addition to the first 10 Prime conformation carcasses processed, for comparative purposes, four additional Prime conformation carcasses were processed at a later date. While these additional four carcasses were not utilized in the Standard, Choice, Prime comparisons they were utilized in the development of prediction equations (to be discussed later). Group 3, Table I, corresponds to the initial 10 Prime conformation carcasses plus the additional four.

Upon arrival at the Oklahoma State University Meat Laboratory, via refrigerator truck, the Prime conformation carcasses were stored in a one to two degree centigrade cooler maintained at approximately 70 percent humidity. No more than a week of storage elapsed prior to cutting.

Cutting procedure, data collected etc., followed the routine outlined by Martin (1965). Briefly, muscles and muscle systems of the fore quarter and hind quarter, after having been trimmed to three and two inch minimum thickness respectively, were classified as thick muscle. All other lean tissue represented thin muscle. This concept, referred to as "thick and thin" muscle yields, is based on the theory that although carcass conformation may not be closely related to total separable lean, trimmed wholesale cuts or retail yield, there may be a yet undisclosed relationship between carcass conformation and the yield of thick high value muscle and the thin lower value muscle.

At this point it should be pointed out and emphasized that weights

TABLE II

DESCRIPTION OF THICK MUSCLES AND MUSCLE SYSTEMS TO INCLUDE WHOLESALE CUT AND SCIENTIFIC MUSCLE NOMENCLATURE

Name	Wholesale Cut	Major Muscles
HIND QUARTER		
Knuckle	Round	Vastus intermedius, Vastus lateralis, Vastus medialis and Rectus femoris
Eye Round	Round	Semitendinosus
Bottom Round	Round	Biceps femoris
Top Round	Round	Semimembranosus and Adductor
Top Butt	Sirloin	Gluteus medius
Strip Loin	Shortloin	Longissimus dorsi
Tender Loin	Loin	Psoas major and Iliacus
FORE QUARTER		
Rib Roast	Rib	Longissimus dorsi
Chuck Roast	Chuck	Infraspinatus, Supraspinatus Triceps brachii, Serratus ventralis, Longissimus dorsi, Subscapularis and other smaller muscles

and measurements were taken on the hind quarter muscles both before and after trimming to the minimum two inch thickness requirement for thick muscle of the hind quarter as defined by Martin (1965). In phases II and III of this study and in the development of prediction equations, intact muscles and muscle systems of the hind quarter were considered thick muscle without having been trimmed to the two inch minimum thickness requirement. Fore quarter thick muscle cutting procedure in this study remained the same as described by Martin (1965). A description of thick muscles and muscle systems is presented in Table II.

Carcass components were expressed as a percentage of the streamlined carcass weight; i.e., kidney, pelvic and heart fats removed; and the resulting data along with their respective standard deviations were compared to the U.S.D.A. Choice and Standard conformation data reported by Martin (1965). Carcass component ratios, ratio of thick muscle to bone etc., were also obtained for comparison.

Phase II

This phase, initiated in the fall of 1965, was conducted to obtain further information concerning the effects of carcass conformation on the yield of thick and thin muscle from carcasses differing drastically in conformation. Forty feeder calves, 20 U.S.D.A. Choice and 20 U.S. D.A. Common, were selected for this phase. The Choice feeder calves were all out of one Angus herd, the birthdays, breeding and management practices of which were known. The Common feeder calves were purchased through an order buyer in Southeast Oklahoma. The Common feeder steers could best be described as a mixture of breeds. Market personnel listed them as "Okie" no. 5s. It was anticipated that the carcasses produced from these common feeder calves would be in the U.S.D.A. Standard and Good conformation grades. Likewise, the Choice feeder calves were expected to produce carcasses with minimum Choice carcass conformation or better.

Following a 10 day adjustment period at the Fort Reno Livestock Research Station, each group of feeder steers was randomly assorted into two groups, weighed and assigned to feeding pens at random. Figure 1 presents the "field" layout of the experiment. One pen of each group was randomly selected to be fed 100 days. The remaining two pens were fed for 140 days. A fattening type ration, the composition of which is shown in Table III, was fed *ad libitum*. Feed consumption was recorded by pen.

Live weights were taken every 4 weeks, following an over night shrink, and then again at the time the animals were taken off trial. The week preceding slaughter color photographs and a series of visual estimates (conformation, muscling score, depth of body etc.) were made. These estimates were purely subjective and each animal was independently evaluated by not less than five people familiar with livestock judging and evaluation.

	Days on Feed	
Feeder Grade	100	140
Choice	n = 10	n = 10
Common	n = 10	n = 10

Figure 1. Experimental Layout for Phase II

TABLE III

FEEDLOT RATION[a] COMPOSITION

Ingredient	Pounds for One Ton Mix	Percent Composition
Shelled corn	550	27.5
Alfalfa hay	250	12.5
Cottonseed hulls	500	25.0
Oats	200	10.0
Cottonseed meal	200	10.0
Bran	200	10.0
Molasses	100	5.0
Total	2,000 lbs.	100%

[a]Cost, $42.00 per ton (does not include cost of mixing, etc.)

After the animals had been properly weighed off feed (over night shrink) at the end of the feeding period they were trucked to Oklahoma City for slaughter. Wilson and Company in Oklahoma City agreed to buy and slaughter the animals. Upon arrival at the packing-house, the experimental animals were unloaded and scheduled to be slaughtered as a lot. The actual slaughter procedure was carried out under normal commercial slaughter house conditions. On the slaughter floor hide weights were obtained and the right fore cannon bone of each animal was identified, tagged and saved.

Following an over night shrink and chill period, routine carcass information was collected in Oklahoma City before the right side of each carcass was shipped to the Oklahoma State University Meat Laboratory for further processing. Routine carcass information included carcass grade, tracing the rib eye and fat thickness between the 12th and 13th ribs, making linear carcass measurements and photographing the full side and rib eye. A U.S.D.A. Federal Meat Grader evaluated the marbling degree, maturity group and carcass conformation grade. Final carcass grade and conformation grades were recorded to the nearest 1/3 grade; i.e., low Choice, average Choice, etc.

Upon arrival at the Meat Laboratory the right sides were stored prior to cutting as described in phase I. Again the cutting procedure as described by Martin (1965) was utilized to evaluate the carcasses in phase II. One slight modification in data collection was made to record physical separation data (i.e., thick meat, thin meat, fat and lean) by wholesale cut. Thick muscle, thin muscle, fat and bone were weighed and recorded for each wholesale cut as well as on a pooled basis by quarter. Maximum length, width and depth measurements were recorded to the nearest 0.1 inch for all hind quarter thick muscles and rib roast. In earlier work, only selected muscles were measured (Martin 1965).

Phase III

Phase III was conducted to obtain further information regarding the effects of carcass conformation on carcass desirability. Unlike phase II, where a constant feeding period of either 100 or 140 days was used, phase III consisted of feeding three different "types" of cattle to a live weight that would, based on anticipated dressing percentages, result in a 600 pound carcass. Forty-three animals, representing two breeds and one group of crossbred steers were utilized in this experiment. Angus, Charolais X Angus crossbreds and Ayrshires correspond to groups 8, 9 and 10, respectively, in Table I. Following a 10 to 14 day adjustment period at the Fort Reno Station, each group was randomly assorted into two lots making a total of six lots or pens. A fattening ration, see Table III, was fed ad libitum and feed consumption was recorded by pen.

Live weights were taken every two weeks after an over night shrink. If an animal was anticipated to make the desired weight before the next regular two week weighing he was weighed weekly. Angus steers were slaughtered the first week they weighed 965 pounds, Charolais X Angus 980 pounds and Ayrshires 1025 pounds.

Carcass data collected, measurements made and carcass cutting procedure paralleled that of phase II with the exception of visual estimates. Preliminary analyses had indicated that visual estimates were of little value and it was felt that phase II provided adequate results in this area.

Shear Data

An objective measure of tenderness was obtained on the carcasses of phases I and II using the Warner-Bratzler Shear Machine. After the carcass thick muscles had been weighed, measured and recorded, a two inch thick steak was obtained from the anterior end of the strip loin from which cores would be obtained. The steaks were double wrapped and frozen until all carcasses of that particular phase had been processed.

Following an over night thaw in a cooler, the two-inch thick Longissimus dorsi steaks were cooked in deep fat. The cooking oil was maintained at 150^{o}C. and the steaks were cooked to an internal temperature of 66^{o}C. Three, one inch diameter cores were obtained from each steak and each core was subsequently sheared three times giving a total of nine shears per steak. The average of these nine shears was taken as the average shear value for each carcass.

Statistical Analyses

Means, standard deviations, analyses of variance, correlations and multiple regression equations were computed by the IBM 7040 data processing machine located in the computing center at Oklahoma State University. Techniques and procedures were followed as outlined by Steel and Torrie (1960).

The data in phase II (2 x 2 factorial arrangement) were analyzed by the least squares method using a Doolittle technique. This type of analysis was necessary because subclass numbers were disproportionate (four animals were removed before the trial was complete). The analysis of variance was computed on the basis that the sums of squares associated with each source of variation, except the correction factor, was adjusted for the other sources of variation. The prototype of these analyses with sources of variation and degrees of freedom follows:

Source	Degrees of Freedom
Total	36
Correction factor	1
Conformation	1
Days on feed	1
Conformation X Days on feed	1
Residual (error)	32

The data in phase III were analyzed using the HiAOV computer program supplied by the Statistics Department. The prototype of these analyses with the sources of variation and degrees of freedom follows:

Source	Degrees of Freedom
Total	43
Correction factor	1
Conformation	2
Residual (error)	40

Duncan's New Multiple Range Test was used to test for differences between conformation group means when a significant F ratio was obtained. Because of differences in numbers of animals in different conformation groups the following modification was used; significant studentized ranges were obtained and multiplied by s rather than $s_{\bar{x}}$ to give a set of intermediate significant ranges. For any desired comparison, the appropriate intermediate value was multiplied by:

$$\sqrt{1/2\ (1/r_i + 1/r_j)}$$

where:

r_i = number of carcasses in group i and

r_j = number of carcasses in group j.

This modification for Duncan's New Multiple Range Test was proposed by Kramer (1956); its validity has not been verified.

Stepwise multiple linear regression analyses were used for the data obtained in phases I and II of this study. The program used was from the Share General Program Library. The original program was written for the IBM 7090 computer, but it had been adapted and modified by the O.S.U. computer and statistical laboratory personnel for the IBM 7040 computer at Oklahoma State University.

This stepwise procedure entered one variable at a time into the regression equation starting with the variable which had the largest potential variance reduction. The potential variance reduction of all remaining variables was next considered and the variable selected that reduced the variance the most in a single iteration, etc.

The model assumed for the least squares multiple regression analysis was as follows:

$$Y_{ij} = \beta_o + \sum_{k=1}^{9} \beta_k X_k + e_{ij}$$

Where:

Y_{ij} = thick muscle, thin muscle, total muscle, fat or bone for the j^{th} carcass in the i^{th} conformation group,

β_o = Constant,

X_k = k^{th} independent variable from the j^{th} carcass in the i^{th} conformation group,

β_k = k^{th} constant associated with the k^{th} variable and,

e_{ij} = random effect peculiar to each animal.

CHAPTER IV

RESULTS AND DISCUSSION

Phase I

Historically, superior beef carcass conformation (determined subjectively) has been associated with desirability. So-called superior conformation carcasses have been described as being heavy muscled, meaty carcasses with thick, plump, bulging rounds, full meaty loins and ribs and thick fleshed meaty chucks. However, more recently researchers have begun to question this type of an evaluation. Many believe that carcass conformation, within itself, does not adequately reflect desirability from the standpoint of cutability.

Phase I consisted of comparing comparable weight carcasses, representing three different carcass conformation grades, with respect to thick and thin muscle percentage distribution. Earlier work (Martin 1965 and 1966) showed that U.S.D.A. Choice and Standard conformation carcasses, similar in degree of fatness, were almost identical with respect to thick and thin muscle yields. In order to gain further information concerning thick and thin muscle distribution as effected by carcass conformation, phase I of this study was initiated.

Comparable weight U.S.D.A. Prime conformation carcasses were selected, processed and compared to results reported by Martin (1965). The averages of some of the carcass characteristics of each conformation grade are shown in Table IV. It can be seen that all three

TABLE IV

COMPARISON OF AVERAGE CARCASS CHARACTERISTICS: PHASE I

Characteristics	Conformation High Standard	Conformation Low Choice	Conformation Low Prime	Pooled Standard Deviation
Number of carcasses	10	10	10	-----
Marbling score[a]	6.60	6.10	8.40	3.30
Fat thickness 12th rib, in.	0.29	0.35	0.46	0.07
Rib eye area, sq. in.	11.26	12.79	13.36	0.93
Kidney, pelvic and heart fat wt., lb.	33.01	24.40	26.64	3.84
Streamlined carcass wt., lb.[b]	567.33	575.38	566.90	26.03

[a]Marbling was scored on a 1-10 numerical scale, 1 = devoid, 10 = abundant.

[b]Cold carcass weight minus weight of kidney, pelvic and heart fats.

conformation grades are very similar with respect to average streamlined carcass weight; i.e., kidney, pelvic and heart fats removed. Initial plans were to select carcasses similar with respect to average fat thickness at the 12th rib and square inches of rib eye area. Guidelines as set forth in the materials and methods section were followed as close as practical; nevertheless, the Prime conformation carcasses averaged 0.17 and 0.11 inches more fat thickness at the 12th rib than did the Standard and Choice conformation carcasses, respectively. Square inches of rib eye area followed the same pattern, Prime more than Choice and Choice more than Standard carcasses. While marbling score was not considered in selection, the Prime conformation carcasses excelled in marbling. The Choice carcasses had the lowest average marbling score of the three conformation grades studied.

Yields of thick and thin muscle and of total muscle, fat and bone are summarized in Table V. Again it is pointed out that the information on Choice and Standard carcasses was reported by Martin (1965). This data is relisted only for clarity and convenience of comparison with the Prime conformation data. Also, since the Standard and Choice carcasses had been subjected to statistical procedures, additional statistical analysis to include Prime conformation carcasses was not valid. This being the case, only the means and corresponding standard deviations are presented for comparisons. Prime conformation carcasses were observed to have a slightly higher percent of thick muscle than either the Standard or Choice carcasses; 32.24 as compared to 30.57 and 31.50 respectively.

Thin muscle yields were observed to follow the opposite pattern; 35.43, 34.61 and 33.76 percent for Standard, Choice and Prime

TABLE V

AVERAGE PERCENTAGE YIELDS OF THICK AND THIN MUSCLE
AND OF TOTAL MUSCLE, FAT AND BONE: PHASE I

	Carcass Conformation		
	Standard	Choice	Prime
Trait[a]	Mean S.D.	Mean S.D.	Mean S.D.
Thick muscle	30.57 ± 0.73	31.50 ± 0.89	32.24 ± 1.05
Thin muscle	35.43 ± 1.03	34.61 ± 1.43	33.76 ± 0.94
Total muscle[b]	66.00 ± 1.31	66.11 ± 2.13	66.00 ± 1.73
Total fat	16.88 ± 2.21	19.48 ± 2.17	20.71 ± 1.78
Total bone	17.11 ± 1.79	14.39 ± 0.67	13.09 ± 0.78

[a]All traits are expressed as a percentage of the streamlined carcass weight.

