THE RELATIONSHIP OF CERTAIN LIVE HOG SCORES AND MEASUREMENTS TO TRAITS ASSOCIATED WITH CARCASS MERIT

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J. O. G., Jr.

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INTRODUCTION

The lower demand for lard and fat cuts of pork in recent years has emphasized the need for increased production of hogs yielding a high proportion of lean cuts. Improvement in the meatiness of market hogs would result in a better competitive position for pork in comparison with other meats. Furthermore, the production of meat-type hogs would result in decreased quantities of fat, thus, reducing the supply of lard. These factors would tend to improve the prices paid for slaughter hogs in general and could give considerable benefit to the producer.

Many meat packers have recently adopted the new trimming standards for wholesale pork cuts as proposed by the provisions committee of the American Meat Institute. These standards require a closer trim than has previously been used and result in still further surplus of lard. Consequently, packer buyers are likely to discriminate still more against extremely fat hogs.

Although investigations have shown that feeding and management practices may influence carcass fatness, the lean cut yield from the live hog has not been increased to any great extent. These studies have indicated that any advantage gained from the production of leaner carcasses was offset by decreased dressing percentage and reduced rate of gain; consequently, the net return was not increased under such management.

Comparisons of breeding lines have shown considerable hereditary differences in their ability to produce lean, well-muscled carcasses. Any permanent improvement in pork carcasses must necessarily be made by changing the genotype of the animals through selection of individuals with more desirable phenotypes.

Carcass evaluation necessitates slaughtering the animal; therefore, progeny or sib testing of potential breeding stock is the most widely used method of evaluating an individual's genotype in swine carcass improvement programs. Considerable attention has been given various scoring systems and live animal measurements in efforts to obtain useful estimates of individual merit. However, only recently have attempts been made to relate body measurements and scores directly to carcass characteristics which are highly associated with carcass value.

The development of acceptable methods to accurately appraise live hogs in relation to their carcass and cutout values is of fundamental importance to the entire swine industry. This ever increasingly important problem serves as the basis of this study.

REVIEW OF LITERATURE

Collaborators of the Regional Swine Breeding Laboratory initiated the first extensive study of the accuracy of scoring techniques used in swine selection. The scoring system these workers used was based on the following characteristics: 1) vigor, health and thriftiness; 2) quality; 3) length of body; 4) details of conformation; 5) animal as a whole; and 6) absence of defects. Evaluation of the system was based largely on repeatabilities and agreement between judges as to the differences existing between pigs.

a. Accuracy of Scores

Lush and Craft (1937, 1938) found significant differences between scores given different pigs and also the scoring levels of four judges. Correlations obtained between the scores given the same pig by different judges (+.45 to +.62) were evidence that the scoring, to some extent at least, did record values on which the four judges agreed. These workers observed that there was drifting of scoring levels of individuals from day to day and from group to group. Error in the scores was markedly diminished by averaging the scores given by the four judges.

Lush (1938) studied the repeatability of scores made by the same man. Thirty pigs were scored twice by the same man with a three day interval between the first and second scoring. This worker found a correlation of +.85 between the scores given the same pig on different occasions. Observed changes from day to day in the general scoring level and in the scoring levels for the different points were very small.

In comparing scoring systems, Hetzer and Phillips (1939) found no important differences between two plans. One plan was based on descriptive terms and the other on a series of sketches. Correlations between scores given the same pig by different judges and correlations between average scores given the same pig on different occasions were obtained. The systems were appraised by comparisons of these correlation coefficients.

b. Accuracy of Measurements

Studies by Phillips and Dawson (1936) revealed the relative accuracy of three methods of obtaining body measurements on swine. These workers found direct measurements taken with a caliper and tape measure were more accurate and were obtained in less time than either those secured by a scaling instrument (Kelley, 1933) or by measuring animal photographs.

Whatley (1941) found wide differences in body measurements of the same pig by different men. Some of this variation was thought to be due to differences in the techniques employed. Correlations between measurements by the same man for various characteristics ranged from +.74 for body-depth to +.07 for body-length. Hetzer et al. (1950) calculated the repeatability of single measurements on the same hog to determine the relative accuracy of various measurements. These workers found estimates of repeatability for single measurements that ranged from +.56 to +.77 and from +.83 to +.93 for the averages of four measurements. The increase in accuracy resulting from several measurements appear to be large enough in all cases to justify obtaining more than one measurement where such practice is feasible.

c. Relationship Between Live Animal Scores and Measurements with Carcass Characteristics

Winters (1939) determined average live animal scores and measurements of hogs within the same carcass grade. These data were from 52 hogs in two breeding groups. Average scores and measurements of the hogs that yielded No. 1 carcasses were not very different from those in hogs yielding No. 2 carcasses within breeding group. Within breed, the hogs yielding No. 2 carcasses were scored lower for shape of ham and market grade than those yielding No. 1 carcasses. No differences were found between carcass grades in the following average live animal measurements: length of body, width of body, depth of body and length of foreleg.

Ferrin (1939) reported a negative correlation between live animal length measurements and carcass backfat.

Phillips et al. (1939) made a comparison of live animal scores with specific carcass characteristics. Yield of trimmed loin was correlated with length of body score, +.50, and width of body score, -.58. Yield of ham was associated with width of body score, -.49, and length of leg score, +.40. Average backfat (5 measurements) was correlated with the scores on width of body, +.64, and shape of back, +.50. Length of body as scored was correlated with length of carcass, +.61, indicating that the scoring committee was quite successful in detecting differences in body length.

Bogart et al. (1940) reported significant correlations between carcass scores as determined by visual inspection of eight carcass items and the scores for certain items in the live animals. However, live-hog score for grade was found to be the only item of practical value for estimating carcass score.

