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Estimating total separable lean in beef carcasses by using multiple area measurements of the longissimus dorsi in combination with other measurements

Robert Hailey Epley Jr.

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To the Graduate Council:

I am submitting herewith a thesis written by Robert Hailey Epley Jr. entitled "Estimating total separable lean in beef carcasses by using multiple area measurements of the longissimus dorsi in combination with other measurements." 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.

J.W. Cole, Major Professor

We have read this thesis and recommend its acceptance:

C.B. Ramsey, C.S. Hobbs

Accepted for the Council:
Carolyn R. Hodges
Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)
March 13, 1961

To the Graduate Council:

I am submitting herewith a thesis written by Robert Hailey Epley, Jr. entitled "Estimating Total Separable Lean in Beef Carcasses by Using Multiple Area Measurements of the Longissimus Dorsi in Combination with other Measurements". 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.

[Signature]
Major Professor

We have read this thesis and recommend its acceptance:

[Signature]
We have read this thesis and recommend its acceptance:

[Signature]

Accepted for the Council:

[Signature]
Acting Dean of the Graduate School
ESTIMATING TOTAL SEPARABLE LEAN IN BEEF CARCASSES BY USING
MULTIPLE AREA MEASUREMENTS OF THE LONGISSIMUS DORSI
IN COMBINATION WITH OTHER MEASUREMENTS

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
Robert Hailey Epley, Jr.
March 1961
ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to the following persons who assisted in the completion of this thesis:

To Professor J. W. Cole for his patient guidance throughout the graduate program and for his assistance in preparing the manuscript for this thesis.

To Dr. R. J. Cooper for aiding in the statistical analysis and revision of parts of this thesis.

To Dr. C. B. Ramsey and Dr. C. S. Hobbs for critically reading and aiding in the revision of parts of this thesis.

To his wife, Mary, for her tolerance, encouragement and assistance.

Robert H. Epley, Jr.
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CHAPTER I

INTRODUCTION

Quality has played the major role in determining the value of a beef carcass for many years. Recently, edible portion or yield of lean meat is obtaining a major role more equal to that of quality in evaluating beef animals. Therefore, a relatively simple and reliable method should be derived for estimating muscling or leanness.

The literature indicates that physical composition of various cuts is highly related to physical composition of the entire carcass. Weights of muscles and bones have been obtained in attempts to develop useful criteria for estimating carcass leanness. Although these methods have proven highly significant in estimating carcass lean, they are time consuming, laborious and costly.

The official grade standards of the United States Department of Agriculture evaluate beef according to conformation, finish and marbling in the ribeye. Objective measurements for estimating yield of closely trimmed wholesale cuts are being studied at the present time in order to classify beef according to cutability.

A limited number of investigations have shown only a small relationship between carcass leanness and area of the Longissimus dorsi muscle at the twelfth rib. This investigation was undertaken to determine whether an average of area measurements taken at the fifth rib, twelfth rib and last lumbar vertebra would give an improved estimate of total carcass lean. Also, the relationship of carcass length, carcass weight and fat thickness over the twelfth rib to pounds of carcass lean was determined.
Bratzler (1958) reported that meat research has become an important part of animal experiments in the past fifty years. Formerly, meat research was closely related to the nutrition and production phases of animal research. Recently, due to an improvement of laboratories and other facilities, meat researchers are able to obtain more reliable information on their product. Competition for the consumer's food dollar has necessitated evaluating animals in a feeding experiment by measures more inclusive than pounds of gain.

Research related to the estimation of beef carcass composition is limited. Some researchers have found that the physical and chemical composition of a certain cut is a good indicator of the composition of the entire carcass. Hooper (1944) analyzed data from 92 cattle. He reported that physical and chemical composition of the wholesale rib cut, sixth to twelfth ribs inclusive, and the ninth-tenth-eleventh rib cut were highly associated with physical and chemical composition of the entire carcass.

Hankins and Howe (1946) related the percent separable lean of the ninth-tenth-eleventh rib cut to percent separable lean of the dressed carcass and percent protein of the edible or boneless portion of the dressed carcass. Correlation coefficients between separable lean of the ninth-tenth-eleventh rib cut and separable carcass lean were 0.90 for 84 steers, 0.72 for 36 heifers, and 0.85 for all 120 cattle. Correlation coefficients between separable lean of the ninth-tenth-eleventh
rib cut and protein content of the edible portion were 0.82 for the steers, 0.77 for the heifers and 0.82 for all the cattle. The following equation for predicting carcass leanness, based on data from the 120 cattle, was calculated:

\[
\hat{Y} = 15.56 + 0.81 X
\]

where

\[
\hat{Y} = \text{Predicted percent separable lean of the dressed carcass, and}
\]

\[
X = \text{Percent separable lean of the ninth-tenth-eleventh rib cut.}
\]

This equation has been used by researchers for many years as a reliable method for estimating leanness or muscling in the beef carcass.

Orme, Pearson, Bratzler, Magee and Wheeler (1959), using the above regression equation developed by Hankins and Howe (1946), found that live animal weight, chilled carcass weight, primal cut weight and estimated carcass lean in almost all instances were significantly related to weights and various length and width measurements of the fore and hind cannon bones. However, the association of the cannon bone measurements with percent primal cuts and percent estimated carcass lean was considerably lower. Correlation coefficients obtained between ribeye area and the various cannon bone measurements were not statistically significant.

