CARCASS STUDIES ON HOGS
OF DIFFERENT BREEDING

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By

JOE V. WHITEMAN

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THESIS AND ABSTRACT APPROVED:

J. A. Whatley
Thesis Adviser

J. C. Hillier
Faculty Representative

A. E. Darlow
Head of the Department

R. C. McIntosh
Dean of the Graduate School

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INTRODUCTION

Breeding studies with swine have usually stressed such characteristics as body conformation, rate and economy of gain, and sow productivity. Little emphasis has been placed on carcass merit except as it is affected by body type. That carcass merit has received little attention is easily explained in light of the following facts: (1) Selection for carcass merit can be done only by progeny test or through the slaughter of collateral relatives. (2) Little if any market premium has been paid for the hogs with carcasses of superior merit.

Unquestionably many breeders have thought that they were selecting for carcass merit in selecting for body conformation and probably they have influenced the quantity and quality of the carcass components to some extent. Research, however, indicates that external body conformation gives a poor indication of most carcass traits. Consequently it is necessary to slaughter an animal to get the best appraisal of its carcass merit. This is impossible if the animal is to be used for breeding purposes.

Assuming some degree of heritability for carcass traits, the next best method of determining an individual's carcass merit, can be found by slaughtering close relatives. The success of this method would be directly proportional to the heritability of the traits in question. If carcass traits are heritable, it should be possible to characterize inbred lines for carcass traits. These lines should be more homozygous for these traits than the average of the hog population and should transmit these characteristics to some degree in crosses with other inbred lines.

In order to check the veracity of such reasoning, this study was conducted. An attempt was made to characterize certain Duroc inbred lines and to determine if these characteristics were transmitted to a measurable extent in two-line and three-line crosses within the Duroc breed. Two other breeds were also crossed with Durocs to compare the carcass merit of these breed crosses with Duroc line crosses. Supplemental information such as the influence of sex on carcass fatness was also studied.

REVIEW OF LITERATURE

Reports dealing specifically with differences in hog carcasses related to the breeding of hogs are very limited. However, there is considerable information available dealing with the different aspects of the hog carcass problem. Considerable work has been done in attempting to find methods of evaluating hog carcasses, determining the order of deposition of the various carcass components, studying the effect of rate of gain on the carcass, investigating the relation between conformation and the carcass, and determining carcass differences due to sex.

Warner and others (1934) reported that in 75 hog carcasses the ratio of combined belly, leaf fat, and skinned back fat and trimmings to chilled carcass weight was correlated with the content of fat in the edible portion of the carcass. This correlation coefficient was 0.91 ± 0.01. The estimated correlation between percentage of combined belly and back fat and the content of ether extract was 0.84 ± 0.02.

The value of average back fat thickness for estimating the fatness of carcasses was investigated by Hankins and Ellis (1934). Their study included 60 carcasses from hogs of different breeds fed under different systems of management. The correlation between the average of five back fat measurements (opposite first and seventh thoracic vertebras, last lumbar vertebra, and at three and one-half and seven vertebra forward from the last lumbar vertebra) and the ether extract of the edible portion of the carcass was 0.84 ± 0.04. Back fat thickness at the seventh thoracic vertebra was the best single back fat measurement.

Their regression equation for estimating the percentage of fat in the carcass (Y) from back fat thickness (X) is given as, $Y = 22.45 + 0.691X$.

McMeekan (1941) studied the use of a sample joint or joints as an indication of carcass composition in 200 pound bacon pigs. Correlations for the loin were 0.94, 0.88, and 0.86 and for ham 0.89, 0.97, and 0.88 with the quantities of bone, muscle and fat, respectively, in the hog carcass. Combined weights of loin and ham gave correlations of 0.94, 0.97, and 0.97 with the carcass for the same components. The correlation of loin lean area with total lean in the carcass was 0.84. The average of five back fat measurements was correlated to fat in the carcass by a coefficient of 0.95. The most predictive single back fat measurement for estimating the fatness of the carcass was at the last rib.

Dickerson and others (1943) attempted to find the relationship between carcass conformation and the value of the live hog. Their study included 278 Poland China hogs slaughtered at 225 pounds average live weight. They concluded that external conformation indicated differences in fat thickness and in length of bone and muscle rather than muscle thickness. Width at the pelvic region and plumpness of ham were the only external measures indicative of muscle thickness. The deeper carcasses yielded more ham and shoulder, while wider carcasses yielded more belly and fat. Plumper hams indicated more ham, belly, and loin.

Cummings (1948) in a study of 741 hogs slaughtered and cut at a packing plant found that chilled carcass weight was correlated with percentage of five primal cuts, -0.40; index of fat cuts, 0.42; average back fat thickness, 0.57; and carcass length, 0.57. In using back fat thickness as a measure of fatness, he preferred to alter the estimate to make allowance for variations in body length. T factor, or the ratio of average back fat thickness to carcass length gave, in his opinion, a more accurate measure of carcass fatness than did the use of average back fat thickness only.

Aunan and Winters (1949) studied the carcasses of thirty hogs from five different breeds in an effort to learn the variations which exist in lean, fat, and bone and their relationships to carcass measurements. The average of three back fat measurements (thickest, thinnest, and opposite the seventh rib) was negatively correlated with the lean content of the carcass, -.625, and with percentage of five primal cuts, -.585. Average back fat thickness was positively correlated with the fat content of the carcass, .792, and with the fat content of the ham, .656, and with the fat content of the picnic, .527. The U factor (carcass weight divided by carcass length and the quotient divided by average back fat thickness) is suggested as a possible carcass evaluation. However, their data indicates that it is less closely associated with fat and lean content of the carcass and percentages of primal cuts than is average back fat thickness.

