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To the Graduate Council:

I am submitting herewith a thesis written by James B. Shepard entitled "The Relationship of Ultrasonic Estimates of Fat Thickness and L. Dorsi to Selected Carcass Traits of Steers and Heifers." 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.

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THE RELATIONSHIPS OF ULTRASONIC ESTIMATES OF FAT
THICKNESS AND L. DORSI TO SELECTED CARCASS
TRAITS OF STEERS AND HEIFERS

A Thesis
Presented to
the Graduate Council of
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CHAPTER I

INTRODUCTION

The use of ultrasonics in estimating muscling and fatness in live animals is a comparatively new technique. Favorable results in previous experiments have indicated a potential use in the livestock industry.

The principal use of ultrasonics, if successfully developed, would be for the selection of breeding animals. It would assist breeders to select those breeding animals which possess a higher proportion of lean in the carcass. Previously, the basis for selecting breeding animals which have superior carcasses, has required carcass evaluation of the offspring of sires and dams which have been selected for type and rapidity and efficiency of weight gains. Due to the long generation interval in cattle, evaluating sires for carcass traits has proved to be a costly process. Many breeders have disposed of a sire before his potential value to the herd, in terms of carcass traits, was known. Ultrasonics may enable breeders to eliminate years of experimental breeding for leanness by being able to evaluate the carcass potential of an animal before it is placed in service.

The purpose of this study was to compare ultrasonic estimates of rib-eye area and fat thickness in steers and heifers with the actual carcass values, using interpretations of the somagrams by three different experimenters and an average of the three.

CHAPTER II

REVIEW OF LITERATURE

Limited experimental work has been done to determine the reliability of ultrasonic estimates of carcass characteristics in beef animals. Two techniques used in ultrasonic research are the "A" and "B" scan. In the "A" scan technique, developed by Howry et al. (1952), ultrasonic soundings at various intervals, usually 0.5 to 1 inch, are made on the live animal to determine the hide, fat and muscle thicknesses. Location of ultrasonic soundings are appropriately marked on the animal. A corresponding curvature of the body, as determined by use of solder wire, and depth readings taken directly from the oscilloscope, are plotted on graph paper. The plotted areas are connected with lines resulting in a cross sectional display of the area ultrasonically measured. The main difficulty with this technique is determining which ultrasonic readings should be connected to represent hide, fat and muscle boundaries.

In the "B" scan technique, the longitudinal and vertical locations of the signals on the oscilloscope are synchronized with the position of the transducer in relation to the area being evaluated on the animal. The signals produced on the oscilloscope are such that they remain for a period of time giving a continuous train of signals, i.e., not disappearing immediately after the transducer picks up a new signal. Hence, on the oscilloscope, a complete picture of the area scanned can be seen. However, the equipment for this technique is expensive and elaborate,

Stouffer et al. (1961) modified this technique, giving much the same result by focusing a Polaroid Land Camera on the oscilloscope and taking a time exposure recording the momentary signals which appear on the oscilloscope as the animal is scanned.

Temple (1956) obtained ultrasonic estimates of fat thickness from 60 cattle at points 3, 7 and 11 inches from the vertebral column over the last rib using the "A" scan technique. The average of 4 readings made by two men showed a significant relationship ($P < 0.01$) with actual fat thickness at the 3- and 7-inch positions ($r = 0.42$ and 0.55 , respectively), but failed to be significant at the 11-inch position ($r = 0.25$). The difference between operators of the ultrasonic instrument was not significant.

Campbell et al. (1959) obtained ultrasonic estimates of longissimus dorsi muscle depth and area over the last rib region at points 1, 1.5 and 2 inches off spinal column of 65 sheep divided into two groups and using the "A" scan technique. Correlation coefficients between estimated and actual rib-eye depth were 0.68 for group I and 0.49 for group II. Significant ($r = 0.62$ and 0.44) values for groups I and II respectively were obtained between ultrasonic estimates and actual rib-eye area.

Hazel and Kline (1959) compared ruler probe measurements of fat thickness with ultrasonic estimates on 56 market weight hogs using the Kelvin and Hughes Mark V instrument with a 2.5 mc. transducer and the "A" scan technique. Measurements were taken at the 6th rib, 12th rib and last lumbar vertebra approximately 2 inches off the mid-line over the 1. dorsi muscle. Two difficulties with the experiment were movement of the

hog causing variation on the oscilloscope and the difficulty in distinguishing the fascia layer from the surface of the l. dorsi muscle. The simple correlation coefficient between the ultrasonic estimate of fat thickness and per cent lean cuts was $-.90$. The corresponding correlation coefficient between the mechanical probe and per cent lean cuts was $-.89$.

Price et al. (1960) studied the usefulness of ultrasonics in evaluating live animals by estimating fat thickness and lean depth of 158 hogs divided into two groups using the Sperry Reflectoscope equipped with a 2.25 mc. crystal. On group I, ultrasonic estimates of fat thickness were made 1.5 inches off the mid-line at points opposite the last lumbar, the last thoracic and the first thoracic vertebrae and averaged. Soundings for lean depth were made at three locations in the last rib region and averaged. In group II lean depth probes were taken at the center of the back only 1.5 inches off the mid-line. Significant correlation coefficients were found between ultrasonic fat estimates and live fat probes ($r = 0.81$). Estimated and actual fat thickness likewise were significantly associated ($r = 0.82$). Ultrasonic estimates of fat thickness were significantly associated with cut-out but the apparent value of this method is less than that of the live probe. This disagrees with results obtained by Hazel and Kline (1959) who reported a correlation coefficients of $-.90$ between ultrasonic estimates of fat thickness and per cent lean cuts. Ultrasonic estimates of l. dorsi muscle depth were significantly related to depth determinations taken from the carcass tracings ($r = 0.30$).

Stouffer et al. (1960) obtained ultrasonic estimates of rib-eye area and fat thickness at the 12th and 13th rib region of cattle and hogs

using the model 396 Reflectoscope and the "A" scan technique. Simple correlation coefficients between estimated and actual fat thickness ranged from 0.32 to 0.54 for 152 beef steers and heifers in three groups. Ultrasonic estimates of rib-eye area were associated with from 5 to 72 per cent of the variation in actual rib-eye area over all groups. Estimates of fat thickness in 42 hogs were more accurate than for cattle ($r = 0.92$). Estimated and actual rib-eye area in the hogs likewise showed a highly significant association ($r = 0.70$).