Orme et al. (1960) found high interrelationships between weights of eight muscles or muscle groups and pounds of separable carcass lean of 43 mature Hereford cows. Sixty-four to 92 percent of the variation in total separable carcass lean was associated with the weights of certain entire muscles. With slaughter weight held constant, standard partial regression coefficients obtained between the weight of certain muscles or muscle groups and carcass lean were: Biceps femoris, 0.97; sirloin
tip muscle group, 0.82; Longissimus dorsi, 0.79 and inside round muscle group, 0.72. These results indicate the validity of using the weight of certain entire muscles to estimate leanness or muscling in a particular mature beef animal.

Tallis et al. (1959), using both steers and heifers, found that length and height of the carcass and circumference at the navel were the most valuable measurements for describing type in beef cattle. Ratios of weight to height and weight to length were correlated with dressing percentage, area of ribeye and percent edible portion. The two ratios were positively correlated with ribeye area and negatively correlated with percent edible portion with both steers and heifers. These ratios were positively correlated with dressing percentage in steers but not in heifers. Tallis concluded that the highly significant positive correlations of these ratios with dressing percentage in the case of steers and the significant negative correlations with percent edible portion in both cases must be due primarily to a positive correlation of the ratios with carcass fat.

Kennick and England (1960) described a core sampling technique for estimating the fat and protein content of steer carcasses. Two pairs of probe samples were taken—one pair between the eight and ninth ribs and one pair between the tenth and eleventh ribs. One of each pair of probes was taken through the deepest portion of the Longissimus dorsi muscle. This was termed the eye probe. The second of each pair of probes was taken perpendicular to the ribs through the center of the seam of fat which separates the Longissimus dorsi and Longissimus costarum.
muscles from the Obliquus abdominis externus and Latissimus dorsi muscles. This was termed the side probe. Weight of fat in the two side probes, along with warm carcass weight, was significantly related to percent fat and protein in the boneless ninth-tenth-eleventh rib cut. Using these measurements, equations were derived for predicting the fat and protein content of the edible portion of the ninth-tenth-eleventh rib cut. These equations were combined with those of Hankins and Howe (1946) to predict percent fat and protein in the boneless steer carcass.

Few studies have been undertaken to depict the relationship between area measurements of the Longissimus dorsi muscle and physical composition of the beef carcass. Woodward et al. (1954) found a significant positive association between area of the loin eye muscle and dressing percentage using 635 steers. Area of the loin eye and fat thickness over the loin eye were not correlated significantly. However, with final weight held constant, there was a slight negative relationship between these two measurements. Fat thickness was more highly associated with dressing percentage than was loin eye area.

Woodward et al. (1959), in an evaluation of 56 steer carcasses, found a correlation of 0.41 between area of the eye muscle at the twelfth rib and pounds of lean in the ninth and eleventh rib cuts. However, a correlation of only 0.18 was obtained between area of the eye muscle and percent lean in the ninth and eleventh rib cuts. Woodward pointed out that, because of a positive association between carcass grade and weight, correlations with percentage components of the rib samples probably were more valid. He also stated that carcass width measurements were closely
related to fat while length measurements were more closely related to lean in the rib samples.

Cahill et al. (1956) reported a direct relationship between ribeye area at the twelfth rib and percent edible portion of 40 beef carcasses used in a stilbestrol implantation experiment. In this case edible portion referred to closely trimmed, boneless wholesale cuts.

Orme, Pearson, Magee and Bratzler (1959), working with 31 steer carcasses, indicated that area of the ribeye muscle was negatively related to the percentage of primal cuts. This indicated that an increase in eye muscle area gave a corresponding decrease in the percentage of these various cuts.

Cole et al. (1960) found that area of the loin eye at the twelfth rib was associated with 18 percent of the variation in pounds of separable carcass lean in beef. Also, the relationship of loin eye area to various linear carcass measurements, such as carcass length, leg length and loin length, was quite low. However, these linear measurements were closely related to pounds of separable carcass lean. Carcass width and circumference measurements were closely related to loin eye area. Pounds of separable lean in a particular cut were found to be more descriptive of carcass leanness than any of the other carcass measurements. Correlation coefficients between total carcass lean and lean of the round, chuck, foreshank, sirloin and short loin were 0.95, 0.93, 0.81, 0.80 and 0.75, respectively.

Because area of the Longissimus dorsi muscle has proven to be related to carcass muscling, the question may arise concerning its value
in breeding for "meat type" beef. Knapp and Nordskop (1946) found area of the eye muscle to be 69 percent heritable. Knapp and Clark (1950) reported that area of the eye muscle was 68 percent heritable. Shelby et al. (1955) found area of the eye muscle to be 72 percent heritable and fat thickness over the eye muscle to be 38 percent heritable.

Wallaces Farmer (1957) reported the differences in live animal evaluation and carcass evaluation of International Grand Champion Steers judged as car lot groups. The champions were more uniform than other loads, but there was still a wide spread in both loin eye size and fat covering. It was concluded that the biggest hope in live animal evaluation would be a radar-type instrument using high frequency sound waves to detect the amount of lean, fat and bone in an entire loin cross section.

