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Comparisons of Performance & Carcass Traits of Littermate Boars & Barrows

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COMPARISONS OF PERFORMANCE AND

CARCASS TRAITS OF LITTERMATE BOARS

AND BARROWS

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COMPARISONS OF PERFORMANCE AND

CARCASS TRAITS OF LITTERMATE BOARS

AND BARROWS

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AND BARROWS

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The purpose of this study was to determine differences between littermate boars and barrows for performance and carcass traits in the Iowa and Northeast Iowa Swine Testing Stations. Data were obtained from 917 litters including 1,804 boars and 917 barrows. The data included 1,086 boars and 581 barrows from the Iowa Station at Ames, Iowa, and 718 boars and 336 barrows from the Northeast Iowa Station at New Hampton, Iowa. The Iowa Station data were obtained over a period of 12 seasons from the fall of 1979 through the fall of 1985, and the data from the Northeast Iowa Station were collected in eight seasons from the fall of 1981 through the spring of 1985. The spring testing season included pigs born from November through March, and the fall testing season included pigs born from May through September. Littermate boars and barrows from the following purebred breeds were used: Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland China, Spotted, and Yorkshire.

Boars grew .03 (2.21$\pm$.20 vs. 2.18$\pm$.21) and .10 (2.21$\pm$.18 vs. 2.11$\pm$.22) pounds/day faster ($P<.01$) than littermate barrows in the Iowa and Northeast Iowa Stations. Boars had .58 (.80$\pm$.08 vs. 1.38$\pm$.20) inches less ($P<.01$) backfat than littermate barrows (N=581) in the Iowa Station. In the Northeast Iowa Station, boars were significantly ($P<.01$) leaner than barrows when comparing average backfat of boars with carcass backfat measurements of littermate barrows at the tenth rib (.76$\pm$.06 vs. 1.06$\pm$.21) or the average of three carcass backfat measurements (.75$\pm$.08 vs. 1.29$\pm$.18

and .79±.05 vs. 1.31±.19). Boars had .67 (5.49±.42 vs. 4.82±.67) and .66 (5.62±.28 vs. 4.96±.65) square inches larger (P<.01) loin eye areas than littermate barrows in the Iowa and Northeast Iowa Stations, respectively.

The t test revealed no significant (P>.05) differences between boars and barrows for average daily gain among the eight major breeds in the Iowa Station. However, at the Northeast Iowa Station, the Duroc (2.39±.19 vs. 2.12±.21) and Hampshire (2.16±.17 vs. 2.07±.24) boars grew significantly faster (P<.01) than littermate barrows. The t test also revealed that boars averaged seven days (156.00±10.78 vs. 163.00±12.90) younger (P<.01) at 230 pounds than barrows in the Northeast Iowa Station. Although the sample size was small and the differences nonsignificant, there were some breeds in which barrows appeared to grow faster than boars. The t test for boar-barrow differences among breeds revealed that boars had significantly (P<.01) less average backfat than littermate barrows for eight major breeds in the Iowa Station and for seven breeds in the Northeast Iowa Station. For both stations, the differences in backfat thickness between boars and barrows was lowest for the Hampshire breed and the greatest differences were between boars and barrows in the Chester White, Yorkshire, Berkshire and Landrace breeds. The t test for loin eye area revealed that boars had significantly (P<.01 or .05) greater loin eye area than barrows for all breeds except Poland China in the Iowa Station and Landrace in the Northeast Iowa Station. The sex differences between littermate boars and barrows for backfat and loin eye area were significantly different (P<.01) for all years and seasons in the Iowa and Northeast Iowa Stations. The sex differences between littermate boars and barrows for backfat and loin eye area have been increasing in both stations with the largest increase occurring during the last five years. The differences between boars and barrows for days to 230 pounds were significantly different (P<.01) in all years and seasons for both stations. In comparing data for 1981 and 1985, both boars and barrows averaged ten days younger at 230 pounds in 1985 than in 1981.

Coefficients of correlation for various measurements of performance and carcass cutability between littermate boars and barrows were determined. In general, there were positive associations between boar and barrow data; however, the correlations were relatively low. The predictive value of the barrow data appears to be of little use in estimating breeding values for boars.

Although a limited number of Chester White pens were included in this study, the coefficients of correlation between littermate boars and barrows suggest that castration may have a different effect upon performance and carcass cutability of Chester White than for other breeds. Unfortunately for Chester White breeders, there appears to be a much higher positive correlation between average daily gain and backfat thickness for Chester White boars and barrows than for other breeds. In other breeds, the correlation between growth rate and backfat is low enough to allow simultaneous progress for improving both traits. A similar desirable low correlation was found between growth rate and loin eye area for other breeds.

The coefficients of correlation between backfat and loin eye area were greater for barrows than boars, suggesting that errors of measurement may have been prevalent in the boar data. Large errors in measurement of boar backfat could account for some or all of the increased difference in backfat thickness observed between littermate boars and barrows during recent years.

CHAPTER I

INTRODUCTION

Swine testing stations have gained prominence in supplying data for swine research and selection programs over the last thirty years in the United States. The purpose of swine testing stations is to directly evaluate the genetic differences among boars. The concept of boar testing relies upon the premise that the superior performing boars possess the highest frequency of desirable genes or combinations of genes and that these superior individuals should sire superior performing offspring. In general, swine testing stations make it possible for genetic progress to occur as a result of utilization of superior performing boars that have full or half sibs evaluated in the same pen.

Growth rate, backfat thickness, and feed efficiency can be measured relatively easily and accurately in a testing station under constant environmental conditions. Therefore, these traits that are generally medium to high in heritability may be used in selection programs so that their progress can be quite rapid within purebred swine herds. Generally speaking, the greatest change in swine testing station data has been the reduction of backfat thickness because it is easy to measure accurately and reasonably high in heritability (ave. H^2 = .50). Fortunately, backfat has a relatively high desirable correlation with other meatiness traits.

Data from the Iowa Swine Testing Station in Ames, Iowa, are presented in Table 1. The results (1956 to 1985) indicate the following approximations over the last three decades: growth rate has increased

TABLE 1. SUMMARY OF IOWA SWINE TESTING STATION DATA INVOLVING EIGHT MAJOR BREEDS (1956-1985)[a]

	Trait[b]								
	Pen Average		Boar Average		Barrow Cutout			B-b[c]	
Year	ADG	FE	BF	BI	Length	ABF	LEA	BF	%BV[d]
	(lb/day)		(in)		(in)	(in)	(sq in)	(in)	
1956-1960	1.84	291	1.23	116.2	29.2	1.54	3.66	-.31	25.2
1961-1965	1.95	272	1.03	154.0	29.5	1.38	4.18	-.35	34.0
1966-1970	2.11	254	.88	186.4	29.6	1.25	4.81	-.37	42.0
1971-1975	2.14	250	.85	190.2	30.6	1.25	5.37	-.40	47.1
1976-1980	2.09	246	.80	191.0	31.1	1.29	5.13	-.49	61.3
1981-1985	2.18	252	.81	192.3	31.4	1.40	4.77	-.59	72.8

[a] Barrows were littermates to at least 1 boar in each pen - all penmates had the same sire.

[b] ADG = average daily gain; FE = feed efficiency (Feed/cwt. Gain); BF = backfat (the 1st rib, last rib, and last lumbar vertebra); BI = boar index; ABF = average carcass backfat (the 1st rib, last rib, and last lumbar vertebra); LEA = loin eye area (between the 10th and 11th ribs).

[c] B-b = difference between boar backfat and average carcass backfat of littermate barrow.

[d] %BV = % difference of boar value.

18.5% (1.84 to 2.18 pounds/day), feed efficiency has improved 13.4% (291 to 252), backfat thickness has been reduced 34.1% in boars and 9% in barrows (boars: 1.23 to .81 inches, barrows: 1.54 to 1.40 inches), and carcasses have become 30.3% heavier muscled (LEA: 3.66 to 4.77 sq. inches).

Differences in backfat thickness between boars and barrows have been noticed at the conventional slaughter weight (220 ± 10 pounds). From the late 1950's to the early 1980's, boars showed much greater reduction in backfat thickness (.42 inches) than did barrows (.14 inches). In fact, in recent years, barrow backfat levels have tended to increase again. In the early 1970's, backfat thickness averaged approximately 1.25 inches (adjusted to a 220-pound basis) for barrows, but today the average has increased to 1.40 inches (adjusted to a 230-pound basis), and loin eye area is decreasing.

Since 1978, data have been adjusted to a 230-pound basis as compared to a 220-pound basis heretofore. This adjustment would only account for slight increases in backfat, and this difference should have been offset by progress in only a short time. However, by studying the results more closely, it seems the difference between boar backfat probe and actual carcass backfat thickness of littermate barrows was much greater in the 1980's than in the 1950's. In the 1950's, the difference between boar and barrow backfat was .31 inches, while in the 1980's the difference increased to .59 inches. Furthermore, if selection is to be based on the carcass evaluation data, there must be a positive correlation between the backfat of boars and barrows. The data from results of the late 1970's tend to show that boar backfat probe measurements have been negatively associated with barrow carcass backfat. Therefore, the accuracy in measuring boar backfat is questionable. Another reason for questioning the accuracy is that, theoretically, if genetic improvement has been made on boars then their offspring (barrows) should have lower backfat also.

The purpose of this study is to analyze differences in performance and carcass traits between littermate boars and barrows for data adjusted to a 230-pound live weight basis and also to study the correlations involving conventional carcass cutout variables and various performance traits for eight different breeds at two Iowa swine testing stations (Ames, Iowa, and New Hampton, Iowa).

CHAPTER II

REVIEW OF LITERATURE

Central Swine Testing Stations. Swine testing stations have played a major role in swine selection programs since the early 1950's. In 1954, a formal testing program for swine began at the Ohio Swine Testing Station (Bruner et al., 1958), and numerous swine testing stations were gradually established throughout the United States. In the early years of swine testing station programs in the various states, different programs were offered. Evidently, each station had different standards, testing procedures, traits evaluated and culling procedures. In addition, many stations were testing only slaughter animals (barrows and gilts), some included both boars and slaughter animals, and others were testing only boars. In 1976, 37 of the 40 central stations were testing boars, and 19 of the 37 were also including sibs for slaughter. Only three central stations tested only slaughter sibs (Bereskin, 1977).

In 1981 the National Swine Improvement Federation (NSIF), representing 8 breed associations and 31 central and on-farm swine testing organizations in 25 states, cooperated with the U.S. Department of Agriculture in publishing revised procedures for measuring and recording swine performance. These programs have established greater uniformity of terminology, procedures, and methods of measuring performance information. Thus the programs have been important in accomplishing rapid and accurate communication to foster cooperation among all segments of the swine industry in compiling and using performance records.