Willman and Krider (1943) reported a correlation of +.42 between thickness of carcass backfat and condition (fatness) as determined by visual observation of the live hogs.

Hazel and Kline (1952) introduced a "probing technique" of measuring backfat thickness on live hogs. These workers found a correlation of +.81 between an average of four carcass backfat measurements and an average of four live animal probes obtained by their technique.

Bratzler and Margerum (1953) reported the accuracy to which these judges scored 434 hogs. These hogs were market run (Detroit) representing various breeding groups and weight classifications. Two hundred and sixty-five medium weight hogs (201-220 lbs.) made up the majority scored. Within this group the correlations between live animal scores and carcass measurements for the three judges were as follows: body length score with carcass length, $r_a = +.39$, $r_b = +.42$ and $r_c = +.29$; and backfat score with carcass backfat (one measurement at the 7th rib), $r_a = +.42$, $r_b = +.42$ and $r_c = +.50$. Henning and Evans (1953) reported that four graders were fairly consistent in their estimates of average backfat thickness, hind leg length and body length in live grading 773 market run hogs.

d. Measures of Carcass Value

Before accurate evaluation of scores and measurements as indices of carcass value is possible, there must be established reliable criterion of carcass value. In view of present consumer demand for leanness of pork, it seems fitting to use the "lean to fat ratio of the carcass" as the primary basis for establishing carcass value.

The percentage of primal cuts (hams, loins, bellies and shoulders) and lean cuts (all of the former except bellies) have been the most commonly used criteria of carcass value. The accuracy of these measures in estimating lean to fat ratio can be evaluated only by physical separation of the lean and fat tissues or by chemical analysis. Few such studies are reported in the literature.

Aunan and Winters (1949) found a correlation of +.60 between the percentage lean of the carcass and the percentage of primal cuts. Using chemical analysis, Brown et al. (1951) reported the correlations of both primal cuts and lean cuts with percentage ether extract to be -.67. These workers found percentage lean cuts more highly correlated to percentage protein (+.66), than was percentage primal cuts (+.59). Percentage lean cuts was also correlated to specific gravity, +.78, with a higher degree of association than was percentage primal cuts, +.69.

Working with a group of carcasses, highly variable in weights, Warner et al. (1934) reported a correlation of +.91 between percentage fat cuts (cutting fat and belly) and ether extract. Brown et al. (1951) obtained a correlation of +.78 between percentage fat cuts and ether extract.

These data indicate definite correlations between the percentage of primal, lean and fat cuts to the lean and fat components of pork carcasses. Because the belly cut is subject to more cutting error than the other cuts, it appears that percentage lean cuts may be a more reliable measure of carcass value than the other measures used. Experimental evidence also shows that the percentage lean cuts is more closely associated to carcass leanness than percentage primal cuts.

e. Usefulness of Scores and Measurements in Predicting Carcass Value.

Hetzer _et al_. (1950) compared several body measurements to the yield of primal cuts. Relationship of the average of four measurements with primal cuts and their degree of association were as follows for barrows and gilts, respectively: length (ear to tail), +.20 and +.35; height at shoulders, +.41 and +.50; width at shoulders, -.23 and -.23; width of middle, -.40 and -.47; width at hams, -.08 and -.22; depth of middle, -.43 and -.49; and circumference of chest, +.16 and +.34.

Hazel and Kline (1952) reported a correlation of -.50 between average probe backfat and percentage primal cuts as compared to a correlation of -.45 between average carcass backfat and the same measure of carcass value. In later studies, Hazel and Kline (1953) found the locations behind the shoulder, over the loin and the top of the ham the most accurate of eight sites studied if used to measure fatness and leanness. Zobrisky _et al_. (1953) found significant negative correlations between lean cuts and the live hog backfat probes, and significant positive correlations between probes and total fat of the carcass. Studying the accuracy of live hog probes, DePape and Whatley (1954) reported a correlation of -.67 between percentage primal cuts and the average of six live hog backfat probes.

Heidenreich et al. (1955) reported the relationship of several live animal measurements with percentage primal cuts. Multiple correlations of six body measurements with the per cent of primal cuts for two groups of crossbred hogs were +.50 and +.56. Each of three backfat probe measurements contributed more in explaining the variance in percentage primal cuts than did body length, heart girth or flank circumference measurements.

Studying the accuracy of backfat probes at three sites, Hetzer et al. (1956) found a single measurement in the center of the back more highly correlated with percentage primal cuts than was one made just behind the shoulder or in the middle of the loin. The average of the three probes taken, although not as accurate as the single measurement in the center of the back, was correlated with the percentage primal cuts from -.22 to -.28 for different weight groups. These workers also found all probe backfat measurements significantly correlated with percentage fat cuts (backfat, leaf fat, plates and cutting fat).

Henning and Evans (1953) reported the accuracy to which four men estimated percentage lean cuts. These graders estimated the per cent of four lean cuts in about 65 per cent of the hogs within plus or minus 3 per cent of the actual percentage yield, about 40 per cent within plus or minus 2 per cent and about 25 per cent within plus or minus 1 per cent.

f. Relationship of Certain Carcass Measurements with Measures of Carcass Value

The thickness of backfat is generally regarded as a dependable, practical indication of the fatness of a hog carcass. Usually an average of several measurements (3 to 5 on one or both sides) made along the median line of the split carcass is used as a measure of backfat thickness.

Aunan and Winters (1949) found that the average of three backfat measurements (thickest, thinnest and opposite the seventh rib) was negatively correlated with percentage of five primal cuts, -.58. In other studies, Brown et al. (1951) Cummings and Winters (1951) and Hazel and Kline (1952) reported similar results.