Stouffer (1959) combined a camera and sonar machine to obtain a cross sectional picture of the loin eye muscle in beef and hogs. Comparison of the predicted area and the actual area of the loin eye in a beef steer showed a difference of 0.5 square inch.

Schoonover and Stratton (1957) used a photographic grid to measure ribeye area in beef carcasses. The recording of color, marbling, connective tissue and other quality factors has made this method especially valuable. Schoonover and Stratton, citing Wuthier (1957), reported that the photographic grid could be used to estimate the proportion of lean in a beef carcass by the following formula: proportion of lean equals ribeye area divided by (ribeye area plus area of external fat).

Pierce (1957) conducted an investigation with 459 beef carcasses ranging in U. S. D. A. grade from Canner to Prime. The relationships of
certain objective measurements such as length, width and depth of carcass, side weight and thickness of fat over the ribeye to the yields of the five primal wholesale cuts and retail cuts therein were studied. In addition, the relationships of final grade to yields were determined. Weight and grade accounted for 45 to 75 percent of the variation in yields for the wholesale cuts studied. Finish grade was more closely related to yields of wholesale and retail cuts than was fat thickness over the ribeye. Likewise, no single objective measurement of conformation was consistently more closely related to yields of two-thirds of the wholesale and retail cuts than was conformation grade. However, the effect of conformation was greater than finish on the yield of wholesale loin end, retail loin end, short loin and rib cuts.

According to Murphey (1960) the Federal grade should measure those characteristics of the beef carcass that are associated with its value. Two main factors determine the value of a beef carcass: quality or palatability of the lean meat and percentage of the carcass that is available for sale as trimmed retail cuts. The present grading system places practically no emphasis on "cutability" or combined yield of closely trimmed, retail cuts from the round, loin, rib and chuck. With this in mind, the U. S. D. A. has proposed a dual grading system for beef. A series of tests were made involving 400 carcasses of different sexes, weights and grades. These studies indicated that "cutability" can be estimated with a high degree of accuracy by using measurements of the amount of fat over the ribeye, the amount of kidney and pelvic fat, the size of the ribeye muscle and the carcass weight.
CHAPTER III

PROCEDURE

These data were obtained from 51 carcasses of steers ranging in age from 12 to 20 months, in weight from 650 to 921 pounds, and in federal grade from high Utility to average Prime. Six breeds were represented: Hereford (13), Angus (8), Brahman (4), Santa Gertrudis (7), Jersey (11), and Holstein (8).

The steers were from the University of Tennessee Blount Farm. They were raised under the same environmental conditions and full fed a ration containing approximately 7 parts concentrate to 3 parts roughage from about 4 months of age to slaughter. Each animal was slaughtered at approximately 900 pounds or 20 months of age, whichever was reached first. All animals received as nearly as possible the same pre-slaughter treatment. This consisted of a 24-hour shrinkage period without feed or water. Differences observed after slaughter were assumed to be largely attributed to type, breed and conformation, rather than environment.

Slaughter and carcass evaluations of these steers were conducted at the University of Tennessee Meat Laboratory. Weights of offal or non-carcass components were taken during the slaughter process to be used for other investigations. The warm carcasses were split, weighed, shrouded and hung in a thermostatically controlled 36°F cooler. They were chilled 24 to 48 hours prior to physical separation.

Carcass measurements used in this study, with the exception of chilled carcass weight, were taken from the left side only. Butler et al. (1956), in an experiment involving 77 cattle, found very high correlations
between carcass measurements obtained from each side. He concluded that
data obtained from the left side of a carcass is sufficiently accurate
for most purposes.

Carcass length was measured to the nearest 0.1 inch from the an-
terior edge of the first rib to the anterior edge of the aitch bone. The
left side was divided into wholesale cuts according to the procedure rec-
ommended by Wellington (1953), except that a conventional square cut chuck
was made. Each cut was then physically separated into lean, fat and bone.
Weights of each component were taken to the nearest 0.1 pound. Chilled
carcass weight was taken to the nearest pound. The right side was used
for organoleptic studies in cooperation with the University of Tennessee
College of Home Economics.

Area of the Longissimus dorsi muscle was traced at three locations:
at the fifth rib, where the chuck is separated from the wholesale rib;
at the twelfth rib, where the side is quartered; and at the last lumbar
vertebra, where the short loin is separated from the sirloin. These
locations represent different sizes and shapes of the Longissimus dorsi
muscle. Also, the average of these three area measurements was assumed
to represent an average cross-sectional area of the entire Longissimus
dorsi muscle. The tracings were measured to the nearest 0.01 square
inch by a planimeter. Three fat thickness measurements to the nearest
millimeter were made over the twelfth rib according to the procedure
recommended by Naumann (1951). An average of these three measurements
was used in this study.

