THE ASSOCIATION OF CERTAIN ULTRASONIC MEASUREMENTS WITH INDICES OF LEANNESS AND FATNESS IN CATTLE AND SWINE

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CHAPTER I

INTRODUCTION

As in years past, there is an ever present need for improved methods of selecting superior breeding stock and for more precise evaluation of meat animals. Since the carcass traits, rib eye area and fat cover, are moderately to highly heritable and can be easily obtained, these two carcass measurements have been used as criteria for selecting breeding stock. The ability to accurately estimate these carcass traits on the live animal, rather than having to evaluate data from an animal's ancestors, half sibs, or progeny, could aid the animal producer in selecting superior livestock.

Visual appraisal has long been used in the evaluation of carcass merit, but most people agree that additional criteria must be incorporated with visual appraisal to attain success with this evaluation procedure. Some of the possibilities include the above mentioned carcass traits plus additional carcass measurements of subcutaneous fat over the loin, area of the *semitendinosus*, and fat cover over the *semitendinosus* which could be estimated ultrasonically on the live animal. Hopefully, these new measurements could be of value in predicting indices of carcass leanness and fatness.

The objectives of the present study were the following:

1. To test the accuracy of an ultrasonic device (Ithaco Scanogram, Model 721) for estimating certain carcass parameters of

meatiness in cattle and hogs.

2. To observe the differences in ultrasonically estimated values when the scanograms were independently evaluated by two individuals (interpreters).

3. To study the value of ultrasonic estimates, when made at certain previously unstudied positions, for predicting measures of leanness and fatness in cattle and swine.

CHAPTER II

REVIEW OF LITERATURE

A brief summary of work done with ultrasonics, backfat probing techniques, and methods of carcass evaluation is presented in the following review.

Ultrasonics

Ultrasonics is a branch of science dealing with the principles governing ultrasound, the equipment used to generate the sound, and the practical application of high frequency sound. Ultrasonics deals both with the effects of mechanical vibrations of ultrasonic waves and with the apparatus used to produce and monitor these waves in conducting mediums such as solids, liquids, and gases. Ultrasonic waves are sound waves at a frequency too high to be audible by the human ear which, generally speaking, is above 16,000 cycles per second.

Ultrasonic waves show promise in evaluating live animals because they are non-destructive and provide a directional beam of high frequency sound which can be used to detect boundaries between tissues differing in density. When an ultrasonic beam passing through one medium reaches the boundary of that medium and strikes a dissimilar medium, part of the energy is reflected back through the original medium to the source. The amount of reflection is determined by the nature of the two media or the acoustical impedance of the material, which is the product of the density of the material and the velocity of the sound that passes through it. Echo-ranging, the type of ultrasonics applied to live animal evaluation, involves the transmission of sound energy through a medium and the reception of a reflected echo arising from a medium of different density. These echoes are displayed on a cathode-ray tube and may be read directly or photographed on a Polaroid print.

The source of ultrasonic energy used in live animal evaluation is an electric generator. Once the energy is propagated, it is transmitted to acoustical energy by a transducer.

Howry and Bliss (1952) developed an instrument, the somascope (tissue vision), for the purpose of studying its capability in making soft tissue structures visible in a manner which could be useful for diagnostic purposes in humans. Their main interest was in the study of liver abnormalities. They stated that, when properly applied, the ultrasonic energy could be used to generate a "picture" of the cross section of the specimen in study.

Temple (1956) applied ultrasonic reflectance techniques to the problem of measuring fatness in beef cattle and suggested that this approach appeared promising.

Price et al. (1958) used the Sperry Reflectoscope to estimate the depth of subcutaneous fat and the depth of lean muscles along the top of the back in a limited number of live hogs and cattle. Results indicated that fatness can be accurately measured with ultrasonic equipment. Similarly, these workers demonstrated that ultrasonics may be used to measure the depth of lean in certain parts of the carcass. Work with beef cattle indicated some promise for measuring fat thickness although relationships were much lower than with swine.

Hazel and Kline (1959) tested the accuracy of ultrasonics for measuring fatness in 56 pigs representing five breeds ranging in weight from 190 to 250 pounds. Measurements of fatness were taken with both the ruler probe and the ultrasonic method at three sites: immediately behind the shoulder; at the middle of the back; and at the rear of the loin. Ultrasonic measurements were taken at frequencies of 1.5 mc/s and 2.5 mc/s. These workers found the correlation between average ultrasonic probe at a frequency of 2.5 mc/s and percent lean to be -0.90. The corresponding correlation with ultrasonic probes at a frequency of 1.5 mc/s was -0.76, while that with the mechanical back-fat probe was -0.89. A correlation of -0.77 was found between the ultrasonic probe at the loin and the percent ham (using a 2.5 mc/s transducer).

Campbell et al. (1959) used the somascope to estimate depths of the right and left longissimus dorsi muscles over the last ribs on 65 market lambs. The animals were divided into two groups; one group of 32 and a second group of 33 lambs. The animals were slaughtered and a rib eye tracing was made of the rib eye muscle. The correlation coefficients between somascope readings of rib eye depth and the corresponding carcass measurements were 0.68 and 0.49 for Groups 1 and 2, respectively. Correlation coefficients between somascope readings of rib eye area and actual measured area were 0.62 for Group 1 and 0.44 for Group 2. Actual rib eye area and actual muscle depth were significantly ($P < .01$) correlated ($r = 0.76$ and 0.79 for Groups 1 and 2, respectively).

The depth and area of longissimus dorsi and thickness of subcutaneous fat were determined with ultrasonic equipment on approximately 100 cattle and 40 hogs by Stouffer et al. (1959). When readings were plotted, measured, and compared to actual tracings, close agreement existed between estimated and actual value.

Price et al. (1960a) used the method described by Stouffer (1959) for plotting readings generated from ultrasound equipment. Estimates of the cross-sectional "plot" of the loin area in 41 live hogs were made utilizing ultrasonic reflection measurements coupled with angles of incidence at a scheduled series of sites over the last rib. The correlation between live estimated area and actual loin eye area was 0.74. The method was reported to be both time consuming and tedious. The medial and lateral ends of the loin eye were subjectively "drawn in" since these tissue layers lay parallel to the projected beam of sound, thus making it impossible to ascertain the ends of the loin muscle.

Price et al. (1960b) took ultrasonic readings on 158 pigs with a Sperry Reflectoscope to determine the usefulness of ultrasonic probing in evaluating live hogs and pork carcasses by relating ultrasonic measurements with other measures of leanness and fatness. The animals were divided into groups consisting of 74 pigs (Group I) and 84 pigs (Group II). Group I pigs were placed in a bleeding crate for "soundings" at three locations for lean depth measurement studies. Group II pigs were allowed to stand naturally while one "sounding" was made at the center of the back. Ultrasonic measurements were also made on the hot carcasses of Group II. Both groups were ruler probed after "soundings." Results indicated that ultrasonic measurements of fat were highly related to both live probe and carcass backfat thickness (r = 0.85 and 0.83, respectively). Live ruler probe, carcass backfat, and live ultrasonic measurements of backfat were found to be similar in value for predicting primal cut yields. Ultrasonic estimates of the depth of loin eye muscle over the center of the back in the live animals were significantly related to depth and area of the longissimus dorsi taken from the tracings (r = 0.85 and -0.45).

Zobrisky et al. (1960) used the Branson Sonoray, Model 5 to estimate the loin eye area of 69 live hogs. They found that 10th rib loin eye tracings and high frequency sound estimates of the 10th rib loin eye area for the right and left sides were highly correlated (r = 0.84 and 0.81, respectively).

A Branson Model 5 Sonoray was used by Urban and Hazel (1960) to estimate the amount of backfat on 75 pigs at weaning, at each of three four-week periods thereafter, and at a slaughter weight of 200 pounds. They found that generally the ultrasonic probe was not as good as, or at least no better than a mechanical probe on the 200 pound market pigs. Their results further indicated that estimates of fatness by ultrasonics made early in life were of little value for predicting fatness.

Hedrick et al. (1962) estimated rib eye area and fat thickness on 202 live cattle using the Branson Sonoray, Model 5. The animals were divided into four groups, each group receiving ultrasonic estimates at different locations. They reported correlations between live animal estimates and carcass tracings of the rib eye to range from 0.58 to 0.89. Correlations between live animal estimates of fat thickness and fat thickness measured on the carcass ranged from 0.11 to 0.58.

Stouffer et al. (1961) studied the development of an ultrasonic method for detecting borders of the rib eye and associated fat layers in live animals which would simultaneously record results in a cross-sectional photograph. In the evaluation of 327 cattle and 42 hogs, they used several combinations of equipment in order to refine the method. The equipment consisted of various combinations of driving mechanisms and cameras combined with an ultrasound device. Results from the newly developed method resulted in higher correlations, between ultrasonic rib eye areas and actual carcass rib eye areas, in hogs than in cattle. The same was also true for ultrasonic fat estimates. Stouffer stated that a comparison of repeated ultrasonic measurements indicated significant repeatability of the method. Correlations of 0.90 and 0.71 existed between repeated ultrasonic estimates of fat thickness and rib eye area.

Ultrasonic work done on 60 slaughter steers by Davis and Long (1962) with a Branson Sonoray instrument indicated very high correlations between live animal estimates of rib eye area and fat cover and carcass measurements (0.87 and 0.90, respectively). In a detailed study of ten steers, ultrasonic readings of the *longissimus dorsi*, *biceps femoris*, and forearm muscle:bone ratio were obtained. The correlation coefficients between ultrasonic estimates and actual measurements were reported to be 0.82, 0.32, and 0.55, respectively.

Alsmeyer *et al.* (1963) computed correlations of 0.46, 0.61, 0.60, and 0.55 between ultrasonic subcutaneous fat thickness estimates at two, three, four, and five inches lateral of the animal's midline and the average fat thickness of the carcass. When these ultrasonic values were correlated with the weight of separable fat in the 9-10-11 rib cut, the correlations were 0.40, 0.50, 0.68, and 0.44 for each of the four locations, respectively. Results indicated that the ultrasonic estimates, made at a point four inches lateral of the animal's midline, bore the highest relationship to body composition of any of the positions estimated ultrasonically.

Davis (1963) reported results which suggested that the precision obtained in ultrasonic evaluation of cattle may be dependent upon breed. These breed differences may be due to differences in (1) hide thickness; (2) properties and characteristics of fat tissues; (3) marbling and other muscling characteristics; (4) temperament in relation to muscle tension at time of evaluation; and (5) changes in muscle and fat characteristics during and after slaughter. All of the factors except the latter may affect the response of tissues to sound waves. Davis reported a higher correlation between ultrasonically estimated fat and actual measured fat on the carcass in the Shorthorn breed ($r = 0.80$) as compared to 0.58 in Angus and 0.51 in the Hereford breed.

A Branson Sonoray instrument was used on 60 Hereford steers to estimate the cross-sectional area of the <u>longissimus</u> <u>dorsi</u> by Davis <u>et</u> <u>al</u>. (1964). A more detailed study was conducted on ten of these steers. Results indicated high correlations between corresponding carcass measurements and ultrasonic estimates of rib eye area and fat thickness ($r = 0.87$ and 0.90, respectively). Correlations between ultrasonic estimates of lumbar loin eye area and the corresponding measurements were 0.82. Ultrasonic estimates of the <u>biceps</u> <u>femoris</u> thickness and forearm thickness were found to be positively but non-significantly correlated with actual carcass measurements.

Two hundred thirty-five lambs were evaluated ultrasonically by Moody <u>et</u> <u>al</u>. (1965) to determine the usefulness of this procedure for measuring the longissimus dorsi area and fat thickness. They reported that the area of longissimus dorsi in 81% of the lambs was predicted within 0.2 square inches of the actual area. They also found ultrasonic and carcass fat thickness measurements taken at the 13th rib and 6-7th lumbar vertebra to be significantly ($P < .01$) correlated with carcass fat trim.

Temple et al. (1965) summarized a few of the factors which contribute to errors associated with ultrasonic evaluation of cattle. They were as follows: (1) animal variation, (2) tissue changes during slaughter (Davis 1963), (3) interpretation, and (4) machine manipulation (calibration). They also found that very firm or fat animals were difficult to sonoscope and that muscle and fat configurations differed greatly between the living animal and carcass in a hanging position. Interpretation errors in ultrasonic results arose from failure to identify hide, fascial tissue, and fat and muscle boundaries. Correlations between interpreters ranged from 0.61 (n = 49) to 0.94 (n = 20) for fat thickness and from 0.61 (n = 49) to 0.91 (n = 20) for rib eye area. Changes in line voltage to the unit were found to cause variation in calibration ratios; however, even with constant voltage regulation, calibration ratios varied during operation time.

Ramsey et al. (1965) used ultrasonics to estimate the cross-sectional area of the biceps femoris and obtained results contrary to that of Davis and Long (1962) and Davis et al. (1964). The latter workers had found low correlations between ultrasonic estimates of the cross-sectional area of the biceps femoris and actual area measured on the carcass, whereas Ramsey et al. (1965) observed a correlation of 0.81 between the same estimate and actual measurement on 43 cattle.

Their results indicated that the biceps femoris area, in combination with a measure of body weight, was of significant value in the prediction of beef round composition. These conclusions were made after a correlation of 0.82 was found between predicted biceps femoris area and round separable muscle weight. This muscle area was also significantly ($P < .01$) associated (on a within-breed and sex basis) with untrimmed round weight ($r = 0.76$).

Davis et al. (1966) compared the results obtained by operators working independently with similar ultrasonic equipment. A significant difference was reported between the two operators in interpretation of the rib eye area on sonographs from the same ultrasonic unit. Correlations for four ultrasonic rib eye area and fat thickness estimates with carcass rib eye area and fat thickness measurements did not differ from each other, suggesting that ultrasonic methods for estimating carcass rib eye area and fat thickness are reasonably repeatable.

Watkins et al. (1967) studied the effect of time-sequence and subcutaneous fat thickness on the accuracy of ultrasonically estimating longissimus dorsi area and fat thickness in cattle. As the operator became more experienced, he became more accurate in estimating both muscle size and fat thickness. Greater difficulty was experienced in estimating fat thickness and longissimus dorsi area in similar animals than in those possessing considerable variation in body tissue characteristics.

Ultrasonics was used by Isler and Swiger (1968) to evaluate fat depth on live pigs for predicting carcass composition as measured by percent lean cuts. To make predictions of carcass composition through the use of ultrasonics, a common regression equation was derived which could be used for barrows and gilts of different breeds. The results indicated that lean cut percent could be predicted on the live animal by utilizing six ultrasonic fat measures and live weight ($r = 0.80$). The fat was estimated ultrasonically at points approximately 5 cm. off the midline at the 4th rib, 8th rib, 12th rib, 3rd lumbar and last lumbar vertebrae and on the side of the ham at the point of the greatest bulge. It was also found that the addition of carcass longissimus dorsi area to the prediction equation was of little value for increasing accuracy of estimating lean cut percent.

Johnson et al. (1968) tested the usefulness of ultrasonics in estimating fat thickness and loin eye area. Work on 40 market weight, Yorkshire barrows indicated simple correlation coefficients between the ultrasonic estimates and the corresponding carcass measurements of 0.87 for average backfat thickness, 0.52 for loin eye area at the 10th rib, 0.69 for fat trim when expressed as pounds, and 0.60 for fat trim when expressed as percent of live weight. In a second trial involving 80 pigs, readings for fat thickness and loin eye area were taken in the a.m. and again in the p.m. Correlations between ultrasonically estimated and actual loin eye area were slightly higher in the p.m. than the a.m. The reverse was true for ultrasonically estimated and actual backfat thickness. Correlation coefficients between backfat and loin eye area were 0.91 and 0.85, respectively (average of a.m. and p.m.).

Anderson and Wahlstrom (1969) conducted a study to evaluate methods of ultrasonic measurement of the longissimus dorsi area and also to evaluate fat measurements, taken at the 10th rib and on the ham, in predicting carcass composition. Results of this work indicated the accuracy of estimating the area of the longissimus dorsi was nearly the same when three (left side) or ten (right side) ultrasonic measurements were used (r = 0.61 and 0.64, respectively) which is near the average of those values ranging from 0.52 to 0.84 reported by Price et al. (1960a) and Stouffer et al. (1961). It was shown that ultrasonic measurements on the ham were of little value for predicting the ham and loin percent.