Stouffer et al. (1961) obtained ultrasonic estimates of rib-eye area and fat thickness on 327 cattle divided into 8 groups. The data were analyzed separately because the evaluation technique was different for each group. The Sperry Reflectoscope with a 1.0 mc. transducer was used in Groups I-VII and a Branson Sonoray with a 1.6 mc. transducer was used in Groups VIII and IX. A 35 mm. camera was used to record the reflected images resulting from individual soundings on the oscilloscope from Groups I-IV. In Groups V-IX, a Beattie Oscillitron recording device with a Polaroid Land Camera provided a complete cross-sectional display of the fat and lean areas at the 13th rib region of live cattle. Less time was involved in getting the cross-sectional picture with this type of "B" scan technique. Comparisons of ultrasonic rib-eye area estimates with carcass rib-eye area gave significant correlations ranging from 0.22 to 0.85. Correlation coefficients between ultrasonic estimates and carcass fat thickness measurements were lower in eight of the groups than those reported by other workers ($r = 0.04$ to 0.54). However, in Group IV hogs were used and a correlation coefficient of 0.92 was obtained between

ultrasonic estimates and carcass fat thickness measurements. The author states that the relatively low correlations may be due partially to the amount of pressure by the transducer against the hide and partially to differences in fat thickness at various points between the 12th and 13th rib. Comparison of repeated ultrasonic measurements indicated significant repeatability of the method. Limited data suggest that the positional variation of rib-eye area and fat thickness between the 12th and 13th ribs, changes of shape and size of the rib eye due to slaughtering and hanging, and variation between ultrasonically estimated area and area from which carcass data were obtained, are probable factors accounting for low relationships between ultrasonic and carcass measurements.

Hedrick et al. (1962) obtained ultrasonic estimates of fat thickness on 203 cattle at the 12th and 13th rib area using the Branson Sonoray Model 5 and the "A" scan technique. The chine bones were scribed in 1 of the 4 groups used. Correlation coefficients between estimated fat thickness and actual fat thickness varied from 0.11 to 0.63. A low correlation existed between ultrasonic estimates and actual measurements in the group which had the chine bones scribed. Significant relationships existed between the two methods of measuring fat thickness when the spinous processes were not scribed. Significant relationships existed between ultrasonic estimates of rib-eye area five months prior to slaughter and actual rib-eye area in the carcasses of 36 cattle. However, the relationship between estimated and actual fat thickness measured at the same period was not significant.

Zobrisky et al. (1961) compared ultrasonic measurements of l. dorsi area and back fat thickness with conventional carcass indices of meatiness on 237 hogs. A Branson Model 5 and the "A" scan technique were used. Significant correlation coefficients ($P < 0.01$) were found between estimated and actual l. dorsi area within sex and weight groups. Highly significant correlations were obtained between the four lean cuts and estimated l. dorsi area within sex and weight groups. Likewise, the correlations between total carcass trim fat and back fat thickness were significant ($P < 0.01$) within sex and weight. The results were comparable to those obtained by employing conventional methods of carcass measurements.

Brinks et al. (1962) obtained ultrasonic estimates of rib-eye area, fat depth and fat area at the 12th rib using 39 Herefords and 13 Charolais averaging 908 pounds in weight. Partial correlations between estimated rib-eye area and per cent lean, per cent fat or per cent bone of the 9-10-11 rib cut indicated only slight relationships. Likewise, estimated fat thickness was slightly related to per cent lean, per cent fat and per cent bone but appeared to be more promising for predicting carcass traits than rib-eye area.

Sumption et al. (1963) obtained ultrasonic estimates of fat thickness 9 and 13 cm. off the mid-line at the 12th and 13th rib region of over 400 cattle using the "A" scan technique. No correlation coefficients were shown. However, ultrasonic estimates and actual carcass fat measurements from 10 animals were reported. Variations between actual and ultrasonically estimated fat thickness ranged from 0.02 to 0.10 inches on nine

of the animals, with the ultrasonic estimate being higher than the actual carcass measurement, while actual fat thickness measurements on one animal was 0.03 inch higher than the ultrasonic estimate.

CHAPTER III

MATERIAL AND METHODS

This study was conducted on 25 steers and 24 heifers of the Angus breed which were purchased at the fall feeder calf sales at Columbia and Cookeville, Tennessee. The cattle were on an experimental feeding program at the Middle Tennessee Agricultural Experiment Station, Spring Hill, Tennessee. They were fed a full-feed of high quality corn silage, 5 pounds cracked shelled corn, 1 pound cottonseed meal and 3 pounds alfalfa hay per head per day for 140 days. Then the ground shelled corn and cottonseed meal mixture was increased and the silage decreased until the cattle were on a full feed of grain. They were fed and managed as described by Whittenburg (1963).

Weights and grades. The cattle were slaughtered when live grades of high good to low choice were obtained. The grades were determined by representatives of the University of Tennessee Animal Husbandry Department. At slaughter, the steers averaged weighing approximately 950 pounds and the heifers approximately 775 pounds.

Equipment and technique. A Branson Sonoray Model 52 equipped with a 2.25 mc. transducer was used in this experiment. The longitudinal location of the signal on the oscilloscope was synchronized with the position of the transducer on the animal's back. A Polaroid Land Camera was focused on the oscilloscope and a time exposure taken. This time exposure

was a cross-sectional picture (somagram) of the area scanned. The 10-second film developing process enabled rapid visual appraisal of the picture to determine whether or not the area scanned could be interpreted while the animal was still restrained in a squeeze chute.