These data were statistically analyzed according to the methods
and procedures outlined by Snedecor (1956). Absolute weights of lean rather than percentages were used.
CHAPTER IV

RESULTS AND DISCUSSION

Table I describes the animals studied. Carcass weight ranged from 336 to 567 pounds with an average of 502 pounds. Average carcass weight for the Jerseys, 429 pounds, was considerably below the average for all breeds. Average carcass weight for the Holsteins, 504 pounds, was slightly above the average for all breeds. Brahmans had an average carcass weight of 510 pounds while the Herefords, Santa Gertrudis and Angus had the heaviest carcass weights (524, 531 and 535 pounds, respectively). The low carcass weights of the two dairy breeds were due not only to a lower live weight but to a lower average dressing percentage than the other breeds.

Separable carcass lean ranged from 85.2 to 164.9 pounds with an average of 137.9 pounds for all breeds. Jerseys again were lowest with an average of 116.5 pounds. Holsteins, with a fairly low average carcass weight, were highest in average pounds of separable lean. This was due to a very low fat content when compared to the other breeds. Average pounds of separable lean was high for Brahmans when compared to their carcass weight. Santa Gertrudis were exceeded only by Holsteins in pounds of separable lean. Angus and Herefords were comparatively low in separable lean with 138.5 and 137.0 pounds, respectively.

Carcass length ranged from 42.0 to 49.4 inches. Average carcass length for all breeds was 45.4 inches. The Holsteins, Jerseys and Santa Gertrudis were the longest animals. Carcass length of the Brahmans
<table>
<thead>
<tr>
<th>Measurements</th>
<th>Breed</th>
<th>All Breeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hereford</td>
<td>Angus</td>
</tr>
<tr>
<td>No. of carcasses</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Carcass wt. (lbs)</td>
<td>524</td>
<td>535</td>
</tr>
<tr>
<td>Separable lean (lbs.) (left side)</td>
<td>137.0</td>
<td>138.5</td>
</tr>
<tr>
<td>Carcass length (in.)</td>
<td>43.9</td>
<td>43.6</td>
</tr>
<tr>
<td>Ribeye area, 5th rib (sq. in.)</td>
<td>4.34</td>
<td>4.59</td>
</tr>
<tr>
<td>Ribeye area, 12th rib (sq. in.)</td>
<td>9.16</td>
<td>9.62</td>
</tr>
<tr>
<td>Ribeye area, last lumbar (sq. in.)</td>
<td>8.85</td>
<td>8.33</td>
</tr>
<tr>
<td>Fat thickness 12th rib (mm.)</td>
<td>20.2</td>
<td>21.2</td>
</tr>
</tbody>
</table>
approached the average for all breeds. The Herefords and Angus were the shortest with an average carcass length of 43.9 and 43.6 inches, respectively.

Average ribeye area at the fifth rib for all breeds was 3.98 square inches with a range of 1.91 to 5.83; average at the twelfth rib was 8.80 square inches with a range of 5.95 to 11.95; and average at the last lumbar vertebra was 8.25 square inches with a range of 6.03 to 11.27. Jerseys had the smallest average ribeye area at the fifth and twelfth rib locations, but Brahmans had the smallest area at the last lumbar vertebra. Jerseys were the only breed in which average area at the last lumbar vertebra was larger than that at the twelfth rib. The Brahmans had relatively small ribeye areas at the fifth rib and last lumbar vertebra. However, their average area at the twelfth rib was well above the average for all breeds.

In comparing all of the breeds, the Angus, Herefords and Santa Gertrudis had the largest ribeye areas at all three locations while the Brahmans and the two dairy breeds had the smallest ribeye areas.

As also shown in Table I, fat thickness ranged widely, 3.3 to 34.0 millimeters. Average fat thickness for all breeds was 15.8 millimeters. Differences in fat thickness between breeds were possibly more noticeable than any other carcass measurement. Average fat thickness for Jerseys and Holsteins was 10.5 and 8.0 millimeters, respectively. This low amount of fat covering may account for a higher percent of their carcass weight being expressed in pounds of separable lean than in the other breeds. As would be expected, the Angus and Herefords had a thicker fat covering than the other breeds with an average fat thickness of 21.2 and 20.2
millimeters, respectively. This may account for a lower percent of their carcass weight being expressed in pound of separable lean than the other breeds. Average fat thickness of the Brahmans and Santa Gertrudis was 16.6 and 17.2 millimeters, respectively. These averages approached the average fat thickness for all breeds.

The purpose of this investigation was to obtain useful criteria for estimating carcass leanness rather than to evaluate breed differences. However, a considerable amount of the variation in each of the carcass measurements studied was due to breed and, therefore, should be pointed out. Table II shows an analysis of variance of the measurements studied. A large amount, 51 to 67 percent, of the variation in carcass lean, weight, length and fat thickness can be attributed to breed differences. Breed differences accounted for 45 percent of the variation in ribeye area at the fifth rib, 36 percent at the twelfth rib and 24 percent at the last lumbar vertebra. This noticeable decrease in variation attributed to breed differences from the fifth rib to the last lumbar vertebra may be the result of greater accuracy in measuring loin eye area at the fifth rib than at the twelfth rib or last lumbar vertebra. The measurements at the fifth rib may be more accurate because the muscle is smaller, more uniform in shape and more distinctly outlined than at the other two locations. The physical process of hanging a carcass may distort the area measurement of the Longissimus dorsi more in the posterior region than in the anterior region.