The observed or measured performance of each animal for each trait is the result of its heredity and the total environment in which it is produced. Since differences among animals for economically important traits are due in varying degree to genetic reasons, systematic measurements and use of records in selection can increase the rate of genetic improvement for many traits. Genetically superior individuals can be more readily identified when the animals are maintained under the same management systems and their performance records adjusted for known environmental differences. Through swine testing station programs, primary emphasis has been placed upon improvement of growth rate, carcass composition, and feed efficiency.

In recent years, there has been continuing interest in the relationships between littermate boars and barrows for performance and carcass traits. Numerous research trials, as well as data from swine testing stations, have indicated that boars grow more rapidly, utilize feed more efficiently, and produce carcasses with less fat and more red meat than barrows. However, those results show varying degrees of sex difference because of the variety of breeds and/or strains used, different feeding techniques, and variable slaughter weights.

Average daily gain. Rapid growth is a highly desirable characteristic in swine because of its relatively high relationship to feed efficiency and its economic relationship to overhead costs of buildings. The effect of sex on average daily gain has been studied by numerous workers, but the conclusions have been inconsistent (Table 18). Turton (1969) reviewed several studies on average daily gain and summarized that boars were superior to barrows for average daily gain in about 45% of the reported studies. In about 20% of the studies, there was no difference due to castration, and in the remaining studies barrows were reported superior to boars.

Hansson (1974) studied 169 Landrace (56 boars, 57 barrows, and 56 gilts) and 193 Yorkshire (65 boars, 56 barrows, and 72 gilts) divided randomly among four groups and slaughtered at 154, 198, 243 or 287 pounds live weight, respectively. He found that the boars reached slaughter weight in significantly fewer days than barrows and gilts, except at the 154 pounds level. The difference between boars and barrows was about 10 days ($P<.001$) when slaughtered at 243 pounds. Up to 198 pounds live weight, the gilts were intermediate to boars and barrows, but when they were reared to 243 and 287 pounds, the average daily gain of gilts had decreased. After puberty gilts often refused to eat all the feed given. When fed to higher weights, the boars had about 10% higher average daily gain than gilts and barrows. This report is in general agreement with the results of Pearson et al. (1952), Blair and English (1965), Burgess (1965), and Jones (1971).

For example, Pearson et al. (1952) conducted an experiment to determine the effect of stilbestrol implants for young growing swine of different sexes. He concluded from 30 purebred Duroc pigs (6 lots of 5 pigs each, with two lots of boars, barrows, and gilts) that the control boars grew significantly ($P<.01$) faster than either the control barrows or gilts. Blair and English (1965) conducted a study using 72 littermate purebred Large White pigs (24 each of boars, barrows, and gilts) that were fed individually using a restricted feeding method. They found that boars gained significantly ($P<.001$) faster than barrows and gilts, but found no significant difference between barrows and gilts.

However, there are disagreements and contradictory reports on growth rate, as shown by Winters et al. (1942), Bratzler et al. (1954), Charette (1961), Lidvall et al. (1964), Prescott and Lamming (1964), McCampbell and Baird (1965), Walstra and Kroeske (1968), Fowler et al. (1969), Newell and Bowland (1972), Newell et al. (1973), Pay and Davies (1973), Siers (1975), and Campbell and King (1982).

Winters et al. (1942) were in strong disagreement with many other reports. They used 67 littermate pairs of Poland China boars and barrows and 19 pairs of Minnesota Number 1 pigs for a testing period of 8 to 24 weeks. They found that Poland China boars grew slightly faster than barrows (significant level was found from 8 to 16 weeks or 30 to 100 pounds). In the case of Minnesota Number 1 pigs, the boars were faster growing from 8 to 16 weeks (significant level was found 8 to 12 weeks or 35 to 73 pounds); but thereafter, the barrows grew significantly faster than the boars.

Bratzler et al. (1954) conducted a study comparing 4 pigs each as crossbred boars, control barrows, implanted barrows, and boars castrated at 100, 140, and 180 pounds. They found that treated barrows grew slightly faster than boars, 1.41, 1.52, 1.46, 1.57, and 1.42 pounds/day vs. 1.31 pounds/day, respectively; but there was no statistical difference between the sexes. Similar results between boars and barrows were obtained by Charette (1961) and Newell et al. (1973).

Prescott and Lamming (1964) found no statistical difference between boars and barrows in growth rate. However, the boars grew appreciably slower than barrows, 1.72 vs. 1.81 pounds per day, respectively.

Walstra and Kroeske (1968) compared feeding intensity with growth rate. They found that the barrows grew faster than boars when fed <u>ad</u>

libitum, but with restricted feeding the boars grew faster than the barrows. Fowler et al. (1969) suggested that for high protein rations, boars showed a much greater response than barrows, but the difference was much smaller at lower protein levels.

Newell and Bowland (1972) studied 48 pigs, 16 each of boars, barrows, and gilts for feeding different dietary protein levels, either 18% protein throughout or 16% protein in the growing period (start to 110 pounds), and 13% protein in the finishing period (110 to 198 pounds). They found that for the overall experiment, sex did not significantly influence rate of gain, which averaged 1.59 pounds per day. However, the boars gained (1.92 pounds/day) more rapidly (P<.05) than the gilts (1.76 pounds/day) or the barrows (1.79 pounds/day) in the finishing period. Higher dietary protein level had a significant influence (P<.01) on average daily gain, which was 1.65 pounds/day for the pigs fed the 18% protein diet throughout and 1.52 pounds/day for those fed the 16-13% protein diet. Newell and Bowland (1972) found a signifiant interaction upon rate of gain between dietary protein level and sex for the overall experiment. The boars--and to a lesser extent, the gilts--responded to higher protein levels in terms of rate of gain; the growth rate of barrows was not influenced by dietary protein level. However, Pay and Davies (1973) and Campbell and King (1982) found that no interaction between boars and barrows and protein levels with regard to growth rate.

Siers (1975) studied sex x season interaction by using 114 purebred Yorkshire pigs, including 2 boars, 2 barrows, and 2 gilts each from nineteen individual litters and all fed ad libitum. He found that in the fall season, the gilts grew significantly (P<.05) slower (13%) than the boars, and in the spring season both boars (13%) and barrows (15%) grew faster than gilts (P<.05). However barrows' average daily gain was greater than boars' in the spring but between the boars and gilts in the fall.

Turton (1969) concluded in summarizing several studies that the great variation in the results concerning growth rate is due to the effect of the variety of breeds, strains of the pigs, or different feeding rations and techniques. Turton (1969) further concluded that there are difficulties in comparing the results from experiments performed with pigs of different breeds or under different methods of management.

Backfat thickness. In general, most research results have ranked the sexes in the order of boars, gilts and barrows in terms of superiority for backfat thickness (Table 18). It appears that varying degrees of backfat thickness among the sexes is due to the differences among breeds, feeding techniques, seasons, and slaughter weight.

Bratzler et al. (1954), Hetzer et al. (1956), Charette (1961), Lidvall et al. (1964), Prescott and Lamming (1964), Blair and English (1965), Burgess (1965), McCampbell and Baird (1965), Jones (1971), Newell and Bowland (1972), Pay and Davies (1973), Hansson et al. (1975), Siers (1975), and Cliplef and Strain (1981) reported significantly (P<.05 or .01) less backfat in boars than barrows, and gilts were intermediate (or significantly less backfat than barrows) to boars and barrows.

Hetzer et al. (1956) observed the average of five carcass backfat measurements from pigs slaughtered at approximately 225 pounds was 1.38, 1.57 and 1.54 inches for boars, barrows, and gilts, respectively. Jones (1971) found the average of three carcass backfat measurements in purebred Duroc boars, barrows, and gilts to be 1.10, 1.26 and 1.22 inches when slaughtered at 225 pounds and 1.38, 1.65, and 1.50 inches when slaughtered at 300 pounds. He concluded that there were highly significant differences among the sexes and that growth from 225 pounds to 300 pounds live weight led to increased fat deposition with differences among individuals and sexes becoming more apparent.

Hansson et al. (1975)--using individually restricted fed pigs slaughtered at 154, 198, 243 and 287 pounds live weight--found that both Swedish Landrace and Yorkshire boars had significantly less backfat than barrows, and gilts were intermediate to boars and barrows. Hansson et al. (1975) concluded that the greatest backfat increase occurred from 198 to 243 pounds live weights with Swedish Landrace boars, barrows, and gilts increasing from .79 to .94, .94 to 1.10, and .83 to 1.02 inches, respectively. The Swedish Yorkshire boars, barrows, and gilts increased from .75 to .91, .98 to 1.22, and .91 to 1.10 inches from 198 to 243 pounds live weights.

Siers (1975) studied the effect of sex x season interactions and found that at 220 pounds live weight Yorkshire boars, barrows, and gilts had 1.18, 1.30, and 1.18 inches in the spring season and 1.22, 1.42, and 1.30 inches in the fall season, respectively. He concluded that the barrows were significantly ($P<.01$) fatter than the gilts and the boars in both seasons; however, in the spring season, boars, barrows, and gilts were leaner than in the fall season.

More recently, Cliplef and Strain (1981) reported that the average carcass backfat of faster and slower gaining Yorkshire boar groups was 1.14 and 1.02 inches at 198 pounds slaughter weight. At the same weights, both faster and slower gaining boar groups were significantly leaner than barrow groups (1.54 inches) and gilt groups (1.30 inches).

Pearson et al. (1952) reported that stilbestrol implantation did not materially affect the thickness of backfat in boars, barrows, and gilts (1.44, 1.71, and 1.58 inches at 185 pounds, respectively).

Bratzler et al. (1954) found that delayed castrations at 100 pounds did not significantly influence the thickness of backfat compared to barrows that were castrated at 40.4 pounds, but those castrated at 140 and 180 pounds were significantly leaner. Boars were leaner than barrows castrated at 40.4, 100, 140 or 180 pounds. However, Charette (1961) found that the thickness of carcass backfat was not significantly influenced by delayed castrations at birth, 6, 12, 16, and 20 weeks of age.

Pay and Davies (1973) reported no significant differences for measurements of backfat among pigs fed at different protein levels (16, 18, and 20%) for either boars or barrows, but boars had a significantly lower backfat than barrows. Pay and Davies (1973) concluded that boars did not respond to an increased level of protein in terms of overall growth rate and feed efficiency, from 48.5 to 198 pounds live weight; however, the tendency was toward an increase in protein level producing a corresponding decrease in the fat measurements. A similar finding has been reported by Campbell and King (1982).