[b]Total muscle equals thick muscle plus thin muscle.

respectively. Total muscle yields were almost identical among the three conformation groups.

Fat and bone were observed to differ more than either thick or thin muscle yields. Percent fat ranged from 16.88 (Standard) to 20.71 for Prime. This difference of 3.83 percent less fat for the Standard conformation carcasses was offset by a corresponding increase in percent bone. Standard carcasses averaged 17.11 percent bone on a streamlined carcass weight basis while the Choice and Prime averaged 14.39 and 13.09 percent respectively. Therefore, in this selected population, fat and bone were observed to make up a rather constant percentage of the streamlined carcass weight.

Table VI presents some of the carcass component ratios among the three conformation groups. Those of most interest involve bone and fat. Prime conformation carcasses were observed to have a ratio of total muscle to bone of 5.04:1 as compared to 3.85 and 4.59:1 for Standard and Choice, respectively. Differences in bone to thick muscle ratios are of the same relative magnitude as those for bone to total muscle. These ratios point out that the higher the conformation grade, the higher the muscle-bone ratio. However, in this case the ratio is higher because of a lower proportion of bone and not because of a higher proportion of muscle. In this connection Tyler (1964) made a direct comparison of the cutability of two groups of carcasses having approximately the same yield grade (U.S.D.A. cutability estimate) and the same quality grade but differing substantially in conformation grades. Actual boneless trimmed major retail cut yields from the round, loin, rib and chuck were 49.6 percent for the high conformation group and 49.7 percent for the low conformation group. Fat and bone proved to be the

TABLE VI

CARCASS COMPONENT RATIOS: PHASE I

	Conformation		
	Standard	Choice	Prime
	1:	1:	1:
Bone to total muscle	3.85 ± 0.40[a]	4.59 ± 0.23	5.04 ± 0.35
Bone to thick muscle	1.79 ± 0.19	2.19 ± 0.13	2.46 ± 0.18
Bone to thin muscle	1.49 ± 0.22	2.41 ± 0.12	2.58 ± 0.19
Fat to total lean	3.91 ± 0.57	3.39 ± 0.48	3.18 ± 0.38
Fat to thick muscle	1.81 ± 0.26	1.62 ± 0.22	1.56 ± 0.19

[a]Standard deviation.

major variables. The higher conformation carcasses had only 13.5 percent bone while the lower conformation carcasses had 16.4 percent bone. Also, in this study (Tyler 1964), the higher conformation carcasses had an average ratio of trimmed boneless meat to bone of 5.0 to 1.0. The ratio for the lower conformation carcasses was 4.1 to 1.0.

Stringer et al. (1965) reported a study comparing U.S.D.A. average Good and average Choice conformation carcasses. They found no significant difference in the total retail yield of the carcasses from the two conformation groups.

Results reported herein and those cited suggest that carcass conformation is a reflection of the ratio of total muscle, thick muscle and or retail yield to bone. Higher carcass conformation grades have a higher muscle bone ratio than lower conformation carcasses of comparable weight. Therefore, it goes without saying that among carcasses of comparable degrees of fatness, those ranking highest in conformation will have a higher muscle to bone ratio, thus they will be heavier muscled. Too often however, carcass conformation grades are confounded with fat, both external and internal. In this connection Murphey et al. (1960) reported that finish was four and one-half times as important as carcass conformation scores in predicting boneless retail cuts. When fat is confounded with conformation score it is quite likely that higher conformation carcasses (in comparison to lower conformation carcasses of comparable weight) will be the lowest yielding from the standpoint of retail steak and roast yield even though they may have a higher ratio of muscle to bone than lower conformation carcasses.

Phase II (1966 Trial)

Data used in this phase were obtained from two "types" of animals, Choice and Common feeder steers. Each conformation group (type) was randomly assorted into two groups and assigned to either a 100 or 140 day feeding period. The data were handled as a 2 x 2 factorial for statistical analyses; two levels of conformation and two levels of feeding period time. The group designations, given to the conformation and days on feed combinations in Table VII, correspond to the group designations in Table I. When the experiment started each group consisted of 10 animals, but three steers failed to go on feed and one steer was lost in the packer coolers. Thus, only eight animals in groups 5 and 6 completed the experiment.

Mean simple effects and standard errors for some of the production and carcass characteristics are given in Table VII. The high conformation groups (5 and 7) were considerably heavier than the low conformation groups (4 and 6) when they were initially placed on feed, 135 and 131.7 pounds respectively for the 100 and 140 day groups. Likewise, the high conformation groups produced heavier carcasses. While differences existed in initial weight on feed and cold carcass weight between conformation groups, it was felt that differences in age were not drastically different between conformation groups. Age was known for the Angus steers and based on estimates and limited knowledge the low conformation steers were at least as old as the high conformation steers. This is pointed out because of its relation to production efficiency in terms of time. While production traits were of interest, it was the primary objective of this study to investigate carcass conformation *per se*. Therefore, discussion will center primarily around carcass conformation and its relation to carcass components and muscle weight distribution.

A significant interaction ($P<.05$) was observed for dressing percentage, see Table VII. This necessitates looking at the simple effects. Within the 100 day groups (4 and 5) a difference in dressing percent of 5.82 was observed in favor of the high conformation group, while in the 140 day groups (6 and 7) the difference was only 3.70 percent in favor of the high conformation group. This difference in dressing percent, no doubt, is partially a function of fatness. As the lower conformation animals were fed longer (100 versus 140 days) the difference in dressing percent (compared to the high conformation group) was reduced.

A significant difference was observed in carcass conformation ($P<.01$). Using a scale from 1 through 15 the low conformation carcasses averaged 7.32 (low Good) as compared to 11.86 (high Choice) for the high conformation group. This mean difference represents slightly over one and one-half U.S.D.A. conformation grades. Differences in conformation were anticipated and is the basis on which the low and high conformation grouping was made. Final U.S.D.A. carcass grades (balancing of conformation and quality grades) were 8.02 (average Good) and 10.80 (average Choice) for the low and high conformation groups respectively.

Other characteristics commonly used in carcass evaluation schemes are listed in Table VII. Significant days on feed ($P<.01$) and conformation ($P<.01$) differences were observed with respect to average fat thickness at the 12th rib. Carcasses from 100 day fed steers had less fat than carcasses from 140 day fed steers and the higher conformation steer carcasses had more fat than the low conformation steers. The days on feed effect was expected, but it is not known if fat cover differences would be significantly different between conformation groups had the lower conformation steer carcasses been fed to comparable high conformation weights. Average fat thickness at the 12th rib per 100 pounds of cold carcass followed the same pattern as average fat thickness at the 12th rib. A significant difference in rib eye area ($P<.01$) was observed between conformation groups, 8.90 square inches for the low conformation group and 10.70 for the high conformation group. However, when rib eye area was expressed as square inches per 100 pounds of carcass, the difference between conformation groups was not significant ($P>.05$) and a days on feed effect was observed ($P<.05$). Rib eye area per 100 pounds of carcass decreased as the animals were fed from 100 to 140 days, 2.10 versus 1.93 for the 100 and 140 groups respectively.

U.S.D.A. predicted cutability was effected by both days on feed and conformation. Carcasses from 100 day fed steers had a higher estimated average U.S.D.A. cutability than carcasses from the 140 day fed steers ($P<.01$) and low conformation steer carcasses had a higher average cutability than high conformation steer carcasses ($P<.01$). These results are quite as anticipated since 100 day fed animals would normally have less body fat than 140 day fed animals and their cutability percentage therefore expected to be higher. With respect to conformation, the high conformation steers yielded carcasses that were heavier than those from the low conformation steers therefore the cutability of the former would be expected to be lower since carcass weight has a negative effect on U.S.D.A. predicted cutability (in general heavier weight carcasses are assumed to be fatter, thus lower in retail yield

TABLE VII

MEANS AND STANDARD ERRORS OF MEANS FOR SOME PRODUCTION AND CARCASS CHARACTERISTICS: PHASE II

Conformation[b]	Simple Effects				Standard Errors	Significant Main Effects and Interactions		
Conformation[b]	Low	Low	High	High		Days		Conf.
Days on feed	100	140	100	140	of Treatment			
Group designation	4	6	5	7	means[e]	140 minus 100		Hi minus low
Number of steers	10	8	8	10	-----			
Initial wt. on feed, lb.	430.50	423.80	565.00	555.50	9.08	-----		133.10**
Total gain, lb.	267.00	345.60	260.00	373.50	12.17	96.05**		-----
Cold carcass weight, lb.	406.40	456.10	520.60	575.70	11.89	52.40**		166.9**
Dressing percent	58.25	59.22	64.07	62.92	0.38		DxC*	
Marbling score[b]	4.00	5.38	5.25	5.60	0.21		DxC*	
Conformation score[c]	7.40	7.25	11.62	12.10	0.33	-----		4.54**
Final U.S.D.A. grade[d]	7.40	8.75	10.50	11.10	0.25	-----		2.72**
Average fat thickness 12th rib, in.	0.27	0.42	0.52	0.67	0.04	0.14**		0.26**
Rib eye area, sq. in.	8.84	9.06	10.55	10.86	0.32	-----		1.75**
Average fat thickness per 100 lbs. cold carcass	0.067	0.091	0.100	0.116	0.009	0.016*		.029**
Rib eye area per 100 lbs. cold carcass wt.	2.18	1.99	2.03	1.88	0.25	-0.16*		-----
Cutability, U.S.D.A. prediction	51.43	49.72	49.87	48.25	0.41	-1.67**		-1.52**
Shear value, lb.	13.49	14.68	14.56	13.71	0.40	-----	DxC*	-----

[a]Low conformation = carcasses from common feeder steers; high conformation = carcasses from choice Angus feeder steers.

[b]Scored on a 1 to 10 scale, 1 = devoid, 10 = abundant.

[c]and [d] Scored on a 1 to 15 scale, 1 = low utility, 11 = average choice, 14 = average prime.

TABLE VII (Continued)

[e]Standard error when n = 8 equals Standard error times $\sqrt{10/8}$.

*Level of significance = $P < .05$.

**Level of significance = $P < .01$.

percentage).

Major carcass component means and their corresponding standard errors are given in Table VIII. It was decided to adjust for differences in carcass weights by using a percentage adjustment rather than regression techniques. Brackelsberg (1966) found that adjustment for carcass weight by percent, or ratio, versus adjustment by regression provided similar results.

Total muscle yield (sum of thick and thin muscle yields) was observed to be higher for the low conformation group ($P<.05$). Main effects were 57.94 percent muscle for the low conformation group and 56.32 percent for the high conformation group. Thick muscle yields were effected by both days on feed and conformation group, the 100 day group having a higher yield than the 140 day group and the low conformation group having a higher yield than the high conformation group ($P<.05$). No significant differences were observed for thin muscle between conformation groups ($P>.05$).

Significant days on feed ($P<.01$) and conformation ($P<.01$) effects were observed for percent fat. One-hundred day carcasses had less (2.25 percent) fat than the 140 day carcasses and the low conformation group less (3.90 percent) fat than the high conformation group.

A significant interaction was found, between days on feed and conformation, for percent bone. Looking at simple effects, Table VIII, the 100 day conformation carcasses had 3.70 percent more bone than the 100 day high conformation carcasses and the 140 day low conformation carcasses had 2.39 percent more bone than the 140 day high conformation carcasses.

Analysis for percent fat plus bone were non-significant ($P>.05$),

Table VIII. This points out an apparent canceling effect of fat and bone across conformation groups. The lower conformation groups had higher bone percentages and lower fat percentages than their counterparts. The opposite situation prevailed in the higher conformation group (less bone and more fat). A similar conclusion was reached by Tyler et al. (1964).

Ratio of thick muscle to bone and ratio of total muscle to bone are presented in Table VIII. The 140 day group was observed to have a higher ratio of total muscle to bone than the 100 day group, 4.14:1 and 3.80:1 respectively. Conformation also effected total muscle to bone ratio. The high conformation group had a total muscle to bone ratio of 4.32:1 as compared to 3.63:1 for the lower conformation group. Similar ratios of boneless beef yield to bone have been reported by Kropf and Graf (1959) and Tyler et al. (1964) in comparing carcasses that differed widely in conformation.

Total muscle yield differences between conformation groups was small (1.62 percent) yet ratio of total muscle to bone differed drastically between conformation groups. Therefore, differences in bone "conformation" were effecting muscle bone ratios more than muscle differences. A significant interaction was observed between days on feed and conformation ($P<.05$) for thick muscle to bone ratio. However, simple effects reveal that the high conformation carcasses had much higher ratios of thick muscle to bone than the lower conformation carcasses.

Individual thick muscles and muscle systems were studied with respect to their percentage distribution on a carcass weight basis and the results are presented in Table IX. The data indicated that the

TABLE VIII

ASSOCIATIONS BETWEEN CARCASS CONFORMATION AND DAYS ON FEED WITH RESPECT TO PERCENTAGE[a] CARCASS COMPONENTS AND RATIOS: PHASE II

	Simple Effects					Significant Main Effects and Interactions	
Conformation[b]	Low	Low	High	High	Standard Errors	Days	Conf.
Days on Feed	100	140	100	140	of Treatment		
Group designation	4	6	5	7	means[e]	140 minus 100	Hi minus low
Number of carcasses	10	8	8	10	-----	-----	-----
Carcass components and ratios							
Thick muscle	30.99	29.92	30.30	28.41	0.425	-1.48**	-1.10*
Thin muscle	27.20	27.78	27.16	26.76	0.401	-----	-----
Total muscle[c]	58.19	57.70	57.46	55.17	0.698	-----	-1.62*
Fat[d]	20.20	22.29	23.94	26.34	0.735	2.25**	3.90**
Bone	17.30	14.97	13.60	12.58	0.300	DxC*	
Fat and bone	37.50	37.26	37.54	38.91	0.197	-----	-----
Ratio thick muscle/bone	1.80:1	2.00:1	2.23:1	2.26:1	0.039	DxC*	
Ratio total muscle/bone	3.38:1	3.87:1	4.23:1	4.40:1	0.081	0.34:1**	0.70:1**

[a]Components were expressed as a percentage of the cold carcass weight.

[b]Low conformation = carcasses from common feeder steers; high conformation = carcasses from choice Angus feeder steers.

[c]Sum of thick and thin muscle yields.

[d]Fat does not include kidney, pelvic and heart fats.

[e]Standard error when n = 8 equals standard error times $\sqrt{10/8}$.

*Level of significance = $P < .05$.