Ultrasonic estimates were made on 785 cattle with an ultrasonic "A" scan (sonoray) and an ultrasonic "B" scanner (a device similar to that described by Stouffer et al., 1961) by McReynolds and Arthaud (1970a). Fat estimates on 785 cattle using the "A" scan were made at the 12th to 13th rib location at positions 9 and 13 cm. from the midline. Fat estimates were also made at the 5 cm. location on 63 of the cattle. Correlations between the estimates and carcass measurements were as follows: 5 cm., 0.14; 9 cm., 0.38; 13 cm., 0.55; and the average of the 9 and 13 cm. positions, 0.51. A comparison of the "A" scan and "B" scan (with attached Polaroid camera) was made on 132 cattle. Correlations between estimated fat and carcass fat were 0.25 when using the "A" scan and 0.59 for the "B" scan at the 9 cm. position. The comparable correlations at the 13 cm. position were 0.43 for the "A" scan and 0.47 for the "B" scan.

Further work by McReynolds and Arthaud (1970b) was oriented toward the rate of fat deposition and longissimus dorsi growth of cattle based on ultrasonic estimation at periodic intervals. Ultrasonic fat estimates were made on 63 cattle when the animals were approximately 230 days of age and at four subsequent six-week intervals. Area estimates were made of the longissimus dorsi on ten cattle at the time of the fat estimate. Results from three groups of the cattle indicated that the correlations between estimated rib eye area and carcass measured rib eye area were 0.26, 0.22, and 0.43.

Gillis (1971) using an ultrasonic scanning device similar to the one used by Stouffer (1959) and an Ithaco Scanogram, Model 721 evaluated 52 Yorkshire, Hampshire, and Yorkshire-Hampshire crossbred pigs. Results indicated that backfat thickness could be ultrasonically estimated more accurately than loin eye area. For 90.7 kg. pigs, the correlation coefficient between estimated and actual backfat was 0.86 while the correlation coefficients between carcass measured and ultrasonically estimated loin eye area at the 14th and 10th ribs were 0.42 and 0.40, respectively.

The literature review indicates that ultrasonics has been used to estimate fat thickness, area of the *longissimus dorsi*, area of the *biceps femoris*, and various other carcass measures. Results generally indicate that this method is more accurate in predicting backfat thickness and *longissimus dorsi* area than in predicting lean cuts or other measures of meatiness. Since ultrasonics has proved to be acceptable in estimating fat cover and *longissimus dorsi* area, these estimates may be useful in combination with other carcass measures in estimating total carcass composition.

Probing Methods

Several workers have shown that methods of probing for fat in swine can be very valuable as a criterion of carcass value. Hazel and Kline (1952) described a simple and rapid "probing" method for measuring backfat thickness on live hogs. In work with 96 pigs, the correlation coefficient between the average of four backfat measurements taken on the carcasses and ruler probe estimates on the live animals was 0.81. The most accurate locations were found to be "just behind the shoulder" and "at the middle of the loin" about one and one-half inches off the midline of the body.

Hazel and Kline (1953) probed live pigs at eight different sites to obtain estimates of fat thickness. These probe estimates were correlated with percent lean cuts and percent fat cuts: behind shoulder over longissimus dorsi, -0.69 and 0.76, respectively; middle of back over the longissimus dorsi, -0.55 and 0.54; middle of the loin over the longissimus dorsi, -0.70 and 0.76; middle of the loin over the lumbar vertebra, -0.48 and 0.53; top of ham, -0.65 and 0.66; tailhead, -0.57 and 0.43; side of shoulder, -0.47 and 0.54; side of ham, -0.29 and 0.40. The correlations between four backfat measurements taken on the carcasses and the percentage of lean cuts and fat cuts were -0.75 and 0.79, respectively.

Live probes were made by DePape and Whatley (1954) on 230 market barrows and gilts. In this study, measurable differences between breeds in fat deposition at 140 days and older were observed.

Hetzer et al. (1956) studied the relationship between various carcass measurements and live hog backfat measurements at four weights and three locations on 140 pigs. In this study the fat-lean ratio in cross section of the rough loin at the last rib was investigated as a possible measure of carcass leanness. Correlation coefficients of approximately -0.60 between fat-lean ratio and several measures of carcass cut-out indicated the relationship may be high enough to be useful when it is impossible to obtain carcass cut-out information.

With little information available in the literature comparing the live probe and Lean Meter, Pearson et al. (1957) used 96 hogs to compare the two methods from the standpoint of both physical carcass measurements and carcass cut-outs. Results indicate that there was little difference in the usefulness of the live probe and Lean Meter to estimate backfat thickness and percentage of either lean or primal cuts. However, the higher relationship for the live probe with both lean areas and with fat trim indicated live probe to be more reliable than the Lean Meter in estimating carcass leanness.

The live probe and Lean Meter have been used in estimating fat thickness on the live animal and, as indicated in the literature, these instruments have been proved to be relatively accurate in estimating this carcass trait. Thus the Lean Meter has, in part, supplemented the live ruler probe for measuring backfat thickness.

Carcass Evaluation

Some of the very early work in carcass evaluation was by Warner et al. (1934). These workers were interested in determining the relationship between the percentage yields of selected cuts and actual fatness and the mathematical relationship between the ratio of fat to lean cuts and the actual fatness of the carcass. Their results indicated a consistent relationship between the content of fat in the edible portion of the pork carcass and the percentages which the weights of certain cuts bear to the carcass weight. The percentage of fat cuts (belly, leaf fat, and skinned backfat and trimmings) increased with an increase in fat content. The coefficient of correlation expressing that relationship was 0.91.

Hankins and Ellis (1934) collected data on 60 hogs in which proximate chemical analysis was obtained. From this data relationships between certain measurements and the fat content of the edible portion of the carcass were obtained. They found that backfat was generally a "practical indication" of the fatness of a pork carcass. They found the correlation between average carcass backfat and chemically determined fat to be 0.84.

McMeekan (1941) found that the relationship of the weight of the psoas major to total muscle was sufficiently strong to justify its use as an index of muscle development. Correlation coefficients between shoulder, loin, and rump fat thickness and the total weight of fat in the carcass were 0.87, 0.93, and 0.94, respectively.

Hetzer et al. (1950) studied the relative value of various live-hog measurements for predicting certain characteristics of the carcasses produced. From the analysis of the yield of lean in the hams, it was found that width at hams was the most important of the measurements for barrows and gilts. Although the predictive values of the measurements studied were not as great as might be desired, it was concluded that the use of certain body measurements offers possibilities of being a valuable tool in estimating carcass yields from live animals.

The carcasses from 203 hogs were used by Whiteman and Whatley (1953) to evaluate two methods of measuring the loin eye muscle and the lean in the butt of the ham. One method of approximating the size of the loin lean area was that of the product of the length and width of the eye. The other method consisted of measuring a tracing of the cross section with a planimeter. The length x width method was found to be nearly as good as the planimeter method for loin lean area estimation and was much easier to obtain. The planimeter method was found to be a more precise estimate of lean in the butt than the length x width estimate.

Kline and Hazel (1955) compared relative areas of the longissimus dorsi measured at the 10th and last ribs with the reference to actual size, their relationship to each other, and the accuracy of the two locations as measures of total lean in the carcass. Loin areas at the 10th and last ribs, percent lean cuts, and percent loin for both right and left sides were studied on 23 carcasses. The loin areas at the last ribs averaged 0.43 square inches greater than those at the 10th ribs. The correlations between the loin eye area at the 10th and last ribs with percent lean cuts were 0.65 and 0.74, respectively. Because of the high correlation between loin areas measured at different locations on the same carcass, they found little increase in accuracy of predicting lean cuts from measuring the loin area in more than one place.

The weight of the defatted ham as a percent of chilled carcass weight was studied as an indicator of pork carcass value by Smith et al. (1957). This relationship was investigated in data obtained from 300 barrows. The correlation between dafatted ham percent and percent lean cuts is partially automatic since the ham comprises one-third of the lean cuts. The correlation between defatted ham percent and percent lean cuts was reported as 0.89.

Holland and Hazel (1958) measured muscle thickness and fat thickness over the supraspinous fossa and over the illium on 105 live barrows and compared these measures with other live and carcass measurements. The average of three backfat probes was a more accurate indicator of percent lean cuts and percent fat cuts than were fat probes over the illium or scapula. These probes were also found to be more accurate as a predictor of percent lean cuts and percent fat cuts than were the carcass measurements; length, area of loin eye at the 10th rib and at the last rib, and backfat measurements.

Pearson et al. (1958) indicated that simple cut indices which involve a minimum number of weights could possibly be adapted to large scale usage in evaluating pork carcasses. These workers studied the relationship of certain simple cut indices to carcass composition. The cut indices of loin index (percentage of trimmed loin to rough loin) and New York shoulder (as a percent of live weight) were found to be significantly ($P < .05$) related to the percent lean cuts of live weight ($r = 0.75$ and 0.77, respectively).

Zobrisky et al. (1959), working with 207 hogs, reported that the yield of the five primal cuts was negatively correlated with the backfat thickness measurements and the weight of ham fat trim. The loin eye cross-sectional area and the yield of loin, ham, and shoulder were significantly correlated ($r = 0.60$) with the yield of total lean.

Pearson et al. (1959), using 292 pork carcasses, investigated the usefulness of rapid measurements of exposed lumbar lean. These workers were involved with determining the relationship of these measurements to carcass cutting yields and loin eye area. Results of the study indicated that depth of lumbar lean can be used as an indicator of loin eye area ($r = 0.64$). Although the various lumbar lean measurements can be used in carcass grading, their use appeared to have little advantage over the use of backfat measurement alone.

Murphey et al. (1960) devised a method by which the yield of retail cuts from beef carcasses could be predicted. The factors essential for the prediction equation are a subjective estimate of the percent kidney, heart and pelvic fat; fat cover over the rib eye (12th rib); rib eye area between the 12th and 13th ribs; and cold carcass weight. Data from approximately 450 beef carcasses and 300 live cattle were used in the development of the equation. The predicted yield by the equation was correlated to the actual yield of mostly boneless retail cuts ($r = 0.923$).

A study was undertaken by Cole et al. (1960) to determine the validity of using loin eye area, the lean content of a particular beef cut, or various other carcass measurements to predict total carcass lean. The area of the loin eye was found to be associated with only 18% of the variation of separable carcass lean, and 5-30% of the variation in the separable lean of the more valuable cuts of beef. The separable lean of a particular cut of beef was found to be more descriptive of carcass leanness or muscling than either the area of the loin eye or the various carcass measurements (carcass length, loin length, round width, round circumference, etc.). Correlation coefficients between total separable carcass lean and the lean from the round, chuck, foreshank, sirloin and short loin were 0.95, 0.93, 0.81, 0.80, and 0.75, respectively.

McCampbell and Baird (1961) collected data on hogs slaughtered at 170, 190, 210, and 230 pounds. They reported that the percent lean cuts and primal cuts decreased as market weight increased. Dressing percent was similar for all groups and loin eye area increased only slightly with weight.

A study was conducted by Bowman et al. (1962) on 42 barrows to evaluate the reliability of certain conventional methods of evaluation and to determine the degree to which examination of full cross-sectional exposures at various points of the body may enhance appraisal. Results indicated specific gravity of the ham to be a good index of leanness. The weight of lean and fat in the ham was highly associated with carcass leanness. Cross sections were taken at eight locations. Of the eight locations, the components of fat and lean at the 10th thoracic vertebra and the 3rd lumbar vertebra best explained variance in percent carcass lean ($R^2 = .85$ and $R^2 = .89$, respectively). The indices generally indicated a lower relation with weight of separable lean than with percent of separable lean.

Carpenter et al. (1962), using 216 carcasses from market weight gilts and barrows, reported a correlation of 0.70 between specific gravity of trimmed ham and the four lean cuts. The next three important indices of leanness were fat thickness at the last lumbar vertebra, fat thickness at the 1st rib, and loin eye area which had correlations with the four lean cuts of -0.69, -0.67, and 0.57, respectively.

Ham-loin index, a commonly used index of carcass meatiness, was studied by Arganosa and Omtvedt (1969). They reported correlations of 0.74 and 0.84 between ham-loin index and lean cuts expressed as pounds and as percent of slaughter weight, respectively.

CHAPTER III

MATERIALS AND METHODS

In this study three groups of market cattle and two groups of market hogs were evaluated ultrasonically by means of the Scanogram, Ithaco, Model 721, (Figure 1) using a 1/2 inch, 2 mc transducer. The work was conducted in an attempt to determine the Scanogram's usefulness for estimating certain carcass parameters known to be of value in estimating carcass composition. The swine were also evaluated for fat thickness with a live probe, the Lean Meter (Duncan, Model SC).

The Model 721 Scanogram is a device which makes use of a combination of two instruments, the Branson Sonoray Live Animal Tester, Model 12 and a Polaroid camera. The transducer of the Model 12 (positioned in a guide which fits the curvature of the animal's body) and the Polaroid camera are linked together by means of a mechanically synchronized drive which moves the transducer along a specified position of the animal's body at the same speed the camera is scanning the oscilloscope of the Sonoray. When high frequency sound waves strike tissues differing in density, part of the high frequency energy passes into the second medium while the remaining energy is reflected back to the Sonoray and appears on the oscilloscope in the form of an "echo." The mechanism allows these "echoes" to be recorded on a Polaroid print (Figure 2). The ability of the Model 721 to record these echoes automatically (rather than recording each observation independently on