Hazel and Kline (1952) introduced the technique of using a simple metal ruler to measure the backfat depth in live pigs as a means of estimating the breeding value of prospective boars and gilts. The correlations between the average of live and carcass measurements at four locations (behind shoulder, middle of back, middle of loin over *longissimus dorsi*, and middle of loin over vertebra) was .81. Measurements made on 96 live hogs at 225 pounds were slightly more accurate as indicators of leanness and percentage of primal cuts than were carcass measurements of backfat thickness. The most accurate locations for probing were just behind the shoulder and at the middle of the loin about 1.5 inches off the midline of the body. DePape and Whatley (1956) reported an intra-breed and sex correlation of .69 between the average of six probes (behind the shoulder, at the middle of the back, and the middle of the loin over the longissimus dorsi on both sides) and the average backfat thickness on the carcass from pigs slaughtered at approximately 210 pounds live weight. Hetzer et al. (1956) reported the correlation of .72 (.62 in boars, .78 in barrows, and .75 in gilts) between the average carcass backfat measurements and the average of three probes (behind the shoulder, at the middle of the back, and at the middle of the loin) at approximately 210 pounds live weight. Holland and Hazel (1958) reported a correlation of .72 between the average of eight backfat measurements (the first, seventh, and last thoracic vertebra, and at the last lumbar vertebra on both sides) on the carcass and the average of three probes (behind the shoulder, at the middle of the back, and at the middle of the loin) at approximately 210 pounds live weight.

Hazel and Kline (1952) reported a correlation between the average of four probes and percentage primal cuts (-.499) slightly larger than the correlation between the average of four backfat measurements on the carcass and percentage primal cuts (-.45). These results were in general agreement with the findings of DePape and Whatley (1956) and Holland and Hazel (1958) that the correlation of -.67 and -.64 for live pig probes and -.58 and -.56 for the average of carcass backfat measurements with percent primal cuts, respectively. However, DePape and Whatley (1956) found that the average of six probes and percent lean cuts (-.57) was lower than the correlation between average carcass backfat measurements and percent lean cuts (-.66). Hetzer et al. (1956) reported the intra-sex and line correlations including live hog measurements taken at approximately 225 pounds live weight of -.28 for average live pig probes and -.29 for average carcass backfat measurements with percentage preferred cuts. Hetzer et al. concluded that with the possible exception of barrows, the measurements of backfat thickness on the live pigs seem to be as accurate for predicting percentage preferred cuts as are measurements of backfat thickness on the carcass.

Hazel and Kline (1952), DePape and Whatley (1956), and Holland and Hazel (1958) reported that the correlations of -.44, -.26, and -.14 (tenth rib) and -.20 (last rib) for average live pig probe and -.41, -.28, and -.16 (tenth rib) and -.09 (last rib) for the measurements of average carcass backfat thickness with the lean area of loin. Holland and Hazel (1958) concluded that the average of three probes on live pigs (behind the shoulder, at the middle of the back, and at the middle of the loin, in each case being 1.5 to 2 inches off the midline of the body) was a more accurate indicator of percent lean cuts and percent fat cuts than were the carcass measurements of backfat, loin area at the tenth rib, loin eye area at the last rib, and carcass length.

Currently, the use of high frequency sound waves (ultrasonics) to detect differences in animal tissue density and thus measure depth of particular tissue layers has been utilized during the past two decades to estimate muscle-fat relationships in farm animals. Hazel and Kline (1959) used an ultrasonic scanning device to estimate fat thickness on 56 pigs weighing from 190 to 250 pounds. Measurements were read two inches off the midline of the back behind the shoulder, at the middle of the back, and at the rear of the loin. The differences due to sex (30 barrows and 26 gilts) and carcass weight were removed. The correlations of average ultrasonic probe at frequencies of 2.5 mc./s. and 1.5 mc./s. with percent lean cuts were -.90 and -.76, respectively, while that with the ruler probe was -.89. Price et al. (1960) showed that the correlation coefficients for the ultrasonic measurements of fat with live ruler probe and carcass backfat thickness were .91 and .88, respectively. Live ruler probes and ultrasonic measurements of fat were equal in value (-.79 ± .01) for predicting lean and primal cut-out.

Burgess (1965) concluded that ultrasonic backfat measurement at the last rib appeared to be the best single indicator of average carcass backfat thickness and was superior to an average of ultrasonic backfat probes at three locations. The ultrasonic backfat measurement at the last rib and the carcass backfat thickness at the last rib are equally suited as indicators of average carcass backfat.

Isler and Swiger (1968) reported that the correlations of ultrasonic backfat with percent lean cuts averaged -.55 while the correlations of carcass backfat with percent lean cuts averaged -.50. This difference might be attributed to the fact that carcass fat was measured on the midline while ultrasonic fat was measured over the longissimus dorsi muscle approximately 5 cm. off the midline at the fourth rib, eighth rib, twelfth rib, third lumbar and last lumbar vertebra.

Loin eye area. Comparisons among boars, barrows, and gilts show that differences in average loin eye area exist (Table 18). In general, boars and gilts have larger loin eye area than barrows. Charette (1961) found that boars and gilts had a significantly larger loin eye area than barrows, but the difference between boars and gilts was not significant. This result is in agreement with the results of Blair and English (1965), Burgess (1965), McCampbell and Baird (1965), Pay and Davies (1973), Hansson et al. (1975), Siers (1975), and Cliplef and Strain (1981). Upon slaughter at 198 pounds, Charette (1961) found no significant difference in loin eye area among barrows that were castrated at birth, 6, 12, 16, and 20 weeks of age. Pay and Davies (1973) found that the loin eye area of boars was significantly larger than for their littermate barrows, but there were no significant differences in loin eye area among three protein diets (16, 18, and 20% protein diets) for either sex.

However, there is disagreement with results obtained by Jones (1971) and Newell and Bowland (1972). They found that gilts were superior to boars or barrows for loin eye area. In the study by Jones (1971), the loin eye area of boars was greater than barrows when slaughtered at approximately 300 pounds live weight, but boars had the smallest loin eye area among sexes when slaughtered at 225 pounds of live weights. Lidvall et al. (1964) and Prescott and Lamming (1964) found no statistical difference among three sexes for loin eye area, but boars had somewhat greater loin eye area than barrows.

CHAPTER III

MATERIALS AND METHODS

Source of data. Swine testing station data used in this study were obtained from 917 litters including 1,804 boars and 917 barrows. The data included 581 barrows and 1,086 boars from the Iowa Swine Testing Station, Ames, Iowa, and 336 barrows and 718 boars from the Northeast Iowa Swine Testing Station at New Hampton, Iowa. The Iowa Station data were obtained over a period of 12 seasons from the fall of 1979 through the fall of 1985, while the data from the Northeast Iowa Station were collected in 8 seasons from the fall of 1981 through the spring of 1985. The spring testing season included pigs born from November through March and the fall testing season included pigs born from May through September. The littermate boars and barrows from the following purebred breeds were used: Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland China, Spotted, and Yorkshire. The distributions of boars and barrows by breed, year, and season are shown in Tables 2 and 3.

The pigs from each litter were fed in duplicate pens of one barrow and from one to four boars each (where the test pen could consist of four to five pigs from one sire). All boar and barrow performance and carcass cutability data were collected from each pen (litter) for a total of 917 pens (litters). From one to three (Ames) or four (New Hampton) boars in each pen were littermates to the barrow. If more than one boar in each pen was a littermate to the barrow, the performance data for the littermate

TABLE 2. IOWA SWINE TESTING STATION--Numbers of Boars and Barrows[a]

Breed / Year / Season[b] / Sex[c]	1979		1980		1981				1982				1983				1984				1985				TOTAL	
	F		S		S		F		S		F		S		F		S		F		S		F			
	B	b	B	b	B	b	B	b	B	b	B	b	B	b	B	b	B	b	B	b	B	b	B	b	B	b
Berkshire	1	1					3	1			2	1	2	1			7	4	3	1	2	1	3	1	23	11
Chester White	1	1	1	1			1	1	3	1	11	5	7	4	2	2	4	2							30	17
Duroc	34	19	16	10	36	20	37	20	54	25	54	30	55	26	32	20	51	25	30	16	23	14	18	9	440	234
Hampshire	11	8	1	1	7	4	8	4	11	6	18	10	5	3	10	5	16	7	9	5	3	1	4	3	103	57
Landrace	7	5	7	3	2	1	10	4	3	1	19	9	12	5	11	5	6	3	8	3	8	4			93	43
Poland China							2	1	3	1			3	2	2	2	5	4	1	1	3	1	3	1	22	13
Spotted	15	10	1	1	7	5	10	6	9	4	20	12	12	8	15	10	17	11	7	4	6	2	5	3	124	76
Yorkshire	18	10	5	3	17	10	25	15	18	8	39	20	26	14	22	11	30	17	29	12	17	7	5	3	251	130
Total	87	54	31	19	69	40	96	52	101	46	163	87	122	63	94	55	136	73	87	42	62	30	38	20	1086	581

[a]The Iowa Swine Testing Station data were obtained over a period of 12 seasons from the fall of 1979 through the fall of 1985.

[b]F=fall; S=spring.

[c]B=boar; b=barrow.

TABLE 3. NORTHEAST IOWA SWINE TESTING STATION--Numbers of Boars and Barrows[a]

Breed	Year / Season[b] / Sex[c]	1981 F B	1981 F b	1982 S B	1982 S b	1982 F B	1982 F b	1983 S B	1983 S b	1983 F B	1983 F b	1984 S B	1984 S b	1984 F B	1984 F b	1985 S B	1985 S b	TOTAL B	TOTAL b
Berkshire				3	1	3	2	1	1	5	2	2	1	5	2			19	9
Chester White				2	1	1	1			3	1	2	1	3	2	1	1	12	7
Duroc		34	21	26	13	35	18	62	27	48	20	25	11	31	14	21	10	282	134
Hampshire		15	7	4	3	18	7	12	6	4	3	7	3	8	3	3	2	71	34
Landrace		3	1	2	1	3	1					3	1					11	4
Poland China								2	1			4	1			4	2	10	4
Spotted		5	3	6	2	8	4	5	2	11	5	5	2	14	8	6	2	60	28
Yorkshire		48	20	9	6	50	19	29	16	24	12	34	16	34	15	25	12	253	116
Total		105	52	52	27	118	52	111	53	95	43	82	36	95	44	60	29	718	336

[a]The Northeast Iowa Swine Testing Station data were obtained over a period of eight seasons from the fall of 1981 through the spring of 1985.

[b]F=fall; S=spring.

[c]B=boar; b=barrow.

boars was averaged. Therefore, many of the 917 values for boar performance represent average values for two, three, or four boars.