From two groups of hogs studied, Brown et al. (1951) found average backfat thickness negatively correlated with percentage lean cuts, -.72 and -.70. Average backfat thickness was positively correlated with percentage fat cuts, +.69 and +.74. Whiteman et al. (1953) found average backfat negatively correlated with percentage lean cuts, -.78 and -.59, in two groups of carcasses studied.

Brown et al. (1951) introduced the use of specific gravity as a measure of "lean to fat ratio" in pork carcasses. These workers found specific gravity of the carcass correlated with percentage primal cuts, +.68 and +.69; percentage lean cuts, +.84 and +.78; and percentage fat cuts -,78 and -.81, in two groups of carcasses in their study.

Whiteman et al. (1953) reported similar results with specific gravity of the carcass and explored the possibility of using specific gravity of the ham as a measure of carcass specific gravity. The correlation between specific gravities of the ham and the half carcass was +.95.

Another measure of carcass leanness that is in general use is loin lean area. It is a measure in square inches of the cross-section of the loin eye muscle (longissimus dorsi).

From two groups of carcasses, Brown et al. (1951) found correlations between loin lean area and percentage primal cuts, +.41 and +.20; percentage lean cuts, +.51 and +.78; and percentage fat cuts, -.47 and -.80. In a study of swine carcass measurements, Whiteman and Whatley (1953) found similar correlations between loin lean area and percentage lean cuts.

Although length has been emphasized in show ring and breeding selection, little evidence is available to illustrate its true relationship with carcass value.

Aunan and Winters (1949) found length of carcass correlated with the per cent lean in the carcass, +.12. When weight was held constant the correlation between length of carcass and total lean in the carcass was +.33. Brown et al. (1951) found length of carcass correlated to percentage primal cuts, +.51; percentage lean cuts, +.54; and percentage fat cuts, -.61.

EXPERIMENTAL OBJECTIVES

The purposes of this study were as follows:

I. To study the relationship of certain swine carcass traits to scores and measurements of similar traits in the live hog.

II. To study the usefulness of live animal scores and measurements for predicting carcass merit.

III. To observe differences in the usefulness of live animal scores by judges with different amounts of experience.

MATERIALS AND METHODS

a. Source of Data

The 80 hogs used in this study were obtained from the Swine Breeding Project of the Oklahoma Agricultural Experiment Station in cooperation with the Regional Swine Breeding Laboratory. These hogs were highly homogeneous in respect to their breeding, all being from the reciprocal crosses of the Duroc OK8 and Beltsville No. 1 OK9 lines that are being maintained at the Oklahoma station.

All hogs used in the study were from test pens of the 1954 fall and 1955 spring farrowing seasons. These test pens included four pigs from a litter, which were self fed a standard ration from weaning until they reached market weight. Two pigs of each sex from each litter were selected to make up a test pen when possible. The two barrows were slaughtered from each litter except in a very few instances when two barrows were not available. The data for this study were obtained at the time the hogs reached slaughter weight (185-210 lbs. shrunk live weight).

b. Scoring Procedure

When animals reached the desired weight range, they were scored independently by three judges for length, backfat thickness, meatiness and dressing per cent. The score card used is described in Table I.

TABLE I

Score Card Used in Scoring Live Animals

Characteristic	Live animal scores									
	0	1	2	3	4	5	6	7	8	9
Body length (To .5 of an inch)	26.5	27.0	27.5	28.0	28.5	29.0	29.5	30.0	30.5	31.0
Backfat thickness (To .1 of an inch)	2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3
Dressing per cent (To a whole per cent)	68	69	70	71	72	73	74	75	76	77
Meatiness (Relative estimate)	Poor →				→ Average →				→ Superior	

The hogs were scored at some time convenient to the judges during the 24 hour shrink period previous to slaughter. Although the judges worked separately and at different times, each was aware of the period of time hogs had been off feed at the time of scoring.

The scoring was done by recording the value assigned to the specific measurements thought most closely associated with the hog in question by the individual judge. The scores for length, backfat thickness and meatiness were totaled to give each hog a total score for each judge. Average scores for the various items were obtained for each hog by averaging scores given by the three judges.

c. Length and Backfat Measurements

Live animal body length and probe backfat measurements were made on these hogs at the time they were weighed off feed previous to slaughter.

Length measurements were obtained with a caliper constructed from straight wooden bars with one fixed and one sliding straight side arm. The length measurements were taken by the same person in triplicate and averaged in order to reduce the measurement variations caused by changes in the position of the animal.

Probe backfat measurements were taken behind the shoulder and at the middle of the loin about one and one-half inches off the center of the mid-line on both sides. These four measurements were averaged to give a live animal measurement of backfat thickness.

Different probing techniques were used in different seasons. The 50 hogs slaughtered during the winter of 1954-55 (fall farrowing) were probed by the technique described by Hazel and Kline (1952). Briefly, small incisions were made with a scalpel through the skin at the selected sites and a narrow metal ruler was pressed through the layer of fat to the firm tissue underneath. The ruler was withdrawn and the measurements from the scaled instrument were recorded to the nearest one-tenth of an inch.

The 30 hogs slaughtered during the summer of 1955 were probed with an instrument, known as a "lean-meter", developed at Purdue University. The lean-meter is a pistol-like apparatus equipped with a sliding probe (needle) which may be pressed through the skin into fat and muscle tissues. The instrument measures electrical conductivity of tissue in contact with the tip of the probe. An indicator dial shows whether the probe is in fat of muscle tissue. This is possible since there is a difference in the conductivity of fat (low conductivity) and lean (high conductivity) tissues. A scale (marked in tenths of an inch) on the lean-meter indicates the fat thickness of the distance from the outer skin to the lean tissue.

d. Slaughtering and Dressing Hogs

After animals had been scored and measured as described above, they were slaughtered in the college meat laboratory. Shrunk live weights were obtained just previous to slaughter for use in yield calculations.