Two different ultrasonic readings were taken on the left side of each animal at two locations. In order to be consistent with the location on each animal, a point approximately 7 inches lateral to the vertebral column and between the 12th and 13th rib was located, and an imaginary line from this point to, and perpendicular with, the vertebral column was used as the reference for the first reading. This scan was made at right angles to the line of the l. dorsi and vertebral column. A point approximately four inches from the vertebral column was used as a reference for the second reading which was longitudinal over the l. dorsi muscle and parallel with the vertebral column. This provided a crossing point of the two separate scans. The hair was clipped from these two areas and mineral oil was applied to the hide to transmit the sound waves from the transducer to the hide. Ultrasonic readings were taken at each of the two above-described locations on each animal. It was necessary to repeat some of the scans due to movement of the animal or operational difficulty with the instrument. The crossing point of the two readings was identified on the somagrams by pressing downward very sharply on the transducer as it passed over the crossing point of the perpendicular and longitudinal scans. This technique made a slight indentation on the somagram. The fat measurement from the somagram was taken to the right of

this area, approximating the area on the carcass from which the actual fat measurement was taken.

All animals were slaughtered at the Neuhoff Packing Company within a two-week period after ultrasonic measurements were made. At the time of the slaughter the carcasses were tagged to identify them in the cooler. Hot carcass weights were recorded and the chine bones of each carcass were scribed by the conventional packing house method prior to entering the cooler.

After the carcasses had been in the cooler approximately 24 hours, one side of each carcass was ribbed and conformation grade, marbling, maturity, carcass grade, per cent kidney fat and adjusted kidney fat information were provided by a Federal Meat Grader. Carcass length was measured from the anterior edge of the aitch bone to the anterior edge of the first rib. Length of both right and left sides of 24 heifer and 5 steer carcasses were measured and averaged. Carcass length measurements on 20 steers came from only the right side because the packer had shipped the left side. Rib-eye tracings and fat thickness measurements were made between the 12th and 13th ribs. This approximated the location of the ultrasonic reading on the live animal. Rib-eye tracings were made on the left side of the carcass of 24 heifers and 5 steers and on the right side of 20 steer carcasses which had the left side shipped.

A roast approximately 3 inches in thickness was taken from the 12th rib region of each carcass. Fat measurements, in mm., were made on the posterior side of this 12th rib roast, three-fourth distance across the 1. dorsi muscle on the same sides from which rib-eye tracings were taken.

Likewise, this location approximated the area where ultrasonic readings were taken on the live animal.

After fat measurements were taken, the rib roasts were packed in dry ice and shipped to the University of Tennessee where cooking tests were conducted. The rib roasts were cooked in a Despatch oven at 300°F., to an internal temperature of 68°C. Two 1-inch cores were taken and each sheared three times with a Warner-Bratzler shear machine. Total cooking losses were determined.

Somagram interpretations. Each of three researchers made two independent interpretations of fat thickness and rib-eye area from the somagrams. An average of all interpretations also was calculated.

The University of Tennessee prediction equation was used to estimate the pounds of separable muscle in one-half of each carcass (Cole et al., 1962). The formula is:

$$Y = 11.73 - (1.73 \times \text{fat thickness over rib-eye, mm.}) + (0.289 \times \text{carcass weight, lb.})$$

An estimated per cent separable muscle was determined by doubling the pounds of separable muscle in one-half carcass and dividing the results by the carcass weight.

The formula used to estimate the per cent of boneless closely-trimmed retail cuts in the round, loin, rib and chuck (Morphey et al., 1960). The formula is:

$$Y = 51.34 + (0.74 \times \text{rib-eye area, sq. in.}) - (5.784 \times \text{fat thickness, in.}) - (0.0093 \times \text{carcass weight, lb.}) - (0.462 \times \text{kidney fat, per cent})$$

Data were analyzed by linear correlation and analysis of variance as outlined by Snedecor (1946). The latter was used to test for significance of difference in various carcass traits between steers and heifers. Data for steers and heifers were analyzed separately in all correlation studies.

CHAPTER IV

RESULTS AND DISCUSSION

Ultrasonic estimates of fat thickness and rib-eye area by three different interpreters, along with an average of the three, were compared to actual carcass traits of 25 steers and 24 heifers. In each table, where applicable, the estimates are listed in order, according to the amount of experience in somagram interpretation. The first interpreter was the most experienced.

Mean differences. Analyses of variance were performed to test for significance of differences between sexes in various carcass traits. As shown in Table I, a significant difference existed between steers and heifers in average carcass length with carcasses of steers being 1.3 inches longer. A portion of this variation between sexes may be attributed to the difference in live weights when slaughtered, with steers weighing approximately 175 pounds more than the heifers. If adjustments for carcass weight differences had been made, the carcass length difference might have been much lower.

A significant difference ($P < 0.05$) was found in conformation grade with the mean of the steers being 0.6 higher than that of heifers. It is believed that nutrition has been over-emphasized in this area and that sex and breeding have a more prominent place in determining differences in conformation grade between sexes than does nutrition. No significant

TABLE I
MEANS, STANDARD ERRORS AND MEAN SQUARES FOR SELECTED CARCASS MEASUREMENTS AND GRADES

Item	Carcass length in.	Conformation grade	Marbling score	Carcass grade	Estimated kidney and pelvic fat %	Actual fat thickness in.	Estimated fat thickness in.
Means and standard errors							
Steers	44.7 $\pm$.36	12.6 $\pm$.16	5.2 $\pm$.21	11.3 $\pm$.27	4.1 $\pm$.07	.40 $\pm$.003	.44 $\pm$.07
Heifers	43.4 $\pm$.32	12.0 $\pm$.16	5.2 $\pm$.16	11.7 $\pm$.22	4.2 $\pm$.06	.44 $\pm$.003	.47 $\pm$.02
Mean squares							
Source of variation							
Sex	21.98**	4.38*	0.03	1.90	0.12	0.02	0.01
Error	2.87	0.65	0.84	1.50	0.12	0.02	0.01

*P < .05.

**P < .01.

differences between sexes were found for marbling, carcass grade and estimated kidney and pelvic fat.

Fat thickness. Ultrasonic estimates of fat thickness over the 1. dorsi muscle in the 12th and 13th rib region were slightly higher than actual fat thickness in both steers and heifers. Estimates were 0.04 and 0.03 inches higher than the actual in steers and heifers, respectively. In actual fat thickness, heifers were 0.04 inches fatter than steers. In estimated fat thickness, heifers were 0.03 inches fatter than steers. The difference between steers and heifers was not significant for either actual or estimated fat thickness. Temple (1956) found difficulty in locating the area on the carcass which exactly corresponded to the area scanned on the animal while it still was alive. Stouffer et al. (1961) indicated that differences in the estimated and actual fat thickness and rib-eye area could be caused by variations in the ribbing technique, scribing of the chine bones and changes in the shape of the rib-eye due to hanging of the carcass.

