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To the Graduate Council:

I am submitting herewith a thesis written by A. Estes Reynolds entitled "Ultrasonic estimates of muscle and fat thickness in live cattle as predictors of carcass yield." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C. B. Ramsey, Major Professor

We have read this thesis and recommend its acceptance:

J. W. Cole, M. R. Johnston

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Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

May 10, 1967

To the Graduate Council:

I am submitting herewith a thesis written by Aaron Estes Reynolds, Jr., entitled "Ultrasonic Estimates of Muscle and Fat Thicknesses in Live Cattle as Predictors of Carcass Retail Yield." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

C B Ramsey
Major Professor

We have read this thesis and recommend its acceptance:

J M Cole

M B Johnston

Accepted for the Council:

Hilton A. Smith
Vice President for
Graduate Studies and Research

ULTRASONIC ESTIMATES OF MUSCLE AND FAT THICKNESSES IN LIVE CATTLE AS PREDICTORS OF CARCASS RETAIL YIELD

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Aaron Estes Reynolds, Jr.

June 1968

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ABSTRACT

The purposes of this study were to determine the relationships between both linear and ultrasonic measurements in 84 live beef steers and carcass composition. Fat thickness over the longissimus dorsi measured ultrasonically was positively related to retail cuts weight but negatively related to retail cuts percent, accounting for about 35 percent of the variance. Biceps femoris muscle depths tended to have higher associations with cutout measures than did longissimus dorsi or infraspinatus muscle depths. Live weight, which was used in all multiple regression equations, generally accounted for a larger amount of the variance in carcass composition than any other single measurement. Estimated round mass (a linear measurement, beginning at the tail, then encircling the leg and continuing to the dorsal midline between the hooks) and live weight were of significant value in predicting round separable muscle weights (R^2=0.58). Live weight and either estimated round mass or biceps femoris muscle depth were the most accurate predictors of round separable muscle weight. Biceps femoris depth and live weight were the most effective estimators of retail cuts weight.

Fat thickness over the *longissimus dorsi* and live weight were the only variables which had a significant effect in predicting percent retail cuts. In conclusion, these predictions of carcass composition were sufficiently accurate and valid for steers, but should not be used on heifers or bulls without further testing.

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CHAPTER I

INTRODUCTION

The need for a simple and accurate method of detecting differences in fatness and muscling of live beef animals has become pronounced with the interest in relating carcass excellence to live animal evaluation. It has been demonstrated that cattle vary in their ability to grow and gain efficiently, but the composition of this gain has not been studied sufficiently. An accurate method is needed to determine the amount of muscle, fat and bone tissue deposited in the live animal. With this information, a more accurate prediction of the retail yield of the carcass could be made and the muscle and fat content of breeding animals could be calculated.

Subcutaneous fat thickness and *longissimus dorsi* area are widely accepted as objective measures of carcass meatiness. However, the relationship between *longissimus dorsi* muscle area and carcass cutout generally has been low on a weight constant basis and this muscle area is difficult to obtain in the live animal. In some instances research has shown that subcutaneous fat thickness and the depth of the *longissimus dorsi* and other muscles accounted for a larger amount of the variance in retail yield than did *longissimus dorsi* area. Depths of fat layers and muscles can be more accurately estimated in the live animal with ultrasonic techniques than areas of muscles.

The purposes of this study were to determine the relationships of various linear measurements and ultrasonic measurements of subcutaneous fat thicknesses and muscle depths in the live animal to yield of round separable muscle and trimmed retail cuts; and to develop equations for predicting carcass composition from measurements on the live animal.

CHAPTER II

EXPERIMENTAL PROCEDURE

I. SOURCE OF DATA

This two-year study included 84 steers. In 1965, 48 Hereford steers were fed and, in 1966, 18 Hereford and 18 Angus Steers were fed. All were purchased in East Tennessee Feeder Calf Sales. They were fed one of three rations--low, intermediate or high energy for 180 and 210 days, respectively, for the two years. Feeding and management practices were explained by Backus (1968). Environmental conditions were considered similar during the feeding trials for both years.

II. LIVE ANIMAL DATA

In an attempt to obtain accurate weights, the steers were weighed on two consecutive days, both initially and before slaughter. A linear measurement, designated as round length, was obtained by measuring from the most prominent projection on the hock (distal extremity of the fibula or lateral malleolus) to a point just anterior to the tail head on the dorsal midline. A point half this distance between the hock and the dorsal midline was marked as the location for measurements of biceps femoris muscle width and depth and thickness of subcutaneous and intermuscular fat. Biceps femoris width was determined by palpating the anterior and posterior boundaries of the muscle, including the ischiatic head, and measuring between these two points.

The Branson Model 12 and Model 52 Sonorays were used to estimate thicknesses of hide, subcutaneous fat, biceps femoris muscle and intermuscular fat depot at each of the following locations on the round. Measurements of all muscle depths were made with the somascope calibrated for fat (calibration standard of Model 12 Sonoray was set equal to 3.3 cm. on the oscilloscope). All measurements were made on the left side of the steers.

Location 1 on the round was at the midpoint of the round length measurement at the center of the main body of the biceps femoris (figures 1 and 2). Location 2, 3 and 4 were 1 inch anterior, 1 inch posterior and 1 inch proximal to location 1, respectively. Twenty-five of the steers in 1965 were measured at all four locations, but depth measurements at only location 1 were made on all 48 steers.

Ultrasonic estimates of hide, subcutaneous fat and

Figure 1. Locations of ultrasonic measurements on the round are marked with the white dots. Location 1 is the center dot. Locations 2, 3 and 4 are 1 inch anterior, 1 inch posterior and 1 inch proximal to the center dot, respectively. The operator is measuring hide, fat and muscle depths at location 1 on the loin with the Model 12 Sonoray.

Figure 2. Locations of the four ultrasonic measurements on the round are shown as they appeared on the carcass.

longissimus dorsi muscle depth were made on the loin at three locations. Locations 1, 2 and 3 were at points one-half the width of the *longissimus dorsi* posterior to the twelfth rib, posterior to the thirteenth rib and 2 inches posterior to the thirteenth rib, respectively (figure 3). In addition, fat thickness was ultrasonically estimated at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end between the twelfth and thirteenth ribs. This location closely approximated that at which fat thickness was routinely measured in the carcass. Depth measurements at locations 1 and 2 on the loin were made on only 25 of the 1965 steers. Location 3 was not measured on any of the 1965 steers, but the additional fat measurement was taken on all 48 animals.

The hide and subcutaneous fat thickness over the *infraspinatus* muscle in the shoulder and the depth of the *infraspinatus* also were ultrasonically estimated. Points of estimation were determined by measuring the distance from the point of the shoulder (lateral condyle of the humerus) to the dorsal midline along the spine of the scapula. Location 1 was half the distance from the point of the shoulder to the dorsal midline at a point 1 inch posterior to the spine of the scapula. Locations 2 and 3 likewise were about 1 inch

Figure 3. The locations at which tissue depths were measured ultrasonically on the loin in the live animal are shown on the carcass. Location 1 is posterior to the twelfth rib, location 2 is posterior to the thirteenth rib and location 3 is 2 inches posterior to location 2.

posterior to the spine of the scapula and were 2 and 4 inches distal to location 1, respectively (figure 4). These depth measurements were not made on the 1965 steers. Each of the locations for ultrasonic estimations of tissue thickness on the round, loin and shoulder are shown on a carcass in figure 5.

In an attempt to estimate the mass of the round, a single linear measurement was taken according to the method of Burgkart and Vőlkl (1964). The measurement was obtained by placing the end of a steel measuring tape against the tail at the pins (tuber ischii) and drawing the tape down and across the outside of the round over the proximal end of the tibia, which was located by palpation. Then, the tape was drawn around the leg and up over the back to a point on the dorsal midline between the hooks (tuber coxae) as shown in figure 6. Duplicate measurements were made. This measurement was taken only on the 1966 steers.

III. CARCASS DATA

<u>Data Obtained at the Packing Plant</u>

A 12-hour shrinkage period without feed or water was allowed for all animals prior to slaughter. The animals then were trucked approximately 10 miles to the East Tennessee

Figure 4. The three sites of ultrasonic measurement of tissue depths on the shoulder were over the infraspinatus muscle.

Figure 5. The 10 sites at which ultrasonic measurements of hide, fat and muscle depths were made on the live animal are shown as they appeared on the carcass.

Figure 6. Round mass was estimated by measuring the distance from the tail at the pins to the dorsal midline between the hooks. The measuring tape encircled the leg and passed over the proximal end of the tibia.

Packing Company at Knoxville for slaughter. Equal numbers were slaughtered from each treatment on consecutive weeks until all steers had been slaughtered. Twelve and 18 animals were slaughtered on consecutive weeks for the two years, respectively.

Each animal was tagged for identification prior to complete removal of the hide. Individual hot carcass weights were recorded after washing and before shrouding. Chilled carcass weights were calculated using a 2.5 percent cooler shrink. Dressing percent was determined by dividing the average of the two live weights taken on consecutive days into the chilled carcass weight. After the carcasses were chilled for 2 days at about $1^{o}C.$, the carcass measurements were taken. Carcass length was measured from the anterior edge of the first rib to the anterior edge of the aitch bone. The left side of each carcass was ribbed between the twelfth and thirteenth ribs, and the outline of the cross section of the longissimus dorsi muscle was traced on acetate paper and measured with a compensating polar planimeter. Subcutaneous fat thickness (hereafter referred to as fat thickness) over the longissimus dorsi muscle was measured directly from the carcass at a point three-fourths the cross sectional length of the longissimus dorsi from the chine end. Carcass grade, conformation grade, maturity score, marbling score and estimated percent kidney, pelvic and heart fat were obtained from a federal grader. The left side of each carcass was purchased and shipped to the University of Tennessee Meat Laboratory for a detailed carcass yield analysis.

Data Obtained at the University of Tennessee Meat Laboratory

The carcasses were held in a 3°C. cooler until approximately 1 week after slaughter. Several linear measurements were made. Rump length was measured from the posterior extremity of the ischium to the anterior extremity of the ilium and the midpoint was marked. Hock to hip length was measured from the distal extremity of the fibula (lateral malleolus) to the midpoint of the rump length measurement. Exterior round length was measured from the break joint (distal extremity of the small tarsal bones) to the midpoint of the rump length. The interior round length was measured from the break joint to the anterior edge of the aitch bone. Loin length was measured from the anterior edge of the aitch bone to a point seven and one-fourth vertebrae anterior to the lumbo-sacral joint.

Wellington's (1953) procedure was used in cutting the carcass into wholesale cuts. The round, loin, rib and chuck were further cut into trimmed, partially boneless retail cuts and weighed. All retail cuts were trimmed, when necessary, to approximately three-eights inch of subcutaneous fat. The sacral vertebrae were removed from the sirloin steaks, and portions of the body of the thoracic vertebrae were removed from the rib cut along with a portion of the ribs. Sections of ribs and sternum were removed from the arm pot roasts and the chine bones were removed from the chuck roasts. These retail cuts on a weight basis will hereafter be referred to as retail cuts weight. The percent of trimmed retail cuts (hereafter called retail cuts percent) was obtained by dividing the total weight of the round, loin, rib and chuck retail cuts by the side weight.

The wholesale round, after being weighed, was trimmed to approximately three-eights inch of subcutaneous fat and weighed again to obtain the trimmed round weight. By taking one-half the live round length measurement and measuring from the distal extremity of the fibula in the carcass, the midpoint of the round was determined. This location was nearly the same as the one at which ultrasonic measurements 1, 2 and 3 were made on the round in the live animal. At this point, the round was cut in half, and a tracing of the cross section of the *biceps femoris* was made on acetate paper and measured with a compensating polar planimeter. Subcutaneous fat, muscle and intermuscular fat depot (hereafter referred to as seam fat) depths were made at the center of the muscle (location 1). Muscle width also was measured at the widest part (figure 7). The hind shank and all of the bones in the rump then were removed. The heel of round roast from the hind shank and all of the remaining parts were weighed for round retail cuts yield. Physical separation of muscle, fat and bone was then performed on the shankless round and these components were weighed. The biceps femoris muscle, including the small portion from the hind shank, was excised and weighed separately. Only that portion of the muscle in the wholesale round was included.

Weights and measurements were taken to the nearest 0.1 lb., 0.1 cm., or 0.01 square centimeter with the exceptions of live weight and hot carcass weight which were taken to the nearest pound.