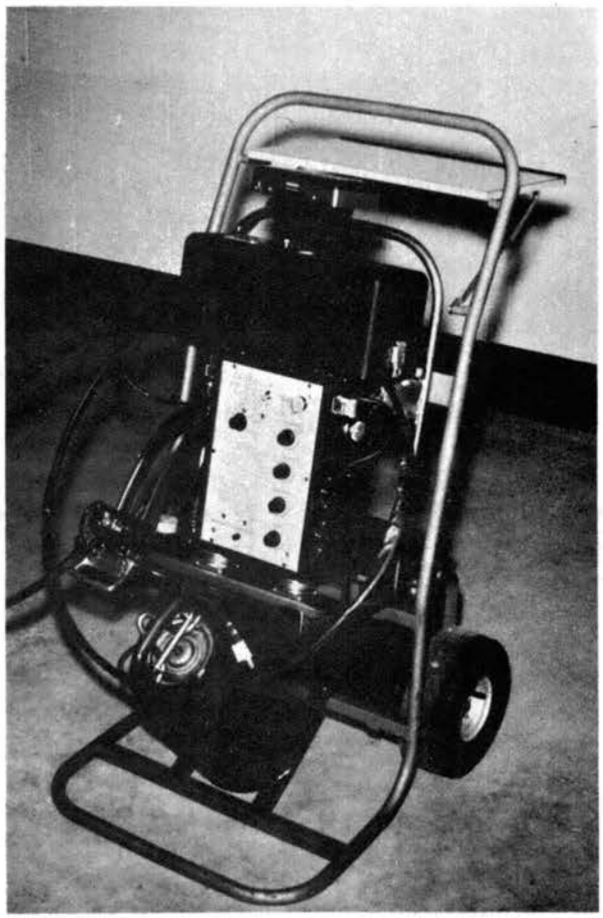

Figure 1. The Ithaco, Model 721
Scanogram

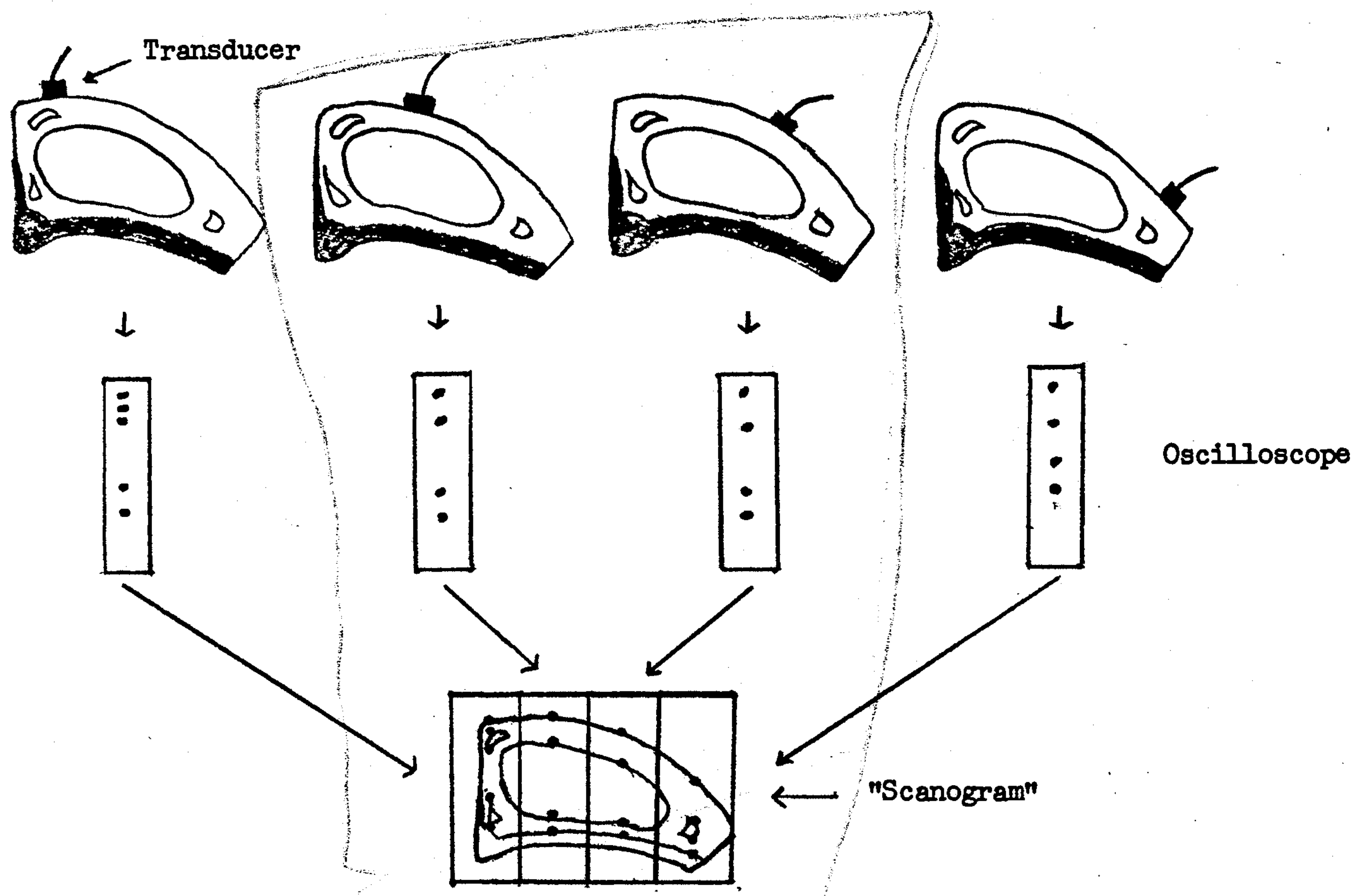

Figure 2. Illustration of How a Scanogram Is Produced

graph paper as was done when using the Branson Sonoray Model 5 Live Animal Tester) greatly reduces the time required to make fat depth and muscle area estimates on an animal.

These studies involved comparisons between ultrasonic estimates taken on the live animal (plus selected warm carcasses) and actual measurements made on the chilled carcasses. The study was initiated in March of 1970 and completed in November of 1970. Since different measurements were taken on each group, data collected were statistically analyzed by group. The groups contained the following animals: 28 Hereford steers (1000 pounds); 94 Angus steers and heifers (800-1000 pounds); 67 Yorkshire, Hampshire, and Duroc gilts and barrows (200-220 pounds); 36 Hereford-Angus crossbred steers (1000 pounds); and 59 Yorkshire, Hampshire, and Duroc gilts and barrows (200-220 pounds), which will henceforth be referred to as Group 1, Group 2, Group 3, Group 4, and Group 5, respectively.

Scanogram Evaluation of Cattle

Procedures for ultrasonically evaluating Groups 1 (28 steers) and 2 (94 steers and heifers) were similar. Each animal was placed in a metal holding chute to restrain its head and body movement. After being placed in the chute, the hair was clipped with electric clippers between the 12th and 13th ribs from the midline to a point approximately 15 inches ventral to the midline. A light weight paraffin oil (Conoco No. 7 series) was applied to the skin at this position to serve as a coupling agent for the ultrasound. Animals were scanned until two interpretable pictures were obtained for each carcass measurement being estimated. This usually required making three to four scans at each scanning position.

All scanograms for cattle measurements were made to one-third scale and were converted to an estimate of the actual size by using the following formulae: (estimated fat cover x 3) and (estimated muscle area x 9).

Data generated from Groups 1 and 2 were considered as pilot work with the instrument. In Group 4 (36 cattle) additional sites for estimation of carcass measurements were added. They consisted of a fat cover and muscle area estimate at the approximate midpoint of the semitendinosus and a linear fat estimate over the short loin. The semitendinosus scan was made in an attempt to estimate fat cover and area of the muscle and to determine the relationship between estimates of fat cover and area of the muscle with total carcass composition. After the scan was made, its position was identified by subcutaneously injecting a small quantity of meat branding ink (a vegetable dye). The procedure was carried out on all sites of ultrasonic measurement for cattle. The linear scan was made from a point two inches ventral to the midline from the illium of the pelvic girdle to a point eight inches anterior. The scan was made in an attempt to determine the value of a Scanogram estimate of fat at this position as an estimator of carcass merit. Figure 3 illustrates the positions at which ultrasonic estimates were made on cattle.

Scanogram Evaluation of Swine

All hogs in Groups 3 (67 barrows and gilts) and 5 (59 barrows and gilts) were made ready for ultrasonic evaluation by brushing or washing. Each animal was placed in a restraining crate for scanning. Once

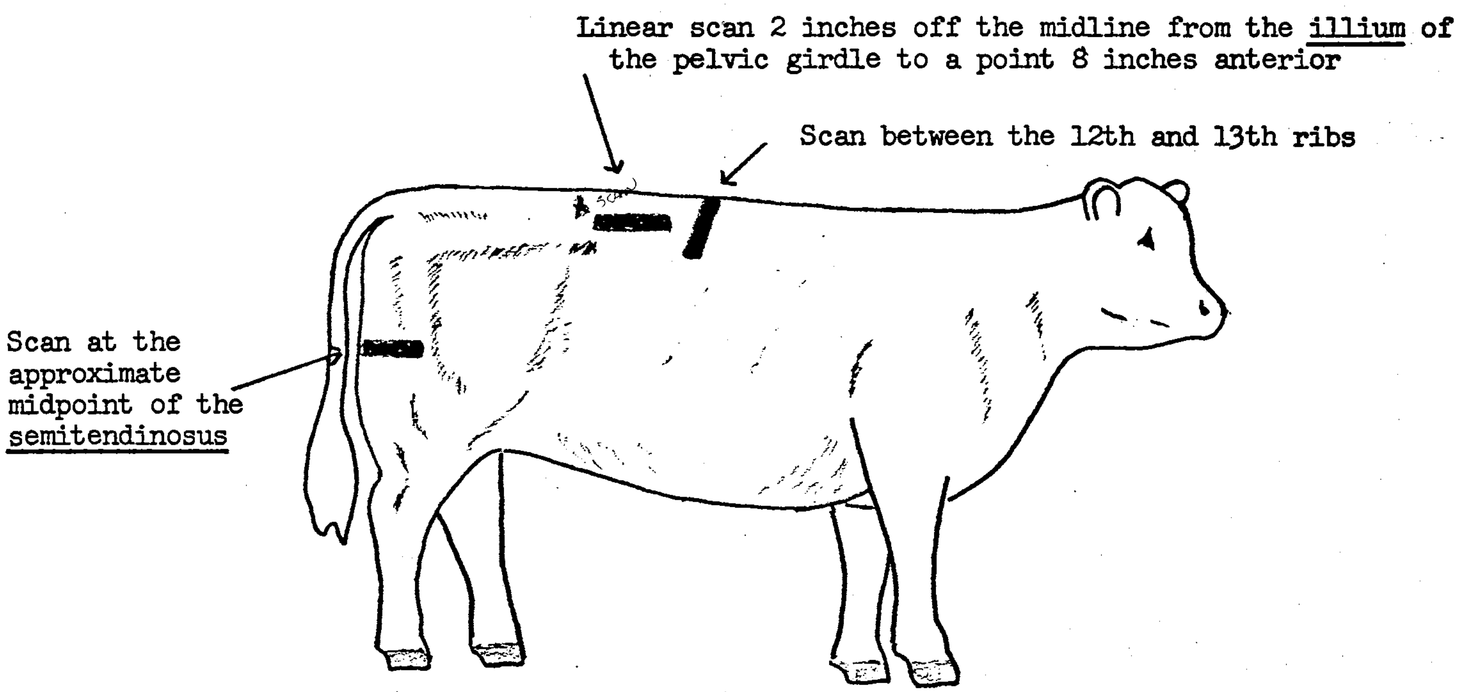

Figure 3. Illustration of the Scan Positions - Group 4

in the crate the animal was further restrained by placing an automotive seat belt across the shoulders and by lifting the animal "off the ground" by means of a five inch pipe which ran the entire length of the crate. The hair was clipped at positions where Scanogram readings were taken. As with cattle, the positions at which readings were to be taken were pre-oiled by covering the site with light weight paraffin oil as described above.

All scanograms made on swine were to one-half scale and were converted to actual size by using the following formulae: (estimated fat thickness x 2) and (estimated muscle area x 4).

Readings for estimated backfat thickness were taken on animals in Group 3 (67 barrows and gilts) at three locations: at the 1st rib, last rib, and last lumbar vertebra. Loin eye area was estimated at the 10th rib. These locations were found by either palpation or visual estimation. After the readings had been made, the animal was tatooed for carcass identification at the position where the readings were taken. When the carcasses of these animals were processed, cuts were made and fat measurements taken at the position indicated by the tatoo. By using this procedure, if the point on the live animal where the reading was taken was not quite on target, the measurement made on the chilled carcass would be at the same point as designated in the living animal. These procedures were also used on Group 5 (59 barrows and gilts).

Animals of Group 5 were treated in the same manner prior to ultrasonic evaluation as those in Group 3. The same scan locations were used on the animals in Group 5 as were used on animals in Group 3. In addition to these scans, three new scan sites were selected. They included a scan at the 13th rib, a linear fat scan over the midline behind the 13th rib, and a scan at the approximate midpoint of the *semitendinosus*.

The 13th rib position was selected in an attempt to avoid the *trapezius* which often causes problems with interpretation of the 10th rib scan since its presence makes it difficult to determine the exact dorsal edge of the *longissimus dorsi* in the scanogram, Stouffer *et al.* (1959). At the 13th rib the only major muscle present in the carcass cross section is the *longissimus dorsi*. The linear scan was made directly on the midline from the 13th rib to a point eight inches posterior in an attempt to estimate average backfat thickness in this area. The *semitendinosus* scan was made at the approximate mid-point of the muscle (located in the ham) in an effort to estimate fat cover and muscle area at this point. Figure 4 illustrates the positions where Scanogram estimations were made in hogs.

For this group of animals, scans were also made on their warm carcasses which were mounted (unsplit and head on) in a standing position, hopefully, to preserve the muscle shapes and position of the live animal, Figure 5. These scans were made in an attempt to relate live estimates to those in the warm carcass. The same sites were scanned on the warm carcasses as were scanned on the live animals, except for the linear scan. This scan was not made on the warm carcasses because of the time factor involved in changing both the cam and guide sets which are needed to make linear scans. In the 20 minutes necessary to change the cam and guide sets, the carcasses would cool below the point at which high frequency sounds could penetrate the carcass sufficiently to produce good pictures. Poor

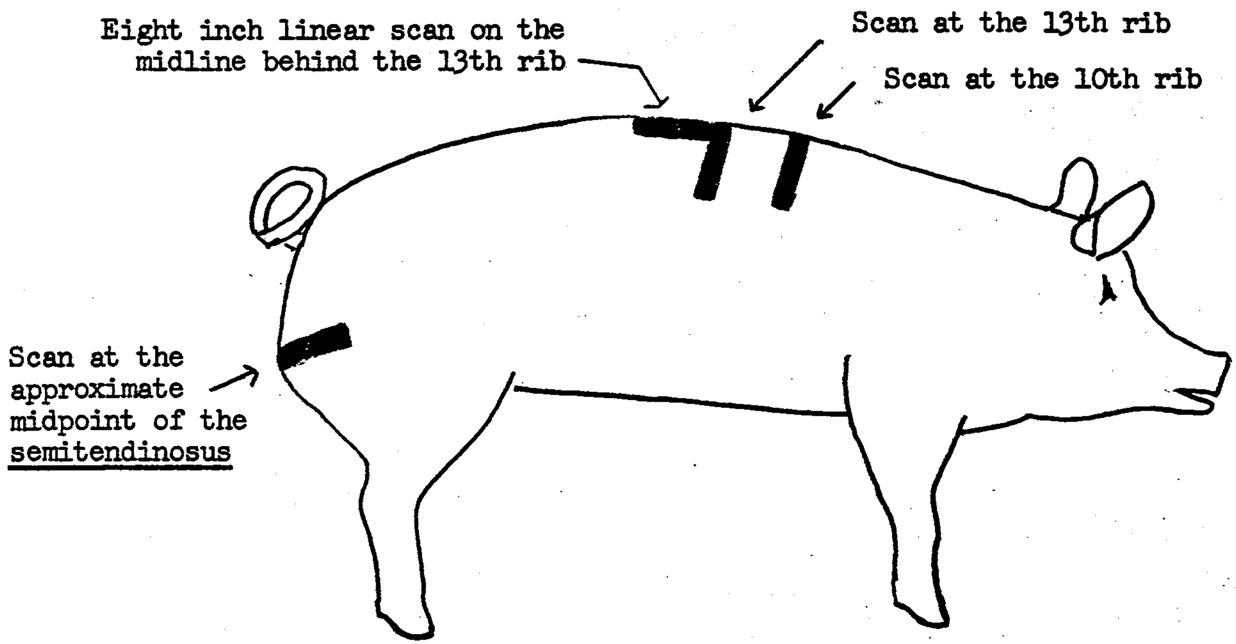

Figure 4. Illustrations of the Scan Positions - Group 5

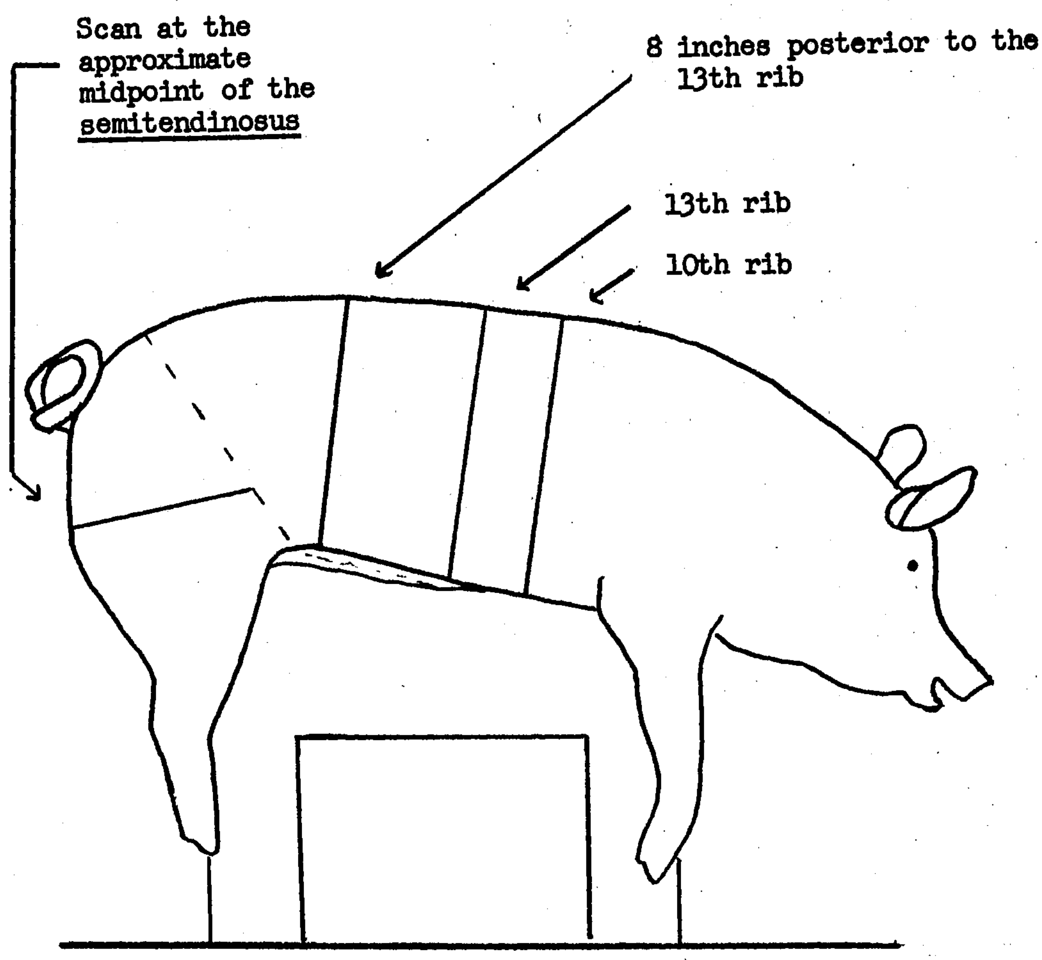

Figure 5. Illustration of a Mounted, Unsplit Carcass and the Positions at Which Cross Sections Were Made