Hetzer and others (1950) studied the relative value of various live hog measurements for predicting certain characteristics of the carcass. Eight body measurements were taken on each of the 141 pigs and correlations calculated between measurements and between these measurements and yield of five primal cuts and yield of lean in the ham. Body measurements included: (1) length from ear to tail, (2) height at shoulders, (3) width at shoulders, (4) width of middle, (5) width at hams, (6) depth at chest, (7) depth of middle, and (8) circumference at chest. Standard partial regression coefficients were used to determine the relations of body measurements to yield of five cuts and yield of lean meat in the hams. Depth of middle was the most important measurement associated with the yield of five primal cuts in both barrows and gilts. Width of middle and height at shoulders were next in importance for barrows while height at shoulders and width at shoulders were next for the gilts. The width at ham measurement showed the most predictive value for estimating yield of lean meat in the hams of both sexes.

Brown _et al_. (1950) investigated the possibility of using specific gravity as a measure of the relative leanness or fatness of carcasses. Using correlations, he found that specific gravity was more closely associated with carcass length, percentage of primal cuts, percentage of lean cuts, chilled weight, weight per inch of length, and percentage of fat cuts than was either back fat thickness or loin lean area. The highest correlation was between specific gravity and percentage of lean cuts.

McMeekan (1940) slaughtered Large White pigs at birth, 4, 8, 16, 20, 24, and 28 weeks of age to determine the order and rate at which the various carcass components were developed. Figure 1 shows the rate of development of the fat, lean, bone, and skin components during this 28 week period.

The bone and skin components increased at a relatively constant rate. Lean developed rapidly, starting early and increasing slightly in rate of growth throughout the entire 28 weeks. The fat content of the carcass remained low from birth until the sixteenth week. Then fat was deposited at an increasing rate and gradually became responsible for the largest portion of the increase in carcass weight. The carcass was composed of equal amounts of lean and fat at 26 weeks of age.

By measuring and counting muscle fibers from tissue cross-sections, McMeekan concluded that lean or muscle tissue increases in size primarily by means of individual muscle fiber growth. He was not able to find any increase in muscle fiber numbers per tissue after the birth of the pig.

To find the effect of restricted rations on the growth curve and on the pig's carcass, McMeekan (1938) (1940A) designed an experiment as follows:

Lot	Designation	Birth to 16 wks.	16 wks. to slaughter
1	High-High	Full-fed	Full-fed
2	High-Low	Full-fed	Restricted
3	Low-High	Restricted	Full-fed
4	Low-Low	Restricted	Restricted

Inbred Large White pigs were used in the experiment. The ration for the restricted lots was quantitatively reduced so that the intake was approximately one-half that of the full-fed lots. The growth curves of the four lots are shown in Figure 2.

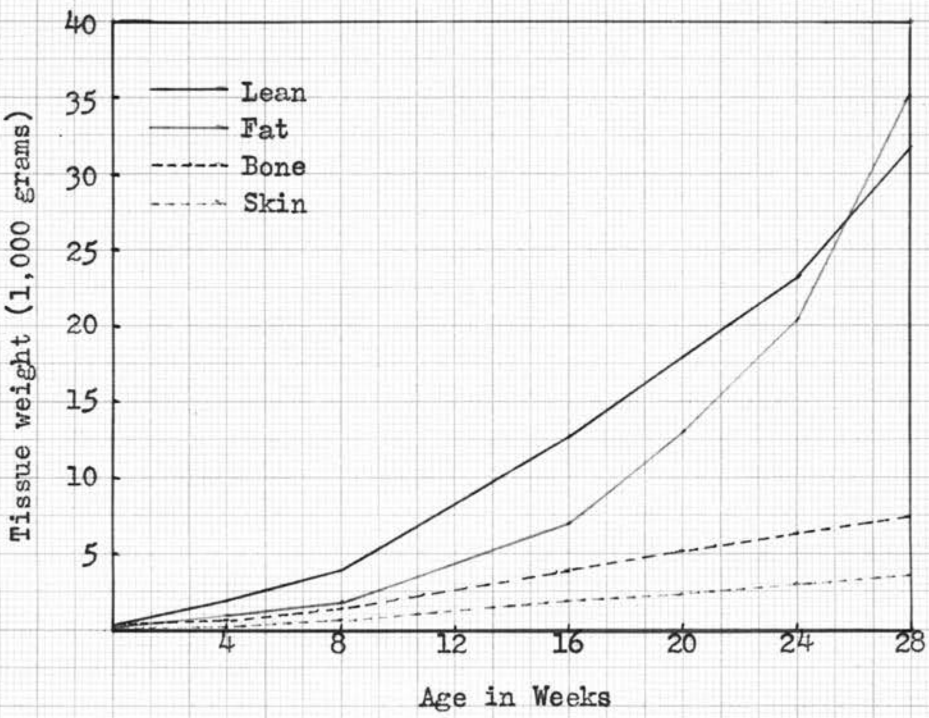

Figure 1. Growth Curves for Fat, Lean, Bone, and Skin (McMeekan 1940).