IV. METHODS OF ANALYSIS

Statistical analyses were performed using the procedures outlined by Snedecor (1956). Simple correlation coefficients were calculated on an overall basis between selected traits. Multiple regression analyses based on the

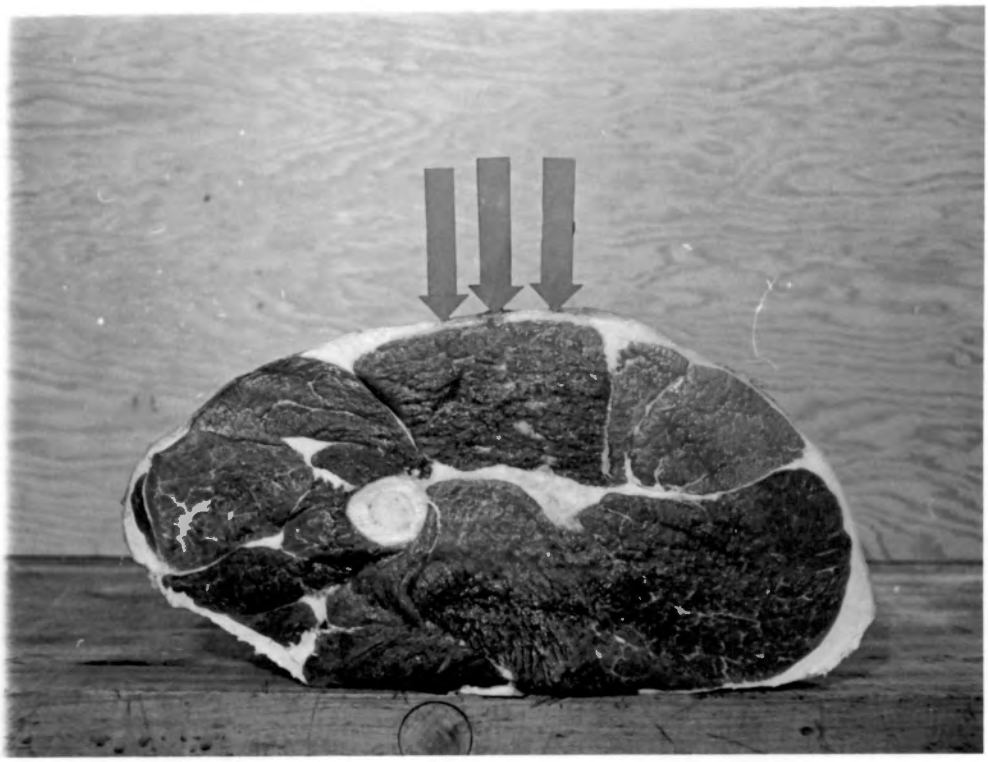

Figure 7. This cross section of a round shows the subcutaneous fat layers, biceps femoris muscle and intermuscular fat depot which were measured ultrasonically in the live animal. The arrows indicate locations 2, 1 and 3, respectively, from left to right.

method of least squares were used to determine the relationship of selected combinations of carcass and live traits to actual round separable muscle and retail cuts yield. Equations for predicting carcass composition were calculated.

Because some of the live measurements were not taken on all the animals during the two years, separate analyses were made on the data from the two years. Combined analyses then were made on those measurements which corresponded for the two years. These analyses will be designated as analysis 1 (48 steers, 1956), analysis 2 (36 steers, 1966) and analysis 3(25 steers of 1965, and 36 steers of 1966).

CHAPTER III

RESULTS AND DISCUSSION

The potential of ultrasonics as a nondestructive and accurate method for estimating muscling and fatness in the live beef animal has been demonstrated in the United States by Stouffer et al. (1961), Hedrick et al. (1962), Ramsey et al. (1965), Moody et al. (1965) and Meyer et al. (1966). Some of the biological and technical factors which affect the accuracy of high-frequency sound techniques are sound wave frequency, positional variation on the animal, air entrapment in the hair, variations in pressure on the transducer, post-mortem tissue changes and handling practices, instrument calibration, interpretation of the pips on the oscilloscope and the physiological state and size of the animal (Temple et al., 1956; Hazel and Kline, 1959; Stouffer et al., 1961; Hedrick et al., 1962; Backus, 1963). Temple et al. (1965) and Watkins et al. (1967) reported variation due to technicians and increased accuracy with experience.

Previous research has dealt with the area of the longissimus dorsi and biceps femoris muscles as predictors of retail yield. Ribeye area has been shown to be of little value in predicting carcass muscle content (Cole *et al.*, 1960). However, Cundiff *et al.* (1967) used the depth of the *longissimus dorsi* muscle to predict the weight and percent of boneless steak and roast meat (BSRM). Davis *et al.* (1964) used the depth of the *biceps femoris* to estimate the weight of trimmed retail cuts. These two studies suggest that further research should be done on the use of muscle depths as estimators of carcass composition. This study was designed to evaluate the effectiveness of muscle and fat thicknesses as estimators of carcass composition. Muscle thicknesses rather than muscle areas were studied because less errors are involved in estimating muscle thicknesses ultrasonically. Some linear live measurements also were considered as possible predictors of carcass composition.

I. MEANS AND STANDARD ERRORS FOR ANALYSES 1 AND 2

Data were collected on 84 Angus and Hereford steers bought in the 1965 and 1966 Tennessee Feeder Calf Sales. The 48 Hereford steers in 1965 ranged in live weight from 635 to 989 lb. In 1966 the 18 Angus and 18 Hereford steers ranged from 688 to 1095 lb. in live weight. The live weight mean for the 1965 steers was 807.7 lb. The 1966 steers, which were on feed 30 days longer, had a live weight mean of 894.5 lb.

The means and standard errors for the live animal traits used in statistical analysis 1 for the 1965 steers are found in table 1. This table includes only those live measurements which were taken on all 48 steers in 1965. The means for fat thickness over the longissimus dorsi (0.84 cm.), fat thickness over the biceps femoris (0.25 cm.) and biceps femoris depth (6.52 cm.) were less than those for the heavier 1966 steers. However, the round length (91.75 cm.), biceps femoris width (21.51 cm.) and biceps femoris width times depth (140.60 $cm.^2$) were greater for the 1965 steers.

The means and standard errors for all live animal traits for the 1966 steers (analysis 2) are shown in table 2. The mean fat thickness over the longissimus dorsi measured ultrasonically between the twelfth and thirteenth ribs was 0.95 cm. The means of the estimated biceps femoris depths ranged from 6.69 to 7.01 cm. at the different locations. The means for fat thickness measurements taken at the various locations on the round had a narrow range (0.33 to 0.38 cm.). These means were much less than those of measurements taken over the loin (range of 0.92 to 1.05 cm.) or shoulder (range of 0.96 to 1.04 cm.).

TABLE 1. MEANS AND STANDARD ERRORS OF LIVE ANIMAL TRAITS AND SIMPLE CORRELATION COEFFICIENTS BETWEEN THESE TRAITS AND ROUND SEPARABLE MUSCLE WEIGHT AND RETAIL CUTS WEIGHT AND UNTRIMMED ROUND WEIGHT - ANALYSIS 1

			r		
Item	Mean	Standard error	Untrimmed round weight	Round separable muscle weight	Retail cuts weight
Live weight, lb.	807.6	13.8	0.94**	0.84**	0.96**
Round length, cm.	91.75	0.44	0.81**	0.77**	0.81**
Fat over *longissimus dorsi*, cm.^{2}[a]	0.84	0.06	0.64**	0.50**	0.64**
Biceps femoris - location 1					
Fat thickness, cm.	0.25	0.01	0.55**	0.39**	0.56**
Muscle depth, cm.	6.52	0.07	0.79**	0.74**	0.77**
Muscle width, cm.	21.51	0.17	0.60**	0.60**	0.52**
Width x depth, cm.^{2}	140.60	2.42	0.78**	0.76**	0.73**

**P<.01.

[a]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

TABLE 2. MEANS AND STANDARD ERRORS OF LIVE ANIMAL TRAITS - ANALYSIS 2

Item	Location	Mean	Standard error
Live weight, lb.	..	894.5	14.7
Round length, cm.	..	90.4	0.4
Round mass, cm.	..	176.77	1.21
Fat over *longissimus dorsi*, cm.[a]	..	0.95	0.09
Biceps femoris			
Fat thickness, cm.	1	0.34	0.03
Muscle depth, cm.	1	6.69	0.10
Muscle width, cm.	1	19.34	0.33
Width x depth, $cm.^2$	1	129.46	3.56
Fat thickness, cm.	2	0.35	0.03
Muscle depth, cm.	2	6.52	0.10
Seam fat, cm.	2	1.23	0.08
Fat thickness, cm.	3	0.38	0.03
Muscle depth, cm.	3	6.71	0.10
Seam fat, cm.	3	1.28	0.07
Fat thickness, cm.	4	0.33	0.03
Muscle depth, cm.	4	7.01	0.11
Seam fat, cm.	4	1.01	0.08
Longissimus dorsi			
Fat thickness, cm.	1	1.05	0.08
Muscle depth, cm.	1	5.66	0.07
Fat thickness, cm.	2	0.97	0.07
Muscle depth, cm.	2	5.60	0.08
Fat thickness, cm.	3	0.92	0.08
Muscle depth, cm.	3	5.31	0.11
Infraspinatus			
Fat thickness, cm.	1	0.96	0.07
Muscle depth, cm.	1	3.64	0.08
Fat thickness, cm.	2	1.04	0.09
Muscle depth, cm.	2	4.06	0.09
Fat thickness, cm.	3	1.00	0.10
Muscle depth, cm.	3	5.26	0.11

[a]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

The mean depth of the infraspinatus muscle in the shoulder increased with distance from the dorsal midline. Much less variation was found in means for subcutaneous fat thickness at the three locations over the infraspinatus.

II. SIMPLE CORRELATION COEFFICIENTS BETWEEN LIVE ANIMAL TRAITS AND MEASURES OF CARCASS COMPOSITION FOR ANALYSES 1 AND 2

Simple correlation coefficients between the live animal traits and measures of carcass composition of the 48 steers of 1965 are shown in table 1, page 22 (analysis 1). Live weight was the best indicator of all three composition measures, being associated with 70 to 92 percent of the variance in these measures. Subcutaneous fat thickness over the biceps femoris muscle had the lowest association with two of the three cutout measures. Round length, biceps femoris depth and biceps femoris width times depth were similar in their relationships to composition measures, being associated with from 53 to 66 percent of the variance in the composition measures.

The simple correlation coefficients between selected traits of the 1966 steers are given in table 3. Lower relationships were found between live weight and the two measures

TABLE 3. SIMPLE CORRELATION COEFFICIENTS BETWEEN LIVE ANIMAL TRAITS AND ROUND SEPARABLE MUSCLE WEIGHT, RETAIL CUTS WEIGHT AND RETAIL CUTS PERCENT - ANALYSIS 2

Item	Location	Round separable muscle weight	Retail cuts weight	Retail cuts percent
Live weight	..	0.69**	0.94**	-.57**
Round length	..	0.59**	0.59**	-.17
Round mass	..	0.72**	0.73**	-.23
Fat over *longissimus dorsi*[a]	..	0.32	0.63**	-.57**
Biceps femoris				
Fat thickness	1	0.09	0.32	-.43**
Muscle depth	1	0.56**	0.62**	-.16
Muscle width	1	0.45**	0.53**	-.19
Width x depth	1	0.60**	0.69**	-.22
Fat thickness	2	0.26	0.45**	-.49**
Muscle depth	2	0.46**	0.53**	-.31
Seam fat	2	0.06	0.28	-.46**
Fat thickness	3	-.03	0.23	-.48**
Muscle depth	3	0.61**	0.65**	-.48**
Seam fat	3	0.00	0.34*	-.49**
Fat thickness	4	0.08	0.32	-.45**
Muscle depth	4	0.57**	0.71**	-.47**
Seam fat	4	0.26	0.44**	-.33*
Longissimus dorsi				
Fat thickness	1	0.36*	0.66**	-.58**
Muscle depth	1	0.05	0.25	-.28
Fat thickness	2	0.38*	0.71**	-.69**
Muscle depth	2	-.01	0.16	-.21
Fat thickness	3	0.17	0.51**	-.62**
Muscle depth	3	0.21	0.30	-.40*
Infraspinatus				
Fat thickness	1	0.53**	0.71**	-.47**
Muscle depth	1	0.04	0.28	-.38*
Fat thickness	2	0.54**	0.70**	-.40*
Muscle depth	2	-.12	0.08	-.28
Fat thickness	3	0.47**	0.62**	-.32
Muscle depth	3	-.19	-.30	0.22

*P<.05.

**P<.01.

[a]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

of composition (round separable muscle weight and retail cuts weight) common to both sets of data. Heavier live weights tended to be accompanied by increased round separable muscle weight and retail cuts weight but decreased retail cuts percent.

DuBose et al. (1967) used boneless, closely trimmed BSRM from the round, loin, rib and chuck as a measure of retail yield and found a similar relationship (r=0.85) between live weight and weight of BSRM. Cundiff et al. (1967) found a simple correlation coefficient of 0.93 between live weight and BSRM weight and -.57 between live weight and percent BSRM.