Rib-eye area. Ultrasonic estimates of average rib-eye area over the 12th and 13th rib region were slightly higher than actual rib-eye area in the steers and slightly lower in the heifers, Table II. On the average, the actual rib-eye area for the heifers was 0.1 inch larger than the steers. In estimated average rib-eye area the steers were 0.05 inch larger than the heifers. However, there was no significant difference between steers and heifers for either actual or estimated rib-eye area.

TABLE II

MEANS, STANDARD ERRORS AND MEAN SQUARES FOR ACTUAL AND ESTIMATED RIB-EYE AREA, PREDICTED CUT-OUT, SHEAR VALUE AND COOKING LOSSES

Item	Actual rib-eye area sq. in.	Estimated rib-eye area sq. in.	Estimated separable muscle lb.	Estimated separable muscle %	Estimated boneless, closely- trimmed retail cuts %	Shear value, 1" cores lb.	Total cooking losses %
<u>Means and standard errors</u>							
Steers	10.8 $\pm$.20	11.0 $\pm$ 1.83	148.5 $\pm$ 2.60	55.6 $\pm$.43	50.4 $\pm$.21	15.5 $\pm$.38	21.2 $\pm$.31
Heifers	10.9 $\pm$.24	10.5 $\pm$ 1.64	129.9 $\pm$ 2.70	54.6 $\pm$.57	50.8 $\pm$.22	15.6 $\pm$.55	21.5 $\pm$.41
<u>Mean squares</u>							
Source of variation							
Sex	0.03	2.45	4254.80**	12.89	2.21	0.06	1.74
Error	1.16	1.98	116.70	6.34	1.62	5.40	2.75

**P < .01.

A highly significant difference between sexes was obtained for estimated pounds of separable muscle in one side of the carcass. The estimates were obtained by using actual fat thickness and carcass weight in the Tennessee equation developed by Cole et al. (1962). Steers had an average of 18.6 pounds more separable muscle than heifers; however, their carcasses also were heavier. When separable muscle was expressed as a per cent of carcass weight, no significant difference existed between the sexes.

No significant difference existed between steers and heifers for estimated per cent of boneless, closely-trimmed retail cuts from the round, loin, rib and chuck, shear value and total cooking losses; however, the heifers had higher means for each of these carcass traits than the steers with one exception. The estimated per cent separable muscle mean was 1.0 per cent higher for the steers than for the heifers.

As shown in Table III, significant simple correlation coefficients were obtained between ultrasonic estimates of fat thickness over the 1. dorsi muscle in the 12th and 13th rib region and actual fat thickness measurements made on the carcasses of both steers and heifers by each interpreter. The coefficients among interpreters ranged from 0.49 to 0.63 on the steers and 0.50 to 0.72 on the heifers. These relationships are similar to those reported by Temple (1956) and Hedrick (1962).

Correlation coefficients between ultrasonic estimates and actual fat thickness for each interpreter on the group of steers were lower than those on the heifers. A possible reason is that actual fat thickness measurements of 20 of the 25 steers were taken on the opposite side of the carcass from which ultrasonic readings were made.

TABLE III
SIMPLE CORRELATION COEFFICIENTS BETWEEN FAT THICKNESS
AND SELECTED CARCASS TRAITS

	Actual fat thickness		Ultrasonic estimate of fat thickness ³	
	Steers	Heifers	Steers	Heifers
Ultrasonic estimates of fat thickness ¹				
Interpretation 1	0.63**	0.72**		
Interpretation 2	0.54**	0.64**		
Interpretation 3	0.49*	0.50**		
Average ³	0.59**	0.69**		
Estimated separable carcass muscle				
Pounds	-.32	-.22	0.26	0.20
Per cent	-.99**	-.99**	-.52**	-.64**
Estimated per cent cuts ²	-.79**	-.71**	-.52**	-.41*
Shear value	0.08	0.09		
Total cooking loss	0.27	0.11		

* $p < .05$.

** $p < .01$.

¹Experience of interpreters ranks in the order listed with interpreter 1 being most experienced.

²Estimated per cent of boneless, closely-trimmed retail cuts from the round, loin, rib, and chuck.

³Average of the three ultrasonic estimates.

Negative correlations existed between the average actual fat thickness and estimated pounds of separable muscle ($r = -.32$ and $-.22$ for steers and heifers, respectively). This indicates that actual fat thickness is not a reliable indicator of this carcass trait, since it is associated with less than 10 per cent of the variation in pounds of separable muscle. A positive association was obtained between the average ultrasonic estimates of fat thickness and estimated pounds of separable muscle ($r = 0.26$ and 0.20 for steers and heifers, respectively). The difference in sign is probably because the ultrasonic estimates only account for approximately 40 per cent of the variation in actual fat thickness. However, high negative correlations ($r = -.99$ and $-.99$ for steers and heifers, respectively) were found between actual fat thickness measurements and the estimated per cent separable muscle. This increase in relationship with fat thickness, when separable muscle is expressed as per cent of carcass weight, is thought to be, in part, a result of a positive association between fat thickness and carcass weight and also because the correlation between fat thickness and per cent separable muscle is, in fact, a correlation between fat thickness and per cent separable fat due to the automaticity in the relationship of per cent fat and per cent muscle. The average ultrasonic estimates of fat thickness were significantly associated ($P < 0.01$) with from 26 to 40 per cent of the variation in the estimated per cent of separable muscle in both steer and heifer carcasses, respectively.

Correlations between the estimated per cent boneless, closely-trimmed retail cuts from the round, loin, rib and chuck, based on the

USDA yield grade formula (Murphey, 1960) and actual fat thickness were $-.79$ for steers and $-.71$ for heifers, respectively. The corresponding correlations between the average ultrasonic estimates of fat thickness and the estimated per cent cuts were $-.52$ for steers and $-.41$ for heifers. These data indicate that, as fat thickness increases, per cent muscling in the carcass tends to decrease. The data also indicate that ultrasonic estimates are not as valuable as actual fat thickness for predicting cut-out.