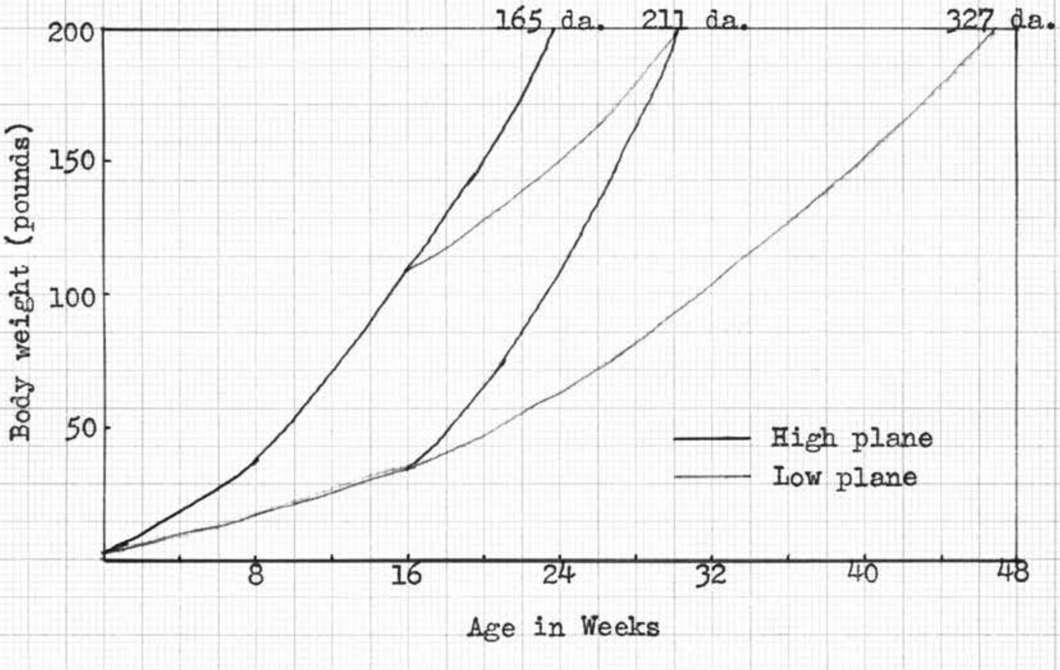

Figure 2. Growth Curves of Four Lots of Pigs on Various Planes of Nutrition (McMeekan 1940A).

A few pigs from each lot were slaughtered at 16 weeks of age. The full-fed (high plane) pigs averaged 113 pounds at this age whereas the restricted (low plane) pigs only weighed 37 pounds. The high and low plane groups had averaged about 40 and 20 pounds respectively at eight weeks of age. Carcasses from 16-week-old pigs showed that the restricted ration had penalized fat deposition most, lean development next and skeletal growth least.

At 200 pounds the pigs that had been on the low plane of nutrition throughout the feeding period were leanest, though the lean was not well developed. The group that was on the low plane to 16 weeks of age then full-fed to 200 pounds (Low-High) had the most fat in the carcass. The second fattest carcasses came from the group that was full-fed from birth to 200 pounds (High-High). McMeekan states that the most desirable carcasses came from the group of pigs that was full-fed to 16 weeks of age and then was restricted on feed intake until they weighed 200 pounds (High-Low). These carcasses were second in leanness to the Low-Low group and had more desirable quality in the lean.

Though the Low-High and the High-Low groups were fed to reach 200 pounds at the same age (211 days), the Low-High pigs were much fatter. McMeekan concludes that the pig tends to develop more lean than fat prior to 16 weeks of age and more fat than lean after that age.

Crampton (1940) studied the effect of early growth rate on leanness of carcass in 247 bacon type pigs. Pigs were allowed to govern their own intake and gains were in no way controlled. Differences in gains were only those which are found in any group of commercial swine. The average daily gain from 60 days of age to

200 pounds was 1.10 ± .14 pounds. Within the range of these data it was concluded that there was no relationship between rate of gain and carcass leanness. There was a non-significant negative correlation between loin lean area and average daily gain.

Arthur (1942) studied the cut-out records from packing plants and found that there is a seasonal pattern. The more profitable cut-out periods are in autumn, early winter, and late spring. No attempt was made to explain these findings.

Baker and others (1943) attempted to determine the relative importance of heredity and environment on the growth of pigs of various ages. They found that the heredity of the pig plays an increasingly important role in development from birth to 112 days. The genetic variance in rate of gain during relatively short intervals increased from 7 to 31%. After 112 days the relative importance of heredity decreased considerably.

Hazel and others (1943) studied the relationship between growth rate and carcass measurements. They found no significant results, indicating that carcass conformation can be changed only slightly over the range studied ($\sigma =$ 28.8 pounds for 180 day weight). They concluded, "There is little to be gained in genetic or nutritional studies by eliminating that portion of the variation in carcass which can be attributed to the observed variation in growth rate."

Blunn and Baker (1947) studied the relation between average daily gain (from 56 days to 112 days, from 112 days to time of slaughter, and from 56 days to slaughter) and depth of back fat, length of hind leg, and circumference of ham. Simple correlations between gain and depth of back fat and gain and ham circumference were low and positive while that between gain and length of hind leg was negative. These data with Durocs indicated that hereditary factors accounted for about 12 percent of the variance for depth of backfat and 23 percent of the variance for length of hind leg.

Using the correlation between paternal half-sibs, Dickerson (1947) found heritability estimates of less than one-third for yield of lean cuts, one-half for the measure of fatness, and nearly three-fourths for length of carcass. Rapid fat deposition and low feed requirements tended to be caused by the same genes. Differences between inbred lines in yield of lean cuts were larger than expected from heritable variations within lines. It is suggested that this may be due to a tendency for good suckling ability to be caused by the same genes that cause slower fat deposition.