quality, uninterpretable scanograms were produced when the mounted, warm carcasses were scanned. The pictures (scanograms) were very bright from the middle to the lower edge of the print and very dark in the upper one-fourth of the print. After this problem arose, probes were made with a meat thermometer at 1 and 3 1/2 inches beneath the skin in the cushion of the ham. A difference of 10 to 12° F. was observed in body temperature at these two depths. Since ultrasonic readings cannot be made successfully on chilled carcasses because temperatures are below normal living body temperature, these temperature differences were suspected as the reason for faulty scanograms on "warm" carcasses. In an effort to correct this problem, the carcasses, immediately upon mounting, were rolled into a small room which had been pre-heated to 110 to 120° F. The carcasses were then scanned in the heated room in an attempt to obtain interpretable scanograms before the carcasses had cooled down.

Lean Meter Probe

On Groups 3 (67 barrows and gilts) and 5 (59 barrows and gilts), live probe backfat measurements were made with the Lean Meter the day before ultrasonic evaluations were made. Animals were probed at a position approximately 1 1/2 inches off the midline at the 1st rib, last rib, and last lumbar vertebra on both the right and left sides. A mean probe estimate was determined by averaging all measurements made on an animal.

Interpretation of Scanograms

In an effort to familiarize the interpreter with the information on the scanograms (Figure 6), some preliminary work was done. This study consisted of scanning the live animal, photographing from the chilled carcass the cross section of the area scanned in the live animal, reducing the photograph to the same scale as the scanogram, and comparing muscle, fat and bone boundaries on the two pictures.

Scanograms of animals in all study groups were evaluated by two individuals working independently as soon as possible after readings were made. Efforts were made to interpret all of the scanograms before measurements were made on the chilled carcasses. This was done in an effort to eliminate the bias which could enter into interpretation of scanograms.

Scanograms were interpreted by placing the picture under a plex-i-glass cover and tracing the fat, muscle, and bone boundaries onto acetate paper. The fat thicknesses were measured with a ruler graduated in hundredths of an inch, and muscle areas were measured with a compensating polar planimeter.

Beef Carcass Cutting Methods

Animals in Groups 1 (28 steers) and 2 (94 steers and heifers) were slaughtered and processed at local packing plants. The data collected on these groups consisted of the following: cold carcass weight; rib eye area between the 12th and 13th ribs; fat cover at the 12th rib; and estimated percent kidney, heart, and pelvic fat. From this data percent cutability was calculated according to Murphey _et_ _al_. (1960). Cutability was the end-point for carcass muscling evaluation for these animals.

Animals in Group 4 (36 steers) were slaughtered at the Oklahoma

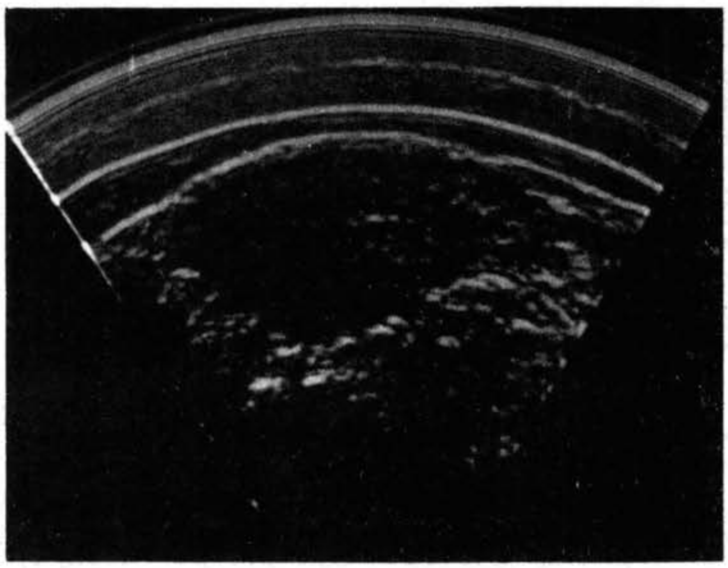

Figure 6. A Transverse Scanogram Taken at the 13th Rib in Swine

State University Meat Laboratory the day following Scanogram evaluation. These animals were scanned and slaughtered in groups of six as they reached approximately 1000 pounds live weight.

After slaughter and chilling, the right sides of all carcasses were separated into the wholesale cuts of loin (short and sirloin), rib, round, chuck, brisket, foreshank, plate, and flank, and the wholesale cut weights recorded. The wholesale rib was removed from the plate to provide an 11 inch rib cut. The loin and flank were separated with a 6 inch rib cut left on the loin. The shank and brisket were removed 1 1/2 inches above the humero-radial articulation parallel to the back of the chuck. The round and loin were separated by cutting on a line extending from the 3rd or 4th sacral vertebra to a point one inch anterior to the aitch bone. Before any trimming was done, tracings of the rib eye area and fat cover at the 12th rib were made. A 1/2 inch section was sliced out of the round at the position marked by the meat branding ink in order that the semitendinosus area and fat cover at that position could be traced. A 2 x 8 inch section of fat was removed from the short loin and the remaining fat depth measured at two inch intervals (three measurements) to obtain the linear fat measurement. The three measurements were then averaged to obtain a mean linear fat measurement.

A trimmed weight was taken on the closely trimmed round, this being the only cut for which a closely trimmed weight was recorded. Each major wholesale cut was boned and defatted leaving only the lean with marbling and narrow bands of intermuscular fat. Weights of the lean, fat, and bone from each of the wholesale cuts were recorded. The weights of the lean, fat, and bone from the foreshank, brisket, plate, and flank were weighed together and recorded as "thin cuts." All lean from the right side of the carcasses was taken to the Oklahoma State University Meat Supply Unit and ground through a chili plate 7/16 inch in diameter and then mixed thoroughly in a power meat mixer (Butcher Boy, 250# automatic mixer). The product was then ground through a hamburger plate (1/8 inch in diameter). As the mass came through the grinder, ten "grab samples" were taken. From these ten "grab samples," two composites were made for ether extraction by randomly selecting five of the "grab samples" for one composite and designating the remaining five samples as the other composite. The method for ether extract analysis was slightly modified from procedures outlined by A.O.A.C. (1960), using a Goldfinch Apparatus.

Cutability as described by Murphey et al. (1960) was computed as well as the actual calculated cutability which is defined as the percentage of cold carcass weight made up of the boneless, very closely trimmed loin, rib, round, and chuck. Other variables included trimmed round as a percent of cold carcass weight; pounds of total lean from the loin, rib, round, and chuck; total pounds of carcass lean; and total pounds of carcass fat-free lean. Fat-free lean was determined by subtracting the total pounds of ether extractable portion from the total pounds of knife separable lean.

Pork Carcass Cutting Methods

The animals in Group 3 (67 barrows and gilts) were slaughtered at the Oklahoma State University Meat Laboratory. These animals were slaughtered in the usual manner, except for being mounted (head on) in a standing position on carcass mounting racks (Figure 5). The carcasses were mounted as a necessity for another study being done with the same group of animals. After work was completed on these carcasses in their mounted position, they were hung up in the customary manner, split warm, and then chilled in a 34-36° F. cooler. Both right and left sides of these carcasses were cut using closely trimmed wholesale cuts of the loin, shoulder, and ham as the end-point of evaluation for carcass muscling. Weights for each rough wholesale cut were recorded. The loins, shoulders, and hams were trimmed closely with care taken in order to keep the lean separated from the fat, and then the weight of the very closely trimmed loin, shoulder, and ham was recorded. Tracings of the loin eye area were made at the 10th rib, and fat measurements were taken at the 1st rib, last rib, and last lumbar vertebra. Percent ham and loin and percent lean cuts of adjusted live weight were calculated. The ham-loin index was computed using the following formula: H-L Index = 10(% ham of adjusted live weight - 10) + 10(loin eye area in square inches).

Animals in Group 5 (59 barrows and gilts) were evaluated and slaughtered according to the same time sequence as Group 3. The only difference was that, unlike the carcasses in Group 3 which were taken off the mounting stands prior to chilling, Group 5 carcasses were chilled on the mounting racks in an effort to preserve the shape of the live animal as nearly as possible in the chilled carcass. This was done in order that studies of the relationship of the live scan to the relatively undisturbed carcass fat and muscle shapes in the mounted chilled carcass could be made. As in other pork work, the position of scans were marked by a tatoo in order that they could be precisely identified in the carcass.

The pork carcasses were cut on a power meat saw with cross sections made at the 10th rib, 13th rib, and at a point eight inches posterior to the 13th rib (Figure 5). These cuts were then split as nearly down the center of the back bone as is possible, using a power meat saw. Only the right sides were used for carcass cut-out data. Tracings were made of the rib eye at the 10th and 13th ribs. The ham was cut perpendicular to the femur at the point indicated by the tatoo so that the area of the semitendinosus and the depth of fat cover over the muscle could be traced. Fat measurements were obtained opposite the 1st rib, last rib, and last lumbar vertebra. Five backfat measurements were also taken from an 8 inch section of the carcass posterior to the 13th rib for purposes of obtaining an average with which to make a comparison of the live scan. Since the carcasses were chilled on mounting stands, the shape of the carcasses was different than one would find with the carcass being chilled in the customary hanging position; therefore, the wholesale cuts were made somewhat differently than those made on a carcass chilled in the usual manner. The shoulder was removed between the 4th and 5th ribs instead of between the 2nd and 3rd. The loin was separated from the side and spare ribs to provide a 3.2 inch rib. The ham was removed by cutting at the 3rd sacral vertebra and halfway between the aitch bone and the last lumbar vertebra. An attempt was made to standardize the "new" cutting procedure in order that reasonably precise weights could be recorded for the "modified" wholesale cuts. Each cut was then closely trimmed and the trimmed weight recorded. The cuts were then boned and intermuscular fat bands in excess of 1/4 inch in thickness were removed. The lean, fat, and bone weights from each cut were recorded. When all separable lean had been obtained, the lean mass was mixed together in preparation for grinding and sampling for ether extract analysis. The lean mass was first ground through a coarse plate (7/16 inch) into a mixer (Leland Food Mixing Machine, Model 100DA). After thorough mixing, the mass was then ground through a fine plate (1/8 inch hamburger plate). Ten "grab samples" were taken as the mass came through the grinder for the second time. From these ten "grab samples," two composites were made by the method described in the beef cutting section for ether extraction analysis (A.O.A.C., 1960). All indices (ham-loin index, percent lean cuts, and percent ham and loin) calculated in Group 3 (67 barrows and gilts) were also computed for this group. Fat-free lean determination was the end-point used as the measure of carcass lean. This was computed by subtracting the pounds of ether extractable portion from the total pounds of knife separable lean.

Statistical Analyses

Means, standard deviations, and correlation coefficients among group totals and the variance accounted for by certain variables were determined according to the methods outlined by Steel and Torrie (1960).

CHAPTER IV

RESULTS AND DISCUSSION

The results of this study are discussed by species (cattle and swine) and by animal group because different Scanogram estimates and carcass measurements were made between groups.

Appearing in tables for all respective groups will be the following terms or abbreviations: Estimate 1, Estimate 2, Estimate Mean, and S.T. Area or Fat. Estimates 1 and 2 are independent interpretations of scanograms (ultrasonic pictures) by two persons, Estimate 1 being made by the author and Estimate 2 by a laboratory technician. The Estimate Mean is the mean of Estimates 1 and 2. S.T. is used as an abbreviation for the *semitendinosus*.

Cattle Studies

Live Scanogram Estimates for Cattle - Groups 1 (N = 28) and 2 (N = 94)

The means and standard deviations for Groups 1 and 2 Scanogram estimates and actual carcass measurements are presented in Table I. Correlation coefficients were determined between the live estimates and actual carcass measurements. Highly significant ($P < .01$) correlations were found between all estimates of fat cover and the actual fat cover in both groups. The highest correlation coefficient was that of 0.89 between Estimate 1 and the actual fat cover for Group 1 which is in

TABLE I

MEANS AND STANDARD DEVIATIONS OF SCANOGRAM ESTIMATES AND ACTUAL CARCASS MEASUREMENTS FOR GROUPS 1 AND 2 (CATTLE)

Scanogram Estimates and Carcass Measurements	Group 1[a]		Group 2[b]	
	Mean	S.D.	Mean	S.D.
FAT COVER (in.)				
Estimate 1	0.50	±0.25	0.40	±0.11
Estimate 2	0.48	±0.18	0.48	±0.13
Estimate Mean	0.49	±0.19	0.44	±0.12
Actual	0.56	±0.24	0.54	±0.20
RIB EYE AREA (sq. in.)				
Estimate 1	11.42	±1.49	10.49	±0.98
Estimate 2	11.78	±1.44	11.06	±1.36
Estimate Mean	11.60	±1.21	10.77	±1.00
Actual	11.55	±1.63	10.38	±1.03

[a]N = 28

[b]N = 94

close agreement with results reported by Hedrick _et_ _al_. (1962). These correlations along with those between estimates and actual rib eye area are presented in Table II. Highly significant correlations ($P < .01$) were found between Estimate 1 and the actual rib eye area in Groups 1 and 2 (r = 0.85 and 0.74, respectively). These correlations were comparable to those reported by Davis and Long (1962). Correlations of 0.44 and 0.23 were found between Estimate 2 and the actual rib eye area (Groups 1 and 2, respectively). These values were statistically significant ($P < .05$).

Live Scanogram estimates were correlated with the percent cutability of the carcasses in Groups 1 and 2. A correlation of -0.84 was found between Estimate 1 fat cover and the percent cutability. This along with all other correlations between percent cutability and Scanogram estimates of fat cover and rib eye area, except Estimate 2 for rib eye, were highly significant ($P < .01$) for Group 1. In Group 2 all correlations between percent cutability and live ultrasonic estimates, except Estimate 2 for rib eye area, were also highly significant ($P < .01$). The correlation between Estimate 2 for rib eye area and percent cutability was statistically significant ($P < .05$). The data are presented in Table III.

To study variation in estimates between interpreters, comparisons were made between Estimate 1 and Estimate 2. Results presented in Table IV indicate that there was a highly significant relationship between Estimate 1 and Estimate 2 for fat cover in both groups. Rib eye area estimates in Group 2 were significant at $P < .05$, and no statistical significance was observed between rib eye estimates in Group 1.