In the present study round length, which was measured from the most prominent projection on the hock to a point just anterior to the tail head on the dorsal midline, was significantly associated with all three measures of composition of the 1965 steers. However, round length accounted for only 3 percent of the variance in retail cuts percent in the 1966 steers. Cundiff et al. (1967), using several linear measurements on the round, found simple correlation coefficients ranging from 0.25 to 0.60 with BSRM weight and a range from -.13 to 0.30 with percent BSRM.

Simple correlation coefficients between estimated study. Ultrasonic measurements of longissimus dorsi depth at the three locations in the present study were associated with 16 percent or less of the variance in actual longissimus dorsi area between the twelfth and thirteenth ribs. These measurements appear to hold little promise for estimating cutout in steers like those used in this study.

Fat thickness over the longissimus dorsi at all locations measured was positively related to retail cuts weight, indicating that the fatter steers tended to have heavier retail cuts weights. Significant ($P<.01$) negative associations were found between fat thickness and retail cuts percent. The positive relationships between measurements of fat over the longissimus dorsi and round separable muscle weight were much lower, ranging from 3 to 14 percent. Round separable muscle contains very little subcutaneous or intermuscular fat and was found by Ramsey et al. (1968) to be an excellent predictor of total carcass muscle ($r=0.89$). On the other hand, partially boneless, closely trimmed retail cuts from the round, loin, rib and chuck tend to give an advantage to the fatter animals because of their greater amount of intermuscular fat which is weighed with the trimmed cuts. Also, many steers in this study had less than three-eights inch of subcutaneous fat. These steers were penalized on retail cuts weight and percent because much more subcutaneous fat was weighed with the retail cuts of the fatter steers. These relationships help explain the lower association between fat thickness and round separable muscle weight in the present study. In addition, there is a confounding of fatness and weight in this study in that the heavier steers were fatter (r=0.67). The positive relationship between fat thickness and retail cuts weight probably was a result of the fatter steers tending to weigh more (r=0.56). Thus, even though the retail cuts were trimmed, the fatter steers tended to produce a greater weight of these cuts than the thinner steers. However, on a percent of side weight basis, the fatter steers tended to produce a lower percent of their side weight as trimmed retail cuts. Therefore, the relationship between fat thickness and retail cuts percent was negative. Brinks _et al_. (1962), Hedrick _et al_. (1965) and Brackelsburg (1967) also found that fat thickness over the loin was a good predictor of retail yield as well as an excellent indicator of carcass fatness.

In analysis 2 (table 3, page 25), significant ($P<.01$) positive correlation coefficients were found between fat thickness over the _infraspinatus_ and round separable muscle weight and retail cuts weight, while significant negative correlations were found between two of the measurements and retail cuts percent. Fat thickness over the infraspinatus was more highly associated with round separable muscle weight than was fat thickness over the longissimus dorsi.

A significant ($P<.05$) negative association was found between the infraspinatus muscle depth at location 1 and retail cuts percent; however, all other coefficients between infraspinatus depth and cutout measures were not statistically significant.

III. COMPARISON OF INDIVIDUAL ULTRASONIC AND LINEAR MEASUREMENTS

To determine the value of the muscle and fat depths taken at each of the locations on the round, loin and chuck, multiple regression analyses were performed using live weight and individual muscle and fat depths as the independent variables. The dependent variables in analysis 1 (1965 steers) were untrimmed round weight, round separable muscle weight and retail cuts weight. In the 1966 data (analysis 2) the dependent variables were round separable muscle weight, retail cuts weight and retail cuts percent. The individual ultrasonic and linear measurements then were compared on the basis of their significant contribution in the equation and their additive effect in the coefficients of multiple determination. Live weight was used as an independent variable in all equations because it consistently accounted for a large amount of the variation in carcass cutout. These results substantiate the reports of several other workers, including Cundiff *et al.* (1967) and DuBose *et al.* (1967).

Linear and Ultrasonic Measurements for Analysis 1

Table 4 shows results of multiple regression analyses performed on data from the 1965 steers. The live measurements listed were the only ones common to all 48 steers. Live weight was associated with 89 percent of the variance in the dependent variable, untrimmed round weight, and made a significant ($P<.01$) contribution to its prediction in all combinations tested. Including live weight and round length in an equation raised the association with untrimmed round weight only 1 percent (R^2=0.90). Further adding of *biceps femoris* depth increased the association to R^2=0.91. However, round length did not make a significant contribution in this combination nor in subsequent ones which included up to six independent variables (R^2=0.92). On a live weight constant basis, width of the *biceps femoris* was as effective in predicting untrimmed round weight as was the ultrasonic estimate

TABLE 4. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH UNTRIMMED ROUND WEIGHT - ANALYSIS 1

r^2 or b	Live weight	Round length	*B. femoris* depth[a]	Fat over *l. dorsi*[b]	Fat over *b. femoris*[a]	Width of *b. femoris*[a]	R^2	Se
r^2	0.89**	0.66**	0.62**	0.41**	0.30**	0.36**	....	....
b	0.051**	0.33*	....	....	....	....	0.90**	1.98
b	0.046**	0.21	2.30**	....	....	....	0.91**	1.85
b	0.048**	0.20	2.26*	-.06	....	....	0.91**	1.86
b	0.049**	0.20	2.27*	-.05	-.17	....	0.91**	1.88
b	0.050**	0.11	1.54	-.08	-.08	0.63*	0.92**	1.81
b	0.050**	....	2.61**	....	....	....	0.91**	1.87
b	0.053**	....	2.54**	-.08	....	....	0.91**	1.88
b	0.053**	....	2.55**	-.07	-.23	....	0.91**	1.89
b	0.053**	....	1.63	-.09	-.11	0.68*	0.92**	1.80
b	0.054**	....	....	....	....	0.92*	0.91**	1.84
b	0.049**	....	1.73*	....	....	0.67*	0.92**	1.77
b	0.052**	....	1.61	-.09	....	0.69*	0.92**	1.78
b	0.050**	....	1.75*	....	-.18	0.66*	0.92**	1.79

*P<.05.

**P<.01.

[a]Depths taken at location 1 on the round were used for these calculations.

[b]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

of biceps femoris depth. Subcutaneous fat thickness over either the longissimus dorsi or biceps femoris did not significantly ($P<.05$) contribute to the prediction of untrimmed round weight in the various combinations of variables tested.

When the same independent variables were used in predicting round separable muscle weight (table 5), only live weight, biceps femoris depth and biceps femoris width made significant contributions in the combinations of variables tested. Live weight alone had less influence on round separable muscle weight ($r^2=0.71$) than on untrimmed round weight ($r^2=0.89$). Live weight and biceps femoris depth in combination were associated with 74 percent of the variance in round muscle. The addition of biceps femoris width increased the coefficient of multiple determination to 0.77, but only live weight and biceps femoris width exerted a statistically significant influence. Measures of subcutaneous fat thickness were of little value in estimating round muscle weight.

When retail cuts weight was the dependent variable (table 6), the only independent variables exerting a significant influence were live weight and biceps femoris depth. These in combination were associated with 93 percent of the variance in retail cuts weight. However, live weight alone was highly related to retail cuts weight ($r^2=0.92$).

TABLE 5. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH ROUND SEPARABLE MUSCLE WEIGHT - ANALYSIS 1

r^2 or b	Live weight	Round length	*B. femoris* depth[a]	Fat over *l. dorsi*[b]	Fat over *b. femoris*[a]	Width of *b. femoris*[a]	R^2	Se
r^2	0.71**	0.59**	0.55**	0.25**	0.15**	0.37**	....	....
b	0.018**	0.25	....	....	....	....	0.74**	1.47
b	0.015**	0.19	1.26	....	....	....	0.76**	1.42
b	0.020**	0.16	1.17	-.13	....	....	0.78**	1.39
b	0.023**	0.14	1.22	-.11	-.57	....	0.79**	1.36
b	0.024**	0.08	0.74	-.12	-.51	0.42	0.81**	1.32
b	0.019**	....	1.53*	....	....	....	0.74**	1.45
b	0.024**	....	1.40*	-.14	....	....	0.76**	1.40
b	0.026**	....	1.42*	-.12	-.62	....	0.78**	1.37
b	0.026**	....	0.80	-.13	-.54	0.46*	0.80**	1.31
b	0.021**	....	....	....	....	0.59**	0.76**	1.41
b	0.018**	....	0.93	....	....	0.46*	0.77**	1.39
b	0.024**	....	0.73	-.16	....	0.50*	0.79	1.33
b	0.022**	....	0.98	....	-.65	0.42	0.79**	1.35

*$P<.05$.

**$P<.01$.

[a]Depths taken at location 1 on the round were used for these calculations.

[b]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

TABLE 6. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH RETAIL CUTS WEIGHT - ANALYSIS 1

r^2 or b	Live weight	Round length	B. femoris depth[a]	Fat over l. dorsi[b]	Fat over b. femoris[a]	Width of b. femoris[a]	R^2	Se
r^2	0.92**	0.66**	0.60**	0.41**	0.31**	0.27**	....	....
b	0.146**	0.69	....	....	....	....	0.92**	4.64
b	0.135**	0.46	4.62*	....	....	....	0.93**	4.43
b	0.145**	0.40	4.42*	-.29	....	....	0.93**	4.41
b	0.149**	0.38	4.48*	-.26	-.60	....	0.93**	4.45
b	0.149**	0.38	4.49*	-.26	-.60	-.01	0.93**	4.50
b	0.144**	....	5.30**	....	....	....	0.93**	4.46
b	0.155**	....	4.99*	-.32	....	....	0.93**	4.42
b	0.157**	....	5.02*	-.29	-.72	....	0.93**	4.45
b	0.157**	....	4.79*	-.29	-.69	0.17	0.93**	4.50
b	0.159**	....	....	....	....	0.87	0.92**	4.73
b	0.144**	....	5.10*	....	....	0.15	0.93**	4.50
b	0.155**	....	4.70*	-.32	....	0.22	0.93**	4.46
b	0.149**	....	5.18*	....	-.94	0.09	0.93**	4.52

*$P < .05$.

**$P < .01$.

[a] Depths taken at location 1 on the round were used for these calculations.

[b] A single fat measurement taken at a point three-fourths the cross sectional length of the longissimus dorsi from the chine end at the twelfth rib.

Depth Measurements Taken on the Round

The 36 steers in 1966 were ultrasonically measured at four locations on the round, four on the loin and three on the shoulder to determine if additional measurements would give more accurate predictions of carcass composition.

Live weight alone accounted for 47 percent of the variance in round separable muscle weight of the 1966 steers (table 7 - analysis 2). The addition of the four biceps femoris depth measurements (separately) increased the accuracy in predicting round separable muscle by 4, 2, 7 and 4 percent, respectively. Only location 3 had a significant ($P<.05$) effect on a live weight constant basis. Live weight plus all four of the depth measurements accounted for 56 percent of the variance in round separable muscle weight, but only live weight had a significant ($P<.05$) effect in the equation. Location 2 had a negative effect.

On a live weight constant basis, only the measurement of fat thickness over the biceps femoris at location 3 had a significant effect in predicting round separable muscle weight. Live weight and this fat measurement were slightly more effective in predicting round separable muscle weight (R^2=0.56) than were live weight and the muscle depth at the same location (R^2=0.54). Each of the four subcutaneous fat

TABLE 7. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE WEIGHT AND ROUND DEPTH MEASUREMENTS WITH ROUND SEPARABLE MUSCLE WEIGHT - ANALYSIS 2

r^2 or b	Live weight	Location 1	2	3	4	R^2	Se
			Biceps femoris depth				
r^2	0.47**	0.31**	0.21**	0.37**	0.33**	....	....
b	0.017**	1.09	....	....	....	0.51**	2.00
b	0.019**	....	0.69	....	....	0.49**	2.04
b	0.016**	....	....	1.44*	....	0.54**	1.94
b	0.017**	....	....	....	0.96	0.51**	2.01
b	0.014*	1.12	-.92	1.39	0.14	0.56**	1.99
			Fat over biceps femoris				
r^2	0.47**	0.01	0.07	0.00	0.01	....	....
b	0.024**	-3.50	....	....	....	0.51**	2.00
b	0.023**	....	-.90	....	....	0.48**	2.07
b	0.025**	....	....	-5.59*	....	0.56**	1.91
b	0.024**	....	....	....	-4.26	0.52**	1.99
b	0.024**	-1.49	2.12	-4.99	-.60	0.56**	1.98
			Seam fat in the round				
r^2	0.47**	....	0.00	0.00	0.07	....	....
b	0.023**	....	-.90	....	....	0.50**	2.03
b	0.025**	....	....	-1.97*	....	0.54**	1.94
b	0.022**	....	....	....	-.09	0.47**	2.08
b	0.024**	....	-.63	-2.13	1.02	0.56**	1.96

*P<.05.

**P<.01.

measurements had a negative association with round separable muscle on a weight constant basis. Fat measurements at all four locations combined were no more effective than location 3 in predicting round separable muscle weight.