Testing procedures. After delivery to the testing stations, boars and barrows were given an adjustment period of 7 to 10 days before being weighed "on-test." Boars and barrows were individually weighed "on-test" at an average pen weight ranging between 65 and 75 pounds and were taken off test when the pen averaged between 220 and 240 pounds. Average daily gain and feed efficiency were calculated when the average weight of each pen was nearest to 230 pounds. Age of boars at both stations and age of barrows at the Northeast Iowa Station were adjusted to 230 pounds live weight. All pigs were fed *ad libitum* during the test period. All test pigs were housed on solid concrete floors with straw used as bedding.

In the Iowa Station, loin eye area and backfat thickness of boars were both measured ultrasonically; however, at the Northeast Iowa Station, backfat was measured with a steel probe (mechanical probe) in 1981 and 1982. In the Northeast Iowa Station, all loin eye area estimates were ultrasonically determined and the backfat measurements were also ultrasonically determined in 1983, 1984, and 1985. Backfat measurements were taken about 2 inches off the midline at the first rib (possibly the fourth or fifth ribs), last rib, and last lumbar vertebra. Loin eye measurements were taken at the tenth rib.

Barrows were slaughtered at weights near 230 pounds, and all carcass data were adjusted to a 230-pound basis. Carcass length was measured from the front of the first rib to the aitch bone. Loin eye area was the cross sectional area of the *longissimus dorsi* muscle measured between the tenth and eleventh ribs. Backfat on all the barrows from the Iowa Station and for the years 1981, 1982, and 1983 from the Northeast Iowa Station was the average of three midline measurements taken at the first rib, last rib, and last lumbar vertebra. For barrows slaughtered from the Northeast Iowa Station during 1984 and 1985, carcass backfat was measured at the tenth rib--at a location 3/4 of the distance from the backbone to the edge of the longissimus dorsi muscle. For barrows from the Northeast Iowa Station, percent muscle was calculated according to procedures outlined by the National Pork Producers Council (1983). Lean gain per day on test was obtained for barrows in the Iowa Station during 1984 and 1985. Both the Iowa Station and the Northeast Station calculated Boar Index using the Iowa indexing procedure where Boar Index = 250 + 50 (daily gain) - 50 (feed/lb. gain) - 50 (backfat probe).

Statistical Procedures. In preliminary analysis, all littermate boar and barrow performance and carcass cutability data were analyzed using standard statistical procedure as outlined by Steel and Torrie (1980). In this case, the analysis of variance was a nested classification with unequal subclass numbers used in determining variance components. The main effects of stations and breeds were chosen as fixed effects, while the years and seasons were chosen at random. The differences between the eight levels of breed were associated with a different set of levels of season, the twenty levels of season were associated with a different set of levels of year, and finally the twelve levels of year were associated with a different set of levels of station. However, the breeds could be combined with all levels of the other factors, and accordingly, observations were made on the total of 917 pens. However, a problem was found because there were no degrees of freedom for some variables in 1979, 1980, 1981, and 1985. When these years had only one season (Tables 2 and 3), the degrees of freedom equaled zero. The zero degrees of freedom indicate that precise statistical information was impossible to obtain. Therefore, all the data combinations of years, seasons, and breeds with degrees of freedom equal to zero were deleted to allow for a valid analysis of variance. The data were then reanalyzed using nested classification with equal degrees of freedom for main effects. Combined data from both stations were anlayzed for three years (1982, 1983, and 1984), six seasons, and four breeds (Duroc, Hampshire, Spotted, and Yorkshire) for a total of 544 pens.

The t test was used to determine differences between boars and littermate barrows for backfat, average daily gain, loin eye area, and days to 230 pounds.

Coefficients of correlation were obtained for all possible combinations of variables using the complete data set. In addition, coefficients of correlation were obtained within breed and within station to determine if different relationships existed among the breeds and stations. The correlation matrix was also obtained for four different periods for the Northeast Iowa Station (1981, 1982 and 1983; 1981 and 1982; 1983; and 1984 and 1985).

CHAPTER IV

RESULTS AND DISCUSSION

Average daily gain. Overall means, standard deviations, and relative differences between boars and barrows for average daily gain in the Iowa and Northeast Iowa Stations are shown in Table 4. The t test for the average daily gain revealed that boars grew significantly (P<.01) faster than barrows in both stations. This result is in accord with the findings of Pearson et al. (1952), Blair and English (1965), Burgess (1965), Jones (1971), and Hansson (1974); it is contradictory to the findings of Winters et al. (1942), who found Minnesota Number 1 barrows grew faster (P<.01) than boars. Bratzler et al. (1954), Charette (1964), Newell et al. (1973), Lidvall et al. (1964), Prescott and Lamming (1964), Newell and Bowland (1972), and Siers (1975) found no significant difference between boars and barrows for average daily gain.

Differences in average daily gain between littermate boars and barrows show that boars grew .03 (2.21±.20 vs. 2.18±.21) and .10 (2.21±.18 vs. 2.11±.22) pounds/day faster than barrows in the Iowa and Northeast Iowa Stations, respectively. Therefore, the differences between boar and barrow values expressed as a percentage of boar values are relatively small (under 5%) for average daily gain.

Backfat thickness. Overall means, standard deviations, and relative differences between boars and barrows for backfat in the Iowa and Northeast Iowa Stations are shown in Table 4. The t test for backfat thickness revealed that boars had significantly (P<.01) less average backfat than

TABLE 4. OVERALL MEANS, STANDARD DEVIATIONS, AND RELATIVE DIFFERENCES BETWEEN BOARS AND BARROWS FOR AVERAGE DAILY GAIN, BACKFAT, AND LOIN EYE AREA IN THE IOWA AND NORTHEAST IOWA SWINE TESTING STATIONS

	Station									
	Iowa					Northeast Iowa				
Trait	N	Boars	Barrows	B-b	%BV	N	Boars	Barrows	B-b	%BV
ADG (lb)	581	2.21±.20	2.18±.21	.03**	1.36	336	2.21±.18	2.11±.22	.10**	4.52
BF (in)	581	.80±.08	1.38±.20	- .58**	72.50	---	---	---	---	---
BF (in)[a]	---	---	---	---	---	131	.75±.08	1.29±.18	- .54**	72.00
BF (in)[b]	---	---	---	---	---	96	.79±.05	1.31±.19	- .52**	65.82
BF (in)[c]	---	---	---	---	---	109	.76±.06	1.06±.21	- .30**	39.47
LEA (sq in)	581	5.49±.42	4.82±.67	.67**	12.22	336	5.62±.28	4.96±.65	.66**	11.74
D230 (day)[d]	581	150.00±10.46	---	---	---	336	156.00±10.78	163.00±12.90	7.00**	4.50

[a]Boar backfat = average of three mechanical probe measurements, barrow backfat = average of three midline carcass measurements (1981 and 1982).

[b]Boar backfat = average of three ultrasonic measurements, barrow backfat = average of three midline carcass measurements (1983).

[c]Boar backfat = average of three ultrasonic measurements, barrow backfat = depth of fat over the *longissimus dorsi* at tenth rib (1984 and 1985).

[d]Days to 230 pounds (Iowa Swine Testing Station, Days to 230 pounds was only obtained by boars).

**$P<.01$ (*t* test for differences between boars and barrows).

barrows in both stations. In the Northeast Iowa Station, boar backfat thickness was significantly (P<.01) less than for barrows (see Table $4^{a,b,c}$). This result is in accord with the findings of Bratzler et al. (1954), Hetzer et al. (1956), Charette (1961), Lidvall et al. (1964), Prescott and Lamming (1964), Blair and English (1965), Burgess (1965), McCampbell and Baird (1965), Jones (1971), Newell and Bowland (1972), Pay and Davies (1973), Hansson et al. (1975), Siers (1975), and Cliplef and Strain (1981); it disagrees with the findings of Pearson et al. (1952), who reported boars had thicker backfat than barrows. However, in the Pearson et al. (1952) study the boars were approximately 35 pounds heavier than other treatment groups at final weights.

Differences in backfat thickness between littermate boars and barrows show that boars had .58 (.80±.08 vs. 1.38±.20) inches less backfat thickness than barrows for the overall period in the Iowa Station. In the Northeast Iowa Station, backfat measurements were measured differently for three different periods. The difference between the average boar backfat and the tenth rib backfat of littermate barrows was .30 (.76±.06 vs. 1.06±.21), which was a significantly smaller difference than the differences between average boar backfat and the average carcass backfat of littermate barrows--.54 (.75±.08 vs. 1.29±18) and .52 (.79±.05 vs. 1.31±.19). Sex differences for backfat thickness expressed as a percentage of boar values were relatively high (39.47%, 72.00%, and 65.82%).

Loin eye area. Overall means, standard deviations, and relative differences between boars and barrows for loin eye area in the Iowa and Northeast Iowa Stations are shown in Table 4. The t test for loin eye area revealed that boars had significantly (P<.01) greater loin eye areas (ultrasonically estimated at tenth rib) than barrows (actual loin eye area at tenth rib) in both stations. The loin eye areas of boars averaged .67 (5.49±.42 vs. 4.82±.67) and .66 (5.62±.28 vs. 4.96±.65) square inches larger than loin eye areas of littermate barrows (actual loin eye area at tenth rib) in the Iowa and Northeast Iowa Stations, respectively. The difference between boar and barrow loin eye area expressed as a percent of boar loin eye area was slightly over 10 percent. This result is in agreement with the findings of Charette (1961), Blair and English (1965), Burgess (1965), McCampbell and Baird (1965), Jones (1971), Pay and Davies (1973), Hansson et al. (1975), Siers (1975), and Cliplef and Strain (1981); it is in disagreement with the findings of Jones (1971), who found barrows and gilts had larger loin eye area than boars when slaughtered at 225 pounds. Lidvall et al. (1964), Prescott and Lamming (1964), and Newell and Bowland reported no significant differences between boars and barrows for loin eye area.

Days to 230 pounds. Overall means, standard deviations, and relative differences between boars and barrows for days to 230 pounds in the Northeast Iowa Station are shown in Table 4. The t test for days to 230 pounds revealed that boars averaged seven days younger (P<.01) at 230 pounds than barrows (156.00±10.78 vs. 163.00±12.90). Hansson (1974) suggested that boars reached a slaughter weight of 243 pounds about ten days younger than barrows.

Other traits. Overall means and standard deviations for selected performance and carcass traits in the Iowa and Northeast Iowa Stations are shown in Table 5. Entry weight and age were 57.12±11.84 pounds and 67.69±9.34 days and 56.52±11.06 pounds and 73.30±12.38 days in the Iowa and Northeast Iowa Stations, respectively. These figures indicate that entry weight at both stations was about the same, but entry age at the Iowa

TABLE 5. OVERALL MEANS AND STANDARD DEVIATIONS FOR SELECTED PERFORMANCE AND CARCASS TRAITS IN THE IOWA AND NORTHEAST IOWA SWINE TESTING STATIONS

	Station			
	Iowa		Northeast Iowa	
Trait[a]	N	Mean ± s	N	Mean ± s
D230B (Day)	581	150.00±10.46	336	156.00±10.78
Feed Efficiency	581	2.49± .18	336	2.46± .13
Boar Index	581	196.37±14.74	336	199.08±12.26
Entry Weight (lb)	581	57.12±11.84	336	56.52±11.06
Entry Age (day)	581	67.69±9.34	336	73.30±12.38
Length (in)	581	31.40± .89	336	31.68± .86
LG/Day (lb)	64	0.74± .06	---	---
% Muscle	---	---	336	54.42±3.14

[a]D230B = days to 230 pounds for boar; LG/day = lean gain per day on test.