**Level of significance = $P < .01$.

TABLE IX

ASSOCIATIONS BETWEEN CARCASS CONFORMATION AND DAYS ON FEED WITH RESPECT TO PERCENTAGE[a] INDIVIDUAL MUSCLES AND MUSCLE SYSTEMS AND CARCASS COMPONENT YIELDS BY QUARTER: PHASE II

	Simple Effects					Significant Main Effects and Interactions	
Conformation[b]	Low	Low	High	High	Standard Errors	Days	Conf.
Days on Feed	100	140	100	140	of Treatment		
Group designation	4	6	5	7	means[c]	140 minus 100	Hi minus low
Number of carcasses	10	8	8	10	-----		
Hind quarter components							
Strip	2.47	2.33	2.36	2.22	0.058	-0.14*	-----
Tender	1.19	1.11	1.16	1.17	0.027	-----	-----
Top butt	2.47	2.31	2.40	2.23	0.043	-0.17*	-----
Knuckle	3.09	2.90	2.90	2.67	0.060	-0.22**	-0.22**
Top round	3.94	3.71	3.88	3.60	0.079	-0.25**	-----
Bottom round	3.71	3.59	3.59	3.40	0.075	-----	-----
Eye round	1.32	1.25	1.37	1.31	0.040	-----	-----
Thick muscle hind	18.19	17.20	17.66	16.60	0.303	-1.03	-----
Thin muscle hind	7.85	7.60	7.42	7.32	0.149	-----	-0.35*
Fat hind	6.22	7.05	6.84	7.54	0.082	0.77**	-----
Bone hind	7.12	6.02	5.49	5.16	0.156	DxC*	
Fore quarter components							
Rib roast	3.53	3.47	3.46	3.08	0.081	-0.22*	-0.23*
Chuck roast	9.25	9.24	9.17	8.73	0.163	-----	-----
Thick muscle fore	12.78	12.71	12.63	11.81	0.179	-----	-0.52*
Thin muscle fore	9.36	10.00	9.02	8.82	0.182	DxC*	
Fat fore	6.29	6.62	7.87	8.33	0.241	-----	1.64**
Bone fore	6.16	5.29	4.86	4.35	0.111	-0.69**	-1.12**

TABLE IX (Continued)

[a]Components expressed as a percentage of cold carcass weight.

[b]Low conformation = carcasses from common feeder steers; high conformation = carcasses from choice Angus feeder steers.

[c]Standard error when n = 8 equals Standard error times $\sqrt{10/8}$.

*Level of significance = $P < .05$.

**Level of significance = $P < .01$.

yield of only one thick muscle (percent of cold carcass weight) in the hind quarter was associated with conformation while most muscle yields were effected by the length of feeding period. Analysis revealed that the lower conformation group had a higher yield of knuckle (P<.05) than the high conformation group. The days on feed effects that are present were expected. Generally, the 140 day group had lower percentage yields because of the effect of increased fat on lowering percentage yields as the feeding period was increased from 100 to 140 days.

A significant interaction was observed with respect to bone in the hind quarter. An analysis of simple effects (Table IX) revealed that within both conformation groups the 140 day groups (6 and 7) have lower percentage bone than the corresponding 100 day conformation groups. However, this difference was not as great within the high conformation group (.33%) as compared to (1.10%) for the 100 day group. Significant conformation associations with percentage bone were also detected at the 100 and 140 day levels of feeding period. In both cases the high conformation groups had significantly (P<.05) less bone than the low conformation groups.

Fore quarter component yields are presented in Table IX. Low conformation carcasses were observed to have a higher yield of rib roast and thick muscle of the fore quarter than the high conformation group (P<.05). On the other hand, high conformation carcasses had a higher fore quarter fat content than the low conformation group. Interactions were observed with respect to thin muscle and bone in the fore quarter. These interactions represent differences in magnitude of response and necessitate an evaluation of the simple effects.

Thick muscles and muscle systems were also studied with respect to distribution on a thick muscle basis (Table X). This type of an analysis eliminated the effect of fat and bone content on percentage distribution of thick muscle.

When each thick muscle was expressed as a percentage of the total thick muscle content, the day effects were completely eliminated and a significant conformation effect on thick muscle distribution was observed for only three muscles. The lower conformation group had a higher yield of knuckle ($P<.05$) than the high conformation group. The high conformation group excelled in yield of eye of round and tender ($P<.05$).

Earlier, it was pointed out that differences in thick muscle between the two conformation groups was indeed small (see Table VIII) and when these thick muscles are studied with respect to their percentage distribution very small differences were found, even though the U.S. D.A. carcass conformation grades between the low and high conformation groups differed substantially.

Butterfield (1963), in an extensive study involving several types and conformation groups, found that breed, degree of fatness and conformation exerted little or no effect on carcass muscle weight distribution.

Phase III

In order to eliminate some of the variation in carcass weight which prevailed in phase II, animals in phase III were fed to a relatively uniform live weight, rather than on a time constant basis. Three different types of animals were utilized; dairy (Ayrshire), crossbred (Charolais X Angus) and beef (Angus) steers. It was anticipated that these three different types of cattle would provide a wide range

TABLE X

ASSOCIATIONS BETWEEN CARCASS CONFORMATION AND DAYS ON FEED WITH RESPECT TO PERCENTAGE[a] DISTRIBUTION OF THICK MUSCLE: PHASE II

	Simple Effects				Standard Errors of Treatment means[c]	Significant Main Effects and Interactions	
Conformation[b]	Low	Low	High	High		Days	Conf.
Days on feed	100	140	100	140			
Group designation	4	6	5	7		140 minus 100	Hi minus low
Number of carcasses	10	8	8	10	-----	-----	-----
Hind quarter thick muscle							
Strip	7.99	7.80	7.80	7.81	0.166	-----	-----
Tender	3.85	3.74	3.83	4.13	0.075	-----	0.18*
Top butt	8.00	7.71	7.92	7.83	0.092	-----	-----
Knuckle	9.97	9.70	9.57	9.39	0.134	-----	-0.36*
Top round	12.68	12.39	12.81	12.67	0.148	-----	-----
Bottom round	11.96	12.00	11.85	11.97	0.142	-----	-----
Eye round	4.26	4.16	4.51	4.58	0.097	-----	0.33**
Total thick muscle hind	58.71	57.50	58.29	58.38	0.388	-----	-----
Fore quarter thick muscle							
Rib roast	11.43	11.61	11.44	10.85	0.265	-----	-----
Chuck roast	29.84	30.89	30.26	30.74	0.391	-----	-----
Total thick muscle fore	41.27	42.50	41.70	41.59	0.441	-----	-----

[a]Thick muscles and thick muscle components expressed as a percentage of total thick muscle.

[b]Low conformation = carcasses from common feeder steers; high conformation = carcasses from choice Angus feeder steers.

[c]Standard error when n = 8 equals to Standard error times $\sqrt{10/8}$.

*Level of significance = $P < .05$. **Level of significance = $P < .01$.

in carcass conformation.

Means and standard errors for some production and carcass characteristics are given in Table XI. While the dairy steers averaged roughly 35 pounds less in cold carcass weight than the crossbred and beef steers the variation is not as great as in phase II where the high conformation carcasses averaged over 116 pounds more than the low conformation carcasses with respect to cold carcass weight.

Both the crossbred and beef steers dressed significantly higher ($P<.05$) than the dairy steers (61.11, 61.93 versus 57.55 respectively). Conformation scores represented a wide spread among the three groups. Dairy carcasses averaged 6.69 (low Good) while both the crossbred and beef carcasses were high Choice, 11.60 and 11.53 respectively. Conformation was scored from 1 through 15; 1 equals low Utility and 15 equals high Prime. Marbling scores were not significantly different among the three groups, see Table XI. Therefore, final U.S.D.A. carcass grades were lower for the dairy carcasses primarily because of inferior conformation. Conformation has long been a primary factor in U.S.D.A. beef carcass grading standards. Its inclusion has been based upon the opinion that it is related to retail yield, especially of the preferred cuts.

With regard to average fat thickness at the 12th rib and average fat thickness per 100 pounds of cold carcass weight, the "beef" carcasses had significantly more ($P<.05$) than either the dairy or crossbred carcasses. Crossbred carcasses had significantly ($P<.05$) more square inches of rib eye area per 100 pounds of cold carcass weight (2.11 versus 1.78 and 1.98 for the dairy and beef carcasses respectively) and a higher ($P<.05$) average U.S.D.A. predicted cutability than either

TABLE XI

MEANS AND STANDARD ERRORS OF MEANS FOR SOME PRODUCTION AND CARCASS CHARACTERISTICS: PHASE III

Conformation[a] Group Designation	Dairy 8	Crossbred-Beef 9	Beef 10	Standard Errors of Treatment Means[f]	Significant Differences[b]
Number of Steers	13	15	15	---	---
Initial wt. on feed, lb.	472.30	555.60	562.00	12.00	9,10 > 8 (P < .05)
Total grain, lb.	507.90	421.70	408.00	13.12	8 > 9,10 (P < .05)
Cold carcass cut., lb.	564.30	597.40	600.60	5.72	9,10 > 8 (P < .05)
Dressing percent	57.55	61.11	61.93	.392	9,10 > 8 (P < .05)
Marbling score[c]	5.46	5.40	6.33	.316	N.S.
Conformation score[d]	6.69	11.60	11.53	.277	9,10 > 8 (P < .05)
Final U.S.D.A. Grade[e]	8.00	10.39	10.87	.281	9,10 > 8 (P < .05)
Average fat thickness 12th rib, in.	0.42	0.50	0.73	.042	10 > 8,9 (P < .05)
Rib eye area, sq. in.	10.06	12.59	11.91	.196	9 > 10 > 8 (P < .05)
Average fat thickness per 100# cold carcasses, in.	0.075	0.083	0.121	.007	10 > 8,9 (P < .05)
Rib eye area per 100# cold carcasses cut., sq. in.	1.78	2.11	1.98	.030	9 > 10 > 8 (P < .05)
Cutability, U.S.D.A. Prediction, %	48.15	50.87	48.89	.425	9 > 10,8 (P < .05)
Shear value, lb.	13.81	15.70	13.05	.350	9 > 10,8 (P < .05)

[a]Dairy = Ayrshire steers, Crossbred-Beef = Charolais X Angus steers, Beef = Angus steers.

[b]N.S. = non significant (P > .05).

[c]Scored on a 1-10 scale, 1 = devoid, 10 = abundant.

[d&e]Scored on a 1-15 scale, 1 = low utility, 11 = average choice, 14 = average prime.

[f]Standard error for n = 13 equals to standard error times $\sqrt{15/13}$.

the dairy or beef carcasses.

Yields of thick, thin and of total muscle, fat, bone, fat plus bone and muscle bone ratios are summarized in Table XII. Charolais X Angus crossbred carcasses were observed to have significantly higher ($P<.05$) yields of thick, thin and total muscle than the dairy or beef carcasses. The advantage in total muscle yield for the crossbred steers was quite substantial and represents over 5 percent of the cold carcass weight. No significant differences ($P>.05$) were found between dairy and beef carcasses with respect to muscle yields even though there was a difference of over one and one-half U.S.D.A. conformation grades between the two groups.

The three groups differed considerably in yields of fat and bone. Angus (beef) carcasses had on the average 5.21 percent more fat trim than the crossbred carcasses and 4.51 percent more than the dairy carcasses. Bone yields followed somewhat of a different pattern. Ayrshire (dairy) carcasses were observed to have a significantly higher ($P<.05$) yield of bone than the crossbred carcasses (1.79 percent). The crossbred carcasses in turn had a significantly ($P<.05$) higher yield of bone than the beef carcasses (1.36 percent). The combined percentages of fat and bone for the dairy and beef carcasses (37.91 and 39.27 respectively) were not significantly different ($P>.05$). However, the combined percentages of fat and bone within the crossbred carcasses was observed to make up a significantly ($P<.05$) smaller percentage of the cold carcass than either the dairy or beef carcasses (see Table XII).

Ratio of muscular tissue to bone is a common descriptive term often used in subjective evaluations and discussions. In this study the lower conformation dairy carcasses had significantly ($P<.05$) lower

TABLE XII

ASSOCIATIONS BETWEEN CARCASS CONFORMATION AND PERCENTAGE[a] CARCASS COMPONENTS AND RATIOS: PHASE III

Conformation[b] Group Designation	Dairy 8	Crossbred-Beef 9	Beef 10	Standard Errors of Treatment Means[f]	Significant Differences[c]
Number of Carcasses	13	15	15		
Carcass Components and Ratios					
Thick muscle	28.91	32.52	29.22	0.380	9 > 8,10 ($P < .05$)
Thin muscle	26.47	28.22	26.10	0.390	9 > 8,10 ($P < .05$)
Total muscle[d]	55.38	60.74	55.32	0.714	9 > 8,10 ($P < .05$)
Fat[c]	23.20	21.50	27.71	0.836	10 > 8,9 ($P < .05$)
Bone	14.71	12.92	11.56	0.335	8 > 9 > 10 ($P < .05$)
Fat and Bone	37.91	34.42	39.27	0.550	8,10 > 9 ($P < .05$)
Ratio thick muscle/Bone	1.98:1	2.53:1	2.54:1	0.044	9,10 > 8 ($P < .05$)
Ratio total muscle/Bone	3.79:1	4.72:1	4.81:1	0.073	9,10 > 8 ($P < .05$)

[a]Components expressed as a percentage of cold carcass weight.

[b]Dairy = carcasses from Ayrshire steers; Crossbred-Beef = carcasses from Charolais X Angus crossbred steers; Beef = carcasses from Angus steers.

[c]N.S. = non significant ($P > .05$).

[d]Sum of thick and thin muscle yields.

[e]Fat does not include kidney, pelvic and heart fats.

[f]Standard error for n = 13 equals to standard error times $\sqrt{15/13}$.

ratios of both thick muscle and total muscle to bone than the crossbred and beef type carcasses. In the case of ratio of total muscle to bone, these differences represent 0.93:1 and 1.02:1 (crossbred and beef type respectively). It is of interest to note that the lower conformation dairy and the higher conformation beef type carcasses were almost identical with respect to total muscle yields, 55.38 and 55.32 respectively, yet the muscle to bone ratios are significantly different ($P<.05$). Again it is emphasized that muscle bone ratios differ not because of muscle variation but because of bone variation between the dairy and beef carcasses.

The crossbred (Charolais X Angus) carcasses were similar and not significantly different ($P>.05$) from the beef carcasses with respect to thick and total muscle to bone ratios. However, the crossbred carcasses of similar weight to the beef carcasses had a higher bone content (12.92 percent versus 11.56 percent), thus a higher percentage muscle yield was observed.

Therefore, it appears that carcass conformation is a reflection of muscle bone ratio since the crossbred and beef carcasses were similar with respect to carcass conformation and total muscle to bone ratio. On the other hand, it is apparent that bone muscle ratios do not adequately evaluate carcasses with respect to muscling. These ratios would be meaningful only when used in conjunction with percentage yield knowledge of one or more of the tissues involved.