Similar results were found using live weight and seam fat between the biceps femoris and semimembranosus muscles to predict round separable muscle weight. Seam fat was not measured at location 1. Live weight and all three seam fat measurements combined accounted for 9 percent more of the variance in round separable muscle weight (R^2=0.56) than did live weight alone. Thus, the biceps femoris muscle depth, subcutaneous fat thickness and seam fat measured at location 3 were the most accurate predictors of round muscle yield when live weight was included in the models. Muscle depth, subcutaneous fat thickness and seam fat depth at all locations combined were only slightly more effective in predicting round muscle than was location 3. Measurements taken at location 2 were the least effective predictors of the four locations.

As shown in table 8 (analysis 2), live weight accounted for 89 percent of the variation in retail cuts weight. Depth of the biceps femoris muscle taken at location 3 and 4 on the round had a significant effect when included with live

TABLE 8. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE WEIGHT AND ROUND DEPTH MEASUREMENTS WITH RETAIL CUTS WEIGHT - ANALYSIS 2

r^2 or b	Live weight	Location 1	2	3	4	R^2	Se
			Biceps femoris depth				
r^2	0.89**	0.38**	0.28**	0.43**	0.50**	....	....
b	0.132**	2.37	....	....	....	0.90**	4.30
b	0.136**	....	1.62	....	....	0.90**	4.39
b	0.128**	....	....	3.21*	....	0.91**	4.17
b	0.123**	....	....	....	3.77**	0.91**	3.98
b	0.120**	1.22	-2.18	2.00	3.32	0.92**	4.06
			Fat over *biceps femoris*				
r^2	0.89**	0.10	0.20**	0.05	0.10	....	....
b	0.145**	-4.77	....	....	....	0.89**	4.42
b	0.140**	....	2.05	....	....	0.89**	4.47
b	0.148**	....	....	-10.48*	....	0.90**	4.20
b	0.146**	....	....	....	-6.20	0.90**	4.39
b	0.144**	-3.81	8.53	-11.18	-.27	0.91**	4.27
			Seam fat in the round				
r^2	0.89**	....	0.08	0.11*	0.20**	....	....
b	0.142**	....	-.12	....	....	0.89**	4.48
b	0.141**	....	....	0.35	....	0.89**	4.48
b	0.137**	....	....	....	2.28	0.90**	4.35
b	0.138**	....	-1.76	-.39	3.43	0.90**	4.42

*P<.05.

**P<.01.

weight in the models. However, these combinations accounted for only 2 percent more of the variance in retail cuts weight than did live weight alone. A model including live weight and all four depth measurements accounted for 92 percent of the variance in retail cuts weight, but only live weight had a significant ($P<.01$) effect.

Live weight and thickness of the subcutaneous fat over the biceps femoris at locations 1 and 2 did not account for any more of the variance in retail cuts weight than did live weight alone. Combining live weight and the fat thickness measurement at either location 3 or 4 raised the association 1 percent ($R^2=0.91$). Similar relationships with retail cuts weight were found when live weight and seam fat at the various locations were combined. Neither of the three seam fat measurements singly, nor all three combined, made a significant contribution in predicting cutout when live weight was in the model. These results show that biceps femoris muscle depth, fat thickness and seam fat depth in the round at locations 3 and 4 accounted for a larger amount of the variance in retail cuts weight than those taken at the other two locations. Depth of the biceps femoris was a slightly more accurate predictor of retail cuts weight than either subcuatenous fat over the biceps femoris or seam fat in the round.

Only 32 percent of the variance in retail cuts percent was associated with live weight (table 9 - analysis 2). The addition of biceps femoris depths to the equations accounted for 0 to 4 percent more of the variation in retail cuts percent. When depths taken at all four locations were used in combination with live weight in an equation, only live weight and the depth at location 1 had a positive and significant ($P<.01$) effect in predicting retail cuts percent (R^2=0.52).

Combinations of live weight and fat thickness over the biceps femoris at the four locations accounted for 5 to 9 percent more of the variance in retail cuts percent than live weight alone. However, the only significant contribution was made by the measurement at location 3 (R^2=0.41). When live weight and all four fat thickness measurements were used in combination, a coefficient of multiple determination of 0.45 was achieved. Only live weight had a significant effect, however.

On a live weight constant basis, a significant effect in estimating retail cuts percent was found for seam fat in the round ultrasonically estimated at locations 2 and 3. Location 3 showed a slightly larger coefficient (R^2=0.42) than did location 2 (R^2=0.41). In combination, live weight and the three seam fat measurements accounted for 14 percent

TABLE 9. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE WEIGHT AND ROUND DEPTH MEASUREMENTS WITH RETAIL CUTS PERCENT - ANALYSIS 2

r^2 or b	Live weight	Location 1	2	3	4	R^2	Se
			Biceps femoris depth				
r^2	0.32**	0.03	0.10	0.23**	0.22**	....	....
b	-.015**	0.74	....	....	....	0.36**	1.59
b	-.012**	....	-.11	....	....	0.32**	1.63
b	-.009*	....	....	-.73	....	0.36**	1.59
b	-.010*	....	....	....	-.54	0.34**	1.61
b	-.011**	2.33**	-.85	-.72	-.97	0.52**	1.43
			Fat over biceps femoris				
r^2	0.32**	0.18**	0.24**	0.23**	0.20**	....	....
b	-.010**	-2.81	....	....	....	0.37**	1.58
b	-.010**	....	-3.18	....	....	0.39**	1.55
b	-.010**	....	....	-4.01*	....	0.41**	1.52
b	-.010**	....	....	....	-3.32	0.38**	1.56
b	-.009**	1.51	-3.30	-4.60	1.25	0.45**	1.55
			Seam fat in the round				
r^2	0.32**	....	0.21**	0.24**	0.11*	....	....
b	-.010**	....	-1.21*	....	....	0.41**	1.52
b	-.010**	....	....	-1.65*	....	0.42**	1.51
b	-.011**	....	....	....	-.49	0.33**	1.62
b	-.010**	....	-1.00	-1.31	0.55	0.46**	1.50

*P<.05.

**P<.01.

more of the variance in retail cuts percent than live weight alone.

From the above results, it can be concluded that biceps femoris muscle depth, fat thickness over the biceps femoris and seam fat in the round measured at location 3 were the most accurate predictors of round separable muscle weight and retail cuts percent, when each was included in an equation with live weight. However, on a live weight constant basis, none of the measurements on the round accounted for more than an additional 2 percent of the variance in retail cuts weight than live weight alone.

Tissue Depth Measurements Taken on the Loin and Shoulder

As previously mentioned, the longissimus dorsi muscle is not a good indicator of carcass muscling. DuBose et al. (1967) found that longissimus dorsi area was not as useful in predicting BSRM as was kidney fat or fat over the longissimus dorsi. Fitzhugh et al. (1965) found similar results. Ramsey et al. (1962) reported that fat thickness over the longissimus dorsi was superior to both carcass grade and yield grade in predicting percent separable lean and fat in the carcass.

In the present study, on a live weight constant basis ultrasonic estimates of *longissimus dorsi* depth at all three locations separately or in combination were of little or no practical value in predicting round separable muscle weight (table 10), retail cuts weight (table 11) or retail cuts percent (table 12). Likewise, on a live weight constant basis none of the four ultrasonic measurements of subcutaneous fat thickness over the *longissimus dorsi* made a significant contribution in the equations predicting round separable muscle weight or retail cuts weight. However, measurements at locations 1, 2 and 3, when included in models with live weight, had a significant effect in predicting retail cuts percent (table 12). Location 2 (posterior to the thirteenth rib) was of the most value, accounting for 49 percent of the variance in retail cuts percent when included in an equation with live weight. The lack of a significant effect by the fat thickness measurements in the present study may be due to the fact that the animals were fed three different rations - low, intermediate and high energy levels. Rations with higher energy produced fatter, growthier and heavier steers. Thus there may be a confounding of weight and fat thickness of the steers.

On a live weight constant basis, *infraspinatus* muscle depth at location 2 on the shoulder had a significant ($P<.05$)

TABLE 10. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH ROUND SEPARABLE MUSCLE WEIGHT - ANALYSIS 2

r^2 or b	Live weight	Location 1	2	3	4[a]	R^2	Se
			Longissimus dorsi depth				
r^2	0.47**	0.00	0.00	0.04	....	....	....
b	0.022**	-.61	....	....	....	0.48**	2.06
b	0.022**	....	-.73	....	....	0.49**	2.05
b	0.022**	....	....	-.04	....	0.47**	2.08
b	0.022**	-.53	-.70	0.35	....	0.50**	2.10
			Fat over longissimus dorsi				
r^2	0.47**	0.13	0.15	0.03	0.10	....	....
b	0.025**	-1.04	....	....	....	0.49**	2.05
b	0.026**	....	-1.21	....	....	0.49**	2.03
b	0.026**	....	....	-1.47	....	0.52**	1.98
b	0.027**	....	....	....	-1.39	0.51**	2.00
b	0.026**	1.27	....	-1.73	-.90	0.54**	2.01
			Infraspinatus depth				
r^2	0.47**	0.00	0.01	0.04	....	....	....
b	0.023**	-.86	....	....	....	0.50**	2.03
b	0.023**	....	-1.32*	....	....	0.54**	1.94
b	0.022**	....	....	-.12	....	0.47**	2.08
b	0.026**	-.10	-1.80*	0.80	....	0.56**	1.95
			Fat over infraspinatus				
r^2	0.47**	0.28**	0.29**	0.22**	....	....	....
b	0.019**	0.80	....	....	....	0.48**	2.06
b	0.018**	....	1.17	....	....	0.50**	2.02
b	0.019**	....	....	0.63	....	0.49**	2.05
b	0.018**	-.05	1.73	-.53	....	0.51**	2.07

*P<.05.

**P<.01.

[a]A single fat measurement taken at a point three-fourths the cross sectional length of the longissimus dorsi from the chine end at the twelfth rib.

TABLE 11. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH RETAIL CUTS WEIGHT - ANALYSIS 2

r^2 or b	Live weight	Location				R^2	Se
		1	2	3	4[a]		
		Longissimus dorsi depth					
r^2	0.89**	0.06	0.03	0.09	....	....	....
b	0.140**	1.61	....	....	....	0.89**	4.39
b	0.141**	....	0.12	....	....	0.89**	4.48
b	0.141**	....	....	0.03	....	0.89**	4.48
b	0.141**	2.32	-.48	-.63	....	0.90**	4.54
		Fat over longissimus dorsi					
r^2	0.89**	0.44**	0.51**	0.26**	0.40**	....	....
b	0.135**	1.80	....	....	....	0.89**	4.43
b	0.130**	....	3.30	....	....	0.90**	4.47
b	0.141**	....	....	0.24	....	0.89**	4.48
b	0.142**	....	....	....	-.01	0.89**	4.48
b	0.137**	4.91	....	-1.76	-1.88	0.90**	4.49
		Infraspinatus depth					
r^2	0.89**	0.08	0.01	0.09	....	....	....
b	0.140**	0.73	....	....	....	0.89**	4.47
b	0.145**	....	-2.63	....	....	0.90**	4.23
b	0.139**	....	....	-1.53	....	0.90**	4.37
b	0.141**	2.96	-3.82*	-.21	....	0.91**	4.15
		Fat over infraspinatus					
r^2	0.89**	0.50**	0.49**	0.39**	....	....	....
b	0.127**	4.20	....	....	....	0.90**	4.24
b	0.122**	....	5.97**	....	....	0.93**	3.67
b	0.129**	....	....	3.30*	....	0.91**	4.14
b	0.123**	-.13	8.51**	-2.51	....	0.93**	3.70

*P<.05.

**P<.01.

[a]A single fat measurement taken three-fourths the cross sectional length of the longissimus dorsi from the chine end at the twelfth rib.

TABLE 12. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH RETAIL CUTS PERCENT - ANALYSIS 2

r^2 or b	Live weight	Location 1	2	3	4[a]	R^2	Se
		Longissimus dorsi depth					
r^2	0.32**	0.08	0.04	0.16*	....	....	....
b	-.012**	-.70	....	....	....	0.35**	1.60
b	-.012**	....	-.47	....	....	0.34**	1.62
b	-.010**	....	....	-.73	....	0.38**	1.56
b	-.011**	-.20	-.05	-.64	....	0.38**	1.61
		Fat over *longissimus dorsi*					
r^2	0.32**	0.34**	0.47**	0.38**	0.33**	....	....
b	-.007	-1.48*	....	....	....	0.40**	1.54
b	-.004	....	-2.52**	....	....	0.49**	1.42
b	-.007*	....	....	-1.71**	....	0.46**	1.46
b	-.007	....	....	....	-1.29	0.39**	1.55
b	-.007	0.31	....	-1.87	-.06	0.46**	1.50
		Infraspinatus depth					
r^2	0.32**	0.15*	0.08	0.05	....	....	....
b	-.011**	-.95	....	....	....	0.38**	1.56
b	-.012**	....	-.62	....	....	0.35**	1.59
b	-.012**	....	....	0.26	....	0.33**	1.63
b	-.009*	-.75	-.83	0.82	....	0.43**	1.54
		Fat over *infraspinatus*					
r^2	0.32**	0.22**	0.16*	0.10	....	....	....
b	-.010*	-.71	....	....	....	0.34**	1.60
b	-.011**	....	-.40	....	....	0.33**	1.63
b	-.012**	....	....	-.03	....	0.32**	1.63
b	-.010*	-.90	-.88	0.94	....	0.36**	1.64

*$P<.05$.