The carcasses were dressed packer style with head off and leaf fat removed. The weight of the leaf fat was obtained for each hog. Carcasses were placed in a cooler where they remained until thoroughly chilled.

e. Carcass Measurements

The following measurements were taken on each carcass, while the carcass hung on the rail:

carcass length - average of measurements taken on both sides, from the anterior edge of the first rib to the aitch bone.

backfat thickness - average of the measurements taken on both sides of the split carcass at the first rib, seventh rib, last rib and sixth lumbar vertebra, including skin.

The entire carcass (both sides) was processed in the following manner: Both sides were weighed and totaled to obtain a cold carcass weight. The carcass was then separated into wholesale cuts - hams, shoulders, sides and loins. The ham was removed from the side by sawing at right angle to the hind leg and mid-way between the aitch bone and the curvature of the lumbar vertebrae. The ham was cut off and rounded so as to leave maximum flank on the belly. The tail bone was removed and the hind foot removed by sawing through the hock joint. At this point the untrimmed hams were air weighed and water weighed in a fashion similar to that described by Brown et al (1951) for the whole carcass. The hams were skinned about two thirds of the way to the shank, and the fat beveled down to a very close trim.

The shoulder was removed at the third rib with a cut perpendicular to the backbone. The jowl was removed at the anterior point of the neck bone with a cut made parallel to the cut that removed the shoulder. The neck bones were removed and the front foot was cut off just above the knee joint. The shoulders were skinned and trimmed very similar to the hams.

The loin was separated from the belly by cutting along a line from the point of the shoulder blade at the shoulder end, to the edge of the loin muscle at the ham end. The loins were very closely trimmed. One loin from each carcass was separated at the last rib and a cross-sectional tracing was made of the longissimus dorsi muscle.

The spare-ribs were removed from the side, taking as little lean as possible from the belly. The lower edge of the belly was trimmed to about the teat line, and the loin edge straightened to be parallel with the bottom line. The flank end was cut off enough to allow the belly to fit into a curing tank.

The trimmed hams, shoulders, loins and bellies were weighed separately to one-tenth of a pound. The fat trimmings and skin from all cuts were weighed together and the lean trimmings were weighed and recorded.

From carcasses processed as described above, the following measurements were determined:

ham specific gravity - obtained by dividing the air weight of the untrimmed ham by the air weight minus the water weight.

loin lean area - the average of three planimeter readings of a tracing of the longissimus dorsi muscle.

percentage lean cuts - the totaled weights of the two hams, shoulders and loins divided by the cold carcass weight.

dressing per cent - obtained by dividing the cold carcass weight by the shrunk live weight.

f. Statistical Analysis

The statistical analysis of the data in this study consisted of computing simple and multiple correlations as described by Snedecor (1953). The data were analyzed within season because of differences in techniques used in securing probe backfat measurements. Significant differences between simple correlations were tested by the z-transformation of r's and the t-test.

RESULTS AND DISCUSSION

In the present study hogs were scored by three men for length of body, backfat thickness, meatiness and dressing percentage. Body length and probe backfat measurements were also made on these animals. The hogs were slaughtered and certain carcass characteristics were determined.

The following discussion is presented in three sections. The first section deals with the relationship of certain carcass traits to scores and measurements of similar traits on the live hog. The degrees of association between carcass traits and live animal scores and measurements were obtained by computing simple correlation coefficients as described by Snedecor (1953). Using the same method of analysis, the relationship of these individual live animal scores and measurements to carcass merit were obtained. Percentage lean cuts was used as a measure of carcass merit in this study. These relationships are discussed in Section II. The multiple correlation technique described by Snedecor (1953) was used to determine the relationship between combinations of live animal factors and carcass merit. Section III includes a discussion of these relationships and a discussion of the differences observed between judges' scores for predicting carcass merit as measured by percentage lean cuts.

I. Relationships of Certain Carcass Traits with Scores and Measurements of Similar Traits on the Live Hog

The first part of this discussion deals with the relationship of certain carcass traits to scores and measurements of similar traits on the live hog. Simple correlation coefficients were obtained between carcass characteristics and live animal scores and measurements.

a. Carcass Length

The relationships of live animal scores and measurements of body length to carcass length were investigated. Correlations between scores of body length and actual carcass length are presented in Table II. All correlations between length score and carcass length were positive and significant ($P < .01$). This indicates that judges could detect differences in body length of live hogs that were highly associated with actual carcass length. This observation is in agreement with those of Phillips et al. (1939) and Bratzler and Margerum (1953). None of the correlations in Table II were significantly different from each other. However, season to season differences between correlations of carcass length with scores by the same judge were more variable than between correlations with average scores of the three judges. This indicates that the average score of the committee was probably more reliable than any individual's score for predicting carcass length.

TABLE II

Simple Correlations Between Judges' Scores of Body Length and Actual Carcass Length.

	Judge A	Judge B	Judge C	Judges' Ave.
F1954 (50 hogs)	.69**	.76**	.72**	.85**
S1955 (30 hogs)	.48**	.62**	.82**	.76**

F - fall farrowing season
S - spring farrowing season
** P< .01

TABLE III

Simple Correlations Between Live Animal Measurements and Carcass Measurements.