Individual muscle and muscle systems yields as a percent of the cold carcass weight are reported in Table XIII. Without exception crossbred carcasses had significantly higher percentage yields in all muscles and muscle systems studied. Between the dairy and beef

TABLE XIII

ASSOCIATION BETWEEN CARCASS CONFORMATION AND PERCENTAGE[a] INDIVIDUAL MUSCLES AND MUSCLE SYSTEMS AND CARCASS COMPONENT YIELDS BY QUARTER: PHASE III

Conformation[b] Group Designation	Dairy 8	Crossbred-Beef 9	Beef 10	Standard Errors of Treatment Means[d]	Significant Differences[c]
Number of Carcasses	13	15	15	---	---
Hind Quarter Compenents					
Strip	2.1	2.52	2.34	0.050	9 > 8,10 (P < .05)
Tender	1.13	1.24	1.09	0.027	9 > 8,10 (P < .05)
Top butt	2.23	2.58	2.27	0.054	9 > 8,10 (P < .05)
Knuckle	2.94	3.11	2.70	0.057	9 > 8,10 (P < .05)
Top round	3.41	4.05	3.64	0.075	9 > 8,10 (P < .05)
Bottom round	3.15	3.75	3.41	0.070	9 > 10 > 8 (P < .05)
Eye round	1.08	1.45	1.29	0.031	9 > 10 > 8 (P < .05)
Thick muscle hind	16.05	18.70	16.74	0.310	9 > 8,10 (P < .05)
Thin muscle hind	7.31	8.25	7.48	0.164	9 > 8,10 (P < .05)
Fat hind	6.42	6.64	8.26	0.212	10 > 8,9 (P < .05)
Bone hind	5.90	5.31	4.70	0.149	8 > 9 > 10 (P < .05)
Fore Quarter Components					
Rib roast	3.45	3.62	3.43	0.045	9 > 8,10 (P < .05)
Chuck roast	9.34	10.17	9.19	0.125	9 > 8,10 (P < .05)
Thick muscle fore	12.79	13.79	12.62	0.137	9 > 8,10 (P < .05)
Thin muscle fore	9.38	9.24	8.54	0.152	9 > 10 (P < .05)
Fat fore	7.45	6.84	8.78	0.308	10 > 8,9 (P < .05)
Bone fore	5.28	4.59	4.10	0.118	8 > 9 > 10 (P < .05)

TABLE XIII (Continued)

[a]Components were expressed as a percentage of the cold carcass weight.

[b]Dairy = carcass from Ayrshire steers; Crossbred-Beef = carcasses from Charolais X Angus crossbred steers; Beef = carcasses from Angus steers.

[c]N.S. = non significant ($P > .05$).

[d]Standard error when $n = 13$ equals standard error times $\sqrt{15/13}$.

conformation groups the beef carcasses were observed to have significantly higher bottom and eye of the round yields. Bone and fat yields by quarter followed patterns established for carcass components. The dairy carcasses had ($P<.05$) more hind quarter bone than crossbred carcasses which in turn had more ($P<.05$) than the beef carcasses. With respect to fore and hind quarter fat content, the crossbred carcasses had less than the dairy and beef carcasses ($P<.05$).

Thick muscles and muscle systems expressed as a percent of the total thick muscle are summarized in Table XIV. This represents an attempt to study muscle weight distribution as associated with carcass conformation. In general the crossbred carcasses excelled in hind quarter thick muscle yields. It is of interest to note that the lower conformation dairy carcasses had a higher percentage yield of knuckle (percentage of the total thick muscle) than either the crossbred or beef carcasses. This trend had been observed earlier.

Even though significant differences were observed, as discussed and presented in Table XIV, muscle weight distribution was not associated to any great extent with conformation. For example, hind quarter thick muscle yield of the beef carcasses (56.79) was not significantly ($P>.05$) higher than that of the dairy carcasses (55.67). Since total muscle and thick muscle yields between dairy and beef carcasses were not significantly different ($P>.05$), it is apparent that in this study carcass conformation _per se_ had very little association with muscle weight distribution. That is to say that the higher conformation beef carcasses did not have a higher percentage of high priced cuts (thick muscle) in the hind quarter than the much lower conformation dairy carcasses.

TABLE XIV

ASSOCIATION BETWEEN CARCASS CONFORMATION AND PERCENTAGE[a] DISTRIBUTION OF THICK MUSCLE: PHASE III

Conformation[b] Group Designation	Dairy 8	Crossbred-Beef 9	Beef 10	Standard Errors of Treatment Means[d]	Significant Differences[c]
Number of Carcasses	13	15	15		
Hind Quarter Thick Muscle					
Strip	7.29	7.76	7.65	0.115	9 > 8 (P < .05)
Tender	3.91	3.81	3.73	0.062	N.S.
Top butt	7.85	7.93	7.64	0.101	N.S.
Knuckle	10.18	9.55	9.26	0.120	8 > 9,10 (P < .05)
Top round	11.78	12.47	12.44	0.137	9,10 > 8 (P < .05)
Bottom round	10.90	11.53	11.67	0.139	9,10 > 8 (P < .05)
Eye round	3.76	4.48	4.40	0.078	9,10 > 8 (P ≤ .05)
Total thick muscle hind	55.67	57.53	56.79	0.422	9 > 8 (P < .05)
Fore Quarter Thick Muscle					
Rib roast	11.96	11.19	11.75	0.210	8 > 9 (P < .05)
Chuck roast	32.36	31.27	31.46	0.300	8 > 9,10 (P < .05)
Total thick muscle fore	44.32	42.46	43.21	0.422	8 > 9 (P < .05)

[a]Thick muscles and thick muscle components were expressed as a percentage of the total thick muscle.

[b]Dairy = carcasses from Ayrshire steers; Crossbred-Beef = carcasses from Charolais X Angus Crossbred steers; Beef = carcasses from Angus steers.

[c]N.S. = non significant (P > .05).

[d]Standard error when n = 13 equals standard error times $\sqrt{15/13}$.

Callow (1961, 1962), working with Hereford, Dairy Shorthorn and Friesian steer carcasses, found little or no significant effect of breed or level of nutrition on the distribution of muscular or fatty tissue among the joints. Branaman et al. (1962) reported no significant difference between beef and dairy type cattle with respect to percentage yield of high priced wholesale cuts, trimmed retail cuts or separable lean. Cole et al. (1964) reported percentage separable lean lowest for Angus steer carcasses when compared to either Zebu or dairy type carcasses.

From these data it appears that the critical factors, having to do with cutability (i.e., thick and thin muscle yields) are fat and bone content not conformation. No doubt genetics and nutrient intake play important roles with respect to the percentage of the three major tissues (lean, fat and bone) and this study would suggest that any combination of genetics (or breed variation) and nutritional management that will reduce fat plus bone content is the important consideration when thinking in terms of a more valuable carcass from the standpoint of preferred retail cuts, not the conformation or shape of the carcass. However, one can go one step further and theorize regarding the conformation of the "ideal" beef carcass. Once proper carcass fat content has been obtained, the only thing left to do to improve muscle yield, on a carcass weight basis, is to reduce bone content and this will result in high muscle to bone ratios which will mean high conformation carcasses. The Charolais X Angus steers used in this study represent a group of animals that had the genetic potential to produce 600 pound carcasses with minimum fat content and yet maintain a muscle to bone ratio comparable to the straight bred Angus carcasses. To often carcasses with the so called desirable conformation have low muscle yields because of excessive fat even though they have a desirable muscle to bone ratio.

Prediction Equations

Predicting beef carcass composition from easily obtained data, either from the live animal or carcass, has been the objective of numerous research efforts. Hankins and Howe (1946), Murphey et al. (1960), Cole et al. (1962), Orme et al. (1960), Breidenstein (1962), Brungardt and Bray (1963), Fitzhugh et al. (1965), Henderson et al. (1966), Brackelsberg (1966) and DuBose et al. (1967) have developed equations for estimating carcass composition or some measure of cutability. These references are cited to point out that numerous evaluation techniques for predicting cutability are in the literature at the present time. However, the wide spread acceptance and use of prediction equations depends not only on accuracy, but the ease with which they can be applied. In this connection the U.S.D.A. cutability equation (Murphey et al. 1960) has met with wide acceptance because it can readily be applied under routine packing-house conditions. However, several workers have questioned the validity of the U.S.D.A. equation. Murphey reported a correlation of 0.92 between predicted and actual cut out yield, but Palmer et al. (1961) found a relationship of 0.76 by using the same equation. Other workers, Ramsey et al. (1963) and Brungardt and Bray (1963) report somewhat lower correlations than that reported by Murphey et al. (1960). This may be in part due to the extreme variation in the carcasses used in developing and testing the U.S.D.A. equation. When the equation is applied to a rather uniform group of carcasses its accuracy would be expected to go down.

Strong relationships between the weights of certain muscles and total carcass muscle, in both beef and pork carcasses, have been found by several workers, (Orme et al. 1960), (Butterfield 1963) and (Topel 1965). These workers suggest that certain muscles in combination with certain carcass characteristics may provide a better estimate or prediction of carcass composition than carcass characteristics alone. If this be the case, the added work and expense necessary to obtain these muscle weights may be justified, especially for research purposes.

It was one of the objectives of this study to develop equations to predict carcass composition using certain muscle weights in combination with readily obtainable carcass characteristics and to compare them to equations using only those four carcass variables used in the U.S.D.A. cutability equation. It was further decided to develop the aforementioned equations within two different carcass conformation groupings, i.e., low and high. For this purpose, carcasses in groups 1, 4 and 6 (see Table I) were pooled and designated the low conformation group. This low conformation group was comprized of U.S.D.A. Standard and Good conformation grade carcasses. Groups 2, 3, 5 and 7 were likewise pooled and designated the high conformation group. Carcasses of this group met the specifications for either U.S.D.A. Choice or Prime carcass conformation. Once the equations were developed they were to be tested on groups 8, 9 and 10. It was felt that this would be a critical test since the variation in carcass weight within groups 8, 9 and 10 was rather minimal.

Initially 15 measurements were investigated by a preliminary simple correlation analysis on a pooled within group sum of squares basis. The purpose of this analysis was to select those variables that would measure carcass composition most effectively. Simple correlations between the 15 independent variables and the 5 dependent variables (thick muscle, thin muscle, total muscle fat and bone) by conformation group, are presented in Tables XV and XVI. Within each conformation group, carcass weight and the thick muscles were highly correlated to carcass muscle composition. Carcass weight, average fat thickness at the 12th rib, and kidney fat weight were the best indicators of carcass fat (r ranged from 0.41 through 0.73).

Within the Standard and Good conformation carcasses, thick muscle weights were highly correlated to bone weights, i.e., r = 0.92 between top round weight and bone weight. However, within the Choice and Prime conformation carcasses the relationships were considerably lower (r = 0.46 between top round and bone weight). Within both conformation groups femur and tibia weights were highly related to total carcass bone (0.95, 0.93 and 0.76, 0.65; low and high conformation groups respectively).

At the outset, all thick muscles of the hind quarter were included in the stepwise multiple regression analysis because of their high relationship with carcass muscle components. Based on these preliminary analyses, it was determined that the muscles of the round (bottom, top and eye round muscles), the femur, tibia and the 4 carcass traits used in the U.S.D.A. equation (carcass weight, kidney weight, average fat thickness at the 12th rib and rib eye area) would be used in the final equations.

Tables XVII and XVIII summarize the correlations between these 9 selected independent variables and carcass components on a pooled across

TABLE XV

POOLED CORRELATIONS BETWEEN SELECTED DEPENDENT VARIABLES AND VARIOUS CARCASS TRAITS WITHIN U.S.D.A. GOOD AND STANDARD CONFORMATION GRADE CARCASSES[a]

Trait	Dependent Variables				
	Thick Muscle (lbs.)	Thin Muscle (lbs.)	Total Muscle (lbs.)	Fat (lbs.)	Bone (lbs.)
Carcass weight	0.89	0.87	0.93	0.43	0.68
Weight kidney, pelvic and heart fats	0.30	0.20	0.25	0.50	-0.15
Average fat thickness, 12th rib	-0.19	-0.11	-0.15	0.50	-0.05
Rib eye area	0.52	0.59	0.59	0.02	0.19
Strip weight	0.76	0.74	0.79	0.44	0.44
Tender weight	0.63	0.62	0.66	-0.14	0.87
Top butt weight	0.74	0.79	0.80	0.01	0.84
Knuckle weight	0.70	0.76	0.77	-0.32	0.86
Top round weight	0.78	0.64	0.75	-0.16	0.92
Bottom round weight	0.62	0.59	0.64	-0.24	0.83
Eye round weight	0.48	0.48	0.50	0.03	0.63
Rib roast weight	0.67	0.55	0.64	0.39	0.04
Chuck roast weight	0.73	0.37	0.58	0.42	0.07
Femur weight	0.58	0.62	0.63	-0.26	0.95
Tibia weight	0.59	0.59	0.62	-0.34	0.93

[a]Correlations based on pooled corrected sums of squares from groups 1, 4 and 6.
$r > .41$; significance at $P < .05$ (d.f. = 21)
$r > .53$; significance at $P < .01$ (d.f. = 21)

TABLE XVI

POOLED CORRELATIONS BETWEEN SELECTED DEPENDENT VARIABLES AND VARIOUS CARCASS TRAITS WITHIN U.S.D.A. PRIME AND CHOICE CONFORMATION GRADE CARCASSES[a]

	Dependent Variables				
Trait	Thick Muscle (lbs.)	Thin Muscle (lbs.)	Total Muscle (lbs.)	Fat (lbs.)	Bone (lbs.)
Carcass weight	0.79	0.61	0.74	0.73	0.68
Weight kidney, pelvic and heart fats	0.26	0.06	0.18	0.44	0.11
Average fat thickness, 12th rib	0.06	-0.13	-0.03	0.41	0.26
Rib eye area	0.63	0.61	0.65	-0.12	0.10
Strip weight	0.69	0.63	0.70	0.17	0.21
Tender weight	0.65	0.53	0.63	-0.08	0.04
Top butt weight	0.72	0.67	0.73	-0.09	0.32
Knuckle weight	0.62	0.47	0.58	-0.16	0.26
Top round weight	0.84	0.69	0.81	0.24	0.46
Bottom round weight	0.72	0.58	0.69	-0.08	0.20
Eye round weight	0.84	0.66	0.80	0.19	0.40
Rib roast weight	0.76	0.68	0.76	0.20	0.46
Chuck roast weight	0.65	0.45	0.58	0.40	0.49
Femur weight	0.38	0.27	0.34	0.25	0.76
Tibia weight	0.35	0.26	0.32	0.15	0.65

[a]Correlations based on pooled corrected sums of squares from groups 2, 3, 5 and 7.
$r > .32$; significance at $P < .05$ (d.f. = 35)
$r > .42$; significance at $P < .01$ (d.f. = 35)

TABLE XVII

CORRELATIONS BETWEEN THE SELECTED INDEPENDENT VARIABLES USED IN THE MULTIPLE REGRESSION EQUATIONS, AND THE DEPENDENT VARIABLES WITHIN THE U.S.D.A. STANDARD AND GOOD CARCASS CONFORMATION[a] GRADES

Independent Variables	Dependant Variables				
	Thick Muscle (lbs.)	Thin Muscle (lbs.)	Total Muscle (lbs.)	Fat (lbs.)	Bone (lbs.)
Cold carcass weight, lb.	0.97	0.97	0.98	0.51	0.87
Kidney fat weight, lb.	0.76	0.78	0.78	0.51	0.60
Average fat 12th rib, in.	-0.16	-0.14	-0.15	0.59	-0.21
Rib eye area, sq. in.	0.81	0.79	0.81	0.20	0.70
Top round weight, lb.	0.96	0.94	0.95	0.24	0.94
Bottom round weight, lb.	0.96	0.93	0.95	0.29	0.92
Eye round weight, lb.	0.93	0.79	0.93	0.30	0.90
Femur weight, gm.	0.79	0.78	0.79	0.08	0.97
Tibia weight, gm.	0.83	0.81	0.83	0.06	0.97

[a]Standard and Good conformation carcasses include groups 1, 4 and 6; n = 27.
Correlations calculated across groups
$r > .38$; significance at $P < .05$ (d.f. = 25)
$r > .49$; significance at $P < .01$ (d.f. = 25)

TABLE XVIII

CORRELATIONS BETWEEN THE SELECTED INDEPENDENT VARIABLES USED IN THE MULTIPLE REGRESSION EQUATIONS, AND THE DEPENDENT VARIABLES WITHIN THE U.S.D.A. CHOICE AND PRIME CARCASS CONFORMATION[a] GRADES

Independent Variables	Dependent Variables				
	Thick Muscle (lbs.)	Thin Muscle (lbs.)	Total Muscle (lbs.)	Fat (lbs.)	Bone (lbs.)
Cold carcass weight, lb.	0.85	0.80	0.83	0.22	0.68
Kidney fat weight, lb.	-0.12	-0.25	-0.21	0.64	-0.11
Average fat 12th rib, in.	-0.36	-0.54	-0.49	0.69	-0.26
Rib eye area, sq. in.	0.84	0.77	0.81	-0.34	0.41
Top round weight, lb.	0.89	0.81	0.86	-0.25	0.66
Bottom round weight, lb.	0.88	0.86	0.89	-0.41	0.67
Eye round weight, lb.	0.88	0.78	0.83	-0.26	0.58
Femur weight, gm.	0.51	0.48	0.50	-0.07	0.87
Tibia weight, gm.	0.29	0.16	0.21	0.11	0.63

[a]Choice and Prime conformation carcasses include groups 2, 3, 5 and 7; $n = 41$, correlations calculated across groups.