TABLE II

CORRELATION COEFFICIENTS BETWEEN THE ACTUAL CARCASS MEASUREMENTS AND ESTIMATE 1, ESTIMATE 2, AND THE ESTIMATE MEAN OF FAT COVER AND RIB EYE AREA FOR GROUPS 1 AND 2 (CATTLE)

Actual Carcass Measurements	Scanogram Estimates		
	Estimate 1	Estimate 2	Estimate Mean
Group 1[a]			
Fat Cover (in.)	0.89**	0.55**	0.82**
Rib Eye Area (sq. in.)	0.85**	0.44**	0.79**
Group 2[b]			
Fat Cover (in.)	0.46**	0.47**	0.49**
Rib Eye Area (sq. in.)	0.74**	0.23*	0.52**

[a]N = 28

[b]N = 94

* $(P < .05)$

** $(P < .01)$

TABLE III

CORRELATION COEFFICIENTS BETWEEN PERCENT CUTABILITY AND ESTIMATE 1, ESTIMATE 2, ESTIMATE MEAN, AND ACTUAL MEASUREMENT OF FAT COVER AND RIB EYE AREA FOR GROUPS 1 AND 2 (CATTLE)

Scanogram Estimates and Carcass Measurements	Group 1[a] Cutability[c] %	Group 2[b] Cutability[c] %
FAT COVER (in.)		
Estimate 1	-0.84**	-0.45**
Estimate 2	-0.49**	-0.43**
Estimate Mean	-0.73**	-0.46**
Actual	-0.91**	-0.84**
RIB EYE AREA (sq. in.)		
Estimate 1	0.65**	0.74**
Estimate 2	0.14	0.23*
Estimate Mean	0.48**	0.52**
Actual	0.77**	0.37**

[a]N = 28

[b]N = 94

[c]Percent Estimated Cutability using the U.S.D.A. Prediction Equation, Murphey _et al._ (1960)

* $(P < .05)$

** $(P < .01)$

TABLE IV

CORRELATION COEFFICIENTS BETWEEN ESTIMATE 1 AND ESTIMATE 2 OF RIB EYE AREA AND FAT COVER FOR GROUPS 1 AND 2 (CATTLE)

Carcass Measurements	Group 1[a]	Group 2[b]
Fat Cover (in.)	0.65**	0.82**
Rib Eye Area (sq. in.)	0.35	0.44*

[a]N = 28

[b]N = 94

* $(P < .05)$

** $(P < .01)$

<u>Live Scanogram Estimates for Cattle - Group 4 (N = 36)</u>

Live Scanogram estimates were made at three locations. The means and standard deviations of these estimates and of the carcass measurements are listed in Table V. Table VI presents the observed relationships between Scanogram estimates on the live animal and actual carcass measurements. Correlation coefficients between estimated and actual fat cover were lower ($r = 0.27$ to 0.38) than the same comparisons for Groups 1 and 2 ($r = 0.46$ to 0.89). Although low, the correlation coefficient between the Estimate Mean and actual fat cover ($r = 0.36$) is significant at the 5% level of probability. The highest correlation coefficients were obtained between linear fat estimates over the short loin and actual carcass fat measurements at this location. Highly significant ($P < .01$) correlations ($r = 0.58$, 0.50, and 0.58) were found between carcass measurements of linear fat and Estimate 1, Estimate 2, and the Estimate Mean. Correlation coefficients between Scanogram estimates of rib eye area and actual rib eye area were 0.49, 0.42, and 0.53, respectively. These values were statistically significant at the 1% level of probability. All comparisons between actual measurements and the corresponding Scanogram estimates of S.T. fat and S.T. area were statistically nonsignificant.

Various indices of carcass meatiness were compared to certain live Scanogram estimates, Table VII. Generally, the correlation coefficients between these variables were nonsignificant. Scanogram estimates of rib eye area appeared to be more closely related to the indices of meatiness than did fat cover, linear fat, or S.T. area. The correlations between live Scanogram rib eye estimates and total

TABLE V

MEANS AND STANDARD DEVIATIONS OF SCANOGRAM ESTIMATES AND ACTUAL CARCASS MEASUREMENTS FOR GROUP 4 (CATTLE)

Scanogram Estimates and Carcass Measurements	Group 4[a]	
	Mean	Std. Dev.
FAT COVER (in.)		
Estimate 1	0.47	±0.11
Estimate 2	0.67	±0.13
Estimate Mean	0.57	±0.13
Actual	0.61	±0.14
LINEAR FAT (in.)		
Estimate 1	0.52	±0.14
Estimate 2	0.86	±0.15
Estimate Mean	0.69	±0.14
Actual	0.58	±0.15
S.T. FAT (in.)		
Estimate 1	0.18	±0.06
Estimate 2	0.55	±0.15
Estimate Mean	0.36	±0.08
Actual	0.18	±0.08
RIB EYE AREA (sq. in.)		
Estimate 1	11.71	±1.79
Estimate 2	12.38	±1.26
Estimate Mean	12.05	±1.33
Actual	11.91	±1.44
S.T. AREA (sq. in.)		
Estimate 1	10.36	±2.22
Estimate 2	13.78	±2.46
Estimate Mean	12.07	±1.88
Actual	11.23	±1.49

[a]N = 36

TABLE VI

CORRELATION COEFFICIENTS BETWEEN THE ACTUAL CARCASS MEASUREMENTS AND ESTIMATE 1, ESTIMATE 2, AND THE MEAN SCANOGRAM ESTIMATE FOR GROUP 4 (CATTLE)

Actual Carcass Measurements	Scanogram Estimates		
	Estimate 1	Estimate 2	Estimate Mean
Group 4[a]			
Fat Cover (in.)	0.27	0.38*	0.36*
Linear Fat (in.)	0.58**	0.50**	0.58**
S.T. Fat (in.)	0.27	0.22	0.29
Rib Eye Area (sq. in.)	0.49**	0.42**	0.53**
S.T. Area (sq. in.)	-0.15	-0.02	-0.10

[a]N = 36

* (P< .05)

** (P< .01)

TABLE VII

CORRELATION COEFFICIENTS BETWEEN CERTAIN LIVE SCANOGRAM ESTIMATES AND INDICES OF MEATINESS FOR GROUP 4 (CATTLE)

	Indices of Carcass Meatiness				
Group 4[a] Live Scanogram Estimates	Total Lean lbs.	Fat-Free Lean lbs.	Lean from the Loin, Rib, Round, Chuck lbs.	Cutability[b] %	Cutability[c] %
FAT COVER (in.)					
Estimate 1	0.01	-0.10	-0.02	-0.28	-0.29
Estimate 2	0.42**	0.22	0.32	-0.28	-0.25
Estimate Mean	0.25	0.08	0.17	-0.31	-0.29
LINEAR FAT (in.)					
Estimate 1	0.23	0.01	0.23	-0.42**	-0.25
Estimate 2	0.07	-0.11	0.07	-0.39*	-0.39*
Estimate Mean	0.16	-0.05	0.04	-0.43**	-0.34*
S.T. FAT (in.)					
Estimate 1	-0.25	-0.34*	-0.32	-0.13	-0.21
Estimate 2	0.36*	0.32	0.44**	-0.01	-0.21
Estimate Mean	0.37*	0.21	0.28	-0.03	-0.27

TABLE VII (CONTINUED)

Group 4[a] Live Scanogram Estimates	Indices of Carcass Meatiness: Total Lean lbs.	Fat-Free Lean lbs.	Lean from the Loin, Rib, Round, Chuck lbs.	Cutability[b] %	Cutability[c] %
RIB EYE AREA (sq. in.)					
Estimate 1	0.43**	0.36*	0.43**	0.02	-0.09
Estimate 2	0.39*	0.42**	0.43**	0.19	0.04
Estimate Mean	0.47**	0.44**	0.50**	0.10	-0.03
S.T. AREA (sq. in.)					
Estimate 1	-0.25	-0.26	-0.26	-0.20	-0.29
Estimate 2	0.47**	0.34*	0.33*	0.12	0.02
Estimate Mean	0.02	0.07	0.05	-0.04	-0.15

[a]N = 36

[b]Percent Estimated Cutability using the U.S.D.A. Prediction Equation, Murphey et al. (1960)

[c]Percent Cutability using the pounds of boneless, very closely trimmed lean from the loin, rib, round, and chuck as a percent of chilled carcass weight

* $(P < .05)$

** $(P < .01)$

pounds of lean; pounds of fat-free lean; and pounds of lean from the loin, rib, round, and chuck ranged from 0.39 to 0.47, 0.36 to 0.44, and 0.43 to 0.55, respectively. All values except 0.36 and 0.39 (pounds of fat-free lean and total pounds of lean, respectively) were highly significant at the 5% level of probability. Scanogram linear fat estimates over the short loin appeared to be more closely associated with estimated percent cutability (Murphey <u>et</u> <u>al</u>. 1960) than any other live estimate. The range in correlation coefficients was from -0.39 ($P < .05$) to -0.43 ($P < .01$).

When Scanogram live estimates were compared to the major wholesale cut weights (Table VIII), few significant relationships were observed. Highly significant ($P < .01$) correlation coefficients ($r = 0.42$ to 0.49) were found between Scanogram estimates of S.T. fat and the weight of the round. In most cases Scanogram rib eye area estimates were significantly correlated with the loin, rib, and chuck weight. Twelfth rib fat cover estimates were significantly associated with loin weight. Generally, S.T. area Scanogram estimates were found to be poorly related to wholesale cut weights.

Since the pounds of lean in the major wholesale cuts are of prime importance in determining value of beef carcasses, comparisons of these lean weights with the various live Scanogram estimates are important. These comparisons appear in Table IX. Scanogram estimates of rib eye area were found to be significantly ($P < .01$) associated with pounds of lean in the loin. These estimates also were significantly related to pounds of lean in the chuck, round, and thin cuts, with correlation coefficients ranging from 0.41 to 0.47, 0.35 to 0.45, and 0.40 to 0.51, respectively. Live Scanogram estimates of fat cover, linear fat, and

TABLE VIII

CORRELATION COEFFICIENTS BETWEEN CERTAIN BEEF WHOLESALE CUT WEIGHTS AND LIVE SCANOGRAM ESTIMATES OF LEANNESS AND FATNESS FOR GROUP 4 (CATTLE)

Group 4[a] Live Scanogram Estimates	Wholesale Cuts[b] Loin lbs.	Rib lbs.	Chuck lbs.	Round lbs.	Thin Cuts lbs.
FAT COVER (in.)					
Estimate 1	0.17	0.07	0.15	0.07	0.06
Estimate 2	0.58**	0.33*	0.43**	0.42**	0.34*
Estimate Mean	0.43**	0.23	0.32	0.28	0.24
LINEAR FAT (in.)					
Estimate 1	0.46**	0.03	0.25	-0.21	0.15
Estimate 2	0.31	-0.06	0.18	0.63**	0.13
Estimate Mean	0.41*	-0.01	0.23	0.21	0.15
S.T. FAT (in.)					
Estimate 1	-0.21	-0.10	-0.32	0.49**	-0.05
Estimate 2	0.30	0.27	0.52**	0.42**	0.54**
Estimate Mean	0.27	0.20	0.33*	0.49**	0.46**
RIB EYE AREA (sq. in.)					
Estimate 1	0.53**	0.28	0.45**	0.23	0.41*
Estimate 2	0.42**	0.54**	0.36*	0.18	0.34*
Estimate Mean	0.55**	0.45**	0.47**	0.53**	0.44**
S.T. AREA (sq. in.)					
Estimate 1	-0.21	0.01	-0.20	-0.17	0.03
Estimate 2	0.15	0.01	0.35*	0.44**	0.27
Estimate Mean	-0.02	0.01	0.11	0.20	0.20

[a]N = 36

[b]Untrimmed wholesale cuts

[c]Thin cuts include foreshank, brisket, plate, and flank

* ($P < .05$)

** ($P < .01$)

TABLE IX

CORRELATION COEFFICIENTS BETWEEN CERTAIN BEEF WHOLESALE CUT LEAN WEIGHTS AND LIVE SCANOGRAM ESTIMATES OF LEANNESS AND FATNESS FOR GROUP 4 (CATTLE)

Group 4[a] Live Scanogram Estimates	Wholesale Cut Lean Weights: Loin Lean lbs.	Rib Lean lbs.	Chuck Lean lbs.	Round Lean lbs.	Thin Cuts Lean lbs.
FAT COVER (in.)					
Estimate 1	0.02	-0.03	0.00	-0.07	-0.06
Estimate 2	0.42**	0.07	0.30	0.28	0.23
Estimate Mean	0.26	0.02	0.18	0.13	0.10
LINEAR FAT (in.)					
Estimate 1	0.24	-0.24	0.15	0.08	0.00
Estimate 2	0.01	-0.41*	0.02	-0.01	-0.06
Estimate Mean	0.13	-0.35*	0.09	0.03	-0.03
S.T. FAT (in.)					
Estimate 1	-0.20	-0.07	-0.39*	-0.29	-0.14
Estimate 2	0.42**	0.03	0.32	0.52**	0.56**
Estimate Mean	0.30	0.01	0.20	0.35*	0.45**
RIB EYE AREA (sq. in.)					
Estimate 1	0.46**	-0.00	0.42**	0.43**	0.48**
Estimate 2	0.45**	0.45**	0.41*	0.35*	0.40*
Estimate Mean	0.53**	0.21	0.47**	0.45**	0.51**
S.T. AREA (sq. in.)					
Estimate 1	-0.30	0.01	-0.29	-0.22	-0.02
Estimate 2	0.17	-0.00	0.30	0.43*	0.34*
Estimate Mean	-0.07	0.00	0.02	0.14	0.21

[a]N = 36

* (P< .05)

** (P< .01)

S.T. area compared to the various lean weights generally resulted in nonsignificant correlation coefficients. Comparisons between Estimate 1 and Estimate 2 Scanogram interpretations (Table X) indicated that the two interpreters of the scanograms agreed more closely on rib eye area (r = 0.50) and depth of fat over the short loin (linear fat) (r = 0.74) than on S.T. fat and S.T. area. The correlation coefficients (r = 0.50 and 0.74) were both statistically significant ($P < .01$).

TABLE X

CORRELATION COEFFICIENTS BETWEEN ESTIMATE 1 AND ESTIMATE 2 SCANOGRAM INTERPRETATIONS FOR GROUP 4 (CATTLE)

Group 4[a] Scanogram Estimates				
Average Fat Cover in.	Linear Fat in.	S.T. Fat in.	Rib Eye Area sq. in.	S.T. Area sq. in.
0.69**	0.74**	0.14	0.50**	0.29

[a]N = 36

** ($P < .01$)

Cattle Discussion

Statistically significant correlations were observed between most comparisons made for Group 1 and Group 2 cattle (correlation coefficients at either $P < .01$ or $P < .05$). Many of these correlation coefficients were small and accounted for a small part of the total variation but were still significant. Table XI presents the r^2 values for Groups 1, 2, and 4 cattle. More variation was accounted for in fat cover and rib eye estimates in Group 1 ($r^2 = 0.79$ and 0.72, respectively for Estimate 1) than the estimates for the corresponding measurements in Group 2 ($r^2 = 0.21$ and 0.55, respectively for Estimate 1).

Poor quality scanograms were believed to account for some of the low relationships obtained from comparisons made in Group 2. In many of the scanograms, poor definition of the dorsal edge of the rib was observed.