	F1954	S1955
Live animal length and carcass length --	.87**	.69**
Probe backfat and carcass backfat --	.59**	.39*

* P< .05
** P< .01

Although correlations in both seasons between live animal length measurements and carcass length (TableIII) were highly significant, there was a significant difference (P< .05) between seasons. The predictability of carcass length from live animal length measurements was 76 per cent (square of the correlation coefficient) the first season but only 48 per cent the second season. Because correlations between live animal length measuremements and carcass length were more variable between seasons than were correlations between length scores and carcass length, it appeared that length score was a more reliable means of predicting carcass length than was live animal body length measurement.

Live animal length measurements were made from the poll (anterior point of the base of the ears) to the base of the tail. This measurement includes the neck of the hog which was not included in length of carcass measurements (first rib to the aitch bone). It seems almost certain, that differences exist between hogs in respect to length of neck and height of tail setting, which have an influence on live animal length measurements as made in this study. It is possible that these same factors may influence judges' scores, causing error in their appraisal of body length. To determine if length scores were more closely associated with live animal length measurements than actual carcass length, simple correlations between those items were computed. No significant differences were found between the correlations of length score with live animal length measurement and those of length score with actual carcass length. The correlations between average length score and carcass length (+.85 and +.76) were even higher than correlations between length score and live animal length measurements (+.78 and +.67) for the two groups of hogs studied. The same relationship was true for two of the three individual judges. It is possible that no significant differences in length of neck and height of tail setting existed in the uniform group of hogs in this study. However, if these differences did exist, the data indicates that either the judges were not confused by their presence or else the longer neck and/or lower tail setting were correlated with longer carcasses.

b. Backfat Thickness

The relationships of carcass backfat with live animal scores and probe measurements of backfat were investigated. Correlations between backfat scores of the live hog and actual carcass backfat are presented in Table IV. These correlations compare favorably with a correlation of +.42 reported by Willman and Krider (1943) and correlations of +.42, +.42 and +.50 reported by Bratzler and Margerum (1953) between backfat score and carcass backfat. The squared correlation coefficients indicated that judges were not as successful in predicting carcass backfat as they were in predicting carcass length from live animal scores. Although no significant differences were found between judges or seasons, there were considerable differences in the correlations between backfat score and carcass backfat by different men and between correlations of these same items in different seasons by the same man. The correlations between the judges' average backfat score and carcass backfat were more nearly the same for both seasons, indicating that average score was probably a more reliable means of predicting carcass backfat than any individual's score.

Since different techniques were used in securing probe backfat measurements in different seasons, the relationship of carcass backfat with these measurements is discussed within seasons.

TABLE IV

Simple Correlations Between Judges' Scores of Backfat and Actual Carcass Backfat.

	Judge A	Judge B	Judge C	Judges' Ave.
F1954 (50 hogs)	-.58**	-.29*	-.58**	-.56**
S1955 (30 hogs)	-.29	-.44*	-.46**	-.48**

* $P < .05$
** $P < .01$

In the first season the correlation between probe backfat and carcass backfat was +.59 (Table III) and significant ($P < .01$). This correlation coefficient is not significantly different from any of the correlations between backfat scores and carcass backfat (Table IV) for the F1954 season. However, the square of the correlation coefficients indicated that probe backfat had the highest predictive estimate of carcass backfat (35 per cent) available from live hogs in this season.

During the second season probe backfat measurements were made with the lean-meter, which has already been described. It was discovered at the end of the period, that defective probes (needles) had been used to secure live animal measurements. The correlation between these probe measurements and carcass backfat was computed and found significant (+.39, $P < .05$), however, the predictability of carcass backfat from these probes was low (15 per cent) as determined by squaring the correlation coefficient. It was felt that these data were not representative of those which should have been secured with proper equipment and that comparisons should not be made between the results obtained under these circumstances and those obtained the first season.

c. Carcass Meatiness

Meatiness, as scored in this study, was intended to be a direct estimate of the lean content of the carcass, both in respect to the ratio of lean to fat and in terms of total lean tissue present. The relationship of meatiness score (also other scores and measurements) with carcass merit is considered in the next section of the discussion. The following discussion considers the relationships of meatiness score to carcass characteristics which are indicative of "lean to fat ratio" and "total muscling" of the carcass.

The degrees of association between meatiness score and ham specific gravity (measure of lean to fat ratio) for the different judges and seasons are shown in Table V. The correlation between Judge A's meatiness scores and ham specific gravity was the highest association found between these factors for the F1954 season. The correlation between the same judge's meatiness score and ham specific gravity was the lowest found in the S1955 season. As for length and backfat scores, it appeared that the average meatiness score of the three judges was a more reliable estimate of ham specific gravity than was any individual judge's score.

Simple correlations between judges' scores of meatiness and loin lean area (measure of total muscling) are shown in Table VI. Essentially the same relationships were found as between meatiness scores and ham specific gravity, Table V.

TABLE V

Simple Correlations Between Judges' Scores of Meatiness and Ham Specific Gravity

	Judge A	Judge B	Judge C	Judges' Ave.
F1954 (50 hogs)	.46**	.08	.34*	.39**
S1955 (30 hogs)	.24	.26	.36*	.41*

* P < .05
** P < .01

TABLE VI

Simple Correlations Between Judges' Scores of Meatiness and Loin Lean Area.