**$P<.01$.

[a]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

negative effect in predicting round separable muscle weight when used singly or in combination with locations 1 and 3 (table 10, page 46). Thus, steers with greater depth of the infraspinatus muscle tended to have less round separable muscle. Also, infraspinatus depth at location 2 significantly contributed to the prediction of retail cuts weight when live weight and the depth measurements at locations 1 and 3 were in the equation (table 11, page 47). Again the effect was negative. On a weight constant basis, none of the measurements of infraspinatus depth significantly aided in the estimation of retail cuts percent (table 12, page 48).

Fat thickness over the infraspinatus muscle at any one of the locations or at all three combined, when included in equations with live weight, did not significantly aid in the estimation of round separable muscle weight (table 10) or retail cuts percent (table 12). However, this measurement significantly and positively contributed to the prediction of retail cuts weight at locations 2 and 3 (table 11). Live weight and the three fat thickness measurements combined did not improve the association with retail cuts weight over that of live weight and the measurement at location 2 (R^2=0.93). The positive effect of fat thickness over the shoulder may be explained by the weight and fatness confounding. The with live weight alone and in some combinations with live weight and ultrasonic measurements, had a significant positive effect in predicting round separable muscle weight. Forty-seven percent of the variance in round separable muscle weight was accounted for by live weight which had a signifi- effect in predicting round muscle weight in all except two models. A combination of live weight and round mass accounted for 11 percent more of the variance in round muscle weight than did live weight alone (R^2=0.58). The addition of ultrasonic measurements singly or in various combinations did not significantly increase the coefficients of multiple determination. The combination of live weight and round mass accounted for more of the variance in round separable muscle weight than did any combination of live weight and ultrasonic measurement of tissue depths tested in analysis 2.

Table 14 shows that estimated round mass did not have a significant effect in predicting retail cuts weight in any combination with live weight and ultrasonic measurements tested. Live weight had a significant ($P<.01$) effect in all equations. _Biceps femoris_ muscle depth had a significant effect in all of the equations in which it was used. A coefficient of multiple determination of 0.90 was obtained when live weight and estimated round mass were used in the equation, but addition of the biceps femoris muscle depth gave a coefficient of 0.92. Fat over the longissimus dorsi, fat over the biceps femoris and seam fat in the round did not have a significant effect in predicting retail cuts weight in any combination.

Live weight accounted for only 32 percent of the variance in retail cuts percent, but it had a significant effect in all combinations of variables shown in table 15. However, estimated round mass exerted a significant ($P<.05$) effect in only two of the combinations tested, and none of the ultrasonic measurements used had a significant influence on a live weight and round mass constant basis. The largest coefficient of multiple determination (R^2=0.47) was achieved when all of the variables, with the exception of seam fat in the round and fat over the longissimus dorsi, were used in the equation.

From these results it can be concluded that, in combination with live weight, estimated round mass is the most accurate predictor of round separable muscle weight (R^2=0.58), and biceps femoris muscle depth is the best predictor of retail cuts weight (R^2=0.91). Neither measurement, on a live weight constant basis, significantly contributed to the prediction of retail cuts percent.

TABLE 15. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE WEIGHT, ROUND MASS AND DEPTH MEASUREMENTS WITH RETAIL CUTS PERCENT - ANALYSIS 2

r^2 or b	Live weight	Round mass	B. femoris depth[a]	Fat over l. dorsi[b]	Fat over b. femoris[a]	Seam fat in round[a]	R^2	Se
r^2	0.32**	0.05	0.22**	0.33**	0.20**	0.11*	....	....
b	-.018**	0.09	....	....	....	....	0.38**	1.56
b	-.015**	0.12*	-.87	....	....	....	0.43**	1.52
b	-.011*	0.10	-.73	-.78	....	....	0.45**	1.51
b	-.011*	0.10	-.80	-.33	-2.15	....	0.47**	1.51
b	-.012*	0.10	-.85	....	-2.63	....	0.47**	1.49
b	-.012*	0.07	....	-1.02	....	....	0.42**	1.54
b	-.015**	0.07	....	....	-2.72	....	0.42**	1.54
b	-.012*	0.07	....	-.69	-1.72	....	0.43**	1.55
b	-.015**	0.12*	-.84	....	....	-.21	0.44**	1.54
b	-.014**	0.07	....	....	-2.54	-.21	0.42**	1.56

*$P<.05$.

**$P<.01$.

[a] Depths taken at location 4 on the round were used for these calculations.

[b] A single fat measurement taken at a point three-fourths the cross sectional length of the longissimus dorsi from the chine end at the twelfth rib.

Previous research has shown that linear measurements used in combination with ultrasonic measurements may be used efficaciously as predictors of carcass yield. Cundiff et al. (1967) reported a coefficient of multiple determination of 0.92 using live weight, ultrasonic longissimus dorsi depth, hip to point of shoulder length, a ratio of length of rump to length from hip to shoulder point and subjective muscling score in predicting pounds of BSRM. However, they reported that live weight alone accounted for more than 86 percent of the variation. In predicting percent of BSRM, they found a much lower association (R^2=0.58) using final live weight, average fat thickness over the longissimus dorsi, longissimus dorsi depth measured ultrasonically, round length and the ratio of length of rump to length from hip to shoulder point.

Table 16 shows results of multiple regression analyses containing those live measurements from each general anatomical location which were considered most useful in predicting carcass cutout. In predicting round separable muscle weight, retail cuts weight and retail cuts percent, infraspinatus depth was not significant in any of the tested combinations with live weight, fat over the infraspinatus, biceps femoris muscle depth, fat over the biceps femoris or fat over the longissimus dorsi. Live weight alone accounted for 47 percent

TABLE 16. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH ROUND SEPARABLE MUSCLE WEIGHT, RETAIL CUTS WEIGHT AND RETAIL CUTS PERCENT - ANALYSIS 2

Dependent variable	r^2 or b	Live weight	Infra-spinatus depth[a]	Fat over infra-spinatus[a]	B. femoris depth[b]	Fat over b. femoris[b]	Fat over l. dorsi[c]	R^2	Se
Round	r^2	0.47**	0.01	0.29**	0.33**	0.01	0.10	....	....
separable	b	0.022**	-1.16	0.44	....	....	....	0.54**	1.96
muscle	b	0.015**	....	0.91	0.77	....	....	0.53**	2.01
weight	b	0.027**	-1.16	....	....	-2.77	-.56	0.58**	1.92
	b	0.022**	-.64	0.82	0.80	....	-1.58	0.60**	1.90
Retail	r^2	0.89**	0.01	0.49**	0.50**	0.10	0.40**	....	....
cuts	b	0.123**	-.52	5.64**	....	....	....	0.93**	3.46
weight	b	0.112**	....	5.06**	2.70*	....	....	0.94**	3.44
	b	0.141**	-2.61	....	....	-8.35	2.28	0.91**	4.23
	b	0.116**	0.37	5.65**	2.87*	...	-2.00	0.94**	3.42
Retail	r^2	0.32**	0.08	0.16*	0.22**	0.20**	0.33**	....	....
cuts	b	-.008	-1.00	-1.04	....	....	....	0.39**	1.56
percent	b	-.009*	....	-.23	-.49	....	....	0.34**	1.63
	b	-.007	-.46	....	....	-1.80	-.82	0.42**	1.56
	b	-.003	-.86	-.59	-.53	....	-.84	0.44**	1.56

*P<.05.

**P<.01.

[a]Depths taken at location 2 on the shoulder were used for these calculations.

[b]Depths taken at location 4 on the round were used for these calculations.

[c]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

of the variance in round separable muscle weight, 89 percent in retail cuts weight and 32 percent in retail cuts percent. The largest coefficient of multiple determination (R^2=0.60) in predicting round separable muscle weight was achieved by using live weight, infraspinatus muscle depth, fat over the infraspinatus, biceps femoris depth and fat over the longissimus dorsi. However, only live weight made a significant contribution.

Fat over the infraspinatus was highly significant in all combinations of variables used in predicting retail cuts weight. However, thicker fat was associated with heavier retail cuts. The biceps femoris depth also was significant ($P<.05$) in estimating retail cuts weight in the equations in which it was used. A coefficient of multiple determination of 0.94 was achieved by using live weight, fat over the infraspinatus and biceps femoris depth in the equation, and all three made a significant contribution. None of the other measurements but live weight showed significance in predicting retail cuts weight.

The largest coefficient of multiple determination (R^2=0.44) was obtained in predicting retail cuts percent when all measurements except fat thickness over the biceps femoris were used in the equation. However, all of the measurements failed to show a significant effect in estimating retail cuts percent with the exception of live weight, which was significant when used in combination with fat over the infraspinatus and biceps femoris depth (R^2=0.39). These results show that live weight, fat over the infraspinatus and biceps femoris muscle depth were significant in predicting retail cuts weight. Only live weight had a significant effect in predicting round separable muscle weight and retail cuts percent.

V. MEANS, STANDARD ERRORS AND SIMPLE CORRELATION COEFFICIENTS OF LIVE ANIMAL TRAITS FOR ANALYSIS 3

Sixty-one steers, 25 from 1965 and all 36 from 1966, were used in analysis 3. All 48 steers from 1965 were not used because live measurements at every location were not taken on all steers. The means and standard errors of live measurements which corresponded for the 2 years are found in table 17. At the start of the feeding trials, the mean live weight was 853.7 lb. The mean round length for the two years combined was 90.93 ± .38 cm. The fat thickness over the biceps femoris measured at the different locations gave means ranging from 0.30 to 0.34 cm. The means for biceps femoris muscle depth ranged from 6.45 to 6.83 cm. at the four locations with location 4 having the greatest average depth.

TABLE 17. MEANS AND STANDARD ERRORS OF LIVE ANIMAL TRAITS - ANALYSIS 3

Item	Location	Mean	Standard error
On feed weight, lb.	..	497.7	4.6
Final live weight, lb.	..	853.7	14.7
Round length, cm.	..	90.93	0.38
Fat over *longissimus dorsi*, cm.[a]	..	0.92	0.06
Biceps femoris			
Fat thickness, cm.	1	0.30	0.02
Muscle depth, cm.	1	6.65	0.07
Muscle width, cm.	1	20.32	0.27
Width x depth, $cm.^2$	1	135.31	2.71
Fat thickness, cm.	2	0.32	0.02
Muscle depth, cm.	2	6.45	0.08
Seam fat, cm.	2	1.15	0.06
Fat thickness, cm.	3	0.34	0.02
Muscle depth, cm.	3	6.61	0.08
Seam fat, cm.	3	1.22	0.06
Fat thickness, cm.	4	0.32	0.02
Muscle depth, cm.	4	6.83	0.09
Seam fat, cm.	4	0.99	0.06
Longissimus dorsi			
Fat thickness, cm.	1	0.98	0.06
Muscle depth, cm.	1	5.54	0.07
Fat thickness, cm.	2	0.90	0.05
Muscle depth, cm.	2	5.43	0.08

[a]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

Seam fat in the round ranged from 0.99 to 1.22 cm. Means for fat thickness over the longissimus dorsi at the two locations varied little (0.90 to 0.98 cm.). The means for longissimus dorsi depth at locations 1 and 2 were 5.54 and 5.43 cm., respectively.

The associations between on feed weight and the yield indicators were low (table 18 - analysis 3), but the relationships found between the final live weight and round separable muscle weight, retail cuts weight and retail cuts percent were much higher (r=0.65, r=0.89 and r=-.66, respectively). Round length was significantly related to round muscle weight and retail cuts weight, but the association with retail cuts percent was low and negative. The simple correlation coefficients between fat thickness over the biceps femoris at the four locations on the round and round separable muscle weight were low and nonsignificant. However, fat thickness over the biceps femoris was positively and significantly related to retail cuts weight. Negative and much higher associations were found with retail cuts percent.

The biceps femoris muscle depth was significantly correlated with the three carcass yield indicators, but the coefficients with round separable muscle weight and retail cuts weight were much higher than those with retail cuts percent.