Krider (1949) reported that when pigs from a rapid gaining line and a slow gaining line were group fed, they yielded very similar carcasses at 225 pounds. However, at 154 days the rapid gaining line carcasses had less bone and protein and more fat. When pigs from the rapid and slow gaining lines were pair fed, the carcasses from the rapid gaining line yielded about 4 percent more fat, one-tenth percent less protein and one and four-tenths percent less bone at 225 pounds. These data were not statistically analyzed.

Winters and co-workers (1949) designed an experiment somewhat similar to that of McMeekan (1938) to determine the effect of plane of nutrition on the quality of the carcass. The animals on the Low-Low ration produced the leanest carcasses though there was a tendency for them to lack firmness. High-High carcasses were fattest and yielded the lowest percentage of five primal cuts. High-Low and Low-High carcasses were essentially the same in fatness and yield and intermediate in both measurements to the carcasses from pigs on the extreme rations.

Interest in the relation of body type to carcass merit increased in the early twentieth century due to the excessive fatness of many market hogs and the increased competition of the vegetable fats and oils with lard. Several studies followed in an attempt to determine a type that would not yield excessive fat but would be finished sufficiently to yield good quality carcasses.

Scott (1927) studied the effect of combined carcass and leg length upon carcass quality and yield. The hogs were killed at approximately 180 days of age or the data was corrected to that age. The longer carcasses tended to be heavier in percent lean cuts and lighter in percent fat cuts, except the belly. Long carcasses also tended to lack firmness.

Bull and Longwell (1929) classified 179 hogs into very chuffy, chuffy, intermediate, rangy, and very rangy type. The conclusion was reached that from the butcher's standpoint, the intermediate type was the most desirable. The rangy type was satisfactory if self-fed. Very chuffy pigs tended to be too fat and very rangy pigs yielded carcasses lacking in firmness. Bull and others (1935) continued the over all type study problem and its relation to the economy of swine production and concluded that none of the types of animals included in the study met the pork market demand of the day. The intermediate type most nearly approached the ideal but pigs with the quality and plumpness of the intermediate type, the length of the rangy type and the early maturity of the chuffy type would be ideal.

Hankins (1940) studied the effect of type on the carcass components using small, medium and large type Poland China hogs. In one study, the different types were killed when at a uniform degree of fatness. The small type averaged 149.6, the medium 223.2, and the large 261.9 pounds when killed. The differences in yield were small and in favor of the large type. In another study, the three types were all slaughtered at about 225 (215-234) pounds. The large type yielded a higher percentage of lean cuts but the carcasses tended to be soft.

Zeller (1940), after studying the effect of type on pork production, concluded that the intermediate type best suited market demands, and the flexibility in the time of marketing this type increased its value.

Hankins and Ellis (1945) slaughtered 64 pigs ranging from 167 to 254 pounds in weight to determine the effect of live weight on the yield of the carcass components. It was found that as live weight increased, the weight of ham, shoulder, belly, and back fat increased proportionally. The loin increased but at a slower rate. As carcasses became heavier, bacon increased the most rapidly in percentage of ether extract. The percentage of protein decreased as live weight increased. Five 175-pound hogs yielded about as much lean as four 250-pound hogs.

Barrows and gilts are both used in carcass studies and if differences exist in carcass merit due to sex it is important that it be known. It is a frequent practice to use both barrows and gilts in feeding trials and subsequent slaughter trials. Such a procedure, if sex differences do exist, could confound results of statistical analysis.

Lacy (1932) studied the effect of sex on the primal cuts in swine carcasses. Using litter mates, it was found that barrows gain faster and have a higher yield of fat cuts other than belly. Gilts were found to yield more loin and ham. There was no difference in the yield of belly.

Warner and others (1934) in their study of cutting yields as an index of fatness, observed that barrows were fatter than gilts.

McMeekan (1940) in his work on the shape of the growth curve, found that barrows were characterized by less bone and muscle and more fat than gilts. The extent of the differences was modified by the rate of growth (plane of nutrition) imposed. Both the High-High and the Low-Low levels of maintenance caused the differences between sexes to be reduced.

Bennett and Coles (1946) conducted a study with Yorkshire barrows and gilts to determine the influence of sex on carcass characteristics. Gilts were longer, heavier in the shoulder and ham, lighter in the middle and larger in the loin lean area.

Reports dealing with differences due to breeding are rather scarce. One of the earlier studies is reported by Wiley and others (1898). In this study, representative carcasses from each of six breeds were chemically analyzed to determine differences in the content of water, nitrogenous substances and ether extract. Though only one carcass of each breed, except Durocs, was analyzed and no statistical analysis was made, large differences were noted between breeds.

Hankins and Hiner (1937) reported that the Danish Landrace carcasses studied had heavier loins than Duroc and Poland carcasses.

The hams from Danish Landrace and Poland carcasses were heavier than those from Durocs. No differences were noted in yields of bellies, picnics, and Boston butts.

Dickerson and others (1946) in studying hybrid vigor in single crosses between inbred lines of Poland Chinas, noted that there was a trend for the crosses to have a lower dressing percentage, less fat, and plumper hams than inbred lines.

Bratzler (1947) obtained cut-outs at a packing plant on 17 breeds and breed crosses. Number of carcasses per breed or cross varied from five to 61. The percentage of primal cuts varied from 46.7 to 49.4.