$r > .31$; significance at $P < .05$ (d.f. = 39)

$r > .39$; significance at $P < .01$ (d.f. = 39)

groups within conformation group basis. These correlations, in general, are somewhat higher than the corresponding correlations reported in Tables XV and XVI because they were calculated across groups within conformation rather than on a pooled sum of squares within groups basis. These correlations (Tables XVII and XVIII) are reported to show the effect of increased variation in carcass weight on the correlation coefficients among the selected dependent and independent variables.

Correlations among the independent variables were obtained by conformation group and are presented in Tables XIX and XX. In general, the correlations among the thick muscles were highly significant ($P < .01$). Within the Standard and Good carcasses kidney fat weight tended to be positively correlated with muscle weights while within the Choice and Prime carcasses the corresponding relationships were negative.

Means and standard deviations for the independent variables selected for use in developing multiple regression equations are presented in Table XXI. The means are the weights of the right side components since only the right side of each carcass was separated into its component parts. For prediction purposes the right side dependent variables were doubled so that the resulting multiple regression equations would apply to the whole carcass.

Again it is emphasized that there was more variation in carcass weight within the low conformation carcasses as compared to the high conformation Choice and Prime carcasses and that this weight variation tended to force correlations among carcass components upward.

Prediction equations for the estimation of total pounds of carcass components were calculated within each conformation group using the two sets of independent variables discussed earlier. In each case the

TABLE XIX

CORRELATIONS[b] AMONG THE SELECTED INDEPENDENT VARIABLES USED IN THE MULTIPLE REGRESSION EQUATIONS FOR STANDARD AND GOOD CARCASS CONFORMATION[a] GRADES

Independent Variables		X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Cold carcass weight	X_1	.83	-.03	.77	.93	.92	.91	.77	.80
Kidney fat weight	X_2		.05	.68	.69	.63	.60	.47	.52
Average fat 12th rib	X_3			-.30	-.17	-.12	-.13	-.18	-.22
Rib eye area	X_4				.77	.76	.73	.60	.62
Top round weight	X_5					.96	.94	.87	.90
Bottom round weight	X_6						.97	.86	.89
Eye round weight	X_7							.82	.84
Femur weight	X_8								.98
Tibia weight	X_9								

[a]Standard and Good conformation carcasses include groups 1, 4, and 6; n = 27.

[b]Correlations based on weights (lbs.).

$r > .38$; significance at $P < .05$ (d.f. = 25).

$r > .49$; significance at $P < .01$ (d.f. = 25).

TABLE XX

CORRELATIONS[b] AMONG THE SELECTED INDEPENDENT VARIABLES USED IN THE MULTIPLE REGRESSION EQUATIONS FOR CHOICE AND PRIME CARCASS CONFORMATION[a] GRADES

Independent Variables		X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Cold carcass weight	X_1	.23	-.09	.63	.76	.71	.71	.55	.37
Kidney fat weight	X_2		.53	-.11	-.07	-.15	-.12	-.00	.18
Average fat 12th rib	X_3			-.46	-.44	-.45	-.44	-.21	.21
Rib eye area	X_4				.82	.76	.74	.31	.11
Top round weight	X_5					.83	.84	.58	.33
Bottom round weight	X_6						.81	.60	.36
Eye round weight	X_7							.51	.25
Femur weight	X_8								.72
Tibia weight	X_9								

[a]Choice and Prime conformation carcasses include groups 2, 3, 5 and 7; n = 41.

[b]Correlations based on weights (lbs.).

$r > .31$; significance at $P < .05$ (d.f. = 39).

$r > .39$; significance at $P < .01$ (d.f. = 39).

TABLE XXI

MEANS AND STANDARD DEVIATIONS FOR CARCASS CHARACTERISTICS USED IN DEVELOPING MULTIPLE REGRESSION EQUATIONS

Characteristic (Independent Variables)	Units	Carcass conformation[a] Low Mean S.D.	Carcass conformation[a] High Mean S.D.
No.			
1. Cold carcass weight[b]	lb.	237.35 ± 49.08	284.40 ± 21.88
2. Kidney, pelvic and heart fats[b]	lb.	12.01 ± 4.85	13.49 ± 3.15
3. Average fat thickness 12th rib	in.	0.31 ± .15	0.50 ± .16
4. Rib eye area	sq. in.	9.74 ± 1.60	11.96 ± 1.65
5. Top round[c]	lb.	9.21 ± 2.05	10.85 ± 1.17
6. Bottom round	lb.	8.56 ± 1.70	10.27 ± 1.14
7. Eye round	lb.	3.15 ± 0.81	3.92 ± 0.48
8. Femur weight	gm.	1773 ± 387	1654 ± 171
9. Tibia weight	gm.	1152 ± 224	1092 ± 144

[a]Low conformation = carcasses in groups 1, 4, and 6. See Table I; they represent U.S.D.A. Standard and Good conformation carcasses: high conformation = carcasses in groups 2, 3, 5, and 7; they represent U.S.D.A. Choice and Prime conformation carcasses.

[b]Right side only.

[c]Muscles were weighted to the nearest 1/10 pound.

multiple regression equations calculated from carcass measurements, muscle weights and bone weights are presented first followed by a table of multiple regression equations utilizing only the four U.S.D.A. cutability equation variables. Squared multiple regression coefficients and standard errors of estimates were used to evaluate the equations.

Regression equations for pounds of thick muscle are given in Tables XXII and XXIII for the Standard and Good conformation carcasses and Tables XXIV and XXV for the Choice and Prime conformation carcasses.

In the first regression equation thick muscle was regressed on carcass weight (Table XXII). The resulting equation implies that within the low conformation carcasses, carcass weight alone accounts for 96 percent of the variation in thick muscle. Since a stepwise multiple regression technique was employed, one variable at a time was added to the equation. The second equation in Table XXII includes the variable (of those remaining) which accounts for the most variation in pounds of thick muscle after the effect of carcass weight has been removed, etc.

The equation with four dependent variables (equation 4, Table XXII) accounts for only three percent more of the variation in pounds of thick muscle than equation 1. The standard error of estimate for equation 4 was 3.22 pounds and represents approximately 2.25 percent of the total thick muscle.

Prediction of thick muscle within the low conformation group using only the 4 variables used in the U.S.D.A. cutability equation is shown in Table XXIII. Since carcass weight is included as before (Table XXII), which accounts for 96 percent of the variation in thick muscle, the equation including all four carcass variables accounts for almost exactly as much variation in thick muscle as the equation where muscle

TABLE XXII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATED THICK MUSCLE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 22.358 + 0.501X_1$	.96	25.13	5.33
2.	$\hat{Y} = 17.369 + 0.332X_1 + 5.253X_6$	.97	25.13	4.18
3.	$\hat{Y} = 24.081 + 0.361X_1 + 4.299X_6 - 17.176X_3$	.98	25.13	3.35
4.	$\hat{Y} = 25.050 + 0.355X_1 + 5.549X_6 - 18.230X_3 - 0.00562X_8$	.99	25.13	3.22

[a] $\hat{Y}$ = total carcass thick muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_3 = average fat thickness 12th rib, in.

X_6 = right side bottom round weight, lb.

X_8 = right side femur weight, gm.

TABLE XXIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING THICK MUSCLE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 22.358 + 0.501X_1$	.96	25.13	5.33
2.	$\hat{Y} = 29.618 + 0.499X_1 - 21.477X_3$	.97	25.13	4.29
3.	$\hat{Y} = 24.859 + 0.546X_1 - 19.964X_3 - 0.572X_2$	.98	25.13	4.06
4.	$\hat{Y} = 17.898 + 0.518X_1 - 16.056X_3 - 0.658X_2 + 1.354X_4$	.98	25.13	3.93

[a] $\hat{Y}$ = total carcass thick muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

TABLE XXIV

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING THICK MUSCLE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 47.245 + 11.302X_5$	.79	14.92	6.96
2.	$\hat{Y} = 10.351 + 7.299X_5 + 0.282X_1$	.86	14.92	5.71
3.	$\hat{Y} = 8.944 + 3.765X_5 + 0.237X_1 + 5.129X_6$	.90	14.92	4.79
4.	$\hat{Y} = 11.434 + 3.284X_5 + 0.321X_1 + 4.078X_6 - 0.771X_2$	.92	14.92	4.34

[a] $\hat{Y}$ = total carcass thick muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_5 = right side top round weight, lb.

X_6 = right side bottom round weight, lb.

TABLE XXV

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING THICK MUSCLE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 5.259 + 0.579X_1$	.72	14.92	7.98
2.	$\hat{Y} = 12.487 + 0.363X_1 + 4.525X_4$	.87	14.92	5.50
3.	$\hat{Y} = 15.287 + 0.440X_1 + 3.652X_4 - 1.0628X_2$	.91	14.92	4.58
4.	$\hat{Y} = 15.123 + 0.440X_1 + 3.667X_4 - 1.0701X_2 + 0.319X_3$	.91	14.92	4.65

[a] $\hat{Y}$ = total carcass thick muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

weights were included (.98 versus .99 respectively).

Within the Choice and Prime conformation carcasses, top round weight was the best single indicator of thick muscle (Table XXIV). Top round weight accounted for 79 percent of the variation in thick muscle with a standard error of estimate of 6.96 pounds. When carcass weight, bottom round and kidney fat were included in the equation, 0.92 percent of the variation in thick muscle was accounted for within the Choice and Prime carcasses. While this is less than the variation accounted for within the Standard and Good carcasses, it still is quite high.

When only the four carcass variables were used to predict the thick muscle within the Choice and Prime carcasses, as compared to including muscle and bone weights, only a one percent reduction in R^2 was observed (Table XXV).

Regression equations for pounds of total thin muscle are summarized in Tables XXVI through XXIX. Again, as with thick muscle, it is obvious that carcass weight accounts for a major portion of the variation in thin muscle within the Standard and Good carcasses and that the equations involving muscle weights were no better (practically speaking) than those utilizing only carcass traits. Thin muscle prediction equations for the Choice and Prime carcasses are given in Tables XXVIII and XXIX. Again, as with thick muscle, over 90 percent of the variation in thin muscle was accounted for by both sets of equations.

Prediction of total muscle (sum of thick and thin muscle) within the two conformation groups by the two sets of variables is presented in Tables XXX through XXXIII. As anticipated from the evaluation of thick and thin muscle prediction equations, a major portion of the variation in total muscle within the Standard and Good conformation

TABLE XXVI

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING THIN MUSCLE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FRON DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -61.432 + 0.857X_1$	.95	43.04	9.27
2.	$\hat{Y} = -51.251 + 0.854X_1 - 30.120X_3$	.97	43.04	8.21
3.	$\hat{Y} = -49.705 + 0.749X_1 - 26.224X_3 + 7.063X_7$	.97	43.04	8.02
4.	$\hat{Y} = -48.358 + 0.753X_1 - 26.843X_3 + 7.847X_7 - 0.00256X_8$	.97	43.04	8.18

[a] $\hat{Y}$ = total carcass thin muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_3 = average fat thickness 12th rib, in.

X_7 = right side eye round weight, lb.

X_8 = right side femur weight, gm.

TABLE XXVII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING THIN MUSCLE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -61.432 + 0.857X_1$	.95	43.04	9.27
2.	$\hat{Y} = -51.251 + 0.854X_1 - 30.120X_3$	.97	43.04	8.21
3.	$\hat{Y} = -55.754 + 0.899X_1 - 28.687X_3 - 0.541X_2$	.97	43.04	8.24
4.	$\hat{Y} = -59.572 + 0.884X_1 - 26.544X_3 - 0.588X_2 + 0.743X_4$	.97	43.04	8.39

[a] $\hat{Y}$ = total carcass thin muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

TABLE XXVIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING THIN MUSCLE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -30.137 + 19.636X_6$	.74	25.89	13.22
2.	$\hat{Y} = -93.250 + 13.711X_6 + 0.436X_1$	.81	25.89	11.47
3.	$\hat{Y} = -83.513 + 8.959X_6 + 0.702X_1 - 2.716X_2$	.83	25.89	8.72
4.	$\hat{Y} = -61.278 + 6.109X_6 + 0.755X_1 - 1.917X_2 - 38.114X_3$	.93	25.89	7.39

[a] $\hat{Y}$ = total carcass thin muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat, lb.

X_3 = average fat thickness 12th rib, in.

X_6 = right side bottom round weight, lb.

TABLE XXIX

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING THIN MUSCLE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -96.081 + 0.941X_1$	.63	25.89	15.91
2.	$\hat{Y} = -44.333 + 0.891X_1 - 75.931X_3$	.85	25.89	10.12
3.	$\hat{Y} = -52.112 + 0.983X_1 - 51.458X_3 - 2.255X_2$	.90	25.89	8.39
4.	$\hat{Y} = -55.016 + 0.870X_1 - 41.772X_3 - 2.195X_2 + 2.461X_4$	.91	25.89	8.03

[a] $\hat{Y}$ = total carcass thin muscle weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

TABLE XXX

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING TOTAL CARCASS MUSCLE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -39.074 + 1.358X_1$	.97	67.59	11.43
2.	$\hat{Y} = -21.633 + 1.353X_1 - 51.597X_3$	.98	67.59	8.46
3.	$\hat{Y} = -31.539 + 1.107X_1 - 43.902X_3 + 7.691X_6$	.99	67.59	7.01
4.	$\hat{Y} = -29.748 + 1.0962X_1 - 45.849X_3 + 10.00156X_6 - 0.0104X_8$	.99	67.59	6.83

[a] $\hat{Y}$ = total carcass muscle, lb.