TABLE 18. SIMPLE CORRELATION COEFFICIENTS BETWEEN LIVE ANIMAL TRAITS AND ROUND SEPARABLE MUSCLE WEIGHT, RETAIL CUTS WEIGHT AND RETAIL CUTS PERCENT - ANALYSIS 3

Item	Location	Round separable muscle weight	Retail cuts weight	Retail cuts percent
On feed weight	..	0.31*	0.41**	-.24
Final live weight	..	0.65**	0.89**	-.66**
Round length	..	0.61**	0.63**	-.19
Fat over _longissimus dorsi_[a]	..	0.36**	0.61**	-.59**
Biceps femoris				
Fat thickness	1	0.12	0.36**	-.52**
Muscle depth	1	0.62**	0.65**	-.26*
Muscle width	1	0.40**	0.29*	0.10
Width x depth	1	0.61**	0.56**	-.08
Fat thickness	2	0.19	0.40**	-.52**
Muscle depth	2	0.50**	0.61**	-.34**
Seam fat	2	0.20	0.33**	-.46**
Fat thickness	3	0.04	0.28*	-.52**
Muscle depth	3	0.56**	0.66**	-.38**
Seam fat	3	0.19	0.34**	-.50**
Fat thickness	4	0.16	0.39**	-.48**
Muscle depth	4	0.61**	0.74**	-.49**
Seam fat	4	0.25*	0.38**	-.28*
Longissimus dorsi				
Fat thickness	1	0.35**	0.57**	-.58**
Muscle depth	1	0.31*	0.56**	-.38**
Fat thickness	2	0.40**	0.63**	-.72**
Muscle depth	2	0.27*	0.45**	-.30*

*$P < .05$.

**$P < .01$.

[a]A single fat measurement taken at a point three-fourths the cross sectional length of the _longissimus dorsi_ from the chine end at the twelfth rib.

Width of the biceps femoris gave significant but low relationships with round separable muscle weight and retail cuts weight. Width of the biceps femoris was not significantly related to retail cuts percent.

Low but significant associations were found between fat thickness over the longissimus dorsi measured at the various locations and round separable muscle weight. Fat thickness was highly associated with both retail cuts weight and retail cuts percent. The longissimus dorsi muscle depth at locations 1 and 2 had significant but low correlations with round separable muscle weight and retail cuts percent (r=0.27 and -.30, respectively). However, a higher relationship (r=0.45) was found with retail cuts weight. Thus, excluding live weight, biceps femoris muscle depth was the best predictor of round separable muscle weight and retail cuts weight, while fat thickness over the longissimus dorsi was the best predictor of retail cuts percent.

VI. MULTIPLE REGRESSION ANALYSES USING ULTRASONIC MUSCLE AND FAT DEPTH MEASUREMENTS--ANALYSIS 3

The locations selected for use in the multiple regression analyses were chosen for their ease of location and measurement as well as for the magnitude of their simple correlation coefficients with carcass yield measures. Live weight was used in all equations in combination with the other measurements because of the importance of weight in predicting carcass yield.

Live weight accounted for 42 percent of the variance in round separable muscle weight and made a highly significant contribution in all equations (table 19 - analysis 3). Biceps femoris muscle depth had a significant ($P<.05$) positive effect in all equations in which it was used. Live weight and biceps femoris depth accounted for 4 percent more of the variance in round separable muscle weight (R^2=0.46) than did live weight alone. The addition of fat thickness over the longissimus dorsi did not increase the coefficient of multiple determination, but adding fat over the biceps femoris and seam fat in the round to the equations increased the coefficients to R^2=0.47 and 0.48, respectively. The depth of the longissimus dorsi muscle accounted for an additional 1 percent of the variation when added to the equation. Fat over the longissimus dorsi, fat over the biceps femoris, seam fat in the round and longissimus dorsi muscle depth did not show a significant effect in predicting round separable muscle weight in any combination tried.

The effect of live weight was significant ($P<.01$) in

TABLE 19. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH ROUND SEPARABLE MUSCLE WEIGHT - ANALYSIS 3

r^2 or b	Live weight	*B. femoris* depth[a]	Fat over *l. dorsi*[b]	Fat over *b. femoris*[a]	Seam fat in round[a]	*L. dorsi* depth[c]	R^2	Se
r^2	0.42**	0.37**	0.13**	0.02	0.06*	0.10*	....	....
b	0.010**	1.20*	....	....	....	....	0.46**	2.07
b	0.011**	1.21*	-.26	....	....	....	0.46**	2.08
b	0.012**	1.08*	0.20	-2.38	....	....	0.47**	2.08
b	0.012**	1.07*	-.04	-2.42	0.51	....	0.48**	2.09
b	0.013**	1.21*	0.02	-2.47	0.61	-.70	0.49**	2.09
b	0.016**	....	-.21	....	....	....	0.42**	2.15
b	0.016**	....	0.44	-3.45	....	....	0.44**	2.13
b	0.012**	1.07*	....	-2.48	0.50	....	0.48**	2.07
b	0.010**	1.19*	....	....	0.31	....	0.46**	2.08
b	0.013**	1.21*	0.29	-2.42	....	-.62	0.48**	2.08
b	0.012**	1.34*	-.18	....	....	-.61	0.47**	2.08

*$P<.05$.

**$P<.01$.

[a]Depths taken at location 4 on the round were used for these calculations.

[b]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

[c]Depths taken at location 1 on the loin were used for these calculations.

all equations and it accounted for 80 percent of the variance in retail cuts weight (table 20 - analysis 3). Biceps femoris muscle depth had a significant effect in predicting retail cuts weight when used with live weight (R^2=0.82). The addition of fat over the longissimus dorsi increased the coefficient of multiple determination to 0.83; but when the fat thickness over the biceps femoris was added no additional predictive value was shown. Biceps femoris depth did not show significance in this equation or in the equation in which seam fat in the round was added (R^2=0.84). Longissimus dorsi muscle depth did not increase the coefficient of multiple determination when added to the equation. Biceps femoris depth was significant in this combination but was not significant when used with live weight and the two fat measures in the round. All other measurements did not have a significant effect in predicting retail cuts weight when used in any combination tested.

Biceps femoris depth, on a live weight constant basis, was of no value in predicting retail cuts percent (table 21). Live weight accounted for 44 percent of the variation in retail cuts percent and was significant ($P<.01$) in all equations. Fat thickness over the longissimus dorsi had a significant ($P<.01$) effect in predicting retail cuts percent

TABLE 20. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH RETAIL CUTS WEIGHT - ANALYSIS 3

r^2 or b	Live weight	*B. femoris* depth[a]	Fat over *l. dorsi*[b]	Fat over *b. femoris*[a]	Seam fat in round	*L. dorsi* depth[c]	R^2	Se
r^2	0.80**	0.56**	0.37**	0.15**	0.14**	0.31**	....	....
b	0.093**	4.31*	....	....	....	....	0.82**	6.16
b	0.085**	4.22*	3.42	....	....	....	0.83**	6.07
b	0.086**	4.07	3.97	-2.86	....	....	0.83**	6.11
b	0.086**	4.03	2.85	-3.04	2.40	....	0.84**	6.09
b	0.084**	3.78*	2.75	-2.96	2.23	1.18	0.84**	6.12
b	0.103**	....	3.58	....	....	....	0.81**	6.36
b	0.103**	....	4.89	-6.87	....	....	0.81**	6.37
b	0.089**	4.28	....	1.07	3.17	....	0.83**	6.10
b	0.090**	4.22*	....	....	3.26	....	0.83**	6.04
b	0.084**	3.77*	3.75	-2.78	....	1.44	0.83**	6.13
b	0.083**	3.91*	3.21	....	....	1.45	0.83**	6.14

*P<.05.

**P<.01.

[a]Depths taken at location 4 on the round were used for these calculations.

[b]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

[c]Depths taken at location 1 on the loin were used for these calculations.

TABLE 21. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR LIVE MEASUREMENTS WITH RETAIL CUTS PERCENT - ANALYSIS 3

r^2 or b	Live weight	*B. femoris* depth[a]	Fat over *l. dorsi*[b]	Fat over *b. femoris*[a]	Seam fat in round[a]	*L. dorsi* depth[c]	R^2	Se
r^2	0.44**	0.24**	0.35**	0.23**	0.24**	0.14**	....	....
b	-.014**	-.14	....	....	....	....	0.44**	1.86
b	-.010**	-.10	-1.54**	....	....	....	0.50**	1.78
b	-.009**	-.22	-1.10	-2.03	....	....	0.51**	1.77
b	-.009**	-.23	-1.19	-2.32	0.19	....	0.51**	1.79
b	-.009**	-.24	-1.19	-2.32	0.18	0.07	0.51**	1.80
b	-.010**	....	-1.54**	....	....	....	0.50**	1.76
b	-.010**	....	-1.15	-2.09	....	....	0.51**	1.76
b	-.010**	-.33	....	-4.04*	-.13	....	0.49**	1.81
b	-.013**	-.13	....	....	-.45	....	0.45**	1.87
b	-.009**	-.24	-1.11	-2.30	....	0.09	0.51**	1.79
b	-.010**	-.12	-1.55*	....	....	0.10	0.50**	1.79

*$P < .05$.

**$P < .01$.

[a]Depths taken at location 4 on the round were used for these calculations.

[b]A single fat measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

[c]Depths taken at location 1 on the loin were used for these calculations.

when used in combination with live weight and *biceps femoris* depth or when used with live weight alone (R^2=0.50). Entering fat over the *biceps femoris* in the equation accounted for an additional 1 percent of the variance in retail cuts percent, while adding seam fat in the round and *longissimus dorsi* muscle depth did not have an effect upon the coefficient of multiple determination. Fat over the *biceps femoris* had a significant ($P<.05$) effect in predicting retail cuts percent when used with live weight, *biceps femoris* depth and seam fat in the round (R^2=0.49). Fat thickness over the *longissimus dorsi* also showed a significant effect in the regression equation containing live weight, *biceps femoris* depth and *longissimus dorsi* depth (R^2=0.50). These results show that measures of fatness are important in predicting retail cuts percent, and up to 51 percent of the variance in retail cuts percent was associated with live weight and the two subcutaneous fat thickness measurements.

VII. MEANS, STANDARD ERRORS AND SIMPLE CORRELATION COEFFICIENTS FOR CARCASS TRAITS - ANALYSIS 3

Carcass traits of 25 of the steers in 1965 and all 36 steers in 1966 were studied to compare the effectiveness of live and carcass measurements in predicting carcass composition.

The means and standard errors of the carcass traits of the 61 steers in analysis 3 are found in table 22. The average chilled carcass weight was 487.0 lb. with an average dressing percent of 56.7. The longissimus dorsi area mean was 65.74 $cm.^2$ while the biceps femoris area mean was much greater (106.64 $cm.^2$). Fat thickness over the ribeye averaged 0.88 cm. The mean for the retail cuts weight of the left side was 127.02 lb., with an average yield of 52.77 percent of the left side weight in partially boneless, closely trimmed retail cuts. The average carcass grade was high Good with a range from high Standard to low Prime.

Table 23 (analysis 3) contains the simple correlation coefficients of the carcass traits with the retail yield and muscle indicators. Chilled carcass weight gave significant ($P<.01$) simple correlation coefficients of 0.72, 0.97 and -.72 with round separable muscle weight, retail cuts weight and retail cuts percent, respectively. The association found between carcass weight and retail cuts weight was the highest found ($r=0.97$). Live weight gave similar but slightly lower relationships with the carcass yield indicators. The relationships of left side weight to the carcass yield indicators

TABLE 22. MEANS AND STANDARD ERRORS OF CARCASS TRAITS - ANALYSIS 3

Item	Mean	Standard error
Chilled carcass weight, lb.	487.0	8.5
Dressing percent	56.7	0.3
Left side weight, lb.	237.4	4.4
Longissimus dorsi area, $cm.^2$	65.74	0.84
Fat thickness, cm.	0.88	0.06
Estimated kidney fat, %	2.16	0.14
Conformation grade[a]	11.5	0.2
Carcass grade[a]	10.9	0.2
Carcass length, cm.	114.15	0.40
Rump length, cm.	41.23	0.25
Hock to hip length, cm.	68.66	0.30
Exterior round length, cm.	75.38	0.43
Interior round length, cm.	68.30	0.34
Loin length, cm.	58.89	0.25
Biceps femoris area, $cm.^2$	106.64	1.81
Biceps femoris weight, lb.	7.85	0.10
Biceps femoris width, loc. 1, cm.	19.02	0.15
Biceps femoris depth, loc. 1, cm.	7.28	0.11
Biceps femoris, fat over, loc. 1, cm.	0.45	0.02
Seam fat in round, loc. 1, cm.	1.80	0.09
Untrimmed round weight, lb.	55.21	0.77
Trimmed round weight, lb.	53.85	0.70
Round separable muscle weight, lb.	29.94	0.35
Round separable fat weight, lb.	9.64	0.34
Round separable bone weight, lb.	5.37	0.10
Round cuts weight, lb.	43.04	0.61
Rib weight, lb.	20.73	0.43
Rib cuts weight, lb.	14.87	0.28
Chuck weight, lb.	65.95	1.10
Chuck cuts weight, lb.	38.70	0.61
Loin weight, lb.	38.10	0.73
Loin cuts weight, lb.	30.41	0.46
Plate weight, lb.	18.86	0.54
Brisket weight, lb.	9.45	0.26
Foreshank weight, lb.	7.79	0.11
Kidney knob weight, lb.	7.05	0.35
Flank weight, lb.	14.15	0.42
Retail cuts weight, lb.	127.02	1.84
Retail cuts percent	52.77	0.31

[a]10 = average Good, 11 = high Good.