Station was about 5 days younger than at the Northeast Iowa Station. For boars in the Iowa Station, days to 230 pounds averaged six less than for boars in the Northeast Iowa Station. However, feed efficiency (pen basis) in the Northeast Iowa Station and in the Iowa Station was nearly equal (2.46±.13 vs. 2.49±.18). Boar index, which was based upon three economic traits (ADG, BF, and FE) was also nearly equal, for the Northeast Iowa Station and the Iowa Station (199.08±12.26 vs. 196.37±14.47 units). The carcass length of barrows in the Iowa Station and Northeast Iowa Stations was 31.40±.89 and 31.68±.86, respectively. In the Iowa Station barrows had .74±.06 pound of muscle per day on test and barrows in the Northeast Iowa Stations had 54.42±3.14 percent muscle, respectively.

Breed effect. Overall breed means, standard deviations, and relative differences between boars and barrows for average daily gain, backfat, loin eye area, and days to 230 pounds in the Iowa and Northeast Iowa Stations are shown in Tables 6 and 7.

The t test for average daily gain revealed no significant (P>.05) differences between boars and barrows for the eight major breeds in the Iowa Station. However, at the Northeast Iowa Station, the Duroc (2.39±.19 vs. 2.12±.21) and Hampshire (2.16±.17 vs. 2.07±.24) boars grew significantly (P<.01) faster than littermate barrows. Although the sample size was small and the differences nonsignificant, there were some breeds in which barrows appeared to grow faster than boars. For the Chester White (2.06±.11 vs. 2.19±.21) and Landrace (2.20±.19 vs. 2.23±.20) breeds in the Iowa Station and the Berkshire (2.06±.13 vs. 2.09±.15) and Poland China (2.07±.13 vs. 2.11±.14) breeds in the Northeast Iowa Station, barrows grew faster than littermate boars. Additional observations are needed to make inferences about breed differences; however, these data suggest there may

TABLE 6. OVERALL BREED MEANS, STANDARD DEVIATIONS, AND RELATIVE DIFFERENCES BETWEEN BOARS AND BARROWS FOR AVERAGE DAILY GAIN, BACKFAT, AND LOIN EYE AREA IN THE IOWA SWINE TESTING STATION

		Breed							
Trait	Sex	Berkshire N=11	Chester White N=17	Duroc N=234	Hampshire N=57	Landrace N=43	Poland China N=13	Spotted N=76	Yorkshire N=130
ADG (lb/day)	B	2.21±.23	2.06±.11	2.24±.20	2.19±.23	2.20±.19	2.12±.14	2.18±.18	2.22±.19
	b	2.13±.20	2.19±.21	2.20±.22	2.15±.19	2.23±.20	2.11±.20	2.14±.20	2.19±.23
	B-b	.08	-.13	.04	.04	-.03	.01	.04	.03
	%BV	3.62	6.31	1.79	1.83	1.36	.47	1.83	1.35
BF (in)	B	.83±.08	.85±.10	.79±.08	.75±.05	.82±.07	.83±.06	.83±.07	.79±.08
	b	1.50±.15	1.60±.24	1.34±.19	1.25±.19	1.40±.20	1.34±.13	1.39±.18	1.47±.18
	B-b	-.67**	-.75**	-.55**	-.50**	-.58**	-.51**	-.56**	-.68**
	%BV	80.72	88.23	69.62	66.67	70.73	61.45	67.47	86.08
LEA (sq in)	B	5.30±.25	5.49±.36	5.54±.43	5.66±.46	5.38±.46	5.19±.36	5.40±.37	5.43±.36
	b	4.46±.68	4.69±.58	4.84±.65	5.34±.76	4.56±.63	4.91±.82	4.87±.56	4.63±.60
	B-b	.84**	.80**	.70**	.32**	.82**	.28	.53**	.80**
	%BV	15.85	14.57	12.64	5.65	15.24	5.39	9.81	14.73

**$P < .01$ ($\underline{t}$ test for differences between boars and barrows).

TABLE 7. OVERALL BREED MEANS, STANDARD DEVIATIONS, AND RELATIVE DIFFERENCES BETWEEN BOARS AND BARROWS FOR AVERAGE DAILY GAIN, BACKFAT, LOIN EYE AREA, AND DAYS TO 230 POUNDS IN THE NORTHEAST IOWA SWINE TESTING STATION

		Breed							
Trait	Sex	Berkshire N=9	Chester White N=7	Duroc N=134	Hampshire N=34	Landrace N=4	Poland China N=4	Spotted N=28	Yorkshire N=116
ADG (lb/day)	B	2.06±.13	2.02±.06	2.23±.19	2.16±.17	2.20±.17	2.07±.13	2.12±.12	2.24±.19
	b	2.09±.15	1.93±.10	2.12±.21	2.07±.24	2.09±.31	2.11±.14	2.06±.20	2.15±.24
	B-b	-.03	.09	.11**	.09*	.11	-.04	.06	.09
	%BV	1.46	4.46	4.93	4.17	5.00	1.93	2.83	4.02
BF (in)	B	.79±.04	.77±.04	.76±.07	.72±.07	.84±.06	.73±.05	.78±.05	.77±.06
	b	1.27±.18	1.27±.29	1.20±.19	1.07±.20	1.40±.30	1.10±.32	1.27±.21	1.26±.23
	B-b	-.48**	-.50**	-.44**	-.35**	-.56*	-.37	-.49**	-.49**
	%BV	60.76	64.94	57.89	48.61	66.67	50.68	62.82	63.64
LEA (sq in)	B	5.69±.25	5.65±.22	5.62±.27	5.88±.28	5.39±.10	5.62±.16	5.47±.14	5.56±.28
	b	5.05±.54	4.66±.28	4.93±.56	5.56±.76	4.83±.97	4.59±.35	5.15±.59	4.81±.63
	B-b	.64**	.99**	.69**	.32*	.56	1.03**	.32**	.75**
	%BV	11.25	17.52	12.28	5.44	10.39	18.33	5.85	13.49
D230	B	164.11±9.45	158.14±7.56	154.33±10.42	157.15±12.27	158.00±7.62	158.25±9.81	159.00±8.60	155.90±11.29
	b	166.11±9.27	167.57±10.36	161.90±11.35	164.30±16.40	167.75±9.00	159.25±11.79	163.70±9.48	161.82±14.58
	B-b	-2.00	-9.43**	-7.57**	-7.15**	-9.75	-1.00	-4.70*	-5.92**
	%BV	1.22	5.96	4.91	4.55	6.17	.63	2.96	3.80

*P<.05 (t test for differences between boars and barrows).

**P<.01 (t test for differences between bcars and barrows).

be major differences in boar/barrow performance among the breeds. For the eight major breeds, sex differences between boar and barrow performance expressed as a percent of boar performance are relatively small for average daily gain.

The t test for backfat thickness revealed that boars had significantly (P<.01) less average backfat than littermate barrows (average carcass backfat) for the eight major breeds in the Iowa Station, while at the Northeast Iowa Station, seven major breeds had significant (P<.01 or .05) differences between littermate boars and barrows. The Poland China breed had no significant (P>.05) difference between boars and barrows for backfat thickness; however, only four pens of Poland China pigs were included.

For both stations, the difference in backfat thickness between boars and barrows was lowest for the Hampshire breed, and the greatest differences were between boars and barrows in the Chester White, Yorkshire, Berkshire and Landrace breeds. There is no known physiological difference among the breed that would account for the difference in fatness between boars and barrows; but since Hampshires were the leanest breed, it seems logical that the sex difference should be the smallest. Differences in androgen levels among boars of the various breeds could also be responsible for some sex differences.

The t test for loin eye area revealed that boars had significantly (P<.01 or .05) greater loin eye area (ultrasonically estimated at tenth rib) than barrows (actual loin eye area at tenth rib) for all breeds except Poland China in the Iowa Station and for all breeds except Landrace in the Northeast Iowa Station. There were too few Poland China pigs (13 pens) in the Iowa Station to allow for accurate evaluation of the sex difference. The differences between Landrace boars and barrows was quite large (.56

square inches); however, data were available for only 4 pens of Landrace pigs in the Northeast Iowa Station.

The lowest difference (.32 square inches) in loin eye area between boars and barrows was for Hampshires, and the greatest difference was for the Berkshire, Landrace, Chester White and Yorkshire breeds (.84, .82, .80, and .80 square inches, respectively) in the Iowa Station. The difference between boar and barrow loin eye area expressed as a percentage of boar loin eye area ranged from 5% for Hampshires in both stations to 17% for Chester White in the Iowa Station and 18% for Poland China in the Northeast Iowa Station.

The *t* test for days to 230 pounds revealed that for Chester White, Duroc, Hampshire, Spotted, and Yorkshire boars reached 230 pounds from 5 to 9 days faster ($P<.01$ or .05) than littermate barrows. However, for the Berkshire, Landrace, and Poland China breeds there were no statistical differences between boars and barrows for this trait. For the Landrace breed the difference between boars and barrows was approximately 10 days--but this difference was nonsignificant because of the small number of observations.

Overall breed means and standard deviations for other selected performance and carcass traits are shown in Table 8. Entry weight and entry age were approximately the same among the eight major breeds in the Iowa and Northeast Iowa Stations. However, the Duroc, Hampshire, Landrace, Poland China, and Yorkshire boars were younger at 230 pounds than the Berkshire, Chester White, and Spotted boars in both the Iowa and Northeast Iowa Stations. The feed efficiency and Iowa boar index in the Iowa and Northeast Iowa Stations indicated that the Duroc, Hampshire, and Yorkshire breeds were superior to all other breeds.