Table III shows simple correlations of ribeye area at the twelfth rib, the average of the three area measurements and average area times
### TABLE II
ANALYSIS OF VARIANCE OF MEASUREMENTS STUDIED AND PERCENT VARIATION DUE TO BREED

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mean Square Breed</th>
<th>Mean Square Steers/Breed</th>
<th>% Variation due to breed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees of freedom</td>
<td>5</td>
<td>45</td>
<td>--</td>
</tr>
<tr>
<td>Carcass lean</td>
<td>1,666.1</td>
<td>118.7</td>
<td>61</td>
</tr>
<tr>
<td>Carcass weight</td>
<td>16,061.2</td>
<td>1,578.4</td>
<td>52</td>
</tr>
<tr>
<td>Carcass length</td>
<td>24.0880</td>
<td>1.3444</td>
<td>67</td>
</tr>
<tr>
<td>Ribeye area (5th rib)</td>
<td>2.6735</td>
<td>.3476</td>
<td>45</td>
</tr>
<tr>
<td>Ribeye area (12th rib)</td>
<td>6.6232</td>
<td>1.1703</td>
<td>36</td>
</tr>
<tr>
<td>Ribeye area (last lumbar)</td>
<td>3.0973</td>
<td>.8614</td>
<td>24</td>
</tr>
<tr>
<td>Fat thickness</td>
<td>215.19</td>
<td>22.62</td>
<td>51</td>
</tr>
</tbody>
</table>
length with pounds of carcass lean for each breed. In most of the breeds, average ribeye area and average ribeye area times length were more highly associated with pounds of carcass lean than was ribeye area at the twelfth rib. Likewise, average ribeye area times length was more highly associated with lean than was average ribeye area alone.

Ribeye area and area times length were more highly related to pounds of carcass lean in the Brahmans and Jerseys than in the other breeds. For the Brahmans, correlation coefficients of 0.90, 0.83 and 0.91 were obtained between pounds of separable lean and area of the ribeye at the twelfth rib, average area and average area times length, respectively. This indicated that ribeye area at the twelfth rib was as highly associated with carcass lean as the other two measurements. For the Jerseys, correlation coefficients of 0.88, 0.94 and 0.92 were obtained between pounds of separable lean and ribeye area at the twelfth rib, average ribeye area and average area times length, respectively. This showed that pounds of lean was more highly associated with average ribeye area and average area times length than ribeye area at the twelfth rib.

The correlation coefficients listed in Table III for the Angus and Herefords were not as high as those for the Brahmans and Jerseys. Correlation coefficients of 0.28, 0.50 and 0.56 for the Angus and 0.35, 0.46 and 0.51 for the Herefords were obtained between pounds of lean and ribeye area at the twelfth rib, average ribeye area and average area times length, respectively.

The measurements were not significantly correlated with pounds of carcass lean for the Holsteins and Santa Gertrudis. For the Holsteins,
### TABLE III

SIMPLE CORRELATIONS OF RIBEYE AREA AT THE TWELFTH RIB, AVERAGE RIBEYE AREA*, AND AVERAGE AREA TIMES CARCASS LENGTH WITH POUNDS OF CARCASS LEAN BY BREED

<table>
<thead>
<tr>
<th>Breed</th>
<th>No.</th>
<th>Area 12th rib</th>
<th>Average ribeye area</th>
<th>Average area X length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hereford</td>
<td>13</td>
<td>.35</td>
<td>.46</td>
<td>.51</td>
</tr>
<tr>
<td>Angus</td>
<td>8</td>
<td>.28</td>
<td>.50</td>
<td>.56</td>
</tr>
<tr>
<td>Brahman</td>
<td>4</td>
<td>.90</td>
<td>.83</td>
<td>.91</td>
</tr>
<tr>
<td>Santa Gertrudis</td>
<td>7</td>
<td>.16</td>
<td>.20</td>
<td>-.04</td>
</tr>
<tr>
<td>Jersey</td>
<td>11</td>
<td>.88</td>
<td>.94</td>
<td>.92</td>
</tr>
<tr>
<td>Holstein</td>
<td>8</td>
<td>.06</td>
<td>.21</td>
<td>.35</td>
</tr>
</tbody>
</table>

* Average of three ribeye area measurements taken at the 5th rib, 12th rib and last lumbar vertebra.
a much lower association was observed between pounds of lean and ribeye area at the twelfth rib than between pounds of lean and the other two measurements given. For the Santa Gertrudis, a correlation coefficient of -.04 was obtained between pounds of lean and average area times length. The other two measurements showed very low positive associations with pounds of lean. Due to a small number of animals within each breed, differences in these correlation coefficients may not have been due to breed alone but to sampling.

Table IV lists simple correlation coefficients between the various carcass measurements and pounds of separable carcass lean. Percent variation in pounds of lean which is linearly associated with these measurements is also given.

Fat thickness alone and length alone accounted for very little of the variance in pounds of lean (0.5 percent and 5 percent, respectively). Carcass weight accounted for 56 percent of the variance in pounds of lean. More variation in pounds of lean was associated with carcass weight than with any other single carcass measurement. This high association was expected because separable lean makes up about 50 to 60 percent of the weight of a beef carcass.