TABLE 23. SIMPLE CORRELATION COEFFICIENTS BETWEEN CARCASS TRAITS AND ROUND SEPARABLE MUSCLE WEIGHT, RETAIL CUTS WEIGHT AND RETAIL CUTS PERCENT - ANALYSIS 3

Item	Round separable muscle weight	Retail cuts weight	Retail cuts percent
Chilled carcass weight	0.73**	0.97**	-.72**
Dressing percent	0.44**	0.53**	-.38**
Left side weight	0.74**	0.96**	-.72**
Longissimus dorsi area	0.52**	0.64**	-.44**
Fat thickness	0.31*	0.63**	-.68**
Estimated kidney fat	0.15	0.46**	-.70**
Conformation grade	0.43**	0.64**	-.60**
Carcass grade	0.38**	0.64**	-.69**
Carcass length	0.34**	0.42**	-.23
Rump length	0.41**	0.30*	0.17
Hock to hip length	0.34**	0.27*	0.12
Exterior round length	0.26*	0.13	0.26*
Interior round length	0.30*	0.18	0.20
Loin length	0.23	0.20	0.00
Biceps femoris area	0.73**	0.72**	-.31*
Biceps femoris weight	0.89**	0.82**	-.25*
Biceps femoris width, loc. 1	0.50**	0.47**	-.28*
Biceps femoris depth, loc. 1	0.57**	0.57**	-.24
Biceps femoris fat over, loc. 1	0.08	0.38**	-.56**
Seam fat in round, loc. 1	0.16	0.36**	-.48**
Untrimmed round weight	0.90**	0.94**	-.46**
Trimmed round weight	0.92**	0.92**	-.41**
Round separable muscle weight	....	0.82**	-.25*
Round separable fat weight	0.53**	0.84**	-.69**
Round separable bone weight	0.42**	0.28*	0.07
Round cuts weight	0.88**	0.95**	-.45**
Rib weight	0.65**	0.92**	-.70**
Rib cuts weight	0.68**	0.90**	-.64**
Chuck weight	0.73**	0.94**	-.71**
Chuck cuts weight	0.74**	0.95**	-.52**
Loin weight	0.68**	0.95**	-.65**
Loin cuts weight	0.72**	0.93**	-.53**
Plate weight	0.62**	0.89**	-.76**
Brisket weight	0.56**	0.68**	-.46**
Foreshank weight	0.68**	0.69**	-.24
Kidney knob weight	0.37**	0.63**	-.77**
Flank weight	0.50**	0.81**	-.75**
Retail cuts weight	0.82**	....	-.55**
Retail cuts percent	-.25*	-.55**	....

*P<.05.

**P<.01.

(r=0.74, r=0.96 and r=-.72, respectively) were nearly the same as those found for chilled carcass weight. This indicates that, from a practical standpoint, left side weight and chilled carcass weight may be used interchangeably. DuBose et al. (1967) reported that chilled carcass weight was the best single indicator of carcass muscling (r=0.94 with BSRM weight). Cole et al. (1962a) reported that, as carcass weight increased, the average percent of steaks decreased and percent waste increased. Birkett et al. (1965) found a highly significant association (r=0.97) between carcass weight and weight of the closely trimmed round, loin, rib and chuck and a significant association between carcass weight and percent closely trimmed round, loin, rib and chuck (r=-.52). Cole et al. (1962b) found carcass weight to be more highly associated with pounds of separable muscle (r=0.75) than any other single carcass measurement studied.

Longissimus dorsi area and fat thickness have been extensively used as measures of carcass cutout. However, Cole et al. (1960) reported that ribeye area was associated with only 18 percent of the variance in the separable carcass lean and 5 to 30 percent of the variance in the separable lean of the more variable cuts of beef. Hedrick et al. (1965) found that subcutaneous fat thickness measurements were associated with two to three times as much of the variation in retail yield as were longissimus dorsi area measurements. From table 23, page 72, the simple correlation coefficients for longissimus dorsi area were 0.52, 0.64 and -.44 with round separable muscle weight, retail cuts weight and retail cuts percent, respectively. All were significant ($P<.01$). Fat thickness was significantly ($P<.05$) associated with round separable muscle weight ($r=0.31$), but was more highly related to retail cuts weight ($r=0.63$) and retail cuts percent ($r=-.68$). These results are almost identical to those found with measurements of fat thickness in the live animal. Longissimus dorsi depth measured ultrasonically at location 1 on the loin accounted for 25 percent of the variance in ribeye area. Fat thickness, measured ultrasonically at approximately the same location as measured in the carcass, was associated with 69 percent of the variance in fat thickness in the carcass.

Estimated percent kidney fat was not significantly associated with round separable muscle weight ($r=0.15$), but was more highly related to retail cuts weight ($r=0.46$) and retail cuts percent ($r=-.70$). The actual kidney knob weight gave higher relationships with the same carcass yield indicators ($r=0.37$, $r=0.63$ and $r=-.77$, respectively). This indicates that actual weights of kidney and pelvic fat are more closely related to carcass cutout than are subjective estimates of kidney, pelvic and heart fat. Murphy et al. (1960) found simple correlation coefficients of -.66 and -.63 between kidney fat and percent of bone-in and boneless retail cuts, respectively. Cobb and Ovejera (1965) reported a highly significant simple correlation between yield of trimmed retail cuts and weight of kidney fat (r=-.65). Brungardt and Bray (1963) found similar results. In the present study, both conformation grade and carcass grade were significantly and positively associated with round separable muscle weight and retail cuts weight, but were negatively and significantly related to retail cuts percent. Goll et al. (1961), using 90 Choice, Good and Standard carcasses, found that these grades differed significantly in the average yields of all four thick cuts and that lower grading carcasses were heavier and longer in body, hind leg and loin. Another phase of their study showed that fat exerted more influence upon yield of wholesale cuts than did conformation.

Carcass, rump and hock to hip lengths gave low but significant relationships with round separable muscle weight and retail cuts weight. Exterior and interior round length gave significant associations with round separable muscle weight, but neither was significantly related to retail cuts weight or retail cuts percent. Round length measured in the live animal was a better predictor of round separable muscle weight and retail cuts weight than either of the two carcass measurements of round length. Simple correlation coefficients of 0.59 and 0.64 were found between the live round measurements and the two carcass measurements, respectively. Carcass length gave a negative correlation with retail cuts percent while all other length measurements were positively associated with retail cuts percent. Loin length was not significantly related to any of the yield indicators. It can be concluded that the length measurements taken in the carcass were not effective in predicting carcass yield.

Brungardt and Bray (1963) reported that all linear measurements taken at various locations on the carcass were positively associated with percent retail yield and predicted percent muscle in the carcass. Cobb and Ovejera (1965) reported low and nonsignificant correlations between percent yield of trimmed retail cuts and carcass length ($r=0.13$), length of loin ($r=0.08$), width of shoulder ($r=0.14$), width of round ($r=0.03$) and circumference of round ($r=0.00$). Cole et al. (1960), however, found significant ($P<.01$) relationships between pounds of separable carcass lean and carcass length (r=0.39), length of leg (r=0.53) and loin length (r=0.44). DuBose et al. (1967) found significant simple correlation coefficients between BSRM weight and carcass length (r=0.79) and leg length (r=0.62).

The biceps femoris area gave highly significantly positive relationships with round separable muscle weight (r=0.73) and retail cuts weight (r=0.72). The association of biceps femoris area with retail cuts percent was low and negative (r=-.31). The simple correlation coefficient between biceps femoris area and biceps femoris weight was 0.74, and biceps femoris width times depth was 0.42. These results agree with Ramsey et al. (1965), who found that biceps femoris area was significantly associated with untrimmed round weight (r=0.76), trimmed round weight (r=0.76), round separable muscle weight (r=0.82) and biceps femoris weight (r=0.75). They also reported that live weight and biceps femoris area accounted for 87 percent of the variance in trimmed round weight and 86 percent of the variance in round separable muscle weight. Huff (1965) reported that biceps femoris area was significantly ($P<.01$) related to biceps femoris weight (r=0.73), round separable muscle weight (r=0.88), and round cuts weight (r=0.90). Thus, biceps femoris area should be a useful indicator of round separable muscle weight and retail cuts weight. However, it is difficult to accurately estimate in the live animal.

Weight of that portion of the biceps femoris muscle included in the wholesale round was more highly related to round separable muscle weight (r=0.89) and retail cuts weight (r=0.82) than was biceps femoris area. The biceps femoris muscle weight was not highly related to retail cuts percent. In a study using the weight of certain entire muscles to predict total carcass lean, Orme et al. (1960) found a relationship of 0.96 between the weight of total carcass muscle and weight of the biceps femoris. From these results, it can be concluded that weight of the biceps femoris muscle is an excellent predictor of carcass muscling.

The width of the biceps femoris was found to be significantly associated with round separable muscle weight (r=0.50), retail cuts weight (r=0.47) and retail cuts percent (r=-.28). Width of the biceps femoris in the carcass was a better indicator of carcass yield than was the same measurement in the live animal.

The simple correlation coefficients between biceps femoris depth and round separable muscle weight and retail cuts weight were both 0.57. The biceps femoris depth was not significantly related to retail cuts percent (r=-.24). These results agree with those found when biceps femoris depth, measured ultrasonically at the various locations on the round, was used to predict carcass yield. These ultrasonic measurements gave highly significant associations ranging from 0.50 to 0.62 with round separable muscle weight and a range from 0.61 to 0.74 with retail cuts weight. The relationships of the biceps femoris depth, measured at the various locations in the live animal, were much lower with retail cuts percent (range from r=-.26 to r=0.49). Conversely, Davis et al. (1964) reported that biceps femoris depth was not significantly related to the yield of trimmed round (r=0.42), chuck (r=0.50) or rib (r=0.41); however they only used 10 animals in their study. Thus, in the present study biceps femoris depth was a relatively accurate predictor of round separable muscle weight and retail cuts weight, but it was not an accurate predictor of retail cuts percent.

Neither the fat thickness over the biceps femoris nor the seam fat in the round showed a significant association with round separable muscle weight, but the correlations with retail cuts weight were positive and significant. The highest relationships with these two fat measures were found with retail cuts percent (r=-.56 and r=-.48, respectively). These results are in close agreement with those found using the ultrasonic measurements of fat over the *biceps femoris* and seam fat in the round. These live measurements were more highly associated with retail cuts weight and retail cuts percent than with round separable muscle weight. Huff (1965) found that fat over the *biceps femoris* was associated with less than 14 percent of the variance in retail cuts weight from the round, loin, rib and chuck. He also found a simple correlation coefficient of only 0.09 between round separable muscle weight and fat over the *biceps femoris* muscle. Thackston (1966) reported that fat over the *biceps femoris* muscle yielded highly significant negative associations with actual percent retail yield.

Untrimmed and trimmed round weights gave highly significant positive associations with round separable muscle weight. These coefficients were higher than those for any other variable. The simple correlations between retail cuts weight and both untrimmed and trimmed round weights were 0.94 and 0.92, respectively, but the relationships with retail cuts percent were much lower ($r=-.46$ and $r=-.41$). Brungardt and Bray (1963) found simple correlation coefficients of 0.83 between percent trimmed round and percent retail yield and 0.76 between percent untrimmed round and percent retail yield.

Round separable muscle weight was highly related to retail cuts weight (r=0.82), but was associated with only 6 percent of the variance in retail cuts percent (r=-.25). The fact that the correlation between round separable muscle weight and retail cuts percent was low may be due to the effect of fat in the retail cuts. Cole et al. (1960) found the weight of separable muscle in the round to be associated with 90 percent of the variation in total pounds of separable muscle in the carcass.

In the present study, round separable fat was significantly related (P<.01) to round separable muscle weight (r=0.53), retail cuts weight (r=0.84) and retail cuts percent (r=-.69). Round separable fat was also highly related to fat over the longissimus dorsi (r=0.74). Huff (1965) found that the simple correlation coefficients between round separable fat weight and side weight, hindquarter weight and forequarter weight were considerably higher than those for round separable muscle. This indicated that some of the increase in weight was due more to fat deposition than muscle development.