A low positive relationship existed between the shear value of a 1-inch core of cooked muscle taken from the 12th rib section and actual fat thickness. Less than 1 per cent of the variation in shear value was associated with the variation in fat thickness. Higher associations were found between total cooking losses and actual fat thickness ($r = .27$ and 0.11). It may be noted that the higher correlation coefficient was obtained on the steers in which the actual fat thickness measurements were taken on the side opposite to that on which ultrasonic estimates were made on 20 of the 25 animals.

Difficulty was experienced in locating the area on the live animal which would correspond to the point three-fourths the length of the 1. dorsi from the chine end. In order to determine what effect an error in location would have on fat thickness estimates, the ultrasonic estimates of fat thickness at points one-half and three-fourths the length of the 1. dorsi were compared. The simple correlation coefficients for estimated fat thickness taken at points one-half and three-fourths the length of the 1. dorsi muscle were 0.73 for steers and 0.48 for heifers.

These results indicate that an error in location could greatly affect the fat thickness estimate. Since the fat layer is known to slide away from the mid-line and over the 1. dorsi when the carcass is split and the chine bones are scribed, this could explain some of the rather low correlations obtained between actual and estimated fatness. Even though the fat thickness is measured at the proper location on the live animal, this location may be covered by a different thickness of fat in the carcass. (This comparison was made by number 3 interpreter only.)

Rib-eye area. Actual rib-eye area and the ultrasonic estimates by three interpreters were significantly related ($P < 0.01$) for the heifers. Ultrasonic estimates of rib-eye area were associated with from 27 to 38 per cent of the variation in the actual rib-eye area, Table IV. These results are in agreement with those reported by Stouffer and Wellington (1960), Stouffer et al. (1961), and Hedrick (1962). Correlations for each of the interpreters on the group of steers were not significant ($P < 0.05$). A possible explanation for these low correlations is that rib-eye tracings were made on the right side of the carcass on 20 of the 25 steers while ultrasonic estimates were made on the left side. Comparison of data in Tables III and IV shows that, even though actual fat thickness measurements and rib-eye tracings were made on the opposite side of the carcass from which ultrasonic estimates were made, estimated fat thickness correlations were still significant for each interpreter on the group of steers while neither of the rib-eye correlations were significant on the same group. A possible explanation for the variation is that when any error is obtained in the somagram interpretation, it is

TABLE IV
SIMPLE CORRELATION COEFFICIENTS BETWEEN RIB-EYE
AREA AND SELECTED CARCASS TRAITS

	Actual rib-eye area		Ultrasonic estimate of rib-eye area ³	
	Steers	Heifers	Steers	Heifers
Ultrasonic estimates of rib-eye area ¹				
Interpretation 1	0.30	0.58**		
Interpretation 2	0.22	0.63**		
Interpretation 3	0.03	0.53**		
Average ³	0.19	0.61**		
Estimated separable muscle per cent	0.02	-.12	-.06	-.04
Estimated per cent cuts ²	0.43*	0.35	-.23	0.16

* $P < .05$.

** $P < .01$.

¹Experience of interpreters ranks in the order listed with interpreter 1 being most experienced.

²Estimated per cent of boneless, closely-trimmed cuts from the round, loin, rib, and chuck.

³Average of the three ultrasonic estimates.

magnified 6.25 times because this standard factor was used to convert somagram interpretations to actual size. Also, it is more difficult to interpret muscle boundaries on the somagram than fat boundaries. This indicates that positional variation between the ultrasonically estimated area and the area from which measurements are taken on the carcass may be more important in the case of ultrasonic estimates of rib-eye area than for ultrasonic estimates of fat thickness. Likewise, the correlation coefficients for fat thickness on the group of heifers tended to be higher than those for rib-eye area, indicating that fat thickness estimates are easier to obtain than rib-eye area estimates.

A very low positive correlation ($r = 0.02$) was obtained between actual rib-eye area and the estimated per cent separable muscle on the group of steers while a low negative correlation ($r = -.12$) was obtained on the group of heifers. This indicates that actual rib-eye area was of little value in determining the estimated per cent separable muscle in the carcass. Negative correlations also were obtained between ultrasonic estimates of rib-eye area and the estimated per cent separable muscle for both steers and heifers ($r = -.06$ and $-.04$). Likewise, ultrasonic estimates of rib-eye area were of little value for estimating the per cent separable muscle in the carcass.

A significant association existed between actual rib-eye area and the estimated per cent of boneless, closely-trimmed retail cuts from the round, loin, rib and chuck on the group of steers but failed to be significant on the heifers ($r = .43$ and 0.35 , respectively). These findings are similar to those reported by Cole et al. (1960).

Ultrasonic estimates of rib-eye area were negatively associated with the estimated per cent of retail cuts in the round, loin, rib and chuck in the steers ($r = -.23$) and positively associated in the heifers ($r = 0.16$). Ultrasonic estimates of rib-eye area were of little value in estimating per cent cuts.

Longissimus dorsi depth. Table V shows comparison between ultrasonic estimates of l. dorsi muscle depth, taken at the 12th and 13th rib region and the actual muscle depth measurement, taken at the center of the l. dorsi muscle on the carcass. Low positive associations, ranging from $r = 0.13$ to $r = 0.38$, among interpreters, were obtained with the steers while the range with the heifers was from $r = 0.06$ to $r = 0.20$. The changes which are known to occur in muscle shapes after slaughter and hanging on the rail may partially account for these low correlations.

Positive correlations were obtained between marbling score and shear value for the group of steers ($r = 0.16$) while a negative correlation ($r = -.26$) was obtained on the heifers. These relationships indicate that marbling has little effect on meat tenderness as measured by shear value. In the steers there was a slight tendency for meat from the more highly-marbled animals to be less tender.