Variance in lean attributed to area of the Longissimus dorsi muscle at the fifth rib and last lumbar vertebra was 33 percent and 15 percent, respectively. Ribeye area at the twelfth rib accounted for 35 percent of the variation in pounds of lean. This indicated that ribeye area at the twelfth rib accounted for only slightly more of the variation in pounds of lean than area at the fifth rib but considerably more than area at the last lumbar vertebra. Cole et al. (1960) found only 18 percent
TABLE IV
SIMPLE CORRELATIONS BETWEEN VARIOUS CARCASS MEASUREMENTS AND POUNDS OF CARCASS LEAN IGNORING BREED DIFFERENCES

<table>
<thead>
<tr>
<th>Measurement</th>
<th>r</th>
<th>Variance in lean accounted for (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat thickness</td>
<td>.07</td>
<td>.5</td>
</tr>
<tr>
<td>Carcass length</td>
<td>.23</td>
<td>5</td>
</tr>
<tr>
<td>Carcass weight</td>
<td>.75</td>
<td>56</td>
</tr>
<tr>
<td>Ribeye area at 5th rib</td>
<td>.57</td>
<td>33</td>
</tr>
<tr>
<td>Ribeye area at 12th rib</td>
<td>.59</td>
<td>35</td>
</tr>
<tr>
<td>Ribeye area at last lumbar vertebra</td>
<td>.39</td>
<td>15</td>
</tr>
<tr>
<td>Average ribeye area of three measurements</td>
<td>.63</td>
<td>39</td>
</tr>
<tr>
<td>Average ribeye area X length</td>
<td>.73</td>
<td>53</td>
</tr>
<tr>
<td>Ribeye area at 12th rib X carcass length</td>
<td>.68</td>
<td>46</td>
</tr>
</tbody>
</table>
of the variation in pounds of separable lean to be associated with loin eye area at the twelfth rib.

Thirty-nine percent of the variance in pounds of separable lean was associated with the average of the three *Longissimus dorsi* muscle area measurements. This was a slight improvement over ribeye area at the twelfth rib and fifth rib and a definite improvement over area at the last lumbar vertebra. Average ribeye area multiplied by carcass length was associated with 53 percent of the variation in pounds of lean. More variation in pounds of lean was associated with this variable than with any measurement studied with the exception of carcass weight. Ribeye area at the twelfth rib times carcass length accounted for 46 percent of the variation in pounds of lean. This was an improvement over the twelfth rib measurement alone and almost as good as average ribeye area times length in accounting for variation in pounds of separable lean.

Multiple correlations between combinations of the carcass measurements studied and pounds of separable carcass lean are listed in Table V. Variation in lean attributed to combinations of the measurements will be compared with the results listed in Table IV for individual measurements.

Carcass length and ribeye area at the twelfth rib accounted for 52 percent of the variation in pounds of lean. This was a definite improvement over either measurement alone. As was true when length and fat thickness were used independently, these two measurements used together tell very little about the variation in pounds of lean. A combination of ribeye area at the twelfth rib and fat thickness account for 41 percent of the variation in lean. This showed a slight improvement over area at
TABLE V
MULTIPLE CORRELATIONS BETWEEN VARIOUS CARCASS MEASUREMENTS AND POUNDS OF CARCASS LEAN

<table>
<thead>
<tr>
<th>Combinations of measurements</th>
<th>R</th>
<th>Variance in lean accounted for (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length, area at 12th rib</td>
<td>.72</td>
<td>52</td>
</tr>
<tr>
<td>Length, fat thickness</td>
<td>.31</td>
<td>10</td>
</tr>
<tr>
<td>Area at 12th rib, fat thickness</td>
<td>.64</td>
<td>41</td>
</tr>
<tr>
<td>Fat thickness, weight</td>
<td>.84</td>
<td>71</td>
</tr>
<tr>
<td>Area at 12th rib, weight</td>
<td>.75</td>
<td>57</td>
</tr>
<tr>
<td>Length, weight</td>
<td>.80</td>
<td>64</td>
</tr>
<tr>
<td>Length, area at 12th rib, fat thickness</td>
<td>.72</td>
<td>52</td>
</tr>
<tr>
<td>Length, area at 12th rib, weight</td>
<td>.81</td>
<td>66</td>
</tr>
<tr>
<td>Length, fat thickness, weight</td>
<td>.84</td>
<td>71</td>
</tr>
<tr>
<td>Length, area at 12th rib, fat thickness, weight</td>
<td>.85</td>
<td>72</td>
</tr>
<tr>
<td>Length, area at 5th rib, area at 12th rib, area at last lumbar, fat thickness, weight</td>
<td>.88</td>
<td>78</td>
</tr>
</tbody>
</table>
the twelfth rib alone and a definite improvement over fat thickness alone.