	Judge A	Judge B	Judge C	Judges' Ave.
F1954 (50 hogs)	.40**	.19	.24	.39**
S1955 (30 hogs)	.25	.22	.35	.38*

* P < .05
** P < .01

Although Judge A's scores were correlated with loin lean area to a higher degree than any other scores in the F1954 season, comparisons of correlations between seasons indicated that average score was the most reliable estimate of muscling.

d. Dressing Per Cent

Dressing per cent is one of the factors commonly considered in the buying and selling of slaughter hogs. The three men, who appraised the live hogs in this study, scored the hogs for dressing per cent prior to slaughter. The correlations between dressing per cent scores and actual dressing per cent are presented in Table VII. Study of these data indicated that dressing percentage could not be predicted by these judges to a satisfactory degree. It seemed certain that a dependable estimate of carcass value could not be made from estimates of dressing per cent unless considerable improvement could be made in the accuracy to which dressing per cent was scored. For this reason dressing per cent scores were not considered any further in the analysis of the data in this study.

TABLE VII

Simple Correlations Between Judges' Scores of Dressing Per Cent and Actual Dressing Percentage.

	Judge A	Judge B	Judge C	Judges' Ave.
F1954 (50 hogs)	-.36**	.28*	.12	.22
S1955 (30 hogs)	.19	.07	-.13	.06

* $P < .05$
** $P < .01$

II. Relationships of Individual Live Animal Scores and Measurements to Carcass Merit in Swine

The relationship of certain live animal scores and measurements to the corresponding carcass characteristics have been discussed. The following discussion deals with the relationship of carcass merit to these same scores and measurements of the live hogs. Percentage lean cuts of the cold carcass (hams, loins and shoulders) was used as a measure of carcass merit or carcass value in this study. Correlations of percentage lean cuts with live animal scores and measurements and carcass measurements were determined. Comparisons between correlations revealed the relative usefulness of the scores and measurements for predicting carcass value.

a. Length Score and Measurement

Study of the correlations of percentage lean cuts with live animal length scores (Table VIII) and measurements (Table IX) revealed that no appraisal of length was highly-associated with carcass value. Carcass length was significantly correlated with percentage lean cuts (Table X) the second season only and then the predictability of carcass value was only 14 per cent. Although differences in body length were detectable by live animal scores and measurements, the squared correlation coefficients indicated they were of little value in predicting carcass value as measured by percentage lean cuts.

TABLE VIII

Simple Correlations Between Judges' Scores of Various Body Characteristics and Percentage Lean Cuts of the Cold Carcass.

		Judge A	Judge B	Judge C	Judges' Ave.
% lean cuts with scores of:					
length-	F1954	.08	.02	.22	.12
	S1955	.32	.15	.23	.28
backfat-	F1954	.37*	.12	.30*	.31*
	S1955	.38*	.53**	.30	.52**
meatiness-	F1954	.45**	-.02	.27	.32*
	S1955	.54**	.35	.44*	.60**

* P<.05
** P<.01

TABLE IX

Simple Correlations Between Percentage Lean Cuts and Live Animal Measurements.

	F1954	S1955
% lean cuts with measurements of:		
length	.07	.15
probe backfat	-.57**	-.32

** P< .01

TABLE X

Simple Correlations Between Percentage Lean Cuts and Various Carcass Characteristics.

	F1954	S1955
% lean cuts with the following characteristics:		
carcass length	-.02	.38*
ham specific gravity	.50**	.66**
loin lean area	.47**	.56**
carcass backfat	-.42**	-.78**

* P< .05
** P< .01

b. Backfat Score and Probe

Although judges were not as successful in predicting carcass backfat as carcass length, backfat score was more closely associated with carcass value than was length score. This could be expected since the correlations between actual carcass length and percentage lean cuts (-.02 and +.38) were much lower than those between actual carcass backfat and percentage lean cuts (-.42 and -.78) for the two groups of carcasses in this study.

Probe backfat was more highly correlated with percentage lean cuts (Table IX) than was backfat score (Table VIII) for the F1954 season. As already mentioned, the data from probe backfat measurements for the S1955 season are not comparable since mechanical defects were found in the lean-meter. Probe backfat was more highly correlated with percentage lean cuts (-.57) than was actual carcass backfat (-.42). This is in agreement with Hazel and Kline (1952) who reported a correlation of -.50 between probe backfat and percentage primal cuts as compared to -.45 between carcass backfat and the same measure of carcass value.

c. Meatiness Score

In the foregoing section, it was observed that Judge A's meatiness scores (F1954) were more highly associated with ham specific gravity and loin lean area than were the other judges' scores. Correlations between meatiness scores and percentage lean cuts (Table VIII) indicate that differences also existed between judges in the usefulness of their meatiness scores for predicting carcass value.

Meatiness scores were more highly correlated with percentage lean cuts the second season than they were the first, which may indicate that through practice the ability to satisfactorily estimate carcass value from live hogs can be developed.

Correlations between Judge A's live animal meatiness scores and percentage lean cuts for the two seasons (+.45 and +.54) compare favorably with correlations between ham specific gravity and percentage lean cuts (+.50 and +.66) and correlations between loin lean area and the same measure of carcass value (+.47 and +.56). This indicates that an experienced judge may predict carcass value by visual appraisal of the live hog very nearly as accurately as carcass value can be determined from ham specific gravity or loin lean area obtained from the carcass.

III. Relationships of Combinations of Live Animal Scores and/or Measurements with Carcass Merit in Swine

In the preceding sections, relationships of individual live animal scores and measurements with certain carcass traits and with carcass merit were considered. The present section deals with combinations of live animal scores, live animal measurements and live animal scores and measurements as they are related to carcass merit in swine.

a. Live Animal Scores

Total score was the first combination of live animal factors given consideration. Scores for length, backfat and meatiness were totaled for each hog for each judge to give a total score. The square of the correlation coefficients between total score and percentage lean cuts revealed the relative effectiveness of predicting carcass merit from total score. The correlations are shown in Table XI.