In Tables III and IV, with one exception, higher correlation coefficients were obtained for interpreter 1, who was the most experienced in making interpretations of the somagrams. Likewise, interpreter 2 ranked second in experience and his correlation coefficients ranked second with one exception. This indicates that knowledge of the anatomy

TABLE V
SIMPLE CORRELATION COEFFICIENTS BETWEEN ACTUAL AND
ESTIMATED L. DORSI MUSCLE DEPTH

	Actual <u>L. dorsi</u> muscle depth	
	Steers	Heifers
Ultrasonic estimates of <u>L. dorsi</u> muscle depth ¹		
Interpreter 1	0.13	0.20
Interpreter 2	0.19	0.11
Interpreter 3	0.27	0.13
Average	0.28	0.06

¹Experience of interpreters ranks in the order listed with interpreter 1 being most experienced.

of the area ultrasonically estimated and experience in interpreting somagrams are aids in obtaining reliable ultrasonic estimates of fat thickness and muscling in live animals.



CHAPTER V

SUMMARY AND CONCLUSIONS

Twenty-five steers and 24 heifers of the Angus breed, averaging 775 and 950 pounds, respectively, were used to compare ultrasonic estimates of fat thickness and rib-eye area at the 12th and 13th rib region with actual carcass traits, using Branson Sonoray Model 52. Steers and heifers differed significantly in carcass length, conformation grade and estimated pounds of separable muscle. Differences in other carcass traits studied were not significant. Three workers of varying experience interpreted each somagram. The reliability of the ultrasonic estimates generally were proportional to the experience of the interpreters. Among interpreters, estimated fat thickness was associated with from 24 to 51 per cent of the variation in actual fat thickness. Comparison of ultrasonic rib-eye area with carcass rib-eye area gave significant correlation coefficients ranging from 0.53 to 0.63 for heifers. Correlations between actual and estimated rib-eye area for steers were not significant, probably because carcass tracings were taken from the right side, which was on the opposite side from which ultrasonic estimates were made. Estimated 1. dorsi depth, for steers and heifers, compared to actual depth were not significant, with correlation coefficients among workers ranging from 0.11 to 0.27. Actual and ultrasonic estimates of fat thickness, on steers and heifers, were not significantly related to estimated pounds of separable muscle. However, both actual

and ultrasonic estimates of fat thickness, for steers and heifers, were significantly associated with estimated per cent separable muscle.

Actual and ultrasonic estimates of fat thickness, of steers and heifers, was significantly associated with estimated cut-out; however, the ultrasonic estimate coefficients were slightly lower. Actual fat thickness, of steers and heifers, compared to shear value and total cooking losses, indicated very low relationships. Comparison of actual rib-eye area with estimated cut-out showed a significant relationship ($r = 0.43$) for the steers but not for heifers ($r = 0.35$). Actual rib-eye area was not significantly associated with estimated pounds of separable muscle.

It can be concluded from this study that ultrasonic estimates of fat thickness and 1. dorsi muscle area are fair indicators of carcass fat thickness and rib-eye area.



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LITERATURE CITED

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APPENDIX



TABLE VI
SELECTED ACTUAL CARCASS TRAITS FOR STEERS

Animal number	Carcass weight	Carcass length	Fat thickness	Rib-eye area	Kidney and pelvic fat	<u>L. dorsi</u> <u>thickness</u>
	lbs.	in.	in.	sq. in.	%	in.
10	602	45.13	.59	12.62	4.5	2.60
11	517	43.00	.39	12.51	4.5	2.40
12	528	43.00	.62	10.47	4.0	2.50
13	498	42.50	.23	10.00	4.5	2.40
14	595	47.87	.35	10.71	4.7	2.70
15	506	46.50	.31	11.03	4.0	2.55
16	516	45.00	.39	10.83	4.5	2.80
17	435	43.00	.55	8.31	4.0	2.25
18	492	44.13	.51	10.82	4.5	2.75
19	533	44.00	.43	10.55	3.5	2.75
20	576	45.00	.59	11.01	4.0	2.50
21	574	46.00	.47	10.42	4.0	2.45
22	516	42.00	.29	10.33	4.5	2.55
23	507	48.00	.31	11.50	3.5	2.55
24	445	41.00	.31	9.29	4.0	2.55
25	588	45.50	.27	11.30	4.5	2.75
26	552	44.50	.23	12.08	4.0	2.80
27	530	42.62	.47	10.37	3.5	2.25
28	552	44.75	.59	10.91	4.0	2.60
29	558	46.00	.39	11.02	4.5	2.45
30	548	46.37	.19	10.49	3.5	2.40
31	585	46.50	.59	11.73	4.5	2.75
32	540	45.87	.23	9.57	4.0	2.20
33	532	43.87	.35	11.91	4.5	2.75
34	542	45.62	.35	11.70	4.0	2.75

TABLE VII
SELECTED ACTUAL CARCASS TRAITS FOR HEIFERS

Animal number	Carcass weight	Carcass length	Fat thickness	Rib-eye area	Kidney and pelvic fat	L. dorsi thickness
	lbs.	in.	in.	sq. in.	%	in.
45	535	45.26	.19	11.22	4.5	2.75
46	492	44.75	.51	10.08	4.0	2.50
48	451	44.50	.39	13.38	4.5	2.60
49	492	43.13	.59	12.15	4.5	2.75
55	584	45.00	.74	12.15	4.0	2.90
56	541	44.50	.27	12.20	4.5	2.40
57	480	43.37	.39	11.46	4.5	3.10
58	433	44.00	.27	9.55	4.0	1.85
59	507	42.37	.59	12.63	4.0	2.75
65	507	45.50	.51	12.01	4.5	3.00
66	492	44.75	.31	9.93	4.5	2.50
67	464	43.50	.55	10.92	4.0	2.35
68	476	44.00	.39	9.93	3.5	2.45
69	522	44.50	.59	11.71	4.0	2.90
75	493	43.13	.39	11.39	4.5	2.50
76	454	41.87	.47	11.01	4.5	2.30
77	453	42.37	.43	9.58	4.0	2.30
78	466	43.00	.39	9.87	4.0	2.55
79	388	40.00	.31	9.57	4.0	2.25
85	514	44.37	.47	11.68	4.5	2.30
86	462	42.00	.59	9.85	4.5	2.15
87	428	40.00	.78	9.53	4.5	2.15
88	401	42.00	.19	10.50	4.0	2.50
89	407	42.00	.31	9.42	4.5	2.25