The next three combinations are of carcass weight and one of the other carcass measurements. A considerable amount, 71 percent, of the variation in pounds of lean can be attributed to a combination of fat thickness and carcass weight. This high linear relationship would merit the use of the combination of fat thickness and weight in estimating carcass leanness or muscling. This agrees with Murphey (1960) who found that cutability of a beef carcass could be estimated accurately by using carcass weight and fat thickness along with ribeye area at the twelfth rib. A combination of ribeye area at the twelfth rib and carcass weight accounted for 57 percent of the variation in lean. The addition of ribeye area at the twelfth rib to carcass weight accounted for practically no more of the variation in lean than when weight was used alone. Variation in lean attributed to carcass length and weight was 64 percent. This was slightly higher than when weight was used alone.

The combination of the three measurements (length, ribeye area at the twelfth rib and fat thickness) accounted for 52 percent of the variation in carcass lean. This was the same as when only length and area at the twelfth rib were used together. However, the addition of ribeye area at the twelfth rib to the combination of length and fat thickness greatly improved the association with pounds of separable lean. The addition of length to the combination of ribeye area at the twelfth rib and fat thickness also improved the association with pounds of lean. Length, ribeye area at the twelfth rib and weight, when used together, accounted for 66 percent of the variation in pounds of lean. The addition of weight
increased the amount of variation in lean accounted for when only length and area at the twelfth rib were used. The addition of length to the combination of ribeye area at the twelfth rib and weight also made an improvement. However, variation in lean attributed to the addition of ribeye area at the twelfth rib to the combination of length and weight did not increase materially. Seventy-one percent of the variation in pounds of lean was associated with the combination of carcass length, fat thickness and weight. This was an improvement over the combination of weight and length and fat thickness and length. However, the addition of length did not increase the percent variation in lean accounted for when only weight and fat thickness were used together.

Carcass length, ribeye area at the twelfth rib, fat thickness and carcass weight, when considered together, accounted for 72 percent of the variation in pounds of lean. This was practically no more than when only weight and fat thickness were used together. Seventy-eight percent of the variation in pounds of lean was attributed to the combination of all six measurements (carcass length, ribeye area at the fifth rib, twelfth rib, last lumbar vertebra, and carcass weight). This was only a slight improvement over the combination of weight and fat thickness.

As shown in Table I, there was a wide range in weight among the carcasses studied. The multiple correlations in Table V indicated that weight in combination with carcass length, ribeye area at the twelfth rib or fat thickness accounted for 57 to 71 percent of the variation in pounds of carcass lean. Two partial correlations were studied to determine the effect of ribeye area at the twelfth rib and fat thickness on pounds of
lean when weight was held constant. The partial correlation coefficient of ribeye area at the twelfth rib with pounds of carcass lean holding weight constant was 0.23. This indicated a low positive association between ribeye area at the twelfth rib and pounds of lean when variation due to weight was removed. Orme, Pearson, Magee and Bratzler (1959) indicated a negative relationship between ribeye area and the percentage of primal cuts. The partial correlation coefficient of fat thickness with pounds of carcass lean holding weight constant was -.58. Therefore, when carcass weight is held constant, fat thickness is much more closely associated with a carcass lean than is ribeye area at the twelfth rib.

Table VI lists simple correlations between all possible combinations of the measurements studied. Carcass length is negatively associated with most of the other measurements. The correlation coefficient between length and fat thickness is -.50. This indicates that an increase in carcass length gives a corresponding decrease in fat thickness. As was shown in Table I, the two dairy breeds were longer with less fat thickness than the other breeds.

Simple correlation coefficients between the three area measurements of the Longissimus dorsi muscle were 0.52 to 0.53. This indicates a similar positive relationship between these measurements. A low positive association was observed between each of the three ribeye area measurements and fat thickness. This agrees with Woodward et al. (1954) who found that area of the eye muscle and fat thickness were not significantly correlated. Table IV indicates a moderate relationship (0.50, 0.59 and 0.39) between ribeye area measurements and pounds of carcass
### TABLE VI

**MULTIPLE CORRELATIONS BETWEEN VARIOUS CARCASS MEASUREMENTS AND POUNDS OF CARCASS LEAN**

<table>
<thead>
<tr>
<th>$x_1$</th>
<th>$x_2$</th>
<th>$x_3$</th>
<th>$x_4$</th>
<th>$x_5$</th>
<th>$x_6$</th>
<th>$x_7$</th>
<th>$x_8$</th>
<th>$x_9$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$r \geq .273$ significant at 5% level

$r \geq .354$ significant at 1% level

$x_1 = \text{Length of carcass}$

$x_2 = \text{Ribeye area at 5th rib}$

$x_3 = \text{Ribeye area at 12th rib}$

$x_4 = \text{Ribeye area at last lumbar vertebra}$

$x_5 = \text{Average of three fat thickness measurements over 12th rib}$

$x_6 = \text{Chilled carcass weight}$

$x_7 = \text{Average of the three ribeye area measurements}$

$x_8 = \text{Average of the three ribeye area measurements times length}$

$x_9 = \text{Ribeye area at 12th rib times length}$
lean. However, as shown in Table VI, correlation coefficients of carcass weight with ribeye area at the fifth rib, twelfth rib and last lumbar vertebra are 0.61, 0.74 and 0.43, respectively. Likewise, an average of the three ribeye area measurements, average times length, and ribeye area at the twelfth rib times length were more highly related to carcass weight than with pounds of carcass lean.