Winters and co-workers (1948) gathered data from over 700 carcasses representing three breeds, many inbred lines, and crosses of these breeds and lines. Their study led to the following conclusions:

> The carcasses from line crosses were distinctly superior to the carcasses from the parental inbred lines or the outbreds used as a check. The carcasses from crosses of lines belonging to different breeds were superior to line crosses within the Poland China breed.
>
> Superior carcasses were obtained from pigs that made very rapid gains. Slow-growing animals, because of genetic or environmental influences, are not necessary to the production of superior carcasses.

Sierk (1949) reported further on the same carcass study that statistical differences were found between breeding groups for five primal cuts, yield of individual cuts, degree of fatness, and carcass measurements. Minnesota #1 in crosses produced longer carcasses and more high quality bacon. Minnesota #2 increased the yield of loin and reduced the fat content when used in crosses. Certain Poland China lines in crosses increased the yield of ham. The lowest yield of five primal cuts came from some inbred Poland lines and the outbred pigs from three breeds.

MATERIALS AND METHODS

The 136 carcasses used in this study were from the Swine Breeding Project of the Oklahoma Experiment Station in cooperation with the Regional Swine Breeding Laboratory. Four groups of hogs were included in the study and because they were handled differently they cannot be compared directly. Groups one and two were from pigs farrowed in the spring of 1949 and groups three and four were from pigs farrowed in the fall of 1949. Table 1 shows the distribution of the carcasses in the different lines of breeding.

Table 1. Number of Carcasses According to Line of Breeding

Line or Cross	Breed	1949 Spring Pigs		1949 Fall Pigs	
		Group 1	Group 2	Group 3	Group 4
5	Duroc		4		
C	Duroc		5		
S	Duroc		4		
T	Duroc		4		
3	Duroc		4		
LP	Landrace-Poland				5
5x3	Duroc	6			
Cx3	Duroc	6			
Sx3	Duroc	6			
Tx3	Duroc	6		8	8
SxC	Duroc			8	
M10x5	Duroc				4
Cx3-5	Duroc				6
Sx3-5	Duroc				6
Tx3-5	Duroc				6
PolandxDuroc	Crossbred				6
M#2 x Duroc	Crossbred			8	6
Outbred	Duroc	6		8	6
		30	21	32	53
GRAND TOTAL					136

Group one carcasses were from four Duroc two-line cross lots and an outbred Duroc check lot consisting of conventional purebred Durocs. The carcasses were from the first two barrows to reach market weight in each of three litters representing each lot. These pigs were self fed in dry lot and made an average daily gain of 1.39 pounds from weaning (56 days) to slaughter.

Group two pigs were self fed on pasture and gained slower than did the pigs in group one. The average daily gain was 1.19 pounds from weaning to slaughter. These pigs were representatives of inbred Duroc lines 5, T, C, S, and 3. Five gilts from this group were used in the slaughter test when barrows were not available.

Group three carcasses were from pigs on a fat utilization study and included eight carcasses from each of two Duroc two-line cross lots, a Minnesota #2 x inbred Duroc crossbred lot and an outbred Duroc lot. These barrows were individually fed and made average daily gains of 1.84 pounds from an initial weight of 53 pounds to a final weight of 230 pounds.

Group four consisted of 53 carcasses, approximately half barrows and half gilts, and included from four to eight representatives of each of two two-line cross Durocs, three three-line cross Durocs, an outbred Duroc lot, one lot each of outbred Poland x linecross Duroc and Minnesota #2 x linecross Duroc crossbreds, and a lot of Landrace-Polands. These pigs were self fed in dry lot and varied considerably in average daily gain from a low of 1.21 for outbred Durocs to a high of 1.68 for C x 3-5, a three-line cross. The group gained an average of 1.47 pounds per day after weaning.

When the pigs reached the weight range of 219 to 232 pounds, they were taken off feed for twenty-four hours and then slaughtered in the college meat laboratory. The average shrunk weight of all hogs was 217 ($\sigma = 6.05$) pounds. Carcasses were prepared packer style with head off and leaf fat removed. After chilling three days the carcasses were air and water weighed (Brown, 1950) and carcass measurements were made. The carcasses were then chilled for two to three more days and then cut to obtain lean measurements and cut out percentages. All measurements (except loin lean area) were obtained from both halves of the carcass and the average used in the analysis. The entire carcass was cut and trimmed to obtain the percentage of primal cuts.

The following measurements and evaluations were studied:

Specific gravity was obtained by dividing the air weight of the carcass by the air weight minus the water weight.

Carcass length was measured from the anterior edge of the aitch bone to the anterior edge of the first rib.

The back fat measurement used for analysis was the sum of three measurements which were taken opposite the third and last ribs and the sixth lumbar vertebrae. The reported means are the average of these three measurements.

The loin lean area was the product of the two dimensions of the loin eye muscle exposed when the loin is bisected between the last two ribs.

The ham lean area was the product of the two dimensions of the lean exposed at the butt when the ham is severed from the side.

The percentages (based on shrunk live weight) of four primal cuts and each cut individually.

The hams were skinned about two-thirds of the way to the shank and the fat was trimmed to one-fourth inch in thickness. The loins had all external fat removed except scraps at the blade and ham ends. The shoulders were trimmed New York style with all external fat removed about one-half to two-thirds of the way to the shank. Bellies were squared and trimmed as large as possible. The lower edge was trimmed to the teat line and the loin edge straightened to form a rectangle. The forward end of the belly coincided with the cut to remove the shoulder at the third rib. The posterior end was cut as long as possible after removing the ham at a line perpendicular to the long axis of the ham and half way between the aitch bone and the sixth lumbar vertebrae.