TABLE VIII
GRADE AND PALATABILITY FACTORS FOR STEERS

Animal number	Marbling ¹ score	Maturity	Conformation ² grade	Carcass ² grade	Shear value lbs.	Total cooking losses %
10	6	A	14	13	17.82	21.67
11	6	A+	13	10	16.37	19.87
12	6	A+	13	12	19.75	23.43
13	5	A+	12	12	15.15	20.43
14	4	A	12	10	16.01	21.55
15	6	A+	13	12	18.42	23.91
16	5	A+	12	12	13.71	21.91
17	6	A	13	12	14.54	19.90
18	5	A+	14	12	16.24	20.03
19	4	B-	13	10	14.50	20.43
20	5	A+	13	12	11.71	24.70
21	5	A+	13	10	16.56	19.40
22	5	A+	13	12	16.78	23.30
23	4	A+	13	10	15.31	20.90
24	4	A+	13	13	16.91	22.52
25	5	B	13	9	14.52	22.61
26	7	A	13	13	13.00	19.93
27	4	A+	13	10	14.51	20.17
28	7	A+	13	13	13.41	21.32
29	5	A+	12	11	16.31	20.84
30	4	A+	10	10	12.50	18.69
31	6	B-	12	12	15.38	21.95
32	7	A+	12	13	17.61	19.53
33	4	A+	12	10	14.50	20.04
34	4	B-	12	9	16.43	19.84

¹4 = slight, 5 = small, 6 = modest, 7 = moderate.

²9 = low good, 10 = average good, 11 = high good, 12 = low choice, 13 = average choice, 14 = high choice.

TABLE IX
GRADE AND PALATABILITY FACTORS FOR HEIFERS

Animal number	Marbling ¹ score	Maturity	Conformation ² grade	Carcass ² grade	Shear value lbs.	Total cooking losses %
45	5	A+	12	12	13.06	21.28
46	5	A+	12	11	18.53	25.76
48	5	A	13	12	15.04	23.22
49	5	A+	11	11	18.31	23.89
55	5	A+	12	12	14.23	22.93
56	7	A+	13	14	11.55	23.12
57	5	A	12	12	18.55	26.02
58	5	A+	11	11	18.01	18.66
59	5	A+	12	12	22.24	20.54
65	5	A+	13	12	17.70	23.43
66	6	A+	10	11	15.94	21.14
67	4	B-	12	9	14.14	21.81
68	6	A	11	12	18.32	20.78
69	7	A	13	14	13.06	21.19
75	6	A+	12	12	15.46	18.77
76	5	A+	12	12	11.81	20.09
77	5	A+	13	12	16.17	21.49
78	4	A	12	10	15.17	21.17
79	5	A+	12	11	16.59	21.80
85	5	A+	12	12	14.27	18.78
86	5	A+	13	12	16.35	20.67
87	5	A+	13	12	11.78	19.47
88	6	A+	11	12	11.82	19.76
89	4	A+	12	10	16.05	21.08

¹4 = slight, 5 = small, 6 = modest, 7 = moderate.

²9 = low good, 10 = average good, 11 = high good, 12 = low choice, 13 = average choice, 14 = high choice.



TABLE X
CARCASS CUT-OUT ESTIMATIONS FOR STEERS

Animal number	Boneless, closely- trimmed retail cuts	Carcass separable muscle	Carcass separable muscle
	%	lbs.	%
10	49.90	159.8	53.1
11	51.76	143.8	55.6
12	48.95	136.6	51.8
13	51.33	145.3	58.3
14	49.75	168.1	56.5
15	51.39	144.1	57.0
16	50.67	143.5	55.6
17	48.26	113.2	52.1
18	50.16	131.4	53.4
19	50.21	146.7	55.1
20	48.95	152.2	52.9
21	49.11	156.9	54.7
22	50.28	148.7	57.7
23	51.87	144.4	57.0
24	50.67	126.4	56.9
25	50.97	169.6	57.7
26	52.37	160.9	58.3
27	49.57	144.1	54.4
28	49.05	145.3	52.6
29	50.32	155.7	55.8
30	51.37	161.4	58.9
31	49.39	154.8	52.9
32	50.76	157.4	58.3
33	51.27	149.9	56.4
34	51.16	152.8	56.4

TABLE XI

CARCASS CUT-OUT ESTIMATIONS FOR HEIFERS

Animal number	Boneless, closely- trimmed retail cuts	Carcass separable muscle	Carcass separable muscle
	%	lbs.	%
45	51.91	157.1	59.0
46	49.76	131.4	53.4
48	53.11	124.8	55.3
49	50.66	128.0	52.0
55	50.08	147.6	50.6
56	51.98	156.0	57.7
57	51.56	133.2	55.5
58	51.17	124.8	57.6
59	50.83	132.3	52.2
65	50.95	135.8	53.6
66	50.85	140.1	56.9
67	50.01	121.6	52.4
68	50.33	132.0	55.5
69	49.97	136.6	52.4
75	51.25	136.9	55.5
76	50.80	122.2	53.8
77	50.28	123.6	54.6
78	50.33	129.1	55.4
79	51.59	110.0	56.7
85	50.69	139.5	54.3
86	49.10	119.3	51.6
87	48.12	100.8	57.1
88	52.74	119.0	59.3
89	51.26	115.5	56.8