TABLE 8. OVERALL BREED MEANS AND STANDARD DEVIATIONS FOR SELECTED PERFORMANCE AND CARCASS TRAITS IN THE IOWA AND NORTHEAST IOWA SWINE TESTING STATIONS

	Station													
	Iowa							Northeast Iowa						
Breed	N	D230B (day)	FE	BI	Length (in)	EW (lb)	EA (day)	N	FE	BI	Length (in)	%M	EW (lb)	EA (day)
Berkshire	11	157.73 ±10.47	2.61 ±.12	189.04 ±12.09	31.18 ±.64	51.50 ±11.20	71.27 ± 9.91	9	2.59 ±.11	184.06 ±10.40	31.34 ±.66	54.62 ±2.51	58.20 ±6.50	79.00 ±6.75
Chester White	17	156.53 ± 9.95	2.54 ±.13	183.48 ± 8.60	30.50 ±.60	60.18 ±11.95	70.76 ±11.00	7	2.56 ±.09	184.67 ± 5.59	31.30 ±.91	52.21 ±2.67	64.10 ±9.88	75.14 ±7.10
Duroc	234	148.51 ±10.84	2.43 ±.18	201.46 ±14.12	31.10 ±.85	57.42 ±11.92	67.12 ± 9.64	134	2.43 ±.13	202.07 ±12.08	31.48 ±.84	54.66 ±3.06	55.80 ±11.07	70.95 ±11.79
Hampshire	57	151.32 ±12.13	2.47 ±.20	198.45 ±16.41	31.33 ±.72	55.92 ±13.92	67.50 ±11.11	34	2.46 ±.11	198.90 ±12.09	31.62 ±.83	57.40 ±3.07	57.86 ±14.86	74.09 ±17.42
Landrace	43	147.26 ± 8.23	2.54 ±.19	192.27 ±13.91	32.25 ±.85	58.61 ±11.90	66.20 ± 7.88	4	2.64 ±.04	186.60 ± 8.77	32.40 ±1.51	51.60 ±4.65	56.83 ± 9.94	81.25 ± 8.99
Poland China	13	145.85 ±11.11	2.65 ±.15	182.26 ± 6.76	31.18 ±.95	59.73 ± 5.54	62.92 ±10.46	4	2.51 ±.11	191.00 ± 9.13	31.50 ± .53	52.68 ±2.17	58.18 ± 7.40	79.25 ± 8.54
Spotted	76	152.18 ± 9.77	2.60 ±.16	187.56 ±13.01	31.57 ±.77	56.94 ±12.56	68.44 ± 8.31	28	2.57 ±.12	189.06 ± 9.33	31.74 ± .77	54.13 ±2.45	55.71 ± 8.82	73.25 ±10.09
Yorkshire	130	150.62 ± 9.08	2.50 ±.16	196.53 ±12.89	31.76 ±.77	56.53 ±10.69	68.65 ± 8.39	116	2.45 ±.12	200.84 ±10.83	31.95 ± .85	53.63 ±2.87	56.50 ±10.77	74.75 ±12.23

Year and season mean. Overall year and season means and relative differences between boars and barrows for average daily gain, backfat, loin eye area, and days to 230 pounds and overall year and season means for selected performance and carcass traits in the Iowa and Northeast Iowa Stations are shown in Tables 9, 10, and 11.

The t test for sex differences between littermate boars and barrows for average daily gains were not significant (P>.05) except for 1984 and 1985. For the overall season means, the t test showed boars grew faster (P<.01) than barrows in the spring, but there was no significant (P>.05) difference between the sexes in the fall. In the Northeast Iowa Station, the sex differences between littermate boars and barrows for average daily gains were significantly different (P<.01) except for 1981.

The t test for sex differences between littermate boars and barrows for backfat and loin eye area were significant (P<.01) for all years and seasons in the Iowa and Northeast Iowa Stations. The sex differences between littermate boars and barrows for backfat and loin eye area have been increasing in the Iowa Station. The summary of Iowa Station data (Table 1) suggested that the sex difference between boars and barrows for backfat thickness has increased from .31 inches in the 1950's to .59 inches in the 1980's. The largest increase has occurred during the last five years. The increase in the boar-barrow difference for backfat thickness and loin eye area in the swine industry may indicate that swine breeders have indeed been unsuccessful in selecting boars (and gilts) to produce leaner, heavier muscled progeny. Measurement errors associated with ultrasonic estimates of backfat and loin eye area of boars may be attributing to the increase in sex differences. However, in the Northeast Iowa Station the sex difference between boars and barrows for carcass

TABLE 9. OVERALL YEAR AND SEASON MEANS AND RELATIVE DIFFERENCES BETWEEN BOARS AND BARROWS FOR AVERAGE DAILY GAIN, BACKFAT, AND LOIN EYE AREA IN THE IOWA SWINE TESTING STATION

Trait	Sex	Year 1979 N=54	1980 N=19	1981 N=92	1982 N=133	1983 N=118	1984 N=115	1985 N=50	Season Spring N=271	Fall N=310
ADG (lb/day)	B	2.08	2.20	2.16	2.23	2.22	2.22	2.36	2.20	2.22
	b	2.05	2.17	2.17	2.27	2.20	2.15	2.20	2.16	2.21
	B-b	.03	.03	-.01	-.04	.02	.07**	.16**	.04**	.01
	%BV	1.44	1.36	.46	1.79	.90	3.15	6.78	1.82	.45
BF (in)	B	.76	.81	.77	.80	.81	.79	.85	.80	.79
	b	1.29	1.33	1.34	1.36	1.38	1.44	1.50	1.37	1.38
	B-b	-.53**	-.52**	-.57**	-.56**	-.57**	-.65**	-.65**	-.57**	-.59**
	%BV	69.74	64.20	74.03	70.00	70.37	82.28	76.47	71.25	74.68
LEA (sq in)	B	5.90	6.28	5.61	5.53	5.44	5.18	5.19	5.49	5.48
	b	4.90	5.05	4.98	4.99	4.82	4.58	4.42	4.83	4.81
	B-b	1.00**	1.23**	.63**	.54**	.62**	.60**	.77**	.66**	.67**
	%BV	16.95	19.59	11.23	9.76	11.40	11.58	14.84	12.02	12.23

**P<.01 (t test for differences between boars and barrows).

TABLE 10. OVERALL YEAR AND SEASON MEANS AND RELATIVE DIFFERENCES BETWEEN BOARS AND BARROWS FOR AVERAGE DAILY GAIN, BACKFAT, LOIN EYE AREA, AND DAYS TO 230 POUNDS IN THE NORTHEAST IOWA SWINE TESTING STATION

		Year					Season	
Trait	Sex	1981[a] N=52	1982[a] N=79	1983[b] N=96	1984[c] N=80	1985[c] N=29	Spring N=145	Fall N=191
ADG (lb/day)	B	2.22	2.20	2.19	2.20	2.25	2.21	2.20
	b	2.16	2.08	2.10	2.13	2.14	2.13	2.10
	B-b	.06	.12**	.09**	.07**	.11**	.08**	.10**
	%BV	2.70	5.46	4.29	3.18	4.89	3.62	4.55
BF (in)	B	.74	.76	.79	.76	.77	.77	.76
	b	1.28	1.30	1.31	1.03	1.13	1.18	1.25
	B-b	-.54**	-.54**	-.52**	-.27**	-.36**	-.41**	-.49**
	%BV	72.97	71.05	65.82	35.53	46.75	53.25	64.47
LEA (sq in)	B	5.61	5.64	5.59	5.64	5.56	5.59	5.64
	b	4.98	4.98	5.01	4.89	4.94	4.92	4.99
	B-b	.63**	.66**	.58**	.75**	.62**	.67**	.65**
	%BV	11.23	11.70	10.38	13.30	11.15	11.99	11.52
D230 (day)	B	159.63	156.46	157.02	154.23	149.41	152.92	158.28
	b	165.52	164.53	164.35	158.76	156.03	159.81	164.59
	B-b	-5.89**	-8.07**	-7.33**	-4.53**	-6.62**	-6.89**	-6.31**
	%BV	3.69	5.16	4.67	2.94	4.43	4.51	3.99

**P<.01 (t test for differences between boars and barrows).

[a,b,c]Boar and barrow backfat measurements were explained in Table 4.

TABLE 11. OVERALL YEAR AND SEASON MEANS FOR SELECTED PERFORMANCE AND CARCASS TRAITS IN THE IOWA AND NORTHEAST IOWA SWINE TESTING STATIONS

	Station													
	Iowa							Northeast Iowa						
Source	N	D230 (day)	FE	BI	Length (in)	EW (lb)	EA (day)	N	FE	BI	Length (in)	%M	EW (lb)	EA (day)
Year														
1979	54	155.00	2.45	192.64	31.75	50.58	63.78	---	----	----	----	---	---	---
1980	19	154.05	2.47	195.85	31.50	58.00	70.11	---	----	----	----	---	---	---
1981	92	152.20	2.45	197.05	31.45	55.80	68.76	52	2.54	197.10	31.56	55.08	57.50	78.24
1982	133	149.92	2.42	201.09	31.30	57.26	68.71	79	2.44	200.00	31.64	54.84	60.42	75.46
1983	118	150.31	2.51	195.25	31.12	55.00	66.51	96	2.45	198.15	31.70	54.53	54.90	72.42
1984	115	148.73	2.60	192.16	31.56	60.53	68.12	80	2.47	198.82	31.85	54.21	54.61	70.34
1985	50	141.42	2.54	191.10	31.48	63.18	68.16	29	2.40	203.93	31.47	52.34	54.86	69.60
Season														
Spring	271	149.55	2.48	196.25	31.31	58.40	67.14	145	2.40	201.91	31.94	54.08	55.48	71.18
Fall	310	150.40	2.50	196.47	31.48	56.01	68.18	191	2.51	196.93	31.50	54.68	57.30	74.90

backfat measurements at the tenth rib were much smaller in 1984 and 1985 than for the average carcass backfat measurements in 1981, 1982, and 1983 (.27 and .36 vs. .54, .54, and .52 inches).

Season results indicate that the backfat thickness and loin eye area were almost the same in the Iowa Station. However, in the Northeast Iowa Station the backfat thickness of barrows in the spring season was about .07 inches (5.93%) less than in the fall season. Similar results were found by Siers (1975), who reported Yorkshire boars and barrows had slightly thinner backfat thickness in the spring season (1.18 and 1.30 inches) than in the fall season (1.22 and 1.42 inches).

The *t* test for differences between boars and barrows for days to 230 pounds were significant ($P<.01$) in all years and seasons in the Northeast Iowa Station. The difference between boars and barrows was from five to eight days over five years. In comparing data for 1981 and 1985, both boars and barrows averaged ten days younger at 230 pounds in 1985 than in 1981. In addition, days to 230 pounds for boars in the Iowa Station in 1985 averaged 14 days younger than in 1979.

Season results indicate that boars and barrows averaged five days younger at 230 pounds in the spring than in the fall season in the Northeast Iowa Station. Both feed efficiency and boar index were more desirable in the spring than in the fall season. Pen feed efficiency was .11 (4.58%) lower and boar index was 4.98 units (2.47%) higher in the spring than in the fall season.