Animals in Group 4 (36 steers) were ultrasonically evaluated at three different locations: between the 12th and 13th ribs; at the approximate midpoint of the length of the semitendinosus; and over the short loin, two inches off the midline and anterior to the illium of the pelvic girdle. Generally, correlation coefficients between carcass measurements and estimated rib eye area and linear fat were significant. Correlation coefficients between most carcass measurements and estimated S.T. fat and S.T. area were generally nonsignificant. Quite large standard deviations were observed for the estimates of S.T. fat and S.T. area. Correlation coefficients between live Scanogram estimates and carcass measures of leanness and fatness were generally nonsignificant. A few correlations were statistically significant, but generally were very low and accounted for a small fraction of the variation associated with measures of leanness and fatness (Table XI). Scanogram estimates of linear fat accounted for more of the variation associated with actual carcass measurements ($r^2 = 0.34$, 0.25, and 0.34 for Estimate 1, Estimate 2, and the Estimate Mean, respectively) than

TABLE XI

VARIANCE ACCOUNTED FOR IN ACTUAL CARCASS MEASUREMENTS BY SCANOGRAM ESTIMATES FOR GROUPS 1, 2, AND 4 (CATTLE)

Actual Carcass Measurements	Scanogram Estimates		
	Estimate 1 r^2	Estimate 2 r^2	Estimate Mean r^2
Group 1[a]			
Fat Cover (in.)	0.79	0.30	0.67
Rib Eye Area (sq. in.)	0.72	0.19	0.62
Group 2[b]			
Fat Cover (in.)	0.21	0.22	0.24
Rib Eye Area (sq. in.)	0.55	0.05	0.27
Group 4[c]			
Fat Cover (in.)	0.07	0.14	0.13
Linear Fat (in.)	0.34	0.25	0.34
S.T. Fat (in.)	0.07	0.05	0.08
Rib Eye Area (sq. in.)	0.24	0.18	0.28
S.T. Area (sq. in.)	0.02	0.00	0.01

[a]N = 28

[b]N = 94

[c]N = 36

did Scanogram estimates of fat cover, S.T. fat, rib eye area, or S.T. area.

Reasons for the relatively low correlation coefficients between live ultrasonic estimates and actual carcass measurements could be due to poor quality scanograms. Poor penetration of the high frequency sound again resulted in poor definition of the dorsal edge of the rib on the scanograms produced. For this group of animals, as well as all other groups, when scanogram interpretations are converted to actual size, a correction factor must be used. With cattle work, scanograms are made to one-third scale. Under this condition when fat cover is measured on the scanogram, the value is multiplied by a factor of 3 and rib eye area is multiplied by a factor of 9. Hence, fat cover interpretation errors are multiplied by 3 and rib eye interpretation errors are multiplied by 9. Further, as with Group 2 cattle, rather serious malfunctions were encountered with the Scanogram. Corrective measures required that the instrument be shipped to the factory, and ultimately it was replaced by the manufacturer.

Swine Studies

Scanogram and Live Probe Estimates for Swine - Group 3 (N = 67)

Comparisons in Group 3 swine were similar to those made in Groups 1 and 2 cattle. Table XII reports the means and standard deviations for the Scanogram estimates and actual carcass measurements for animals in Group 3. Table XIII presents the correlation coefficients between Scanogram estimates and actual carcass measurements. As in Groups 1 and 2, a rather low correlation can be highly significant because of

TABLE XII

MEANS AND STANDARD DEVIATIONS OF SCANOGRAM ESTIMATES AND ACTUAL CARCASS MEASUREMENTS FOR GROUP 3 (SWINE)

Scanogram Estimates and Carcass Measurements	Group 3[a]	
	Mean	Std. Dev.
AVERAGE BACKFAT (in.)		
Estimate 1	1.15	±0.15
Estimate 2	1.10	±0.13
Estimate Mean	1.12	±0.13
Actual	1.11	±0.16
LOIN EYE AREA (sq. in.)		
Estimate 1	5.56	±0.68
Estimate 2	5.30	±1.13
Estimate Mean	5.43	±0.76
Actual	4.76	±0.46

[a]N = 67

TABLE XIII

CORRELATION COEFFICIENTS BETWEEN ACTUAL CARCASS MEASUREMENTS AND ESTIMATE 1, ESTIMATE 2, AND THE MEAN SCANOGRAM ESTIMATE FOR GROUP 3 (SWINE)

Actual Carcass Measurements	Scanogram Estimates		
	Estimate 1	Estimate 2	Estimate Mean
Group 3[a]			
Average Backfat (in.)	0.69**	0.68**	0.70**
Loin Eye Area (sq. in.)	0.31*	0.39**	0.42**

[a]N = 67

* $(P < .05)$

** $(P < .01)$

the number of animals (n = 67). Highly significant correlations were found between estimates and actual measurements of backfat thickness, although a rather small proportion of the variation is accounted for. Both independent estimates and Estimate Means, when correlated with the actual carcass measurements, were similar (Table XIII). These correlation coefficients ranged from 0.68 to 0.70. Correlations between loin eye area estimates and actual values were much lower (0.31 to 0.42) but still significant at $P < .05$ or $P < .01$. These correlations were much lower than those reported by Johnson et al. (1968) (r = 0.77, 0.79) using a Branson, Model 12, Live Animal Tester. The lower correlation coefficients are thought to be due largely to Scanogram malfunctions.

The relationship of various live estimates to certain carcass measures of meatiness (Table XIV) was studied in an effort to determine whether or not this instrument could be used successfully to estimate certain carcass measurements which would be of value in predicting carcass composition. Highly significant correlations, -0.63, -0.66, and -0.49, were found between Estimate 1 backfat thickness and percent lean cuts, percent ham-loin, and ham-loin index, respectively. Correlations between the above measures of meatiness and the remaining estimates (Estimate 2 and Estimate Mean) of the backfat thickness were also significant at the 1% level of probability. Scanogram estimates of average backfat thickness proved to be a better predictor of leanness than did Scanogram estimates of loin eye area. The loin eye area estimates generally were significant ($P < .05$), with the exception of Estimates 1 and 2 loin eye area when compared to percent ham-loin. A highly significant association was found between the loin eye area

TABLE XIV

CORRELATION COEFFICIENTS BETWEEN CERTAIN LIVE ESTIMATES AND MEASURES OF CARCASS MEATINESS FOR GROUP 3 (SWINE)

Group 3[a] Live Estimates	Indices of Carcass Meatiness: Lean Cuts[b] %	Ham-Loin[b] %	Ham-Loin Index[b]
SCANOGRAM AVERAGE BACKFAT (in.)			
Estimate 1	-0.63**	-0.66**	-0.49**
Estimate 2	-0.58**	-0.60**	-0.46**
Estimate Mean	-0.63**	-0.65**	-0.49**
SCANOGRAM LOIN EYE AREA (sq. in.)			
Estimate 1	0.27*	0.22	0.25*
Estimate 2	0.26*	0.23	0.31*
Estimate Mean	0.31*	0.27*	0.34**
LEAN METER PROBE (in.)			
Average Backfat	-0.69**	-0.72**	-0.58**

[a]N = 67

[b]Calculated on a 24 hour shrink basis

* $(P < .05)$

** $(P < .01)$

Estimate Mean and ham-loin index ($r = 0.34$).

Lean Meter backfat probe estimates were significantly correlated ($P < .01$) with percent lean cuts, percent ham-loin, and ham-loin index. The correlations were -0.69, -0.72, and -0.58, respectively. A highly significant correlation of 0.65 was obtained between Lean Meter estimates and actual backfat thickness.

Correlations of live Scanogram estimates of backfat thickness and loin eye area with the weight of the trimmed lean cuts (ham, loin, and shoulder) are presented in Table XV. Highly significant correlations were found between Scanogram estimates of average backfat thickness and the weight of the trimmed ham. In general, Scanogram estimates of loin eye area were not as closely associated to the weight of the lean cuts as Scanogram estimates of average backfat thickness. No significant correlations were found between any of the live Scanogram estimates and the weight of the trimmed shoulder.

Average backfat thickness Estimates 1 and 2 were found to be much more highly correlated with each other ($r = 0.89$) than loin eye area Estimates 1 and 2 ($r = 0.38$).

<u>Live and Carcass Scanogram and Live Probe Estimates for Swine - Group 5 (N = 59)</u>

Live Scanogram estimates were made on all 59 pigs in Group 5, whereas Scanogram estimates were made on the mounted warm carcasses of only 48 of these animals. Estimates were made on the live animals and the mounted warm carcasses mainly to serve as a method for checking the repeatability of the results obtained in the scanning operation. Table XVI presents the means and standard deviations for all live and warm

TABLE XV

CORRELATION COEFFICIENTS BETWEEN CERTAIN TRIMMED WHOLESALE CUT WEIGHTS AND LIVE SCANOGRAM ESTIMATES OF LEANNESS AND FATNESS FOR GROUP 3 (SWINE)

	Wholesale Cuts[b]		
Group 3[a] Scanogram Estimates	Ham lbs.	Loin lbs.	Shoulder lbs.
AVERAGE BACKFAT (in.)			
Estimate 1	-0.46**	-0.38**	-0.09
Estimate 2	-0.46**	-0.31*	-0.09
Estimate Mean	-0.48**	-0.36**	-0.09
LOIN EYE AREA (sq. in.)			
Estimate 1	0.11	0.22	0.02
Estimate 2	0.32**	0.40**	0.21
Estimate Mean	0.28*	0.39**	0.16

[a]N = 67

[b]Closely trimmed wholesale cuts

* $(P < .05)$

** $(P < .01)$

TABLE XVI

MEANS AND STANDARD DEVIATIONS OF SCANOGRAM ESTIMATES AND ACTUAL CARCASS MEASUREMENTS FOR GROUP 5 (SWINE)

Scanogram Estimates and Carcass Measurements	Live Animal[a,c]		Warm Carcass[b,d]	
	Mean	S.D.	Mean	S.D.
BACKFAT THICKNESS (in.)				
Estimate 1	1.27	±0.19	1.12	±0.15
Estimate 2	1.25	±0.21	1.09	±0.17
Estimate Mean	1.26	±0.20	1.10	±0.16
Actual	1.01	±0.21	1.01	±0.21
S.T. FAT (in.)				
Estimate 1	0.63	±0.10	0.52	±0.06
Estimate 2	0.61	±0.12	0.50	±0.07
Estimate Mean	0.62	±0.10	0.51	±0.05
Actual	0.59	±0.14	0.59	±0.14
LINEAR FAT (in.)				
Estimate 1	1.01	±0.17	e	e
Estimate 2	1.01	±0.21	e	e
Estimate Mean	1.01	±0.18	e	e
Actual	0.92	±0.21	0.92	±0.21
LOIN EYE AREA (sq. in.) (10th RIB)				
Estimate 1	5.00	±0.60	4.68	±0.66
Estimate 2	5.25	±0.66	4.99	±0.64
Estimate Mean	5.12	±0.56	4.83	±0.58
Actual	4.63	±0.77	4.63	±0.77

TABLE XVI (CONTINUED)

Scanogram Estimates and Carcass Measurements	Live Animal[a,c]		Warm Carcass[b,d]	
	Mean	S.D.	Mean	S.D.
LOIN EYE AREA (sq. in.) (13th RIB)				
Estimate 1	4.79	±0.64	4.41	±0.58
Estimate 2	5.21	±0.60	4.99	±0.63
Estimate Mean	5.00	±0.55	4.70	±0.56
Actual	4.97	±0.64	4.97	±0.64
S.T. AREA (sq. in.)				
Estimate 1	4.03	±0.93	3.74	±0.76
Estimate 2	3.22	±0.40	3.16	±0.31
Estimate Mean	3.63	±0.51	3.45	±0.44
Actual	4.19	±0.88	4.19	±0.88

[a]N = 59

[b]N = 48

[c]Scanogram estimates made on the live animal

[d]Scanogram estimates made on the mounted warm carcasses

[e]Estimate not made on the mounted warm carcasses

carcass Scanogram estimates and actual carcass measurements. The correlation coefficients between actual and estimated average backfat on the live animals (Table XVII) were 0.78, 0.80, and 0.72 for Estimate 1, Estimate 2, and the Estimate Mean, respectively. These correlations were slightly lower than those reported by Price et al. (1958, 1960a). Correlations between the same variables for the warm carcasses (Table XVIII) were 0.70, 0.71, and 0.72, respectively. These along with the correlations for live animals were highly significant at the 1% level of probability.

Lean Meter backfat probe estimates indicated that backfat thickness could be estimated more accurately at the last rib by the Lean Meter than at either the 1st rib or last lumbar vertebra (r = 0.51, 0.81, and 0.61; 1st rib, last rib, and last lumbar vertebra, respectively).

Scanogram estimates of loin eye area at the 10th and 13th ribs on the live animals and warm carcasses correlated with carcass measurements were highly significant. The correlation coefficients ranged from 0.41 to 0.66. The correlations from the live animals ranged from 0.41 to 0.62, which was in close agreement with those reported by Gillis (1971) (r = 0.40 to 0.67). Estimates of S.T. fat on the live animal compared to carcass measurements (r = 0.35 to 0.58) were higher than S.T. fat estimates on the warm carcasses compared to carcass measurements (r = 0.31 to 0.40). Highly significant correlations were observed between live linear fat estimates and actual carcass measurements (r = 0.83, 0.77, and 0.82 for Estimate 1, Estimate 2, and Estimate Mean, respectively). The correlation coefficients between actual S.T. area and Scanogram estimates on the live animals

TABLE XVII

CORRELATION COEFFICIENTS BETWEEN ACTUAL CARCASS MEASUREMENTS AND ESTIMATE 1, ESTIMATE 2, AND THE MEAN SCANOGRAM ESTIMATE (LIVE), GROUP 5 (SWINE)

Actual Carcass Measurements	Scanogram Estimates		
	Estimate 1	Estimate 2	Estimate Mean
Group 5[a]			
Average Backfat (in.)	0.78**	0.80**	0.72**
Linear Fat (in.)	0.83**	0.77**	0.82**
S.T. Fat (in.)	0.35**	0.58**	0.53**
Loin Eye Area (sq. in.) (10th Rib)	0.41**	0.62**	0.59**
Loin Eye Area (sq. in.) (13th Rib)	0.45**	0.60**	0.59**
S.T. Area (sq. in.)	-0.02	0.17	0.04

[a]N = 59

** ($P < .01$)

TABLE XVIII

CORRELATION COEFFICIENTS BETWEEN ACTUAL CARCASS MEASUREMENTS AND ESTIMATE 1, ESTIMATE 2, AND THE MEAN SCANOGRAM ESTIMATE (MOUNTED WARM CARCASSES) GROUP 5 (SWINE)

Actual Carcass Measurements	Scanogram Estimates		
	Estimate 1	Estimate 2	Estimate Mean
Group 5[a]			
Average Backfat (in.)	0.70**	0.71**	0.72**
S.T. Fat (in.)	0.36*	0.31*	0.40**
Loin Eye Area (sq. in.) (10th Rib)	0.46**	0.65**	0.61**
Loin Eye Area (sq. in.) (13th Rib)	0.66**	0.48**	0.61**
S.T. Area (sq. in.)	0.07	0.10	0.09

[a]N = 48

* (P< .05)

** (P< .01)

and warm carcasses were statistically nonsignificant.

Scanogram estimates made on the live animals were compared to Scanogram estimates made on the warm carcasses (Tables XIX, XX, and XXI). All correlation coefficients were highly significant except S.T. area for Estimate 2 which was only significant at ($P < .05$). Results indicate that both interpreters were more successful in estimating average backfat thickness than any other trait. Also, in this study, the second interpreter (Estimate 2) was found to be more successful in making estimates than the first interpreter (Estimate 1). Generally, the correlation coefficients between live animal and warm carcass estimates for the Estimate Mean were higher than the coefficients for either Estimate 1 or Estimate 2. Data in Table XXII indicate that interpreters agreed more closely on the average backfat thickness on the live animal and the warm carcass ($r = 0.92$ and 0.89, respectively) than they did on any other estimate. The correlation coefficient between Estimate 1 and Estimate 2 for linear fat on the live animal was highly significant ($r = 0.87$). The correlations between estimates and carcass measurements for linear fat were the highest of any obtained (in swine work) when comparing estimates to actual measurements ($r = 0.83$, 0.77, and 0.82).