As was shown in Table IV, fat thickness and pounds of carcass lean were not closely related \( (r=0.07) \). However, Table VI gives a correlation coefficient of 0.53 between fat thickness and carcass weight. These data indicate that an increase in carcass weight gives a corresponding increase in fat thickness.

Table VII lists prediction equations for pounds of separable lean in a beef carcass. The equations represent measurements or combinations of measurements which showed a correlation of 0.70 or higher with pounds of separable carcass lean (Table IV and V).
### Table VII

**Prediction Equations for Pounds of Lean In The Left Side of a Beef Carcass**

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_6$: Carcass weight</td>
<td>$\hat{Y} = 24.6488 + (.2256)(X_6)$</td>
</tr>
<tr>
<td>$X_8$: Average ribeye area X length</td>
<td>$\hat{Y} = 35.7881 + (.3205)(X_8)$</td>
</tr>
<tr>
<td>$X_1$: Length, $X_3$: Ribeye area 12th rib</td>
<td>$\hat{Y} = -114.0752 + (3.7906)(X_1)$ + (9.0775)(X_3)</td>
</tr>
<tr>
<td>$X_5$: Fat thickness, $X_6$: Weight</td>
<td>$\hat{Y} = 7.1155 + (-1.1493)(X_5)$ + (.2967)(X_6)</td>
</tr>
<tr>
<td>$X_2$: Ribeye area 12th rib, $X_6$: Weight</td>
<td>$\hat{Y} = 24.6704 + (.0445)(X_3)$ + (.2090)(X_6)</td>
</tr>
<tr>
<td>$X_1$: Length, $X_6$: Weight</td>
<td>$\hat{Y} = -84.2369 + (2.3475)(X_1)$ + (.2302)(X_6)</td>
</tr>
<tr>
<td>$X_1$: Length, $X_3$: Ribeye area 12th rib, $X_5$: Fat thickness</td>
<td>$\hat{Y} = -115.3209 + (3.8165)(X_1)$ + (9.0533)(X_3) + (.0179)(X_5)</td>
</tr>
<tr>
<td>$X_1$: Length, $X_3$: Ribeye area 12th rib, $X_6$: Weight</td>
<td>$\hat{Y} = -110.4603 + (2.9152)(X_1)$ + (3.2970)(X_3) + (.1733)(X_6)</td>
</tr>
<tr>
<td>$X_1$: Length, $X_5$: Fat thickness, $X_6$: Weight</td>
<td>$\hat{Y} = -23.9068 + (.7163)(X_1)$ + (-1.0058)(X_5) + (.2892)(X_6)</td>
</tr>
<tr>
<td>$X_1$: Length, $X_3$: Ribeye area 12th rib, $X_5$: Fat thickness, $X_6$: Weight</td>
<td>$\hat{Y} = -44.8279 + (1.1962)(X_1)$ + (1.9919)(X_3) + (-.9214)(X_5) + (.2499)(X_6)</td>
</tr>
<tr>
<td>$X_1$: Length, $X_2$: Ribeye area at 5th rib, $X_3$: Area at 12th rib, $X_4$: Area at 5th rib, $X_5$: Fat thickness, $X_6$: Weight</td>
<td>$\hat{Y} = -732.03 + (18.641)(X_1)$ + (73.331)(X_2) + (17.251)(X_3) + (-1.4813)(X_4) + (-8.6021)(X_5) + (1.9332)(X_6)$</td>
</tr>
</tbody>
</table>
CHAPTER V

SUMMARY AND CONCLUSIONS

Data were obtained from 51 steer carcasses representing 6 breeds. The animals were raised under the same environmental conditions from approximately 4 months of age and fully fed a high concentrate ration to 20 months of age or 900 pounds, whichever the individual reached first. The relationship of carcass length, weight, fat thickness over the twelfth rib, area of the Longissimus dorsi muscle at the fifth rib, twelfth rib and last lumbar vertebra to pounds of separable lean in the left side of each carcass was determined. An average of the three ribeye area measurements was obtained to determine whether an improvement could be made over each individual area measurement. This average was multiplied by carcass length and the relationship to pounds of lean was determined. A considerable amount, 24 to 67 percent, of the variation in these carcass measurements was due to breed differences.

Correlation coefficients between ribeye area at the fifth rib, twelfth rib, last lumbar vertebra, average of these three measurements and average area times carcass length with pounds of separable lean were 0.57, 0.59, 0.39, 0.63 and 0.73, respectively. Of all the measurements studied, pounds of lean was more closely associated with carcass weight ($r = 0.75$).

The combination of weight and fat thickness was far superior to any area measurement and multiple area measurements of the Longissimus dorsi muscle in estimating carcass lean. Multiple correlations showed
that the combination of weight and fat thickness was nearly as closely associated with pounds of lean \((R = 0.84)\) as the combination of all 6 measurements \((R = 0.88)\). This high linear relationship would merit the use of the combination of carcass weight and fat thickness in estimating leanness or muscling in a beef carcass. Likewise, partial correlations indicated that fat thickness was a more accurate indicator of carcass lean \((r = -0.58)\) than was ribeye area at the twelfth rib \((r = 0.23)\) when weight was held constant.

Equations for predicting pounds of separable lean in a beef carcass are given.
LITERATURE CITED