Analysis of variance. The least squares analysis of variance for selected traits in the Iowa and Northeast Iowa Stations are shown in Table 12. Station differences were significant ($P<.01$) for all traits except average daily gain of boars, loin eye area of barrows, boar index, and

TABLE 12. LEAST SQUARES ANALYSIS OF VARIANCE FOR SELECTED TRAITS IN THE IOWA AND NORTHEAST IOWA SWINE TESTING STATIONS (1982, 1983, AND 1984 FOR DUROC, HAMPSHIRE, SPOTTED, AND YORKSHIRE)

		Trait											
Source	df	ADGB	ADGb	BF	ABF	LEAB	LEAb	D230B	Length	FE	BI	EW	EA
Among Station	1		**	**	**	**	*	**	**	**	*		**
Among Year w/n Station	4		**	**	**	**	**		**	**	**	**	**
Among Season w/n Year w/n Station	6	*	**	**	**	**			**	**	**		*
Among Breed w/n Season w/n Year w/n Station	36			**	**	**	**		**	**	**		
Residual	496	.0337	.0435	.0033	.0305	.0638	.3753	106.18	.5914	.0181	151.74	127.64	99.671

*P<.05.

**P<.01.

entry weight. Station differences for loin eye area of barrows and boar index were significant (P<.05), but the station differences for average daily gain of boars and entry weight were not significant (P>.05). Station differences are likely due to sampling differences of the breeds and pigs selected for the testing stations; however, the differences may reflect some genetic differences that are difficult to determine.

Among year within station differences were significant (P<.01) for all traits except average daily gain and days to 230 pounds of boars.

Among season within year within station differences were significant (P<.01) for all traits except average daily gain of boars, loin eye area of barrows, days to 230 pounds of boars, entry weight, and entry age. Among season within year within station differences for average daily gain of boars and entry age were significant (P<.05), but the among season within year within station differences for loin eye area of barrows, days to 230 pounds of boars, and entry weight were not significant (P>.05).

Highly significant among breed within season within year within station differences were observed for most traits, but average daily gain of boars and barrows, days to 230 pounds of boars, entry weight, and entry age were not significant.

Coefficients of correlation. Correlations between performance and carcass traits among all pens in the Iowa Station (N=581) and four different periods for the Northeast Iowa Station (N=227, 131, 96, and 109) are shown in Tables 13, 14, and 15.

The coefficients of correlation between littermate boars and barrows for average daily gain, backfat thickness, and loin eye area were .41, .37, and .21, respectively, in the Iowa Station. In the Northeast Iowa Station, the coefficients of correlation between littermate boars and barrows for

TABLE 13. CORRELATIONS BETWEEN PERFORMANCE AND CARCASS TRAITS AMONG ALL PENS IN THE IOWA SWINE TESTING STATION (N=581)[a]

Trait	(13)	(12)	(11)	(10)	(9)	(8)[b]	(7)	(6)	(5)	(4)	(3)	(2)	(1)
(1) ADG (Boar)	.01	.06	.16	.70	-.09	.13	-.65	-.12	-.26	.14	.10	.41	1.00
(2) ADG (Barrow)	.06	.04	.01	.31	-.11	.53	-.24	-.14	-.14	.14	.11	1.00	
(3) UBF (Boar)[c]	-.06	.03	-.00	-.29	.15	-.23	-.07	-.22	-.02	.37	1.00		
(4) ABF (Barrow)	-.21	.13	.01	-.15	.24	-.37	-.00	-.40	-.16	1.00			
(5) LEA (Boar)	-.07	-.15	-.21	-.05	-.20	-.07	.21	.21	1.00				
(6) LEA (Barrow)	-.11	-.04	.02	.14	-.26	.45	.03	1.00					
(7) D230 (Boar)	-.03	.37	-.32	-.46	.07	-.10	1.00						
(8) LG/Day (Barrow)[b]	.21	.11	.17	.17	-.06	1.00							
(9) FE	.02	.00	.01	-.72	1.00								
(10) Boar Index	.01	.03	.10	1.00									
(11) Entry Weight	.05	.56	1.00										
(12) Entry Age	.01	1.00											
(13) Length	1.00												

[a] $r_{.05}$=.08, $r_{.01}$=.11.

[b] N=64, $r_{.05}$=.25, $r_{.01}$=.32.

[c] UBF=ultrasonic backfat.

TABLE 14. CORRELATIONS BETWEEN PERFORMANCE AND CARCASS TRAITS AMONG 227 PENS IN THE NORTHEAST IOWA SWINE TESTING STATION (1981, 1982, and 1983)[a]

Trait	(14)	(13)	(12)	(11)	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)
(1) ADG (Boar)	-.11	.07	-.00	.16	.75	-.13	-.37	-.61	-.09	.09	.03	.21[b] .02[c]	.54	1.00
(2) ADG (Barrow)	-.12	.17	.03	.14	.41	-.04	-.69	-.35	-.04	.14	.08	.08[b] .18[c]	1.00	
(3) BFP (Boar)[b]	-.21	-.24	.01	.01	-.22	.10	.03	-.03	-.11	-.06	.27	1.00		
UBF (Boar)[c]	-.08	-.19	-.06	-.08	-.20	.01	.01	-.04	-.03	.20	.21	1.00		
(4) ABF (Barrow)	-.63	-.16	-.03	-.04	-.12	.10	-.06	-.00	-.39	-.15	1.00			
(5) LEA (Boar)	.20	-.03	-.03	.10	.21	-.26	-.16	-.13	.26	1.00				
(6) LEA (Barrow)	.86	.03	-.01	.03	-.00	-.07	.03	.03	1.00					
(7) D230 (Boar)	.05	-.11	.45	-.09	-.61	-.29	.68	1.00						
(8) D230 (Barrow)	.09	-.20	.40	-.02	-.38	.20	1.00							
(9) FE	-.09	-.12	.37	.17	-.66	1.00								
(10) Boar Index	.03	.18	-.18	.04	1.00									
(11) Entry Weight	.04	.02	.62	1.00										
(12) Entry Age	.02	-.01	1.00											
(13) Length	.03	1.00												
(14) % Muscle	1.00													

[a]N=227 (1981, 1982, and 1983), $r_{.05}$=0.13, $r_{.01}$=0.17.

[b]BFP=backfat probe; N=131 (1981 and 1982), $r_{.05}$=0.17, $r_{.01}$=0.22.

[c]N=96 (1983), $r_{.05}$=.20, $r_{.01}$=0.26.

TABLE 15. CORRELATIONS BETWEEN PERFORMANCE AND CARCASS TRAITS AMONG 109 PENS IN THE NORTHEAST IOWA SWINE TESTING STATION (1984 and 1985)[a]

Trait	(14)	(13)	(12)	(11)	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)
(1) ADG (Boar)	.03	-.11	-.03	.07	.86	-.34	-.25	-.64	.10	.26	-.13	.15	.46	1.00
(2) ADG (Barrow)	-.06	.13	.05	.05	.38	-.13	-.70	-.33	-.03	.03	-.12	.11	1.00	
(3) UBF (Boar)	-.33	-.07	.05	.02	-.10	.00	-.05	-.12	-.19	-.08	.39	1.00		
(4) ABF (Barrow)	-.77	-.36	.17	.17	-.22	.10	.13	.19	-.38	-.22	1.00			
(5) LEA (Boar)	.24	-.09	.01	-.02	.30	-.19	.07	-.16	.23	1.00				
(6) LEA (Barrow)	.76	-.20	-.07	-.05	.09	.05	-.04	-.08	1.00					
(7) D230 (Boar)	-.02	.01	.41	-.09	-.61	.35	.60	1.00						
(8) D230 (Barrow)	.04	-.15	.34	-.02	-.22	.10	1.00							
(9) FE	.02	-.16	.23	.17	-.74	1.00								
(10) Boar Index	.08	.03	-.14	-.04	1.00									
(11) Entry Weight	-.15	.09	.66	1.00										
(12) Entry Age	-.13	.09	1.00											
(13) Length	.13	1.00												
(14) % Muscle	1.00													

[a] $r_{.05}=.19$, $r_{.01}=.25$.

average daily gain were .54 (N=227) and .45 (N=109); for backfat thickness, .27 (N=131), .21 (N=96) and .39 (N=109); for loin eye area, .26 (N=227) and .23 (N=109); and for days to 230 pounds, .68 (N=227) and .60 (N=109), respectively.

Since carcass traits are more highly heritable than growth traits (.5 vs. .3), the coefficients of correlation between littermates are expected to be higher for the more highly heritable traits such as backfat thickness and loin eye area. These correlations suggest a stronger association between littermate boars and barrows for growth traits than for carcass composition traits; therefore, castration appears to have a more variable effect upon backfat and loin eye area than on growth rate or days to 230 pounds.

Other coefficients of correlation between various traits were statistically significant; however, the numerical values of most of the correlations were less than .25. Therefore, these low correlations indicate that little information on the boars or barrows would be of value for predicting performance or carcass traits for the other sex. These low associations may indicate that some measurement errors may have been involved in obtaining part of the data. The errors most likely would have been in obtaining the estimates of backfat and loin eye area for the boars. On the other hand, if measurement errors were minimal, then the barrow data are probably of little or no value for predicting breeding values of littermate boars. Evidently, the management and/or Board of Directors of the Iowa and Northeast Iowa Stations have concluded that the data for the barrows are not worth the cost involved in testing barrows because they were eliminated from both testing stations beginning with the fall 1986 testing period. These data support this decision.

<u>Coefficients of correlation by breeds</u>. The coefficients of correlation between boar and barrow values and correlations between selected traits for boars and barrows among eight breeds in the Iowa and Northeast Iowa Stations (N=917) and in the Northeast Iowa Station (N=336) are shown in Tables 16 and 17.

The coefficients of correlation between average daily gains of littermate boars and barrows were significant (P<.01) for all breeds except the Chester White. There was a positive (.16) but nonsignificant (P>.05) association between the average daily gains of Chester White boars and barrows. Although there were only 24 pens of Chester White pigs in the study, the data suggest that the effects of castration may be greater for Chester White boars than for boars of other breeds.

The coefficients of correlation between backfat thickness of littermate boars and barrows were significant (P<.05 or .01) for all breeds except the Berkshire and Poland China. There were positive (.06 and .28) but nonsignificant (P>.05) associations between the backfat thickness of Berkshire and Poland China boars and barrows. Although there were only 20 and 17 pens of Berkshire and Poland China pigs, respectively, in the study, the data suggest that the effects of castration upon backfat may be greater for Berkshire and Poland China boars than for boars of other breeds.