X_1 = right side cold carcass weight, lb.

X_3 = average fat thickness 12th rib, in.

X_6 = right bottom round weight, lb.

X_8 = right femur weight, gm.

TABLE XXXI

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING TOTAL CARCASS MUSCLE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -39.074 + 1.358X_1$	.97	67.59	11.43
2.	$\hat{Y} = -21.633 + 1.353X_1 - 51.597X_3$	.98	67.59	8.45
3.	$\hat{Y} = -30.894 + 1.444X_1 - 48.651X_3 - 1.114X_2$	.99	67.59	8.03
4.	$\hat{Y} = -41.674 + 1.402X_1 - 42.600X_3 - 1.246X_2 + 2.097X_4$	.99	67.59	7.94

[a] $\hat{Y}$ = total carcass muscle, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

TABLE XXXII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING TOTAL CARCASS MUSCLE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 20.720 + 31.229X_6$	.79	39.90	18.31
2.	$\hat{Y} = -86.443 + 21.169X_6 + 0.740X_1$	.88	39.90	14.36
3.	$\hat{Y} = -73.612 + 14.908X_6 + 1.091X_1 - 3.578X_2$	.94	39.90	10.46
4.	$\hat{Y} = -67.402 + 10.839X_6 + 0.998X_1 - 3.369X_2 + 4.930X_4$	.95	39.90	9.12

[a] $\hat{Y}$ = total carcass muscle, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat, lb.

X_4 = rib eye area, sq. in.

X_6 = right side bottom round weight, lb.

TABLE XXXIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING TOTAL CARCASS MUSCLE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -90.814 + 1.520X_1$	.69	39.90	22.32
2.	$\hat{Y} = -20.889 + 1.452X_1 - 102.603X_3$	.86	39.90	14.99
3.	$\hat{Y} = -32.665 + 1.591X_1 - 65.556X_3 - 3.413X_2$	.91	39.90	12.29
4.	$\hat{Y} = -39.896 + 1.310X_1 - 41.437X_3 - 3.265X_2 + 6.129X_4$	.94	39.90	10.32

[a] $\hat{Y}$ = total carcass muscle, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

carcasses was accounted for by regressing carcass weight on total muscle ($R^2 = 0.97$). Cole et al. (1962), Birkett et al. (1965), Fitzhugh et al (1965) and DuBose et al. (1967) report that chilled carcass weight alone accounted for more of the variation in separable lean, or some measure of carcass steak and roast meat, than any combination of carcass measurements. As additional variables were added to the equation (Table XXX); average fat thickness, bottom round and femur weight; the standard error of estimate for total muscle was reduced from 11.43 to 6.83 pounds. Equation four implies that if carcass weight, average fat thickness and bottom round weight were held constant the Standard and Good conformation carcasses with the lighter femur weights would have a higher muscle yield. Several workers have found bone to be associated to some extent with retail yields. An increase in bone in beef carcasses has been shown to be associated with a small increase in retail meat yields (Orme et al. 1959, Cole et al. 1960, Wythe et al. 1961 and Brungardt and Bray 1963). In this author's opinion, increased bone content as related to higher retail yields "probably reflects the relationship between bone and fat"; comparable weight carcasses with more bone usually have less fat. It is the combined effect of bone plus fat that results in either lower or higher retail yields.

Within the Choice and Prime conformation carcasses, which were more uniform with respect to carcass weight, the weight of the bottom round proved to be the best single indicator of total muscle ($r^2 = 0.79$), Table XXXII). When carcass weight, kidney fat weight and rib eye area were added to bottom round, the resulting equation accounted for 95 percent of the variation in total muscle within the Choice and

Prime conformation carcasses. Once again, as was the case with thick and thin muscle prediction, the set of equations involving only the 4 variables used in the U.S.D.A. equation predicted total muscle with almost equal accuracy when compared to the equations involving muscle and bone weights.

Other carcass components of interest include fat and bone. Tables XXXIV through XXXVII present the results of fat predictions. Average fat thickness at 12th rib accounted for more variation in carcass fat within both conformation groups, than any other variable studied (r^2 = 0.34 and 0.48; low and high conformation groups respectively).

When carcass weight, top round and tibia weight were added to the equation for predicting fat, within the low conformation group, 83 percent of the variation in fat was accounted for with a standard error of estimate of 7.39 pounds. The equation implies that, holding average fat thickness and carcass weight constant, the carcasses with heavier top rounds and tibias have less fat.

An equation involving the four carcass variables (Table XXXV) accounted for only 64 percent of the variation in total carcass fat. This represents a considerable reduction from the equation including top round and tibia weight (19 percent less variation accounted for).

Within the Choice and Prime carcasses the same general trend was observed with respect to fat prediction (Tables XXXVI and XXXVII) that was found in the low conformation group. The equation using bottom round weight (Table XXXVI) accounted for 12 percent more variation in carcass fat than the corresponding equation using rib eye area (Table XXXVII), 82 versus 70 percent respectively.

Bone prediction equations are summarized in Tables XXXVIII through

TABLE XXXIV

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING FAT CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 70.024 + 65.127X_3$	.34	16.63	13.74
2.	$\hat{Y} = 26.754 + 67.075X_3 + 0.180X_1$	.62	16.63	10.60
3.	$\hat{Y} = 33.565 + 45.699X_3 + 0.591X_1 - 10.605X_5$	.81	16.63	7.76
4.	$\hat{Y} = 42.214 + 44.541X_3 + 0.552X_1 - 6.921X_5 - 0.0287X_9$	.83	16.63	7.39

[a] $\hat{Y}$ = total carcass fat, lb., (kidney fat not included)

X_1 = right side cold carcass weight

X_3 = average fat thickness 12th rib, in.

X_5 = right side top round weight, lb.

X_9 = right tibia weight, gm.

TABLE XXXV

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING FAT CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 70.024 + 65.127X_3$	.34	16.63	13.74
2.	$\hat{Y} = 26.754 + 67.075X_3 + 0.180X_1$	.62	16.63	10.60
3.	$\hat{Y} = 33.846 + 62.899X_3 + 0.218X_1 - 1.536X_4$	.63	16.63	10.73
4.	$\hat{Y} = 39.807 + 60.629X_3 + 0.181X_1 - 1.835X_4 + 0.551X_2$	.64	16.63	10.85

[a] $\hat{Y}$ = total carcass fat, lb. (kidney fat not included)

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

TABLE XXXVI

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING FAT CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 83.802 + 86.161X_3$	.48	20.03	14.58
2.	$\hat{Y} = 63.370 + 60.801X_3 + 2.446X_2$	.59	20.03	13.17
3.	$\hat{Y} = 13.647 + 68.255X_3 + 1.942X_2 + 0.186X_1$	.62	20.03	12.74
4.	$\hat{Y} = 34.057 + 38.542X_3 + 1.190X_2 + 0.692X_1 - 13.604X_6$	.82	20.03	8.88

[a] $\hat{Y}$ = total carcass fat, lb. (Kidney fat not included).

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_6 = right side bottom round weight, lb.

TABLE XXXVII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING FAT CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 83.802 + 86.161X_3$	.48	20.03	14.58
2.	$\hat{Y} = 63.370 + 60.801X_3 + 2.446X_2$	.59	20.03	13.17
3.	$\hat{Y} = 13.647 + 68.255X_3 + 1.942X_2 + 0.186X_1$	.62	20.03	12.74
4.	$\hat{Y} = 19.632 + 48.294X_3 + 1.820X_2 + 0.418X_1 - 5.072X_4$	.70	20.03	11.56

[a] $\hat{Y}$ = total carcass fat, lb. (Kidney fat not included)

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

TABLE XXXVIII

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING BONE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = -9.035 + 0.0745X_9$	.95	17.19	4.07
2.	$\hat{Y} = -8.156 + 0.0487X_9 + 3.132X_5$	.97	17.19	3.00
3.	$\hat{Y} = -3.378 + 0.00115X_9 + 3.644X_5 + 0.0255X_8$	.98	17.19	2.44
4.	$\hat{Y} = -5.012 + 0.00528X_9 + 2.750X_5 + 0.0242X_8 + 0.0318X_1$	.98	17.19	2.43

[a] $\hat{Y}$ = total carcass bone weight, lb.

X_1 = right side cold carcass weight, lb.

X_5 = right side top round weight, lb.

X_8 = right femur weight, gm.

X_9 = right tibia weight, gm.

XLI. Within both conformation groups, prediction accuracy was improved by including muscle and bone weights over the equations utilizing only the four carcass variables.

Summary of Carcass Composition Prediction Equations

Within both conformation groups; low and high; thick, thin and total muscle was predicted with surprising accuracy. More specifically, within the Standard and Good grade carcasses the addition of more than two variables into the multiple regression equations was not very beneficial. Generally, carcass weight and one other variable, easily obtainable from the intact carcass, accounted for over 96 percent of the variation in total pounds of separable muscle.

On the other hand, the inclusion of 3 or 4 variables within the Choice and Prime carcasses seemed to be warranted. Cole et al. (1962) reported that values predicted by an equation including only fat thickness and carcass weight were associated with over 70 percent of the variation in separable lean. Similarly, Fitzhugh et al. (1965) stated that a combination of fat thickness and carcass weight accounted for over 83 percent of the variation in roast and steak meat. In this study, within the Standard and Good conformation carcasses, carcass weight and average fat thickness accounted for 98 percent of the variation in total muscle (Table XXX equation 2). Within the Choice and Prime conformation, these same two variables were associated with 86 percent of the variation in total muscle (Table XXXIII equation 2).

Also, it was evident that very little accuracy was gained in the prediction of thick, thin or total muscle by including certain muscle and bone weights along with easily obtainable carcass traits (i.e.,

TABLE XXXIX

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING BONE CALCULATED WITHIN U.S.D.A. STANDARD AND GOOD CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 4.106 + 0.306X_1$	.76	17.19	8.51
2.	$\hat{Y} = -6.416 + 0.422X_1 - 1.418X_2$	.81	17.19	7.70
3.	$\hat{Y} = 0.409 + 0.409X_1 - 1.280X_2 - 17.172X_3$	.84	17.19	7.38
4.	$\hat{Y} = 0.952 + 0.411X_1 - 1.274X_2 - 17.477X_3 - 0.106X_4$	.84	17.19	7.55

[a] $\hat{Y}$ = total carcass bone weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

TABLE XL

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING BONE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS AND ROUND

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 17.848 + 0.0339X_8$	.76	6.67	3.33
2.	$\hat{Y} = 3.386 + 0.0278X_8 + 0.0865X_1$	.81	6.67	2.96
3.	$\hat{Y} = 5.565 + 0.0263X_8 + 0.106X_1 - 0.400X_2$	.84	6.67	2.72
4.	$\hat{Y} = 5.188 + 0.0233X_8 + 0.110X_1 - 0.444X_2 + 0.00454X_9$	.85	6.67	2.72

[a]$\hat{Y}$ = total carcass bone weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat, lb.

X_8 = right femur weight, gm.

X_9 = right tibia weight, gm.

TABLE XLI

MULTIPLE REGRESSION EQUATIONS FOR ESTIMATING BONE CALCULATED WITHIN U.S.D.A. CHOICE AND PRIME CONFORMATION GRADE CARCASSES FROM DATA OBTAINED FROM THE CARCASS

No.	Estimating Equations[a]	R^2	s_y	Standard Error of Estimate
1.	$\hat{Y} = 15.060 + 0.207X_1$	.46	6.67	4.96
2.	$\hat{Y} = 17.440 + 0.227X_1 - 0.603X_2$	.54	6.67	4.65
3.	$\hat{Y} = 16.727 + 0.263X_1 - 0.701X_2 - 0.688X_4$	.55	6.67	4.63
4.	$\hat{Y} = 20.119 + 0.269X_1 - 0.548X_2 - 1.00538X_4 - 6.608X_3$	.57	6.67	4.62

[a] $\hat{Y}$ = total carcass bone weight, lb.

X_1 = right side cold carcass weight, lb.

X_2 = right side kidney fat weight, lb.

X_3 = average fat thickness 12th rib, in.

X_4 = rib eye area, sq. in.

carcass weight, fat thickness, kidney fat weight and rib eye area). It appears that the four carcass variables mentioned above predict pounds of carcass muscle very satisfactorily.

In general, fat and bone were not predicted with the same accuracy as muscle components. Two or three variables did not account for nearly as much variation in fat as was the case with muscle predictions. Average fat thickness at the 12th rib was the best single predictor of carcass fatness in both conformation groups, but accounted for slightly more variation in fatness within the Choice and Prime conformation carcasses.

Bone predictions were quite accurate when muscle and bone weights were included in the dependent variable set. Tibia weight alone accounted for 95 percent of the variation in carcass bone within the low conformation carcasses. Femur weight was associated with 76 percent of the variation in bone weight within the Choice and Prime carcasses (Tables XXXVIII and XXXIX respectively). Using only carcass variables, 57 percent of the variation in bone was accounted for in the high conformation carcasses as contrasted to 85 percent in the low conformation carcasses.

In this connection, Henderson _et al_. (1966b) reported that multiple correlation and regression coefficients for equations involving the same variables, in many cases, differed significantly among different cattle populations.

Prediction Equation Tests

Several prediction equations developed using the carcasses in groups 1 through 7 (Table I) were applied to groups 8, 9 and 10.

Equations developed from both the high and low conformation carcasses were tested. As described earlier, groups 1, 4 and 6 were pooled and designated the low conformation group (n = 27) and groups 2, 3, 5 and 7 were likewise pooled and designated the high conformation group (n = 41). Also, under consideration were two sets of independent variables. Within each conformation grouping two prediction equations were developed for each dependent variable. Independent variables in set number one included; cold carcass weight, kidney pelvic and heart fat weight, average fat thickness at the 12th rib, rib eye area, top round weight, bottom round weight, eye round weight, right femur weight and right tibia weight.

Variables utilized in set number two included only those four variables used in the U.S.D.A. cutability equation (Murphey et al. 1960); cold carcass weight, kidney pelvic and heart fat weight, average fat thickness at the 12th rib and rib eye area. While these are the same variables (set number two) per se there is one deviation from the Murphey variables. They estimated the percent kidney, pelvic and heart fats while in this study actual pounds of kidney, pelvic and heart fats were used in the equations.

The combinations of prediction equations, developed within two different conformation groupings using two sets of independent variables, were applied to groups 8, 9 and 10 (Angus, Charolais X Angus and Ayrshire carcasses respectively). The equations used to predict each of the three major tissues are presented in Table XLII.