All correlation coefficients between Estimate 1 and Estimate 2 were significant except estimates for S.T. area. In the outset of the study it was hoped that some new, easily obtainable Scanogram estimate position might be found which could be used as an indicator of carcass composition. In so far as swine evaluation is concerned, the linear fat estimate may prove to qualify for such a category. The measurement is quick and easy to make and at this point can be estimated with more

TABLE XIX

CORRELATION COEFFICIENTS BETWEEN ESTIMATE 1 SCANOGRAM MEASUREMENTS MADE ON THE LIVE ANIMALS AND MOUNTED WARM CARCASSES IN GROUP 5 (SWINE)

		Group 5[a] Scanogram Estimates (Warm Carcasses) Estimate 1				
		Average Backfat in.	S.T. Fat in.	Loin Eye Area 10th Rib sq. in.	Loin Eye Area 13th Rib sq. in.	S.T. Area sq. in.
Group 5[a] Scanogram Estimates (Live Animal) Estimate 1	Average Backfat (in.)	0.82**				
	S.T. Fat (in.)		0.53**			
	Loin Eye Area (sq. in.) (10th Rib)			0.54**		
	Loin Eye Area (sq. in.) (13th Rib)				0.57**	
	S.T. Area (sq. in.)					0.54**

[a]N = 48

** (P< .01)

TABLE XX

CORRELATION COEFFICIENTS BETWEEN ESTIMATE 2 SCANOGRAM MEASUREMENTS MADE ON THE LIVE ANIMALS AND MOUNTED WARM CARCASSES IN GROUP 5 (SWINE)

		Group 5[a] Scanogram Estimates (Warm Carcasses) Estimate 2				
		Average Backfat in.	S.T. Fat in.	Loin Eye Area 10th Rib sq. in.	Loin Eye Area 13th Rib sq. in.	S.T. Area sq. in.
Group 5[a] Scanogram Estimates (Live Animal) Estimate 2	Average Backfat (in.)	0.87**				
	S.T. Fat (in.)		0.69**			
	Loin Eye Area (sq. in.) (10th Rib)			0.78**		
	Loin Eye Area (sq. in.) (13th Rib)				0.73**	
	S.T. Area (sq. in.)					0.35*

[a]N = 48

* (P< .05)

** (P< .01)

TABLE XXI

CORRELATION COEFFICIENTS BETWEEN THE MEAN OF ESTIMATE 1 AND ESTIMATE 2 SCANOGRAM MEASUREMENTS MADE ON THE LIVE ANIMALS AND MOUNTED WARM CARCASSES IN GROUP 5 (SWINE)

		Group 5[a] Scanogram Estimates (Warm Carcasses) Mean Estimate				
		Average Backfat in.	S.T. Fat in.	Loin Eye Area 10th Rib sq. in.	Loin Eye Area 13th Rib sq. in.	S.T. Area sq. in.
Group 5[a] Scanogram Estimates (Live Animal) Mean Estimates	Average Backfat (in.)	0.87**				
	S.T. Fat (in.)		0.71**			
	Loin Eye Area (sq. in.) (10th Rib)			0.75**		
	Loin Eye Area (sq. in.) (13th Rib)				0.74**	
	S.T. Area (sq. in.)					0.41**

[a]N = 48

** (P< .01)

TABLE XXII

CORRELATION COEFFICIENTS BETWEEN ESTIMATE 1 AND ESTIMATE 2 ON THE LIVE ANIMALS AND MOUNTED WARM CARCASSES IN GROUP 5 (SWINE)

Scanogram Estimates	Live Animal[a]	Warm Carcass[b]
Average Backfat (in.)	0.92**	0.89**
S.T. Fat (in.)	0.62**	0.36*
Linear Fat (in.)	0.87**	c
Loin Eye Area (sq. in.) (10th Rib)	0.57**	0.60**
Loin Eye Area (sq. in.) (13th Rib)	0.56**	0.70**
S.T. Area (sq. in.)	0.05	0.23

[a]N = 59

[b]N = 48

[c]Estimate not made on the warm carcasses

* $(P < .05)$

** $(P < .01)$

accuracy than any measurement made on swine. When the linear fat estimates were correlated with the weight of the lean cuts (ham, loin, and shoulder), Table XXIII, highly significant correlation coefficients were obtained in all cases except when linear fat was compared to shoulder weight in which the correlation was -0.32, ($P < .05$). The estimate proved to be more closely related to ham weight than loin or shoulder weight. Average Scanogram backfat estimates exhibited the next highest relationship to the lean cut weights. The correlation coefficients between Scanogram estimates of backfat on the live animals and ham, loin, and shoulder weight were -0.42, -0.48, and -0.46; -0.35, -0.31, and -0.33; and -0.26, -0.33, and -0.30; for Estimate 1, Estimate 2, and Estimate Mean, respectively. All values were found to be significant. The correlation coefficients between Scanogram warm carcass estimates of backfat and ham, loin, and shoulder weight were -0.46, -0.54, and -0.51; -0.23, -0.17, and -0.21; and -0.31, -0.33, and -0.33; for Estimate 1, Estimate 2, and Estimate Mean, respectively. Generally, correlation coefficients between other Scanogram estimates and lean cut weights were low. When Scanogram estimates on the live animal were compared to various measures of meatiness, Table XXIV, (total pounds of lean, pounds of fat-free lean, percent lean cuts, percent ham-loin, and ham-loin index), many significant correlation coefficients were found. Highly significant correlation coefficients were found between the Scanogram estimates of backfat and total pounds of lean ($r = -0.62$, -0.34, and -0.67). The same was also true of total pounds of fat-free lean correlated with Scanogram estimates of average backfat thickness ($r = -0.70$, -0.79, and -0.76). Linear fat Scanogram estimates were also significantly associated with total

TABLE XXIII

CORRELATION COEFFICIENTS BETWEEN CERTAIN WHOLESALE CUT WEIGHTS AND SCANOGRAM ESTIMATES (ON LIVE ANIMALS AND WARM CARCASSES) OF LEANNESS AND FATNESS FOR GROUP 5 (SWINE)

Scanogram Estimates	Ham (lbs.)		Loin (lbs.)		Shoulder (lbs.)	
	Live Animal[a]	Warm Carcass[b]	Live Animal	Warm Carcass	Live Animal	Warm Carcass
AVERAGE BACKFAT (in.)						
Estimate 1	-0.42**	-0.46**	-0.35**	-0.23	-0.26*	-0.31*
Estimate 2	-0.48**	-0.54**	-0.31*	-0.17	-0.33**	-0.33*
Estimate Mean	-0.46**	-0.51**	-0.33**	-0.21	-0.30*	-0.33*
S.T. FAT (in.)						
Estimate 1	-0.06	-0.22	-0.05	-0.09	-0.07	-0.01
Estimate 2	-0.07	-0.10	-0.32*	-0.13	-0.14	0.02
Estimate Mean	-0.07	-0.19	-0.22	-0.13	-0.12	0.01
LINEAR FAT (in.)						
Estimate 1	-0.49**	c	-0.45**	c	-0.40**	c
Estimate 2	-0.53**	c	-0.43**	c	-0.32*	c
Estimate Mean	-0.53**	c	-0.46**	c	-0.37**	c
LOIN EYE AREA (sq. in.) 10th RIB						
Estimate 1	0.19	0.20	0.08	0.04	0.22	-0.03
Estimate 2	0.35**	0.33*	-0.13	0.09	0.27*	0.28*
Estimate Mean	0.31*	0.29*	-0.03	0.07	0.27*	0.13

TABLE XXIII (CONTINUED)

Scanogram Estimates	Ham (lbs.)		Loin (lbs.)		Shoulder (lbs.)	
	Live Animal[a]	Warm Carcass[b]	Live Animal	Warm Carcass	Live Animal	Warm Carcass
LOIN EYE AREA (sq. in.) 13th RIB						
Estimate 1	0.07	0.30*	0.15	-0.02	0.01	0.12
Estimate 2	0.43**	0.34*	-0.01	0.05	0.24	0.22
Estimate Mean	0.27*	0.35*	0.07	0.01	0.14	0.19
S.T. AREA (sq. in.)						
Estimate 1	0.09	0.17	-0.23	-0.06	0.10	0.13
Estimate 2	0.20	0.23	0.06	0.15	0.20	0.44**
Estimate Mean	0.16	0.16	-0.18	-0.18	0.20	0.20

[a]N = 59

[b]N = 48

[c]Estimate not made on the mounted warm carcass

* (P< .05)

** (P< .01)

TABLE XXIV

CORRELATION COEFFICIENTS BETWEEN CERTAIN MEASURES OF MEATINESS AND CERTAIN LIVE ESTIMATES FOR GROUP 5 (SWINE)

Group 5[a] Live Estimates	Measures of Meatiness				
	Total Lean lbs.	Fat-Free Lean lbs.	Lean Cuts[b] %	Ham-Loin[b] %	Ham-Loin Index[b]
SCANOGRAM AVERAGE BACKFAT (in.)					
Estimate 1	-0.62**	-0.70**	-0.14	-0.01	-0.61**
Estimate 2	-0.34**	-0.79**	-0.11	-0.11	-0.68**
Estimate Mean	-0.67**	-0.76**	-0.13	0.00	-0.64**
SCANOGRAM S.T. FAT (in.)					
Estimate 1	-0.24	-0.30*	-0.16	-0.10	-0.29*
Estimate 2	-0.18	-0.27*	-0.08	0.07	-0.34**
Estimate Mean	-0.23	-0.31*	-0.13	-0.01	-0.35**
SCANOGRAM LINEAR FAT (in.)					
Estimate 1	-0.61**	-0.64**	-0.02	0.18	-0.62**
Estimate 2	-0.66**	-0.74**	-0.08	0.06	-0.67**
Estimate Mean	-0.67**	-0.74**	-0.05	0.13	-0.67**
SCANOGRAM LOIN EYE AREA (sq. in.) 10th RIB					
Estimate 1	0.42**	0.42**	-0.05	-0.06	0.34**
Estimate 2	0.52**	0.57**	0.12	0.05	0.52**
Estimate Mean	0.53**	0.56**	0.04	-0.00	0.45**

TABLE XXIV (CONTINUED)

Group 5[a] Live Estimates	Measures of Meatiness				
	Total Lean lbs.	Fat-Free Lean lbs.	Lean Cuts[b] %	Ham-Loin[b] %	Ham-Loin Index[b]
SCANOGRAM LOIN EYE AREA (sq. in.) 13th RIB					
Estimate 1	0.42**	0.44**	0.01	0.07	0.46**
Estimate 2	0.62**	0.63**	0.25*	0.22	0.54**
Estimate Mean	0.58**	0.60**	0.14	0.16	0.47**
SCANOGRAM S.T. AREA (sq. in.)					
Estimate 1	0.25*	0.27*	-0.14	-0.22	0.36**
Estimate 2	0.18	0.15	0.07	-0.01	0.23
Estimate Mean	0.30*	0.30*	-0.09	-0.20	0.21
LEAN METER PROBE (in.)					
First Rib	-0.42**	-0.52**	-0.09	-0.02	-0.56**
Last Rib	-0.62**	-0.72**	-0.06	0.04	-0.65**
Last Lumbar Vertebra	-0.67**	-0.75**	-0.10	-0.03	-0.66**

[a]N = 59

[b]Values computed on an adjusted live weight basis

* $(P < .05)$

** $(P < .01)$

pounds of lean and pounds of fat-free lean (r = -0.61, -0.66, and -0.67; and -0.64, -0.74, and -0.74, respectively). Scanogram estimates of loin eye area at the 13th rib were somewhat more highly associated with total pounds of lean and fat-free lean than Scanogram estimates of loin eye area at the 10th rib. Generally, highly significant correlation coefficients were obtained when the live Scanogram estimates were compared to ham-loin index. Significant correlation coefficients were recorded as high as -0.68 between Estimate 2 backfat thickness and ham-loin index and as low as -0.34 between Estimate 2 S.T. fat and ham-loin index. Nonsignificant correlation coefficients were obtained when the percent lean cuts and the percent ham-loin were correlated with the live Scanogram estimates.

Lean Meter probe estimates correlated with total pounds of lean, pounds of fat-free lean, and ham-loin index were highly significant ($P < .01$). Significant correlation coefficients were observed between Lean Meter probe estimates and pounds of fat-free lean (r = -0.52, -0.72, and -0.75 for the 1st rib, last rib, and last lumbar vertebra, respectively).

The data presented in Table XXV indicate that generally lower correlation coefficients were obtained between Scanogram estimates of the various carcass measurements made on the mounted warm carcasses and certain measures of meatiness.

Swine Discussion

In Group 3 highly significant correlations were found between Scanogram estimates of average backfat thickness and the actual backfat measured on the chilled carcasses. Somewhat lower but still highly

TABLE XXV

CORRELATION COEFFICIENTS BETWEEN CERTAIN MEASURES OF MEATINESS AND CERTAIN WARM CARCASS SCANOGRAM ESTIMATES FOR GROUP 5 (SWINE)

Group 5[a] Carcass Scanogram Estimates	Measures of Meatiness: Total Lean lbs.	Fat-Free Lean lbs.	Lean Cuts[b] %	Ham-Loin[b] %	Ham-Loin Index[b]
AVERAGE BACKFAT (in.)					
Estimate 1	-0.58**	-0.65**	-0.13	-0.03	-0.61**
Estimate 2	-0.61**	-0.72**	-0.20	-0.15	-0.68**
Estimate Mean	-0.61**	-0.70**	-0.17	-0.10	-0.66**
S.T. FAT (in.)					
Estimate 1	0.07	-0.43**	-0.20	-0.23	-0.39**
Estimate 2	-0.31*	-0.23	-0.13	-0.13	-0.22
Estimate Mean	-0.28*	-0.39**	-0.19	-0.21	-0.35*
LOIN EYE AREA (sq. in.) 10th RIB					
Estimate 1	0.26	0.32*	-0.10	-0.01	0.34*
Estimate 2	0.44**	0.50**	0.17	0.14	0.52**
Estimate Mean	0.39**	0.46**	0.04	0.07	0.48**

TABLE XXV (CONTINUED)

Group 5[a] Carcass Scanogram Estimates	Measures of Meatiness: Total Lean lbs.	Fat-Free Lean lbs.	Lean Cuts[b] %	Ham-Loin[b] %	Ham-Loin Index[b]
LOIN EYE AREA (sq. in.) 13th RIB					
Estimate 1	0.39**	0.48**	-0.12	-0.10	0.46**
Estimate 2	0.47**	0.50**	0.07	0.09	0.54**
Estimate Mean	0.47**	0.53**	-0.02	-0.00	0.54**
S.T. AREA (sq. in.)					
Estimate 1	0.17	0.25	-0.02	-0.08	0.40**
Estimate 2	0.07	0.07	0.21	0.06	0.16
Estimate Mean	0.17	0.24	0.05	-0.04	0.41**

[a]N = 48

[b]Computed on adjusted live weight basis

* ($P < .05$)

** ($P < .01$)

significant correlation coefficients were observed between Scanogram estimates of the loin eye area and the actual loin eye area. These lower correlations can be partially accounted for. In the period of time these animals were being evaluated, extreme electrical difficulties were experienced with the Scanogram unit. The problem resulted in an excess of "snow" in the scanograms. This made fat and muscle boundaries quite difficult to determine, especially the thin layer of soft connective tissue in the fat over the shoulder. After the manufacturer's representative made several internal adjustments on the unit, reasonably interpretable scanograms were again produced.

A small amount of the variation associated with loin eye area was accounted for (Table XXVI). Estimates of average backfat accounted for 48, 46, and 49 percent (Estimate 1, Estimate 2, and Estimate Mean, respectively) of the variation associated with average backfat.

Highly significant ($P < .01$) correlations were found between Scanogram average backfat thickness estimates and the weight of the trimmed ham. These estimates could be of value in predicting carcass leanness since the correlation between trimmed ham weight and the percent lean cuts was shown to be highly significant ($r = 0.68$).