TABLE XI

Simple Correlations Between Judges' Total Scores of Length, Backfat and Meatiness with Percentage Lean Cuts.

	Judge A	Judge B	Judge C	Judges' Ave.
F1954 (50 hogs)	.41**	.05	.32*	.28*
S1955 (30 hogs)	.53**	.41*	.37*	.52**

* P< .05
** P< .01

Considerable differences existed between judges' predictability of carcass merit from total score. Heretofore, in the discussion of this study, differences between judges have been mentioned with no attempt to explain these differences. The men who visually scored the hogs in this study had varying amounts of experience in making such appraisals.

Judge A, having judged many of the major swine shows throughout the United States, has considerable experience in judging hogs for their apparent carcass merit. Judge B, a swine breeder, has considerable experience in swine selection but not as much practice in judging large classes of slaughter hogs as Judge A. Judge C had little experience in judging swine previous to the initiation of this study.

Differences in the correlations between live animal scores and percentage lean cuts existed between judges (Tables XI and XII). The square of these correlation coefficients revealed a superiority in the predictability of carcass value from Judge A's scores, especially in the F1954 season. It is suggested, that this superiority in the usefulness of Judge A's scores for predicting carcass value was attributable to his greater experience and practice in appraising hogs for their apparent carcass merit.

Further study of the same data indicated no definite trend in superiority of either Judge B or C in respect to each other. It was pointed out that Judge B had considerably more experience in swine selection than Judge C. However, the lack of sufficient practice in appraising hogs specifically for carcass merit by both men was reflected in the correlations between their scores and percentage lean cuts. Further evidence which supports this belief is the increased usefulness of scores by Judges B and C for predicting carcass value the second season as compared to the first. It is suggested that practice in appraising hogs for characteristics indicative of carcass merit may result in scores which are useful in predicting carcass value.

The next question given consideration was whether or not total score was more predictive of carcass value than were scores for individual characteristics. Comparisons of correlations in Tables VIII and XI indicated that total score was more highly associated with carcass value than was either length or backfat score alone. However, scores for meatiness appeared to be as highly associated with carcass value as was total score. This means that when a judge had estimated the desirability of the carcass by giving the animal a meatiness score, he could not improve the estimate simply by adding values which he felt were indicative of backfat thickness or carcass length.

It has been pointed out that some live animal factors were more predictive of carcass value than were others. In using total score as an index of carcass value, each independent variable was given equal influence. It seems reasonable that those factors which were most predictive of carcass value independently should receive more emphasis when considered in a combination. To give variables this weighted influence, the multiple correlation technique described by Snedecor (1953) was employed in the statistical analysis.

Multiple correlations between percentage lean cuts and the three live animal scores included in total score are shown in Table XII.

The multiple correlations for Judge A's scores with percentage lean cuts were +.50 and +.57 as compared to his simple correlations of +.41 and +.53 between total score and percentage lean cuts for the two seasons. Comparison of these correlations show that the multiple correlation technique increased the degree of relationship and therefore, increased the predictability of carcass value.

The correlations in Table XII indicate little evidence which dictates the relative importance of the individual scores. It appears that meatiness score plus either of the scores for length or backfat was as predictive of carcass merit as when the third score was included. Only the average scores for the F1954 season do not support this viewpoint.

The application of the technique of multiple correlation increased the predictability of carcass value only slightly. This is most likely due to a large variance contributed by joint effects arising from the inter-correlations of the three scores with each other.

TABLE XII

Multiple Correlations Between Percentage Lean Cuts and Live Animal Scores.

	Judge A		Judges' Ave.	
	F1954	S1955	F1954	S1955
' R_{1234}	.50**	.57**	.36	.61**
R_{134}	.45**	.55**	.35	.61**
R_{123}	.42**	.45**	.38*	.53**
R_{124}	.49**	.57**	.32	.60**

' Key to measures:
1 = Percentage lean cuts
2 = Length score
3 = Backfat score
4 = Meatiness score
* $P < .05$
** $P < .01$

b. Live Animal Measurements

Multiple correlations between percentage lean cuts and live animal measurements were computed. They are shown in Table XIII. Again only the data for the F1954 season was comparable since the probe measurements in the S1955 season were in error. The multiple correlation between percentage lean cuts and live animal measurements (+.58) was essentially no greater than the simple correlation between percentage lean cuts and probe backfat (-.57). This indicates that length measurement added nothing to the predictability of carcass value when probe backfat was used.

TABLE XIII

Multiple Correlations Between Percentage Lean Cuts and Live Animal Measurements.

	F1954	S1955
' R_{156}	.58**	.34

' Key to measures:
1 = Percentage lean cuts
5 = Live animal length
6 = Probe backfat
** P<.01

c. Live Animal Scores and Measurements

A combination of live animal scores and measurements was investigated as a possible means of predicting carcass merit. The factors selected to be used in this combination were length score, meatiness score and probe backfat. Length score was selected because it is easier to obtain than is length measurement and in this study was as highly associated with carcass value. Meatiness score was selected because it was the only estimate of carcass leanness available from the live hog. Probe backfat was the most successful estimate of carcass backfat and the highest correlated with percentage lean cuts of all the scores and measurements obtained in this investigation. The multiple correlations between these factors and percentage lean cuts are presented in Table XIV. Study of the data in this table revealed, that when probe backfat was included in combinations with scores of length and meatiness, differences which existed in the prediction of carcass merit between judges was greatly reduced.

TABLE XIV

Multiple Correlations of Percentage Lean Cuts with Length Score, Meatiness Score and Probe Backfat (1954 - 50 hogs).