The data were analyzed by groups. No attempt was made to combine the groups since there were environmental differences between groups and minor cutting variations between seasons. It was thought that any results found from an overall analysis would be confounded due to the fact that there were breeding differences between seasons and groups in addition to the environmental differences already mentioned.

Analysis of variance was used to test mean differences. In groups one and four, mean squares for differences between litters within breeding was used in the F-test to determine the significance of differences due to breeding. Variation due to rations was removed in the group three data. In groups three and four where significant differences due to breeding were found, orthogonal comparisons were used to determine the sources of variation causing the significant differences. Table 2 shows the mean squares for breeding and for the error term used by groups. The mean squares for error are included to show the similarity in size of error terms between the groups for the various measurements.

Table 2. Mean Squares for Breeding and Error by Groups.

	Group One		Group Two		Group Three		Group Four	
	Breeding	Error	Breeding	Error	Breeding	Error	Breeding	Error
	d.f. = 4	d.f. = 10	d.f. = 4	d.f. = 16	d.f. = 3	d.f. = 25	d.f. = 8	d.f. = 18
% Primal Cuts	4.238	2.542	9.488	3.819	6.147	3.207	19.702**	1.738
% Ham	1.470	.624	1.882*	.562	2.160**	.400	5.842**	.375
% Loin	.083	.537	1.168	.822	.663	.336	2.412**	.529
% Shoulder	1.265	.827	.612	.504	.567	.502	.952*	.356
% Belly	.742	1.780	.980	1.239	.393	.438	.290	1.092
Carcass Length	.628	.899	2.348	1.133	4.003**	.489	4.239**	.595
Σ 3 B.F. Measurement	.234	.442	.161	.484	.899**	.178	1.413**	.286
Specific Gravity	43.10°	50.730°	23.575°	35.793°	.000185**	.000023	.000151**	.000026
Loin Lean Area	3.466	1.238	.399	.402	2.342*	.305	2.497**	.437
Ham Lean Area	1.082	5.130	11.951*	3.504	4.364	4.672	23.460**	3.503

* Significant at the .05 level.
** Significant at the .01 level.
o Coded.

RESULTS

Any differences in the carcasses of the two-line crosses and outbred Durocs in group one could have been due to random variation (Table 3). Analysis of these data showed no significant differences in any of the ten items studied. However, these single crosses were the result of mating boars of lines 5, C, S, and T to gilts of line 3. Therefore, the differences obtained should be less than those to be expected from unrelated line crosses.

In group two the T-line was significantly inferior to the average of the other four lines in percentage of ham and ham lean area (Table 3). Though not significant, the Tx3 cross in group one showed the same trend. Apparently light hams typify line T Durocs. Though no other statistically significant differences were noted, there was an indication that the lines varied in carcass qualities. For instance, within their respective groups, line 5 carcasses showed the highest percentage of primal cuts because of heavier hams and shoulders. Line 5 also had a larger ham lean area. Line S appeared to be leaner and have heavier hams and shoulders than line C, whereas line C had a larger loin lean area and heavier loins than line S. Table 5 shows that these tendencies also appear when lines T, C, and S are crossed on 3x5 females.

The means for the measurements studied in group three are shown in Table 4. Prior to the collection of data the following set of orthogonal comparisons were planned for analyzing the group three data. These show the major sources of variation causing significant differences (Table 2) due to breeding.

<u>Comparison one</u>. Minnesota #2 cross carcasses were longer, had heavier hams, and were leaner as measured by average back fat and specific gravity than were Duroc carcasses.

<u>Comparison two</u>. Outbred Durocs had heavier hams and larger loin lean area than the two-line crosses.

Table 3. Summary of Carcass Data, Groups One and Two

		Group One (Dry Lot)					Group Two (Pasture)				
Breed		Duroc					Duroc				
Line		5x3	Cx3	Sx3	Tx3	Outbred	5	C	S	T	3
Number of pigs		6	6	6	6	6	4	5	4	4	4
Shrunk Wt.		218	214	214	215	216	213	216	223	215	213
Dressing % 1/		73.4	73.4	73.2	72.6	73.4	74.0	72.0	71.9	70.7	73.4
% Primal Cuts	(x)	44.4	44.1	43.5	42.3	44.3	46.6	43.7	44.4	42.5	43.9
% Ham 2/	(x)	10.9	10.9	11.0	9.9	11.1	11.6	10.6	11.1	9.8	11.2
% Loin 2/	(x)	9.0	9.2	9.0	8.9	9.1	10.0	9.3	8.7	9.8	9.2
% Shoulder 2/	(x)	11.9	11.0	11.4	10.9	11.8	12.2	11.3	11.7	11.1	11.5
% Belly	(x)	12.6	13.0	12.1	12.6	12.3	12.8	12.4	12.8	11.7	12.1
% Fat Trim		20.6	20.2	21.0	21.0	19.9	17.8	19.7	18.4	20.4	20.3
% Lean Trim		3.4	3.8	3.4	3.6	3.8	3.8	3.7	3.8	3.1	3.6
Carcass Length	(x)	29.1	28.5	29.1	29.3	28.8	29.4	27.9	29.4	29.6	28.3
Av. BF Thickness	(x)	1.95	1.97	2.02	1.86	2.01	1.83	1.89	1.78	1.96	1.84
Specific Gravity	(x)	1.018	1.019	1.021	1.022	1.025	1.022	1.025	1.027	1.022	1.023
Loin Lean Area	(x)	4.06	5.19	4.22	4.22	5.80	4.85	5.44	4.58	4.84	4.92
Ham Lean Area	(x)	20.9	20.8	20.7	20.6	21.7	22.7	20.8	22.3	18.7	22.6

1/ Chilled carcass weight as a percentage of shrunk live weight, hogs dressed packer style with head and leaf fat removed.