In Group 5 highly significant correlation coefficients were found between actual carcass measurements and live Scanogram estimates of average backfat thickness and linear fat. Linear fat was estimated quite accurately by both interpreters (Estimate 1 and Estimate 2). The correlation coefficient between actual carcass measured linear fat and pounds of fat-free lean was -0.63. Linear fat was more closely related to total pounds of fat-free lean ($r = -0.63$) than was actual carcass backfat ($r = -0.60$). Results indicate that the linear fat

TABLE XXVI

VARIANCE ACCOUNTED FOR IN ACTUAL CARCASS MEASUREMENTS BY SCANOGRAM ESTIMATES FOR GROUPS 3 AND 5 (SWINE)

Actual Carcass Measurements	Scanogram Estimates: Estimate 1 r^2	Estimate 2 r^2	Estimate Mean r^2
Group 3[a]			
Average Backfat (in.)	0.48	0.46	0.49
Loin Eye Area (sq. in.) (10th Rib)	0.10	0.15	0.18
Group 5 (Live Animal)[b]			
Average Backfat (in.)	0.61	0.64	0.52
Linear Fat (in.)	0.69	0.59	0.67
S.T. Fat (in.)	0.12	0.34	0.28
Loin Eye Area (sq. in.) (10th Rib)	0.17	0.38	0.35
Loin Eye Area (sq. in.) (13th Rib)	0.20	0.36	0.35
S.T. Area (sq. in.)	0.00	0.03	0.00
Group 5 (Warm Carcass)[c]			
Average Backfat (in.)	0.49	0.50	0.51
S.T. Fat (in.)	0.13	0.10	0.16
Loin Eye Area (sq. in.) (10th Rib)	0.21	0.42	0.37
Loin Eye Area (sq. in.) (13th Rib)	0.44	0.23	0.37
S.T. Area (sq. in.)	0.00	0.01	0.08

[a]N = 67

[b]N = 59

[c]N = 48

measurement over the loin might be of value as a predictor of carcass merit. A significant relationship ($P < .01$) was found between Scanogram average backfat estimate on the mounted warm carcasses and actual carcass backfat.

Data in Table XXVI indicate that a small portion of the variation associated with S.T. fat, loin eye area (10th and 13th ribs), and S.T. area was accounted for in Group 5 swine. A larger amount of the variation was accounted for in Scanogram estimates of average backfat and linear fat. The r^2 values (from live animals) ranged from 0.52 to 0.69.

The correlation coefficients were generally significant between measures of meatiness and Scanogram live and warm carcass estimates. Results indicated that linear fat and average backfat thickness could be estimated more accurately than loin eye area at either the 10th or 13th ribs. Results also indicated in both Group 5 (swine) and Group 4 (cattle), that semitendinosus fat cover was quite difficult to estimate and semitendinosus area was nearly impossible to estimate. The low, nonsignificant correlation coefficients between live estimates and carcass measurements of semitendinosus area can be partially explained. In order to accurately estimate the size of any given muscle ultrasonically, the juncture of lean and fat or bone must be determined. A juncture between lean and bone can be interpreted more readily than a juncture between lean and fat. This happens because bone is more dense than fat and can therefore reflect sound waves more readily, thus giving a more clear definition of the separation point between the bone and lean. The semitendinosus has no bone at its most interior point as does the longissimus dorsi (dorsal edge of the rib). Without a dense inter-medium such as bone, the estimation of muscle shape and size is particularly difficult.

The relatively low correlation coefficients between ultrasonic estimates and carcass measurements resulted from errors in scanogram interpretations and malfunctions of the Scanogram unit. During this research (Group 5) two tubes were replaced in the Scanogram, and near the end of the study, the unit failed completely and was replaced by the manufacturer for the second time. Scanograms produced were dull, cloudy, and lacked definition of fat, lean, and bone junctures. If the Scanogram had functioned properly throughout all studies, stronger relationships between estimates and actual values might have been obtained.

CHAPTER V

SUMMARY

One hundred fifty-eight cattle and one hundred twenty-six swine were evaluated ultrasonically with the Scanogram. The swine were also evaluated for backfat thickness with the Lean Meter. There were three groups of cattle and two groups of swine: Group 1 (28, 1000 pound Hereford steers), Group 2 (94, 800-1000 pound Angus steers and heifers), Group 3 (67, 200-220 pound Yorkshire, Hampshire, and Duroc gilts and barrows), Group 4 (36, 1000 pound Hereford-Angus crossbred steers), and Group 5 (59, 200-220 pound Yorkshire, Hampshire, and Duroc gilts and barrows).

The Scanogram was evaluated for its usefulness in estimating certain carcass measurements. Also, the association between certain live and carcass Scanogram estimates and carcass measures of leanness and fatness were studied. It was hoped that some easily obtainable Scanogram estimate on the live animal might be found which could be used as a tool for predicting carcass meatiness.

In the early cattle work, (Group 1) the data indicated that rib eye area could be estimated nearly as accurately as fat cover ($r = 0.85$ and $r = 0.89$ for Estimate 1 rib eye area and fat cover, respectively). In later work (Group 4) Scanogram rib eye area estimates were found to be more highly associated with actual carcass rib eye measurements than Scanogram estimates of fat ($r = 0.49$ and 0.27 for Estimate 1 rib eye area and fat cover, respectively). Correlation coefficients between Scanogram estimates and actual rib eye area measurements were significant ($P < .05$) in all cases. Scanogram estimates of linear fat were highly significant ($P < .01$). The correlation coefficients between actual linear fat and Estimate 1, Estimate 2, and the Mean Estimate were 0.58, 0.50, and 0.58, respectively. The linear fat estimates were more closely associated with estimated percent cutability than Scanogram estimates of rib eye area and average fat cover ($r = -0.42$, -0.39, and -0.43 for Estimate 1, Estimate 2, and the Estimate Mean compared to estimated percent cutability). Generally, associations between carcass measurements and Scanogram estimates of semitendinosus fat and semitendinosus area were nonsignificant. Scanogram estimates of fat cover and linear fat in cattle were more closely related to measures of meatiness in the beef carcass than any other live Scanogram estimate. Many correlation coefficients between Scanogram estimates and actual carcass measurements were found to be statistically significant, but many of these comparisons accounted for a small portion of the variation associated with the carcass measurements (Table XI).

Data from the swine work (Group 5) indicate that linear fat and average backfat thickness could be estimated rather accurately ($r = 0.78$ and 0.83 for Estimate 1 average backfat and linear fat, respectively). Results further indicate that in the live animal, rib eye area could be ultrasonically estimated somewhat more accurately at the 13th rib than at the 10th rib ($r = 0.45$ and 0.41 for Estimate 1 at the 13th and 10th ribs, respectively). In many cases, Scanogram estimates made on the mounted warm carcasses more nearly paralleled their corresponding actual carcass measurements than did Scanogram estimates on the live animal.

More variation associated with carcass measurements was accounted for in swine work (Table XXVI) than beef work (Table XI). Scanogram linear fat estimates on the live hogs accounted for 69 percent (Estimate 1) of the variation associated with the corresponding carcass measurement. Scanogram backfat estimates more closely agreed with actual carcass backfat measurements than did Lean Meter backfat probes. Scanogram linear fat and average backfat thickness estimates were more closely associated with measures of leanness (total pounds of lean and pounds of fat-free lean) than were Scanogram estimates of loin eye area at the 10th and 13th ribs (Table XIV). A highly significant ($P < .01$) relationship was found between the actual linear fat measurement made behind the 13th rib, directly over the midline and total pounds of fat-free lean in the carcass ($r = -0.63$). This measurement was estimated quite accurately ($r = 0.83$). These results indicate that a linear fat measurement over the loin might be of value as a predictor of carcass composition.

It would appear from this study that, provided the Scanogram functioned properly, it could be a useful tool for estimating certain carcass parameters. In any case, the Scanogram is useful only to the extent that the parameters it attempts to measure are related to carcass merit.

LITERATURE CITED

Alsmeyer, R. H., R. L. Hiner and J. W. Thornton. 1963. Results of ultrasonic research on beef cattle in the United States. Proc. Recip. Meat Conf. 16:240.

Anderson, L. M. and R. C. Wahlstrom. 1969. Ultrasonic prediction of swine carcass composition. J. Animal Sci. 28:593.

A.O.A.C. 1960. Official Methods of Analysis. Association of Official Agricultural Chemists. Washington, D. C.

Arganosa, V. G. and I. T. Omtvedt. 1969. Heritability estimates and phenotypic correlations for various measures of carcass meatiness in swine. Okla. Exp. Sta. Misc. Publ. No. 82.

Bowman, G. H., J. A. Whatley, Jr., and L. E. Walters. 1962. Physical indices of leanness in swine. J. Animal Sci. 21:955.

Campbell, Dudley, H. H. Stonaker and A. L. Esplin. 1959. The use of ultrasonics to estimate the size of the longissimus dorsi muscle in sheep. J. Animal Sci. 18:1483. (Abstr.).

Carpenter, J. W., A. Z. Palmer, M. Koger and H. C. Wallace. 1962. Indices of pork carcass meatiness. J. Animal Sci. 21:979. (Abstr.).

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

Davis, J. K. and R. A. Long. 1962. Ultrasonic and other methods of estimating muscling in beef cattle. J. Animal Sci. 21:970. (Abstr.).

Davis, J. K. 1963. Ultrasonic instruments for live animal evaluation. Proc. Recip. Meat Conf. 16:230.

Davis, J. K., R. A. Long, R. L. Saffle, E. P. Warren and J. L. Carmon. 1964. Use of ultrasonics and visual appraisal to estimate total muscling in beef cattle. J. Animal Sci. 23:638.

Davis, J. K., R. S. Temple and W. C. McCormick. 1966. A comparison of ultrasonic thickness estimates of rib-eye area and fat thickness in cattle. J. Animal Sci. 25:1087.

DePape, J. G. and J. A. Whatley, Jr. 1954. Live hog probes at various sites, weights and ages as indicators of carcass merit. J. Animal Sci. 13:957. (Abstr.).

Gillis, W. A. 1971. An evaluation of indices of carcass yield, physical composition and chemical composition in swine; and ultrasonic measurement of the *longissimus dorsi* area and fat thickness in beef and swine. Unpublished PhD. Dissertation, Cornell University, Ithaca, New York.

Hankins, O. G. and N. R. Ellis. 1934. Physical characteristics of hog carcasses as measures of fatness. J. Agr. Res. 48:257.

Hazel, L. N. and E. A. Kline. 1952. Mechanical measurement of fatness and carcass value in live hogs. J. Animal Sci. 11:313.

Hazel, L. N. and E. A. Kline. 1953. Accuracy of eight sites for probing live pigs to measure fatness and leanness. J. Animal Sci. 12:894.

Hazel, L. N. and E. A. Kline. 1959. Ultrasonic measurements of fatness in swine. J. Animal Sci. 18:815.

Hedrick, H. B., W. E. Meyer, M. A. Alexander, S. E. Zobrisky and H. D. Naumann. 1962. Estimation of rib-eye area and fat thickness in beef cattle with ultrasonics. J. Animal Sci. 21:362.

Hetzer, H. O., O. G. Hankins, J. K. King, and J. H. Zeller. 1950. Relationship between certain body measurements and carcass characteristics in swine. J. Animal Sci. 9:37.

Hetzer, H. O., J. H. Zeller and O. G. Hankins. 1956. Carcass yields as related to live hog probes at various weights and locations. J. Animal Sci. 15:257.

Holland, L. A. and L. N. Hazel. 1958. Relationship of live measurements and carcass characteristics of swine. J. Animal Sci. 17:825.

Howry, D. H. and W. R. Bliss. 1952. Ultrasonic visualization of soft tissue structures of body. J. Lab. Clin. Med. 40:579.

Isler, G. A. and L. A. Swiger. 1968. Ultrasonic prediction of lean cut percent in swine. J. Animal Sci. 27:377.

Johnson, C. L., J. C. Hillier, J. V. Whiteman and L. E. Walters. 1968. Predicting fat trim and lean cut yield of hogs using live ultrasonic estimates. J. Animal Sci. 27:1141. (Abstr.).

Kline, E. A. and L. N. Hazel. 1955. Loin area at tenth and last rib as related to leanness of pork carcasses. J. Animal Sci. 14:659.

McCampbell, H. C. and D. M. Baird. 1961. Carcass evaluation of swine slaughtered at 170, 190, 210, and 230 pounds. J. Animal Sci. 20:919. (Abstr.).

McMeekan, C. P. 1941. The use of sample joints and of carcass measurements as indices of the composition of the bacon pig. J. Agr. Sci. 31:1.

McReynolds, William E. and Vincent H. Arthaud. 1970a. Ultrasonic application for estimating fat thickness of beef cattle. J. Animal Sci. 30:186.

McReynolds, William E. and Vincent H. Arthaud. 1970b. Estimating fat depth and longissimus muscle area by use of ultrasonics in beef cattle. J. Animal Sci. 30:503.

Moody, W. G., S. E. Zobrisky, C. V. Ross and H. D. Naumann. 1965. Ultrasonic estimates of fat thickness and longissimus dorsi area in lambs. J. Animal Sci. 24:364.

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

Pearson, A. M., J. F. Price, J. A. Hoefer, L. J. Bratzler and W. T. Magee. 1957. A comparison of live probe and lean meter for predicting various carcass measurements of swine. J. Animal Sci. 16:481.

Pearson, A. M., L. J. Bratzler and W. T. Magee. 1958. Some simple cut indices for predicting carcass traits of swine. I. Cut-out and loin lean area. J. Animal Sci. 17:20.

Pearson, A. M., R. J. Deans and L. J. Bratzler. 1959. Some lumbar lean measures as related to swine carcass cut-outs and loin eye area. J. Animal Sci. 18:1087.

Price, J. F., H. B. Pfost, A. M. Pearson and C. W. Hall. 1958. Some observations of the use of ultrasonic measurements for determining fatness and leanness in live animals. J. Animal Sci. 17:1156. (Abstr.).

Price, J. F., A. M. Pearson and J. A. Emerson. 1960a. Measurement of the cross-sectional area of the loin eye muscle in live swine by ultrasonic reflections. J. Animal Sci. 19:786.

Price, J. F., A. M. Pearson, H. B. Pfost and R. J. Deans. 1960b. Application of ultrasonic reflection techniques in evaluating fatness and leanness in pigs. J. Animal Sci. 19:381.

Ramsey, C. B., J. N. Williams II, C. S. Hobbs, J. W. Cole and R. S. Temple. 1965. Ultrasonic estimates of the biceps femoris as predictors of carcass composition. J. Animal Sci. 24:291. (Abstr.).

Smith, C., R. M. Durham, A. W. Munson, E. L. Lasley and E. A. Kline. 1957. The defatted ham as an indicator of hog carcass value. J. Animal Sci. 16:1072. (Abstr.).

Steel, G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., Inc., New York.

Stouffer, J. R., M. V. Wallentine and G. H. Wellington. 1959. Ultrasonic measurement of fat thickness and loin eye area on live cattle and hogs. J. Animal Sci. 18:1483. (Abstr.).

Stouffer, J. R. 1959. Status of the application of ultrasonics in meat animal evaluation. Proc. Recip. Meat Conf. 12:161.

Stouffer, J. R., M. V. Wallentine, G. H. Wellington and A. Dickman. 1961. Development and application of ultrasonic methods for measuring fat thickness and rib-eye area in cattle and hogs. J. Animal Sci. 20:759.

Temple, R. S. 1956. Estimation of fat thickness in cattle. Master's thesis Colorado A & M College. Cited in Abstracts of Research Work with Ultrasonic Devices for Animal Evaluation compiled by R.S. Temple 4.

Temple, R. S., C. B. Ramsey and T. B. Patterson. 1965. Errors in ultrasonic evaluation of beef cattle. J. Animal Sci. 24:282. (Abstr.).

Urban, W. E. and L. N. Hazel. 1960. Ultrasonic measurement of fatness in swine during the growing-fattening periods. J. Animal Sci. 19:1228. (Abstr.).

Warner, K. F., N. R. Ellis and P. E. Howe. 1934. Cutting yields of hogs as an index of fatness. J. Agr. Res. 48:241.

Watkins, J. L., G. W. Sherritt and J. H. Ziegler. 1967. Predicting body tissue characteristics using ultrasonic techniques. J. Animal Sci. 26:470.

Whiteman, J. V. and J. A. Whatley, Jr. 1953. An evaluation of some swine carcass measurements. J. Animal Sci. 12:591.

Zobrisky, S. E., D. E. Brady, J. F. Lasley and L. A. Weaver. 1959. Significant relationships in pork carcass evaluation. I. Lean cuts as a criteria for live hog value. J. Animal Sci. 18:420.

Zobrisky, S. E., Wm. G. Moody, Wm. Day and H. D. Naumann. 1960. The estimation of loin eye area by high frequency sound. J. Animal Sci. 19:1244.

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