TABLE XII
ULTRASONIC ESTIMATES OF FAT THICKNESS
AND RIB-EYE AREA FOR STEERS

Animal number	Fat thickness, inches interpretation				Rib-eye area, sq. inches interpretation			
	1	2	3	Average	1	2	3	Average
	in.				sq. in.			
10	.60	.50	.47	.52	12.67	11.08	12.25	12.00
11	.45	.52	.40	.46	9.45	8.47	8.80	8.91
12	.60	.52	.55	.56	10.00	10.14	9.83	9.99
13	.28	.18	.27	.24	9.74	10.06	10.12	9.97
14	.45	.51	.52	.49	10.57	12.27	12.67	11.83
15	.27	.30	.31	.29	9.03	9.28	11.12	9.81
16	.37	.42	.40	.40	10.28	11.82	10.94	11.01
17	.35	.32	.30	.32	8.90	8.33	10.73	9.32
18	.47	.42	.45	.45	10.64	10.46	10.63	10.58
19	.45	.66	.52	.54	10.99	9.90	11.37	10.75
20	.70	.77	.67	.71	13.22	12.96	13.05	13.07
21	.55	.66	.66	.62	13.19	13.80	12.89	13.29
22	.32	.30	.40	.34	11.15	11.75	10.60	11.17
23	.27	.30	.27	.28	11.16	10.62	10.51	10.76
24	.32	.43	.56	.44	9.03	9.54	10.38	9.65
25	.50	.52	.55	.52	11.38	12.09	12.28	11.91
26	.50	.60	.51	.54	10.54	10.93	10.05	10.50
27	.50	.52	.46	.49	9.32	7.72	7.80	8.28
28	.50	.55	.55	.53	11.67	12.83	12.23	12.24
29	.40	.45	.45	.43	11.77	12.19	13.41	12.46
30	.25	.25	.34	.28	10.03	9.90	10.18	10.03
31	.55	.57	.57	.56	11.22	11.06	12.15	11.48
32	.55	.40	.36	.44	12.96	11.06	13.51	12.51
33	.35	.30	.35	.33	11.90	12.31	12.93	12.38
34	.35	.37	.35	.36	10.87	10.24	9.96	10.36

TABLE XIII

ULTRASONIC ESTIMATES OF FAT THICKNESS
AND RIB-EYE AREA FOR HEIFERS

Animal number	Fat thickness, inches interpretation				Rib-eye area, sq. inches interpretation			
	1	2	3	Average	1	2	3	Average
	in.				sq. in.			
45	.42	.50	.55	.49	12.06	12.60	11.80	12.15
46	.45	.50	.52	.49	12.55	11.34	12.79	12.23
48	.50	.50	.50	.50	11.77	12.02	12.77	12.19
49	.50	.50	.52	.51	10.41	9.90	9.79	10.03
55	1.00	.60	.55	.72	11.57	11.25	11.60	11.47
56	.45	.47	.47	.46	13.64	12.46	12.66	12.92
57	.47	.50	.47	.48	10.35	10.57	10.67	10.53
58	.35	.43	.36	.38	8.87	9.64	10.15	9.55
59	.45	.40	.32	.36	10.19	10.01	10.51	10.23
65	.60	.52	.52	.55	10.29	10.55	10.67	10.50
66	.35	.37	.35	.36	9.64	9.71	8.90	9.42
67	.48	.47	.50	.48	10.77	10.11	10.76	10.55
68	.45	.47	.50	.47	7.64	7.87	8.86	8.12
69	.62	.70	.52	.61	11.25	12.24	11.54	11.68
75	.40	.47	.45	.44	12.25	11.60	12.47	12.11
76	.40	.50	.36	.42	11.96	12.82	12.18	12.32
77	.42	.40	.40	.41	7.64	7.34	7.96	7.65
78	.50	.47	.35	.44	10.77	10.59	11.54	10.96
79	.30	.47	.27	.35	8.42	8.17	8.51	8.36
85	.50	.47	.47	.48	10.90	11.53	13.28	11.90
86	.55	.57	.60	.57	8.48	8.32	9.76	8.85
87	.65	.60	.62	.62	10.13	9.93	10.44	10.17
88	.45	.28	.42	.38	10.03	8.28	8.54	8.95
89	.35	.27	.32	.31	10.03	8.55	10.67	9.75

TABLE XIV

ULTRASONIC ESTIMATES OF L. DORSI MUSCLE DEPTH FOR STEERS

Animal number	<u>L. dorsi</u> muscle depth interpretation			
	1	2	3	Average
	in.	in.	in.	in.
10	2.50	2.50	2.55	2.53
11	2.15	2.20	1.95	2.09
12	2.20	2.30	2.25	2.27
13	2.30	2.30	2.25	2.28
14	2.40	2.87	2.75	2.71
15	2.30	2.37	2.10	2.22
16	2.50	2.55	2.67	2.56
17	2.00	2.10	2.00	2.03
18	2.50	2.80	2.50	2.60
19	2.40	2.25	2.30	2.66
20	2.90	2.72	2.65	2.67
21	2.60	2.70	2.55	2.63
22	2.40	2.67	2.45	2.52
23	2.15	2.40	2.17	2.23
24	2.10	1.90	2.15	2.04
25	2.40	2.55	2.45	2.43
26	2.30	2.52	2.42	2.38
27	2.30	2.22	2.20	2.21
28	2.55	2.65	2.75	2.63
29	2.90	3.05	2.70	2.87
30	2.00	2.35	2.12	2.17
31	2.50	2.60	2.60	2.52
32	2.60	2.92	2.95	2.81
33	2.90	2.75	2.80	2.68
34	2.40	2.55	2.25	2.39

TABLE XV

ULTRASONIC ESTIMATES OF L. DORSI MUSCLE DEPTH FOR HEIFERS

Animal number	<u>L. dorsi</u> muscle depth interpretation			
	1	2	3	Average
	in.	in.	in	in.
45	2.50	2.77	2.55	2.61
46	2.45	2.60	2.52	2.52
48	2.47	2.75	2.75	2.66
49	2.50	2.75	2.50	2.58
55	2.50	2.57	2.45	2.51
56	2.83	2.95	2.90	2.89
57	2.12	2.20	2.20	2.17
58	1.95	2.35	2.35	2.22
59	2.22	2.30	2.37	2.30
65	2.50	2.60	2.57	2.56
66	2.27	2.32	2.37	2.32
67	2.50	2.42	2.35	2.42
68	1.92	2.12	2.05	2.03
69	2.05	2.60	2.40	2.35
75	2.50	2.57	2.50	2.52
76	2.60	3.00	3.00	2.87
77	1.90	2.00	1.85	1.92
78	2.50	2.52	2.67	2.56
79	1.90	2.22	1.77	1.96
85	2.50	2.80	2.60	2.63
86	2.35	2.37	2.40	2.37
87	2.30	2.72	2.55	2.52
88	2.40	2.55	2.05	2.33
89	2.20	2.20	2.20	2.20