2/ Very closely trimmed.

(x) Measurements statistically analyzed.

Table 4. Lot Means for Carcasses in Group Three.

Breed		Duroc			Crossbred
Line		SxC CxS	Tx3 3xT	OB Duroc	M2 x Inbred Duroc
Number of pigs		8	8	8	8
Shrunk Weight		222	221	220	219
Dressing % 1/		72.4	72.7	72.3	72.8
% Primal Cuts	(x)	43.3	43.1	44.4	45.0
% Ham 2/	(x)	11.1	10.7	11.6	11.9
% Loin 2/	(x)	8.9	9.1	9.2	9.6
% Shoulder 2/	(x)	10.8	11.3	11.3	11.4
% Belly	(x)	12.5	12.0	12.4	12.1
% Fat Trim		20.5	21.1	19.8	18.7
% Lean Trim		3.4	3.4	3.2	3.4
Carcass Length	(x)	28.7	28.9	28.8	30.2
Av. BF Thickness	(x)	2.03	2.06	1.99	1.81
Specific Gravity	(x)	1.028	1.023	1.028	1.034
Loin Lean Area	(x)	4.10	3.63	4.84	4.61
Ham Lean Area	(x)	21.69	22.38	22.85	23.44

1/ Chilled carcass weight as a percentage of shrunk live weight, hogs dressed packer style with head and leaf fat removed.

2/ Very closely trimmed.

(x) Measurements statistically analyzed.

Table 5. Lot Means for Carcasses in Group Four

Breed		Duroc						Crossbred		Landrace Poland
Line		3xT Tx3	N10x5	Cx 3-5	Sx 3-5	Tx 3-5	OB Duroc	Pol x Line Cross Duroc	M2x 3-5	A
Number of Pigs		8	4	6	6	6	6	6	6	5
Shrunk Weight		214	216	217	218	218	215	219	215	217
Dressing % 1/		73.3	73.1	73.7	73.4	72.7	72.8	73.7	73.5	72.7
% Primal Cuts	(x)	45.2	43.5	44.7	44.9	43.5	43.2	46.9	45.9	49.3
% Ham 2/	(x)	11.5	11.0	11.1	12.1	10.7	11.6	12.6	12.4	14.2
% Loin 2/	(x)	9.5	8.5	9.0	8.7	8.6	8.2	9.8	9.3	10.2
% Shoulder 2/	(x)	11.7	11.1	11.4	11.3	11.1	10.6	11.3	11.5	12.1
% Belly	(x)	12.6	12.9	13.1	12.8	13.1	12.8	13.2	12.7	12.9
% Fat Trim		19.6	21.5	21.2	20.1	20.3	21.7	18.2	19.0	14.1
% Lean Trim		3.2	2.7	2.8	3.0	3.1	2.9	2.9	3.3	3.5
Carcass Length	(x)	29.6	29.1	28.8	28.6	29.3	27.9	29.3	30.0	31.0
Av. BF Thickness	(x)	1.82	2.03	2.02	1.95	1.99	2.12	1.89	1.78	1.55
Specific Gravity	(x)	1.029	1.024	1.025	1.026	1.023	1.020	1.032	1.028	1.038
Loin Lean Area	(x)	4.32	3.52	4.24	4.24	3.83	4.22	5.23	4.78	5.78
Ham Lean Area	(x)	20.88	19.58	20.62	21.44	20.05	21.28	23.17	22.58	26.64

1/ Chilled carcass weight as a percentage of shrunk live weight, hogs dressed packer style with head and leaf fat removed.

2/ Very closely trimmed.

(x) Measurements statistically analyzed.

Comparison three. SxC and CxS had a higher specific gravity than Tx3 and 3xT carcasses.

The 53 carcasses in group four represent breeding lots that were of more diverse genetic origin than any other group studied. Table 5 gives the means for the different lots. Variation among these means for the different measurements also is considerably greater than that found in any other group. As might be expected, significant differences were found in nearly all (nine out of ten) measurements. Orthogonal comparisons indicate the following differences to be significant by comparison:

Comparison one. Non Duroc carcasses were superior to Durocs in all measurements except percentages of shoulder and belly.

Comparison two. Landrace-Poland carcasses were superior to crossbreds in all measurements except percentages of loin and belly.

Comparison three. There were no significant differences between Poland cross and Minnesota #2 cross carcasses.

Comparison four. Outbred Duroc carcasses were inferior to line cross carcasses in six measurements, i.e., carcass length, average back fat thickness, specific gravity, and percentages of primal cuts, loin, and shoulder.

Comparison five. There were no significant differences between carcasses from two-line cross Durocs and from three-line cross Durocs.

Comparison six. Tx3 and 3xT carcasses had larger percentages of primal cuts and loin than did N10x5 carcasses.

Comparison seven. Carcasses from lines S and C crossed on 3x5 had a higher percentage of ham than did Tx3-5 carcasses.

Comparison eight. Sx3-5 carcasses had higher percentages of ham than Cx3-5 carcasses.

The outbred Durocs of group four did not produce quite as good carcasses as expected. Outbreds in other group trials have been better than these and it is felt that these may not be typical of that breeding.