	Judge A	Judge B	Judge C	Judges' Ave.
' R_{1264}	.62**	.59**	.59**	.60**
R_{126}	.58**	.59**	.58**	.58**
R_{124}	.49**	.03	.30	.32
R_{164}	.57**	.57**	.58**	.58**

'Key to measures:
1 = Percentage lean cuts
2 = Length score
6 = Probe backfat
4 = Meatiness score
**$P < .01$

The relative amount scores increased the predictiveness of carcass value between judges seems more important when compared to the simple correlation between probe backfat and percentage lean cuts, -.57. Using the multiple correlation of percentage lean cuts with length score, meatiness score and probe backfat, it was found that the combination of factors raised the predictability of percentage lean cuts from 32 per cent (square of the simple correlation -.57) to about 35 per cent (square of the multiple correlations +.59) for Judges B and C and to 38 per cent (square of the multiple correlation +.62) for Judge A. This shows an increase of 6 per cent for Judge A compared to 3 per cent for Judges B and C or twice as much increase in the predictability of percentage lean cuts by the combination with Judge A's scores.

The multiple correlation of percentage lean cuts with the combination of factors was +.60 for average scores and +.62 for Judge A's scores which compares with a correlation on the same hogs of +.68 for percentage lean cuts with four carcass measurements - carcass length, carcass backfat, ham specific gravity and loin lean area (Table XV). This indicates that the selected live animal factors were very nearly as highly correlated with percentage lean cuts as were the carcass characteristics.

TABLE XV

Multiple Correlations Between Percentage Lean Cuts and Carcass Measurements.

	F1954	S1955
' R_{17890}	.68**	
R_{1789}	.64**	.81**
R_{1890}	.66**	.84**
R_{178}	.48**	.79**
R_{179}	.48**	.61**
R_{189}	.62**	.80**
R_{180}	.55**	.83**

' Key to measures:
1 = Percentage lean cuts
7 = Carcass length
8 = Carcass backfat
9 = Loin lean area
0 = Ham specific gravity
** $P < .01$

SUMMARY AND CONCLUSIONS

A study was initiated in the fall of 1954 to determine the relationship of scores and measurements of certain live animal traits with similar traits on the carcass and with carcass value. Eighty hogs were scored by three men for length of body, backfat thickness, meatiness and dressing percentage. Body length and probe backfat measurements were also made on these hogs. The hogs were slaughtered and certain carcass characteristics were determined - carcass length, backfat thickness, ham specific gravity, loin lean area, dressing percentage and percentage lean cuts of the cold carcass.

Simple correlations between certain carcass traits and scores and measurements on the live hogs were computed. These correlations were presented in Tables II, III, IV, V, VI, and VII. From these data the following observations were made:

1. The relationships of scores for length of body, backfat thickness and meatiness to the traits in the carcass indicated that judges were fairly successful in scoring these items in live hogs.
2. Comparisons between seasons indicated that average scores of three judges were more reliable for predicting carcass characteristics than were scores of individual judges.

3. Live animal measurements of body length and probe backfat were significantly correlated with carcass length and backfat, respectively.

4. Based on the data from one season, probe backfat was found to have the highest predictive estimate of carcass backfat of the scores and measurements studied.

5. Judges were not able to satisfactorily predict dressing percentage of individual hogs in this study.

The relationships of these same live animal scores and measurements to percentage lean cuts were studied. Simple correlations between percentage lean cuts and individual live animal scores and measurements and carcass traits are presented in Tables VIII, IX, and X. From these data the following observations were made:

1. No appraisal of carcass length was highly associated with carcass value in this study.

2. Backfat and meatiness scores were more predictive of carcass value than length scores.

3. Probe backfat was more highly associated with percentage lean cuts than was backfat score or actual carcass backfat.

4. Considerable differences were observed among judges in their correlations between meatiness scores and percentage lean cuts.

5. Comparisons between seasons indicated that practice may improve the judge's ability to score live hogs for meatiness, which is highly associated with carcass value.

The relationships of percentage lean cuts to combinations of live animal measurements, live animal scores and live animal scores and measurements were investigated. Simple correlations between total score and percentage lean cuts were computed. Multiple correlations between percentage lean cuts and those items included in the combinations studied were also obtained. These data were presented in Table XI, XII, XIII, XIV, and XV. Study of these data revealed the relative usefulness of the combinations of items for predicting percentage lean cuts. The following observations were made:

1. The data indicated that scores given by an experienced judge were more predictive of percentage lean cuts than were scores given by an inexperienced judge.
2. Total score was not related to carcass value any more than was meatiness score alone.
3. The application of the technique of multiple correlation increased the correlations of percentage lean cuts with live animal scores only slightly. Meatiness score plus either length score or backfat score was as highly associated with carcass value as when all three scores were included.
4. The data indicated that length measurement added nothing to the predictability of carcass value when probe backfat was used.
5. Multiple correlations of percentage lean cuts with length score, meatiness score and probe backfat increased

the predictability of percentage lean cuts from 32 per cent (square of the simple correlation between probe backfat and percentage lean cuts) to 36 per cent for average score and to 38 per cent for an experienced judge.

6. Correlations between percentage lean cuts and the combination of length score, meatiness score and probe backfat compared favorably with those of percentage lean cuts and four carcass characteristics - carcass length, carcass backfat, ham specific gravity and loin lean area.

Combinations of live animal factors as means of predicting carcass value need to be given further consideration before specific recommendations are made. From the present study probe backfat appears to be the only factor which can be recommended extensively for predicting carcass merit in live hogs. It appears that meatiness score, when appraised by an experienced judge, may prove to be valuable for increasing the predictability of carcass value by probe backfat; however, this point needs further investigation.

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