Round retail cuts weight gave approximately the same relationships with the measures of retail yield as did the trimmed and untrimmed round weights. The weights of the rib, chuck and loin were found to have lower correlations with round separable muscle weight than did the trimmed round, untrimmed round and round cuts weights. However, all associations between individual wholesale cuts weights and round separable muscle weight were significant ($P<.01$). Simple correlation coefficients between retail cuts weight and rib, chuck and loin weights were 0.92, 0.94 and 0.95, respectively. Associations between retail cuts percent and rib, chuck and loin weights were negative and highly significant, but they were much lower than those found with retail cuts weight.

The weights of the round, loin, rib and chuck cuts were found to have relationships with round separable muscle weight and retail cuts weight which were similar to those found with the corresponding wholesale cut weights. The thin cuts, the plate, brisket, foreshank and flank, were found to be highly associated with round separable muscle weight and retail cuts weight. However, these thin cuts were negatively and highly correlated with retail cuts percent with the exception of foreshank weight which was not significantly associated with retail cuts percent. Retail cuts weight gave a highly significant negative relationship of -.55 with retail cuts percent.

VIII. MULTIPLE REGRESSION ANALYSES USING LIVE WEIGHT AND CARCASS MEASUREMENTS

In an effort to determine the effect of inaccuracies in ultrasonic measurements made on the live animals and changes in tissue position and configuration after slaughter, regression analyses were performed using carcass measurements which corresponded to measurements made on the live animal. These results are shown in table 24 (analysis 3). In predicting round separable muscle weight, retail cuts weight and retail cuts percent, live weight accounted for 42, 80 and 44 percent of the variation in these carcass yield measures, respectively. Live weight was used in the equation so that the variation due to weight would be the same for both carcass and live measurements. On a live weight constant basis, biceps femoris muscle depth significantly aided in estimating round separable muscle weight (R^2=0.50) and retail cuts weight (R^2=0.82), but was not significant in predicting retail cuts percent (R^2=0.45). These coefficients of multiple determination were slightly higher than those found using the ultrasonic measurements on the live steer in predicting round separable muscle weight (R^2=0.46) and retail cuts percent (R^2=0.44); but the coefficients were identical

TABLE 24. COEFFICIENTS OF DETERMINATION, PARTIAL REGRESSION AND MULTIPLE DETERMINATION AND STANDARD ERROR OF ESTIMATES FOR CARCASS MEASUREMENTS AND LIVE WEIGHT WITH ROUND SEPARABLE MUSCLE WEIGHT, RETAIL CUTS WEIGHT AND RETAIL CUTS PERCENT - ANALYSIS 3

Dependent variable	r^2 or b	Live weight	*B. femoris* depth[a]	Fat over *l. dorsi*[b]	Seam fat in round[a]	Fat over *b. femoris*[a]	R^2	Se
Round	r^2	0.42**	0.32**	0.10	0.02	0.01	....	....
separable	b	0.012**	1.05**	....	....	....	0.50**	1.98
muscle	b	0.013**	1.08**	-1.00	....	....	0.52**	1.97
weight	b	0.012**	1.37**	-1.57	0.70	....	0.54**	1.95
	b	0.013**	1.36**	-.95	0.86	-2.79	0.56**	1.93
Retail	r^2	0.80**	0.32**	0.40**	0.13**	0.15**	....	....
cuts	b	0.101**	2.89**	....	....	....	0.82**	6.10
weight	b	0.092**	2.77**	4.11	....	....	0.83**	5.99
	b	0.087**	3.71**	2.27	2.25	....	0.84**	5.93
	b	0.087**	3.71**	2.65	2.35	-1.68	0.84**	5.98
Retail	r^2	0.44**	0.06	0.47**	0.23**	0.31**	....	....
cuts	b	-.015**	0.27	....	....	....	0.45**	1.85
percent	b	-.010**	0.35	-2.57**	....	....	0.58**	1.64
	b	-.009**	0.20	-2.28**	-.35	....	0.58**	1.64
	b	-.009**	0.19	-1.77*	-.22	-2.30	0.60**	1.62

*$P<.05$.

**$P<.01$.

[a]Carcass measurements taken at location 1 on the round were used for these calculations.

[b]A single measurement taken at a point three-fourths the cross sectional length of the *longissimus dorsi* from the chine end at the twelfth rib.

for retail cuts weight (R^2=0.82). On a live weight constant basis, the other carcass traits did not significantly aid in predicting round separable muscle and retail cuts weight. These results were similar to those found with the ultrasonic measurements on the live steers.

Fat over the *longissimus dorsi* in the carcass was significant in predicting retail cuts percent when used in combination with live weight and the other carcass measurements shown in table 24. When all four of the carcass measurements were used in combination with live weight, the coefficients of multiple determination were 0.56, 0.84 and 0.60 for round separable muscle weight, retail cuts weight and retail cuts percent, respectively. Corresponding coefficients for the live measurements were 0.49, 0.84 and 0.51 respectively, for the three yield indicators. It can be concluded that the carcass measurements gave coefficients of multiple determination which were the same as or slightly higher than those of the live measurements in predicting the carcass yield indicators. The significant effect in prediction of the carcass yield indicators shown by the *biceps femoris* depth and fat thickness over the *longissimus dorsi* was the same for both carcass and live measurements.

Using carcass measurements of fat thickness over the longissimus dorsi, longissimus dorsi area, percent kidney fat and side weight, Brungardt and Bray (1963) found a coefficient of multiple determination of 0.63 with percent retail yield. DuBose et al. (1967) reported a coefficient of multiple determination of 0.92 between the weight of BSRM and ribeye area plus carcass weight. With percent BSRM, they obtained a coefficient of multiple determination of 0.48 with percent kidney fat, ribeye area and fat thickness as the independent variables.

Further multiple regression analyses were run using the yield grade factors to determine the importance of fat thickness measurements and longissimus dorsi area in the carcass. Carcass weight, which alone accounted for 54 percent of the variance in round separable muscle weight, was used in combination with carcass fat thickness over the longissimus dorsi and estimated percent kidney, pelvic and heart fat to predict round separable muscle weight. A coefficient of multiple determination of 0.68 was obtained. The addition of longissimus dorsi area to the equation did not increase the coefficient. Carcass weight, fat thickness over the longissimus dorsi and estimated percent kidney, pelvic and heart fat all showed a highly significant effect in predicting round separable muscle weight.

In estimating the retail cuts weight, carcass weight accounted for 94 percent of the variation and had a highly significant effect. Carcass weight, fat thickness and estimated percent kidney, pelvic and heart fat in combination gave a coefficient of 0.95. When _longissimus_ _dorsi_ area was entered in the equation, the coefficient of multiple determination was the same with significance being shown only by carcass weight and estimated percent kidney, pelvic and heart fat in either equation. Similar results were found with the yield grade factors in estimating retail cuts percent. Carcass weight and estimated percent kidney, pelvic and heart fat showed a highly significant effect in predicting retail cuts percent, but the addition of _longissimus dorsi_ area to the equation did not increase the predictive ability (R^2=0.66).

Murphey _et_ _al_. (1960) reported a coefficient of multiple determination of 0.91 using a single measurement of fat thickness over the ribeye, percent kidney, pelvic and heart fat, carcass weight and ribeye area in predicting percent boneless, closely trimmed, retail cuts.

It can be seen from the results of both studies that fat measurements are of great importance in predicting yield of the carcass, and muscle indicators may or may not have a significant effect. In these cattle ribeye area had practically no value in predicting cutout when carcass weight, estimated percent kidney, pelvic and heart fat and fat thickness were in the equation.

IX. PREDICTION EQUATIONS

The following equations for predicting carcass composition from live animal measurements are recommended because of the ease of obtaining the necessary measurements and because of their effectiveness in predicting cutout. For predicting pounds of separable muscle in the shankless round of one side of the carcass ($\hat{Y}_1$) the following equation from analysis 3 (N=61 steers) is recommended:

$$\hat{Y}_1 = 13.21 + 0.01 \text{ (live weight, lb.)} + 1.20 \text{ (\underline{biceps femoris} depth, location 4, cm.)}$$

These two independent variables were associated with 46 percent of the variance in round separable muscle weight. The standard error of estimate was 2.07 lb.

However, from analysis 2 (N=36 steers) the independent variables in the following equation accounted for 58 percent of the variance in round separable muscle weight ($\hat{Y}_1$):

$\hat{Y}_1$ = 3.94 + 0.01 (live weight, lb.) + 0.18 (round mass, cm.)

The standard error of estimate was 1.86 lb. Unfortunately, the round mass estimation was not taken on the steers in 1965. Therefore, the number of steers is lower than would be desirable for computing a prediction equation.

From analysis 3, the following equation is recommended for predicting pounds of partially boneless, closely trimmed retail cuts from the round, loin, rib and chuck ($\hat{Y}_2$).

$\hat{Y}_2$ = 18.19 + 0.09 (live weight, lb.) + 4.31 (biceps <u>femoris</u> depth, location 4, cm.)

These two variables accounted for 82 percent of the variance in retail cuts weight. The standard error of estimate was 6.16 lb.

In estimating the retail cuts as a percent of the side weight ($\hat{Y}_3$), fat thickness over the <u>longissimus</u> <u>dorsi</u> and live weight were the only variables which showed a significant effect when used in combination. From analysis 3, the following equation is recommended:

$\hat{Y}_3$ = 62.72 - .01 (live weight, lb.) - 1.54 (fat thickness over the <u>longissimus</u> <u>dorsi</u>, cm.)

A coefficient of multiple determination of 0.50 was achieved by using these two variables to predict retail cuts percent. The standard error of estimate was 1.76 percent. This fat thickness measurement was taken at the location in the live animal which closely approximates the usual measurement of fat thickness in the carcass.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The purposes of this study were to determine the relationships between measurements on live cattle and carcass composition and to develop equations for predicting round separable muscle weight, weight of partially boneless, closely trimmed retail cuts from the round, loin, rib and chuck and these retail cuts as a percent of side weight using weights and measurements taken on the live animals. Such equations are needed to aid in selecting breeding stock.

Three linear measurements on the round and ultrasonic measurements of hide, fat and muscle depth at ten anatomical locations were made with the Branson Sonoray Models 12 and 52 on 66 Hereford and 18 Angus steers during 1965 and 1966. Carcass data also were obtained.

Live weight was included in all multiple regression equations predicting carcass cutout because these data and those of several previous workers have shown that live and/or carcass weight generally accounted for a larger amount of variance in carcass cutout measures than any other single measurement. Also, live weight generally was highly related to the other live measurements and these other measurements, therefore, should be studied on a live weight constant basis.

Of all combinations of live measurements studied in multiple regression analyses, estimated round mass used in combination with live weight was the most accurate predictor of round separable muscle weight (R^2=0.58). However, this measurement was not taken on the steers in 1965. Therefore, the number of steers is lower than would be desirable for computing a prediction equation. *Biceps femoris* depth in combination with live weight was the second most accurate predictor of round separable muscle weight. These two variables were associated with 46 percent of the variance in round separable muscle weight. The standard error of estimate was 2.07 lb.

Biceps femoris depth and live weight accounted for 82 percent of the variance in retail cuts weight (standard error of estimate = 6.16 lb.). On a weight constant basis, *biceps femoris* depth was the most accurate single measure of retail cuts weight of the linear and ultrasonic measurements in this study.

In combination with live weight, fat thickness over the *longissimus dorsi* was the only variable which showed a significant effect in estimating retail cuts percent (R^2=0.50).

The standard error of estimate was 1.76 percent.

It can be concluded from this study that sufficiently accurate prediction of carcass composition can be made using live animal measurements of muscle and fat thicknesses and linear measurements on the round. The prediction equations in this study should be valid for predicting carcass composition in steers.

Williams (1965) found that the composition of steers, heifers and bulls differs considerably. Therefore, these prediction equations may not be valid for use on heifers and bulls. Further work should be conducted using potential breeding stock and a greater number of animals in developing these prediction equations.

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VITA

Aaron Estes Reynolds, Jr., was born in Augusta, Georgia on September 28, 1944. He is the son of Mr. and Mrs. Aaron E. Reynolds, Sr. and is one of four children. He was reared on a farm near Grovetown, Georgia and attended Evans Elementary and High School. Upon graduation in 1962 he enrolled at the University of Georgia and majored in Animal Husbandry. While attending the University, he was active in the Block and Bridle Club, was a member of the livestock judging team and was active in the Baptist religious activities on campus. After receiving his Bachelor of Science degree in Agriculture in 1966, he enrolled in the University of Tennessee to pursue a Master of Science degree with a major in Animal Husbandry (with emphasis on Meat Science) and a minor in Food Technology. After graduation from the University of Tennessee in June, 1968, he plans to serve a two-year tour of duty in the United States Army Quartermaster Corp. He was married on October 15, 1967 to Miss Janis Ann Hawes, formerly of Lincolnton, Georgia.