The Effect of Sex Upon Specific Gravity

Of the 53 pigs producing Group Four carcasses, 28 were gilts and 25 were barrows. These included one gilt and one barrow from each of 22 litters but there were no barrow-gilt litter mates among the remaining nine pigs. In order to check any differences in leanness that might exist due to sex, the data were analyzed using specific gravity as the measure of relative fat and lean composition of the carcasses. It was noted that there was a tendency for the gilts to have leaner carcasses (higher specific gravities) and lower average daily gains as measured by age at the time slaughtered.

In light of these differences, it was deemed necessary to analyze the data by means of covariance analysis. Table 6 shows the analysis of covariance. Using the error sums of squares for the two variables and the error covariation quantity, the intra-breed, intra-sex correlation was -0.3067 between specific gravity and age at slaughter. This correlation coefficient was significant at the .05 probability level. Since this correlation exists it is necessary to test the significance of mean differences due to sex by calculating the mean square errors of estimate using the method described by Snedecor (1946).

The 28 gilt carcasses had an average specific gravity of 1.0299 and the 25 barrow carcasses averaged 1.0241. The gilts averaged 193.8 days of age when slaughtered while the barrows averaged 190.3 days old when they were killed. This difference of .0058 in specific gravity is highly significant as shown in Table 6. This indicates that after any effect of age is removed, the gilt carcasses were leaner as measured by specific gravity.

Table 6. Analysis of Covariance of Age at Slaughter (X) and Specific Gravity (Y) and Test of Significance of Adjusted Sex Means of 53 Pig Carcasses in Group Four.

Source of Variation	Degrees of Freedom	Sums of Squares and Products			Errors of Estimate		
		x^2	xy^o	y^{2o}	Sums of Squares	Degrees of Freedom	Mean Square
Total	52	21,949.48	-310.36	2652.79			
Breeding	8	11,170.45	410.18	1210.71			
Sex	1	161.93	268.82	446.27			
Error	43	10.617.10	-997.36	995.81	902.12	42	21.48
Sex and Error	44	10,779.03	-728.54	1442.08	1392.84	43	
Difference for Testing Adjusted Sex Means					490.72	1	490.72**

$r = -997.36 / \sqrt{10,572,614.3510} = -0.3067^*$

$F = 490.72 / 21.48 = 22.845 \quad P.01 = 7.27$

o - For ease of calculation, specific gravity values are coded.
* - Significant at the .05 level.
**- Significant at the .01 level.

DISCUSSION

The results of this study are not intended as characterizing the carcass merits of the various breeds used. However, it is believed that the Duroc lines have been partially characterized with respect to their carcasses. It should be possible to predict with reasonable accuracy the relative carcass merits of certain of the lines in further crossing.

Since the carcass numbers were small, no attempt was made to determine standard deviations for the measurements used. It is of interest to point out, however, that the within group variation as measured by the error mean square was very uniform for the four groups studied. Table 2 gives the error mean square by groups. It would appear that under the conditions of this experiment the error mean squares have been well measured for the characteristics studied. Apparently there is still considerable natural variation in percentage of primal cuts and ham lean area. This may be reduced by increasing the accuracy of cutting and measuring techniques.

There was no indication of differences in percentage of belly. It was observed during the course of the study that longer or deeper carcasses had thinner bellies and short, very fat carcasses had thick bellies. Since there was no accurate measure made of quality, it is impossible to say accurately which line of breeding produced the more desirable bellies. It was noted, however, that all the carcasses of the Landrace-Poland line used in the study were too soft to be highly desirable. This line was the only one showing this carcass characteristic in the study.

The evaluations used were those which more nearly measured the characteristics of interest. However, it is fully appreciated that without some measure of carcass quality, the carcass merit of any line of breeding cannot be fully characterized.

Since there are evidently differences in swine carcasses due to sex, carcass studies must be planned with this fact in mind. The study should be limited to carcasses of one sex or appropriate analysis of data be made to include sex differences as a source of variation. Differences due to sex could become a factor of considerable importance in experiments where the design results in one or more carcasses of each sex being chosen from test litters. If, in analysis, the within litter mean square is used to test the between litter variance, it could be very hard to find significance because the within litter mean square would contain a large portion of the variation due to sex if such variation were not removed by proper statistical control.

SUMMARY

The carcasses of 136 hogs were studied to determine differences due to breeding. Inbred lines, two-line crosses, three-line crosses and outbreds, all Duroc; crossbreds; and an inbred line of Landrace-Polands were included in the study. Carcass measurements and evaluations included specific gravity, carcass length, back fat meaurement, loin lean area, ham lean area, and percentages of four primal cuts. Differences due to breeding were found for all measurements except percentage of belly.

Landrace-Poland carcasses, though somewhat soft, were longest, leanest, and highest in percentages of three lean cuts. The crossbred carcasses used were, in the opinion of the workers, the most desirable carcasses in the study. The quality appeared to be good and the carcasses were longer, leaner, and higher in percentage of ham and loin than those of any other breeding except the Landrace-Poland line.

Few statistically significant differences between the breeding groups representing the Duroc breed were found. Trends, however, were noted and it is believed that certain lines are partially characterized as a result of this study. If inbred lines being developed at the present time can be characterized as to carcass qualities, it should be possible to select lines for crossing that would yield the kind of carcasses desired.

Using specific gravity as the measure of leanness, it was found that gilt carcasses are significantly leaner than barrow carcasses.

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NAME OF AUTHOR: Joe V. Whiteman

THESIS ADVISER: J. A. Whatley

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NAME OF TYPIST: Madaleen Miller