Means and standard deviations for carcass components, both on a total pounds and percent basis by groups, are presented in Table XLIV. Both conformation groups from which the prediction equations were

TABLE XLII

SELECTED MULTIPLE REGRESSION EQUATIONS APPLIED TO CARCASS GROUPS 8, 9 AND 10

Dependent Variables	Estimating Equations[a]
Total Muscle	$\hat{Y}^{b}_{11} = -29.748 + 1.0962X_1 - 45.849X_3 + 10.00156X_6 - 0.0104X_8$
	$\hat{Y}_{12} = -41.674 + 1.402X_1 - 42.600X_3 - 1.246X_2 + 2.097X_4$
	$\hat{Y}_{21} = -67.402 + 10.839X_6 + 0.998X_1 - 3.369X_2 + 4.930X_4$
	$\hat{Y}_{22} = -39.896 + 1.310X_1 - 41.437X_3 - 3.265X_2 + 6.129X_4$
Total Fat	$\hat{Y}_{11} = 42.214 + 44.541X_3 + 0.552X_1 - 6.921X_5 - 0.0287X_9$
	$\hat{Y}_{12} = 26.754 + 67.075X_3 + 0.180X_1$
	$\hat{Y}_{21} = 34.057 + 38.542X_3 + 1.190X_2 + 0.692X_1 - 13.604X_6$
	$\hat{Y}_{22} = 19.632 + 48.294X_3 + 1.820X_2 + 0.418X_1 - 5.072X_4$
Total Bone	$\hat{Y}_{11} = -5.012 + 0.00528X_9 + 2.750X_5 + 0.0242X_8 + 0.0318X_1$
	$\hat{Y}_{12} = 0.409 + 0.409X_1 - 1.280X_2 - 17.172X_3$
	$\hat{Y}_{21} = 5.188 + 0.0233X_8 + 0.110X_1 - 0.444X_2 + 0.00454X_9$
	$\hat{Y}_{22} = 20.119 + 0.269X_1 - 0.548X_2 - 1.00538X_4 - 6.608X_3$

[a]These equations were taken from Tables XXX through XLI. The equation exhibiting the smallest standard error of estimate was selected from each table.

[b]The Y subscripts denote the conformation group and set of independent variables utilized in the equation. The first digit refers to the conformation group; i.e., 1 = low conformation, 2 = high conformation. The second digit refers to the independent variable set; i.e., 1 = carcass plus round variables, 2 = carcass variables only (see Table XLIII for more detail).

TABLE XLIII

DESCRIPTION OF EQUATION CODES USED IN TABLE XLII

Equation Code		Description
$\hat{Y}_{11}$	=	total muscle, fat or bone estimating Equation from the low-conformation-carcasses[a] utilizing independent variable set No. 1.[b]
$\hat{Y}_{12}$	=	total muscle, fat or bone estimating equation from the low-conformation-carcasses utilizing independent variable set No. 2.[c]
$\hat{Y}_{21}$	=	total muscle, fat or bone estimating equation from the high-conformation-carcasses[d] utilizing independent variable set No. 1.
$\hat{Y}_{22}$	=	total muscle, fat or bone estimating equation from the high-conformation-carcasses utilizing independent variable set No. 2.

[a]Low conformation carcasses = sum of groups 1, 4 and 6, see Table I (n = 27).

[b]Independent variable set No. 1 = carcass plus round variables as follows:

X_1 = cold carcass weight (right side only),
X_2 = right side kidney, pelvic and heart fats (lb.),
X_3 = average fat thickness 12th rib (in.),
X_4 = rib eye area (sq. in.),
X_5 = top round weight (lb.),
X_6 = bottom round weight (lb.),
X_7 = eye round (lb.),
X_8 = femur weight (gm.) and
X_9 = tibia weight (gm.).

[c]Independent variable set No. 2 = carcass variables only (X_1 ... X_4), see above.

[d]High conformation carcasses = sum of groups 2, 3, 5 and 7, see Table I (n = 41).

TABLE XLIV

PERCENTAGE AND ABSOLUTE MEANS AND STANDARD DEVIATIONS FOR THE THREE MAJOR TISSUES WITHIN THE PREDICTION EQUATION CONFORMATION GROUPS AND THE THREE TEST GROUPS

	Major Carcass Components					
	Total Muscle		Total Fat		Total Bone	
	Lb. ± S.D.	% ± S.D.	Lb. ± S.D.	% ± S.D.	Lb. ± S.D.	% ± S.D.
Prediction Equation Groups						
Low conformation (n = 27)	283.3 ± 67.6	59.7 ± 2.8	90.5 ± 16.6	19.1 ± 3.51	76.8 ± 17.2	16.2 ± 1.72
High conformation (n = 41)	341.4 ± 39.9	60.0 ± 4.1	126.5 ± 20.0	22.2 ± 3.6	73.9 ± 6.7	13.0 ± 0.91
Test Groups						
Angus (n = 15)	327.5 ± 10.2	55.3 ± 1.7	164.2 ± 14.1	27.7 ± 2.1	68.4 ± 5.5	11.6 ± 0.9
Charolais X Angus (n = 15)	356.0 ± 17.3	60.7 ± 3.1	126.2 ± 22.2	21.5 ± 3.6	75.7 ± 6.1	12.9 ± 1.2
Ayrshire (n = 13)	306.3 ± 19.6	55.4 ± 1.8	129.3 ± 27.0	23.2 ± 3.8	81.1 ± 7.6	14.7 ± 1.8

developed were similar with regard to average percent total muscle, 59.7 ± 14.2 and 60.0 ± 7.0 for the low and high conformation groups respectively. On the other hand, considerable variation existed between the conformation groups with respect to total pounds of carcass muscle. Among the test groups the Charolais X Angus carcasses were very comparable to the high conformation group, from which the prediction equations were developed, both in total pounds and percentage total muscle yield. The Angus and Ayrshire carcasses had a lower muscle yield than the high conformation prediction equation group. Both the Angus and Ayrshire carcasses were fatter, on the average, than the high conformation prediction group.

Variation in bone among the test groups ranged from 11.6 ± 0.9 percent (Angus) to 14.7 ± 1.8 percent (Ayrshires). The high conformation prediction group averaged 13.0 ± 1.2 percent bone and the low conformation group averaged 16.2 ± 3.6 percent.

Actual pounds of muscle versus various predicted values are summarized in Table XLV. Within the Angus carcasses, all equations over estimated the mean actual total muscle (pounds). The simple correlation coefficients between actual and predicted ranged from 0.77 to 0.89. However, it would appear, that the high conformation prediction equations fit the Angus data somewhat better than the low conformation equations. A correlation of 0.89 was obtained between actual and predicted total muscle utilizing the high conformation equation developed from independent variable set number two. However, it should be pointed out that the simple correlation coefficient between actual and predicted values within groups does not adequately evaluate the accuracy of a prediction equation since the correlation coefficient is simply a

TABLE XLV

COMPARISON OF ACTUAL AND VARIOUS PREDICTED VALUES FOR TOTAL MUSCLE WITHIN AND ACROSS THREE BREEDS OR "TYPES" OF CARCASSES

Breed	Equation Code[a]	Total Muscle: Actual Mean ± S.D.	Total Muscle: Predicted Mean ± S.D.	Total Muscle: Difference Act. minus Pred.	Correlation[b]
	11	327.5 ± 10.2	346.1 ± 10.6	-18.6	0.76
Angus	12	327.5 ± 10.2	347.4 ± 9.7	-19.9	0.77
	21	327.5 ± 10.2	342.1 ± 14.7	-14.6	0.77
	22	327.5 ± 10.2	338.4 ± 13.6	-10.9	0.89
	11	356.0 ± 17.3	360.7 ± 15.2	- 4.7	0.84
Charolais	12	356.0 ± 17.3	356.9 ± 12.5	- 0.9	0.68
X Angus	21	356.0 ± 17.3	358.7 ± 18.2	- 2.7	0.82
	22	356.0 ± 17.3	354.4 ± 16.6	1.6	0.74
	11	306.3 ± 19.6	322.3 ± 22.8	-16.0	0.76
Ayrshire	12	306.3 ± 19.6	325.7 ± 27.0	-19.4	0.82
	21	306.3 ± 19.6	287.6 ± 28.2	18.7	0.94
	22	306.3 ± 19.6	303.8 ± 31.4	2.5	0.91
	11	331.0 ± 25.7	343.9 ± 22.6	-12.9	0.88
Across breeds	12	331.0 ± 25.7	344.2 ± 21.4	-13.2	0.82
	21	331.0 ± 25.7	331.4 ± 36.2	- 0.4	0.91
	22	331.0 ± 25.7	333.5 ± 29.6	- 2.5	0.89

[a]The first digit refers to the conformation group from which the equation was developed; 1 = low, 2 = high. The second digit refers to the independent variable set; 1 = carcass plus round variables, 2 = carcass variables only.

[b]Correlation coefficients between actual and predicted pounds of total muscle.

measure of how two things (actual and predicted) vary together. Along with the correlation coefficient the difference between mean predicted and mean actual values, for the dependent variable in question, should be taken into consideration.

Total muscle (lbs.) predictions were surprisingly close to the actual mean value within the Charolais X Angus carcasses. Both the low conformation equations and the high conformation equations appeared to be predicting total muscle within the crossbred carcasses with somewhat equal accuracy. Correlations between actual and predicted ranged from 0.68 to 0.84.

Within the low conformation Ayrshire carcasses the high conformation prediction equations resulted in higher correlations between actual and predicted (r = 0.94 and 0.91, Table XLV) than the low conformation equations (r = 0.76 and 0.82). One explanation for this may be the fact that the Ayrshire carcasses were more nearly comparable in fatness to the high conformation carcasses than to the low conformation carcasses. Relationships between carcass weight and total muscle within the Ayrshire carcasses may be more like the high conformation carcasses than the low conformation group, etc.

Applying the equations across breeds resulted in an averaging effect. Across all test carcasses the high conformation equations resulted in predicted mean values very close to the actual mean value for total muscle, see Table XLV. Correlation coefficients between actual and predicted across breeds were 0.91 and 0.89 for the high conformation equations. Murphey et al. (1960) reported a simple correlation of 0.92 between predicted and actual cut out yield. Palmer et al. (1961) found a relationship of 0.76 by using the same U.S.D.A.

TABLE XLVI

COMPARISON OF ACTUAL AND VARIOUS PREDICTED VALUES FOR TOTAL FAT WITHIN AND ACROSS THREE BREEDS OR "TYPES" OF CARCASSES

Breed	Equation Code[a]	Total Fat Actual Mean ± S.D.	Predicted Mean ± S.D.	Difference Act. minus Pred.	Correlation[b]
	11	164.2 ± 14.1	133.5 ± 11.4	30.7	0.80
Angus	12	164.2 ± 14.1	128.8 ± 10.0	35.4	0.67
	21	164.2 ± 14.1	148.7 ± 13.4	15.5	0.80
	22	164.2 ± 14.1	147.3 ± 11.7	16.9	0.69
	11	126.2 ± 22.2	110.7 ± 17.2	15.5	0.86
Charolais	12	126.2 ± 22.2	112.8 ± 11.2	13.4	0.72
X Angus	21	126.2 ± 22.2	123.3 ± 19.8	2.9	0.83
	22	126.2 ± 22.2	128.0 ± 13.7	-1.8	0.71
	11	129.3 ± 27.0	113.4 ± 18.1	15.9	0.91
Ayrshire	12	129.3 ± 27.0	104.9 ± 13.2	24.4	0.69
	21	129.3 ± 27.0	146.7 ± 20.3	-17.4	0.91
	22	129.3 ± 27.0	140.2 ± 17.2	-10.9	0.83
	11	140.4 ± 27.4	119.5 ± 18.6	20.9	0.91
Across breeds	12	140.4 ± 27.4	116.0 ± 15.0	24.4	0.79
	21	140.4 ± 27.4	139.2 ± 21.2	1.2	0.78
	22	140.4 ± 27.4	138.4 ± 16.1	2.0	0.77

[a]The first digit refers to the conformation group from which the equation was developed; 1 = low, 2 = high. The second digit refers to the independent variable set; 1 = carcass plus round variables, 2 = carcass variables only.

[b]Correlation coefficients between actual and predicted pound of total fat.

TABLE XLVII

COMPARISON OF ACTUAL AND VARIOUS PREDICTED VALUES FOR TOTAL BONE WITHIN AND ACROSS THREE BREEDS OR "TYPES" OF CARCASSES

		Total Bone			
Breed	Equation Code[a]	Actual Mean ± S.D.	Predicted Mean ± S.D.	Difference Act. minus Pred.	Correlation[b]
Angus	11	68.4 ± 5.5	77.7 ± 4.6	- 9.3	0.92
	12	68.4 ± 5.5	88.4 ± 4.2	-20.0	0.52
	21	68.4 ± 5.5	72.2 ± 4.0	- 3.8	0.93
	22	68.4 ± 5.5	74.2 ± 1.9	- 5.8	0.52
Charolais X Angus	11	75.7 ± 6.1	85.2 ± 6.6	- 9.5	0.90
	12	75.7 ± 6.1	93.6 ± 5.2	-17.9	0.54
	21	75.7 ± 6.1	76.9 ± 5.1	- 1.2	0.90
	22	75.7 ± 6.1	75.2 ± 1.9	0.5	0.46
Ayrshire	11	81.1 ± 7.6	81.4 ± 7.6	- 0.3	0.88
	12	81.1 ± 7.6	81.6 ±10.0	- 0.5	0.58
	21	81.1 ± 7.6	76.2 ± 7.2	4.9	0.90
	22	81.1 ± 7.6	71.1 ± 5.0	10.0	0.41
Across breeds	11	74.8 ± 8.1	81.4 ± 6.9	- 6.6	0.78
	12	74.8 ± 8.1	88.2 ± 8.2	-13.4	0.16
	21	74.8 ± 8.1	75.0 ± 5.8	- 0.2	0.84
	22	74.8 ± 8.1	73.6 ± 3.6	1.2	0.08

[a]The first digit refers to the conformation group from which the equation was developed; 1 = low, 2 = high. The second digit refers to the independent variable set; 1 = carcass plus round variables; 2 = carcass variables only.

[b]Correlation coefficients between actual and predicted pound of total bone.

cutability equation.

Actual pounds of total fat and bone were compared to various predicted values and the results are summarized in Tables XLVI and XLVII. Wtih regard to fat prediction, it appears that independent variables set number one was superior to set number two (carcass variables only). Without exception equations utilizing variable set number one resulted in higher correlation coefficients between actual and predicted than the corresponding correlations resulting from the use of variable set number two.

It would appear that prediction equations from the high conformation group predicted closer, on the average, to the actual pounds of carcass fat within and across all three test groups than the low conformation prediction equations. Here again the high conformation carcasses were more comparable in weight and degree of fatness to the test groups than the low conformation carcasses.

Briefly, bone predictions (Table XLVII) were quite accurate on the average when variable set number one was utilized. This is evidenced by the higher correlation in every case when set number one was used as compared to the corresponding equations using independent variable set number two. Apparently bone content is highly related to conformation grade, more so than muscle content. Within the Angus and Crossbred carcasses the high conformation equations came closer to the average actual value, while in the Ayrshire carcasses the low conformation equations produce the most desirable results. This was not the case with total muscle predictions and fat predictions, where the high conformation equations worked best within all test groups.

Prediction Equation Tests Summary

Total pounds of muscle, fat and bone were predicted (within and across breeds) from easily obtainable variables with varying degrees of success. The additional measurements obtained when the round was separated into thick muscles and bones did not substantially increase the accuracy of the prediction of total carcass muscle.

These data suggest that prediction equations for total muscle work best when they are applied to carcasses similar in composition to those from which the equations were developed. The equations developed from the high conformation carcasses for total muscle were not flexible enough to predict very accurately within the Angus and Ayrshire test carcasses (which were fatter than the average of the carcasses from which the equations were developed).

When all three test groups were pooled the equations from the high conformation group produced predicted mean values for total muscle that were very close to the average actual value. However, it should be pointed out that an average effect was observed. Total muscle was over estimated within the Angus carcasses and under estimated in the Ayrshire carcasses using the high conformation equations.

Fat was under estimated within the Angus carcasses and over estimated within the Ayrshire carcasses using the high conformation equations. Just the opposite situation was observed with respect to total muscle. Equations containing muscle and bone weights produced higher correlations between actual pounds of fat and predicted values than the corresponding equations containing only carcass variables. This same pattern was observed relative to bone prediction.

This work would suggest that it is most important to describe the population used in developing prediction equations and that these equations be used on like populations. The consequence of applying prediction equations across populations may severely limit their utility. A similar conclusion was put forth by Henderson *et al*. (1966b).

CHAPTER V

SUMMARY AND CONCLUSIONS

This investigation was conducted to study: (1) the effect of beef carcass conformation on yields of thick and thin muscle; (2) muscle weight distribution as effected by carcass conformation; and (3) prediction equations developed within two different conformation groups.

A total of 113 carcasses were utilized in this study. Phase I was comprized of selected U.S.D.A. Prime, Choice and Standard conformation carcasses. Phases II and III involved feeding different types of steers and studying their carcass composition. High value steak and roasts, referred to herein as thick muscle (Martin _et al_. 1966) were used as the criteria of carcass merit.

Results indicated that there was an advantage for Prime conformation over Choice and Standard conformation carcasses in yield of thick muscle (phase I). However, this advantage was small, less than two percent of the streamlined carcass weight. Total muscle yields among the three selected conformation groups were almost identical. Fat and bone proved to be the major variables. Bone percentage was observed to decrease with an increase in conformation while fat increased. Within this selected population (phase I) bone and fat constituted a rather constant percentage of the streamlined carcass weight.

In phase II comparisons between Choice and Common feeder steers were made. One-half of each conformation group (high and low) was slaughtered after 100 days in the feed lot. The remaining steers were fed 140 days. Results indicated that the low conformation steer carcasses had slightly higher thick and total muscle yields than the high conformation steer carcasses. Again, however, these differences were small. It would appear that conformation per se had very little effect on thick and thin muscle yields as a percentage of the cold carcass weight. Fat and bone were observed to be the major variables. Low conformation carcasses had more bone and less fat than the high conformation carcasses, produced from Choice feeder steers.

Individual thick muscles and thick muscle systems were also studied. The lower conformation carcasses were observed to have significantly higher yields of knuckle and rib roast than the high conformation carcasses. No other significant differences were observed ($P>.05$) between the two conformation groups with respect to individual thick muscle yields.

In almost every case muscle yields were effected by the length of feeding period. One-hundred day fed carcasses had significantly ($P<.05$) higher muscle component yields than the 140 day fed carcasses because of less fat.

Phase III was comprized of 15 Angus, 15 Charolais X Angus crossbred and 13 Ayrshire steer carcasses that were produced from selected feeder steers fed at the Fort Reno Livestock Research Station. Results indicated that the Charolais X Angus carcasses excelled in all categories of muscling as compared to either the straight bred Angus or Ayrshire carcasses. Indirectly these higher muscle yields were due to a lower fat content within the Charolais X Angus carcasses. While significant ($P<.05$) differences did exist in thick and thin muscle distribution pattern among the three breeds, these differences were small. The Charolais X Angus carcasses averaged 18.70 percent of the total thick muscle in the hind quarter while the Angus and Ayrshire carcasses averaged 16.74 and 16.95 respectively. Ratios of total muscle and thick muscle to bone did not differ significantly ($P > .05$) between the Angus and Charolais X Angus carcasses, but since the Charolais X Angus carcasses had a higher bone content they had more muscle as a percentage of the cold carcass weight. Therefore from these data it would appear that carcass conformation is somewhat directly related to ratio of muscle to bone, but has very little effect on thick and thin muscle yields. Fat and bone proved to be the major variables across the three conformation groups. Within the lower conformation carcasses higher bone contents were somewhat offset by lower fat contents. The higher conformation carcasses, with the exception of the Charolais X Angus carcasses, were characterized by having more fat and less bone than the lower conformation carcasses.

Probably the most important single conclusion stems from the fact that carcasses drastically different in conformation had similar muscle weight distribution patterns. Therefore, a measure of total muscle, fat free lean, etc., would adequately determine the merit of a carcass from the standpoint of muscling. There would appear to be, from this study, very little justification for determining thick and thin muscle yields by cutting tests when some measure of total muscling can be obtained quicker and more economically. In this connection roentgenological techniques for determining muscling may prove to be adequate and no correction for differences in conformation between animals would be warranted, based on the evidence from this study.

Multiple regression equations were developed using the data from the first 68 carcasses processed (27 low conformation carcasses and 41 high conformation carcasses) using two different sets of independent variables.

These equations were subsequently tested on the Angus, Charolais X Angus and Ayrshire carcasses that comprized phase III of this study. Within the low conformation carcasses, carcass weight alone accounted for over 95 percent of the variation in total pounds of muscle, whereas in the high conformation groups carcasses weight was associated with only 69 percent of the variation in pounds of total muscle. It appeared that the addition of certain muscle and bone weights, from the round, to the carcass variables used in the U.S.D.A. cutability prediction equation did not substantially increase the accuracy of the total muscle predictions. On the other hand, the addition of individual muscle and bone weights from the round did increase the prediction accuracy of fat and bone.

Results obtained when the prediction equations were applied to the three test groups indicated that, when the equations were applied to carcasses very similar in composition to those from which the equations were developed, they were quite accurate. Correlations of over 0.90 were obtained when the high conformation prediction equations were applied across the three test groups. However, some averaging effects were operating and only within the Charolais X Angus carcasses, which were similar in composition to the carcasses from which the equations were developed, did the predicted mean value for muscle correspond closely with the actual mean value. These results emphasized the need for describing the population from which prediction equations are developed and applying these to like populations.

LITERATURE CITED

Abraham, H. C. 1967. Factors associated with beef carcass cutability. Master's Thesis, Texas A & M University.

Barton, R. A. 1967. The relation between live animal conformation and the carcasses of cattle. Anim. Breed Abstr. 35:1.

Bell, F. L. 1966. Hereford vs okie cattle on the hoof and on the hook. Proc. Univ. of California Feeder's Day. Jan. 1966.

Berg, R. T., and R. M. Butterfield. 1966. Muscle: bone ratio and fat percentages as measures of beef carcass composition. J. Animal Prod. 8:1.

Brackelsberg, Paul O. 1966. Live probes and conventional techniques for predicting beef carcass composition adjusted for weight differences by regression and ratio. Ph.D. Thesis, Oklahoma State Univ. Stillwater, Oklahoma.

Bradley, N. W., L. V. Cundiff, J. D. Kemp and T. R. Greathouse. 1966. Effects of sex and sire on performance and carcass traits of Hereford and Hereford-Red Poll calves. J. Animal Sci. 25:783.

Branaman, G. A., A. M. Pearson, W. T. Magee, Ruth M. Griswold, and G. A. Brown. 1962. Comparison of the cutability and eatability of beef and dairy cattle. J. Animal Sci. 21:321.

Breidenstein, B. C. 1962. More definitive system is needed to predict retail yield of beef carcasses. National Provisioner Convention Issue. p. 77.

Brungardt, V. H., and R. W. Bray. 1963. Estimate of retail yield of the four major cuts in the beef carcass. J. Animal Sci. 22:177.

Butler, O. D., B. L. Warwick and L. C. Cartwright. 1956. Slaughter and carcass characteristics of shortfed yearling, Hereford and Brahman X Hereford steers. J. Animal Sci. 15:93.

Butler, O. D. 1957. The relation of conformation to carcass traits. J. Animal Sci. 16:227.

Butterfield, R. M., 1963. A study of the musculature of the steer carcass. Ph.D. Thesis. University of Queensland, St. Lucia, Australia.

Callow, E. H. 1948. Comparative studies of meat. The changes in the carcass during growth and fattening, and their relation to the chemical composition of the fatty and muscular tissue. J. Agr. Sci. 38:174.

Callow, E. H. 1961. Comparative studies of meat. VII. A comparison between Hereford, Dairy Shorthorn and Friesian steers on four levels of nutrition. J. Agr. Sci. 56:265.

Callow, E. H. 1962. The relationship between the weight of a tissue in a single joint and the total weight of a tissue in a side of beef. Animal Prod. 4:37.

Carroll, F. D. and W. C. Rollins. 1965. Performance of Charbray and Hereford cattle and crosses between them. Animal Prod. 7:119.

Cobb, E. H., and A. Ovejera. 1965. Predicting yield of trimmed retail cuts in beef carcasses. J. Animal Sci. 24:592 (abstr.).

Cole, J. W., L. E. Orme, and C. M. Kincaid. 1960. Relationship of loin eye area, separable lean of various beef cuts and carcass measurements to total carcass lean in beef. J. Animal Sci. 19:89.

Cole, J. W., C. B. Ramsey, and R. H. Epley. 1962. Simplified method of predicting pounds of lean in beef carcasses. J. Animal Sci. 21:355.

Cole, J. W., C. B. Ramsey, C. S. Hobbs, and R. S. Temple. 1964. Effects of Type and Breed of British, Zebu, and Dairy Cattle on Production, Palatability and Composition. III. Percent wholesale cuts and yield of edible portion as determined by physical and chemical analysis. J. Animal Sci. 23:71.

DuBose, L. E., T. C. Cartwright, and R. J. Cooper. 1967. Predicting steak and roast meat from production and carcass traits. J. Animal Sci. 26:688.

Elliot, Henry, Dale W. Zinn, and Ralph M. Durham. 1961. Streamlined hind-quarter for estimating cutout in beef cattle. J. Animal Sci. 20:905 (abstr.).

Fitzhugh, H. A. Jr., G. T. King, F. A. Orts, Z. L. Carpenter and O. D. Butler. 1965. Methods of predicting the weight of boneless roast and steak meat from easily obtained beef carcass measurements. J. Animal Sci. 24:168.

Goll, Darrell E., E. A. Kline, and L. N. Hazel. 1961a. Influence of beef carcass grade and weight on yield of wholesale cuts and carcass measurements. J. Animal Sci. 20:260.

Goll, Darrell, E., L. N. Hazel, and E. A. Kline. 1961b. Relationship between some beef carcass measurements and yield of wholesale cuts. J. Animal Sci. 20:264.

Gottsch, Harold A., R. A. Merkel, and D. L. Mackintosh. 1961. Relationship of muscle, fat, bone, and some physical measurements to beef carcass cutability. J. Animal Sci. 20:917 (abstr.).

Hankins, O. G. and P. E. Howe. 1946. Estimation of the composition of beef carcasses and cuts. U.S.D.A. Tech Bul. 926.

Henderson, Dean W., D. E. Goll, and E. A. Kline. 1966a. Relationship of muscling and finish measurements from three different groups of beef carcasses with carcass yield. J. Animal Sci. 25:323.

Henderson, Dean W., D. E. Goll and E. A. Kline. 1966b. Measures of carcass yield and tenderness of two muscles in four groups of beef carcasses. J. Animal Sci. 25:329.

Hicks, Barbara J. and L. N. Hazel. 1965. Predicting retail yield of beef carcasses from component parts. J. Animal Sci. 24:863 (abstr.).

Kramer, C. Y. 1956. "Extension of multiple range tests to group means with unequal numbers of replication." Biometrics, 12:307.

Kropf, D. H. and R. L. Graf. 1959. The effect of carcass grade, weight and classification upon boneless beef yield. J. Animal Sci. 18:95.

Martin, Everett L. 1965. Effects of beef carcass conformation on thick and thin meat yields. Master's Thesis, Oklahoma State University.

Martin, Everett L., Lowell E. Walters and J. V. Whiteman, 1966. The association of beef carcass conformation with thick and thin muscle yields. J. Animal Sci. 25:682.

Martin, T. G., M. K. Drake, R. R. Garrigus, T. W. Perry, and W. M. Beeson. 1965. Carcass traits of Hereford and Charolais-Hereford Heifers. J. Animal Sci. 24:866 (abstr.).

McMeekan, C. P. 1941. Growth and development in pig with special reference to carcass quality characters IV. The use of sample joints and carcass measurements as indices of carcass composition of the bacon pig. J. Agr. Sci. 31:1.

Murphey, C. E., D. K. Hallett, W. E. Tyler, and J. C. Pierce, Jr. 1960. Estimating yields of retail cuts from beef carcasses. J. Animal Sci. 19:1240. (abstr.).

Orme, L. E., J. W. Cole, C. M. Kincaid, and R. J. Cooper. 1960. Predicting total carcass lean in mature beef from weights of certain entire muscles. J. Animal Sci. 19:726.

Palmer, A. Z., J. W. Carpenter, R. L. Reddish, C. E. Murphey and D. K. Hallet. 1961. Estimated and actual yields of boneless retail cuts from Brahman crossbred carcasses. J. Animal Sci. 20:919 (abstr.).

Ramsey, C. B., J. W. Cole, and C. S. Hobbs. 1962. Relation of beef carcass grades, proposed yield grades, and fat thickness to separable lean, fat, and bone. J. Animal Sci. 21:193.

Steel, Robert G. and James H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, New York, New York.

Stringer, W. C., H. B. Hedrick and M. A. Alexander. 1965. Effects of conformation on cutability of beef. J. Animal Sci. 24:868 (abstr.).

Tayler, J. C. 1964. The relationship between growth and carcass quality in cattle and sheep. A review. Empire J. Expt. Agric., 32:191.

Topel, D. G., R. A. Merkel and D. L. Mackintosh. 1965. Relationship between certain whole muscles and measures of pork carcass muscling. J. Animal Sci. 24:514.

Tyler, W. E., D. K. Hallett, C. E. Murphey, K. E. Hoke and B. C. Breidenstein. 1964. Effects of variation in conformation on cutability and palatability of beef. J. Animal Sci. 23:864 (abstr.).

VITA

Everett Lawton Martin

Candidate for the Degree of

Doctor of Philosophy

Thesis: ASSOCIATION OF BEEF CARCASS CONFORMATION WITH CARCASS COMPOSITION

Major Field: Food Science

Biographical:

Personal Data: Born in Haworth, Oklahoma, October 2, 1941; son of Ernest L. and Erma Jo Martin; married Gloria Ann Calfee, August 19, 1962; father of one son, Mark Everett Martin and one daughter Erin Elizabeth Martin.

Education: Attended grade school at Haworth, Oklahoma; was graduated from Haworth High School in 1959; received the Bachelor of Science from Oklahoma State University with a major in Animal Husbandry, and a commission in the United States Army, in May, 1963, received the Master of Science degree from Oklahoma State University with a major in Food Science, 1965.

Experience: Raised and worked on a livestock farm in Oklahoma; part time meat cutter, Oklahoma State University Meat Laboratory, 1959-1963; graduate assistant, Animal Science Department, Oklahoma State University, 1963-1968.