The coefficients of correlation between loin eye area of littermate boars and barrows were significant (P<.05 or .01) for all breeds except the Chester White, Landrace, Poland China, and Spotted. They were positive for all breeds except for the negative association in the Chester White breed (-.35). The associations between the loin eye area of Landrace, Poland China, and Spotted boars and barrows were very low positive values, but nonsignificant (P>.05). The data suggest that the effects of castration

TABLE 16. CORRELATIONS BETWEEN BOAR AND BARROW VALUES AND CORRELATIONS BETWEEN SELECTED TRAITS FOR BOARS AND BARROWS AMONG EIGHT BREEDS IN THE IOWA AND NORTHEAST IOWA SWINE TESTING STATIONS

				Trait									
Breed	N	$r_{.05}$	$r_{.01}$	ADGB ADGb	BFB BFb	LEAB LEAb	ADGB BFB	ADGB BFb	ADGb BFB	ADGb BFb	ADGB LEAB	ADGB LEAb	ADGb LEAB
Berkshire	20	.43	.55	.59	.06	.47	.20	.35	.36	.04	-.36	-.51	-.03
Chester White	24	.40	.51	.16	.55	-.35	.46	.34	.39	.58	-.19	-.31	-.21
Duroc	368	.10	.14	.40	.37	.21	.11	.05	.04	.14	-.15	-.11	-.02
Hampshire	91	.21	.27	.41	.37	.28	.09	.33	.13	.12	-.39	-.18	-.15
Landrace	47	.29	.37	.45	.33	.14	.40	.31	.27	.11	.06	.08	.02
Poland China	17	.47	.59	.69	.28	.05	.27	.09	.05	-.05	.19	.60	.11
Spotted	104	.19	.25	.35	.36	.04	.02	.19	.10	.16	-.31	.09	-.31
Yorkshire	246	.13	.17	.51	.25	.19	.21	.00	.22	.06	-.14	-.07	-.11

B=Boar

b=Barrow

TABLE 16. (continued)

Breed	N	$r_{.05}$	$r_{.01}$	ADGb LEAb	ADGB D230B	ADGb D230B	BFB LEAB	BFB LEAb	BFb LEAB	BFb LEAb	BFB D230B	BFb D230B	LEAB D230B	LEAb D230B
				Trait										
Berkshire	20	.43	.55	-.64	-.72	-.48	-.14	-.53	-.67	-.27	-.32	.16	.06	.41
Chester White	24	.40	.51	-.18	-.27	.05	.07	-.29	-.08	-.53	.03	.19	.35	-.38
Duroc	368	.10	.14	-.11	-.64	-.23	.05	-.13	-.14	-.37	-.06	-.03	.11	.09
Hampshire	91	.21	.27	.00	-.60	-.45	-.23	-.21	-.40	-.47	-.13	-.21	.39	.05
Landrace	47	.29	.37	-.28	-.64	-.21	.03	-.04	-.17	-.21	-.28	-.20	.15	-.12
Poland China	17	.47	.59	.17	-.54	-.52	-.24	0.18	.06	-.13	-.48	-.02	.13	-.62
Spotted	104	.19	.25	.10	-.66	-.19	.04	-.20	-.17	-.27	-.18	-.04	.27	-.01
Yorkshire	246	.13	.17	-.15	-.60	-.40	.02	-.16	-.07	-.26	-.18	-.08	.06	.06

B=Boar

b=Barrow

TABLE 17. CORRELATIONS BETWEEN BOAR AND BARROW VALUES AND CORRELATIONS BETWEEN SELECTED TRAITS FOR BOARS AND BARROWS AMONG EIGHT BREEDS IN THE NORTHEAST IOWA SWINE TESTING STATION

				Trait										
Breed	N	$r_{.05}$	$r_{.01}$	ADGB %Mb	ADGb %Mb	ADGb D230b	BFB %Mb	BFb %Mb	LEAb %Mb	LEAb D230b	D230b %Mb	D230B D230b	D230b CLb	CLb %Mb
Berkshire	9	.63	.77	-.02	-.24	-.83	-.69	.03	.81	.19	.18	.58	-.70	.38
Chester White	7	.71	.83	-.05	-.31	-.60	-.63	-.91	.81	-.62	-.37	.91	-.27	.61
Duroc	134	.17	.22	-.02	-.02	-.59	-.13	-.49	.84	-.01	.08	.61	-.22	.12
Hampshire	34	.34	.43	.13	-.04	-.79	-.08	-.44	.77	-.12	.08	.78	-.44	-.13
Landrace	4	.88	.96	-.97	-.81	.18	-.47	-.48	.76	.25	-.34	.54	-.59	.39
Poland China	4	.88	.96	.44	.10	-.90	.26	-.75	.71	-.66	-.22	.67	-.09	.01
Spotted	28	.37	.47	-.16	-.10	-.62	-.20	-.70	.80	-.15	.15	.29	.02	.29
Yorkshire	116	.18	.24	-.16	-.16	-.77	-.13	-.37	.80	.08	.19	.72	-.10	.06

B=Boar.

b=barrow.

upon loin eye area may be much greater for Chester White boars than for boars of other breeds.

The coefficients of correlation between average daily gain and backfat thickness of boars were significant (P<.05 or .01) for all breeds except the Berkshire, Hampshire, Poland China, and Spotted. There were positive (.20, .09, .27, and .02), but nonsignificant (P>.05) associations between the average daily gain and backfat thickness of Berkshire, Hampshire, Poland China, and Spotted boars. The coefficients of correlation between average daily gain and backfat thickness of barrows were nonsignificant (P>.05 or .01) for all breeds except the Chester White and Duroc. The correlation between average daily gain and backfat thickness for Chester White boars and barrows was .46 and .58, respectively. Even though the correlation between average daily gain and backfat is significant (P<.05) in the Duroc breed, the magnitude is low enough to indicate that progress could easily be made by selecting for both traits at the same time. In the Chester White breed, the coefficients of correlation between average daily gain and backfat thickness are high enough to indicate that selecting for higher average daily gains will likely result in an increase in backfat thickness. There was a negative (-.05), but nonsignificant (P>.05) association between the average daily gain and backfat thickness of Poland China barrows. There were only 17 pens of Poland China pigs in the study.

The coefficients of correlation between average daily gain of boars and backfat thickness of littermate barrows were nonsignificant (P>.05) for all breeds except the Hampshire, Landrace, and Spotted. The associations were .33, .31, and .19 between the average daily gain of boars and backfat thickness of littermate barrows in the Hampshire, Landrace, and Spotted breeds, respectively. The Berkshire and Chester White breeds had the highest correlation values (.35 and .34) but were nonsignificant (P>.05) because there were only 20 and 24 pens of Berkshire and Chester White pigs. The Yorkshire breed had no association (.00) between average daily gain of boars and backfat thickness of littermate barrows. Similarly, the Duroc and Poland China breeds had very low associations (.05 and .09) between average daily gain of boars and backfat thickness of littermate barrows.

The coefficients of correlation between average daily gain and loin eye area of boars were significant (P<.05 or .01) and negative (-.15, -.39, -.31, and -.14) for the Duroc, Hampshire, Spotted and Yorkshire breeds. These associations suggest that faster growing boars tend to have somewhat smaller loin eye areas; however, there were small nonsignificant (P>.05) positive correlations (.06 and .19) between average daily gain and loin eye area in the Landrace and Poland China breeds. The coefficients of correlation between average daily gain and loin eye area of barrows was significant (P<.05 or .01) for the Berkshire (-.64), Duroc (-.11) and Yorkshire (-.15) breeds. The other coefficients of correlation were low and nonsignificant. The data for calculating the correlations for the barrows was actual loin eye area measured on the carcass; therefore, the correlations of the barrow data should be more reliable than the correlations for the boars since the loin eye area of the boars was estimated ultrasonically. These low associations between average daily gain and loin eye area are desirable since the goal of swine producers is to have pigs grow as fast and have loin eye areas as large as possible. There may be breed differences for this association; however, additional data for the Berkshire, Chester White, Landrace, and Poland China breeds would be necessary for more logical conclusions.

The coefficients of correlation between average daily gain and days to 230 pounds ranged from -.54 to -.72 except for a nonsignificant correlation of -.27 for the Chester White breed. These high negative correlations should be expected since days to 230 is primarily a function of rate of gain. The pre-test environment is the other factor contributing to days required to reach 230 pounds.

The coefficients of correlation between backfat and loin eye area of boars was nonsignificant for all breeds except the Hampshire (-.23); however, the same correlations for barrows were significant (P<.01) for all breeds except the Landrace, Poland China, and Berkshire. The correlations for barrows ranged from -.26 to -.53. Both loin eye area and backfat measurements for barrows were actual carcass measurements; therefore, the accuracy of these correlations should not be questioned. On the other hand, all loin eye area estimates and a portion of the backfat estimates for the boars were taken ultrasonically. Because of the greatly different associations between backfat and loin eye area for boars and barrows, it seems logical to assume a great deal of error in estimating either backfat or loin eye area, or both, for boars. It is possible, however, that there is a different relationship between these two traits for boars and barrows.

For barrows in the Northeast Iowa Station (Table 17), the coefficients of correlation between average daily gain and percent muscle were nonsignificant (P>.05) for all breeds. In the Landrace breed, the correlation was -.81 with only four barrows involved in the study. It is desirable to have low, nonsignificant associations between these traits because the goal of most swine producers is to increase both growth rate and percent muscle.

The coefficients of correlation between backfat thickness and percent muscle of barrows were significant (P<.01) for all breeds except the

Berkshire, Landrace, and Poland China. The coefficients of correlation between loin eye area and percent muscle of barrows were significant (P<.05 or .01) for all breeds except the Landrace and Poland China, which were positive (.76 and .71) but nonsignificant (P>.05). There were only four pens each of Landrace and Poland China pigs in the study. These data tend to indicate that loin eye area had a greater effect upon percent muscle than backfat. The mean of the significant breed correlations between backfat and percent muscle was .58 while the mean of the significant breed correlations between loin eye area and percent muscle was .80.

The coefficients of correlation between days to 230 pounds of littermate boars and barrows were significant (P<.01) for all breeds except the Berkshire, Landrace, Poland China, and Spotted (Table 17). The associations were positive (.58, .54, .67, and .29) but nonsignificant (P>.05) between boars and barrows for days to 230 pounds in the Berkshire, Landrace, Poland China, and Spotted breeds. In the study there were only 9, 4, 4, and 28 pens of Berkshire, Landrace, Poland China, and Spotted pigs, respectively. The data suggest that the effects of castration upon days to 230 pounds may be smaller for Chester White, Duroc, Hampshire, and Yorkshire boars than for boars of other breeds.

The coefficients of correlation between days to 230 pounds and carcass length of barrows were significant (P<.05 or .01) for the Berkshire, Duroc, and Hampshire breeds. There was inconsistency of correlation coefficients among the breeds; however, the data suggest that Berkshire, Hampshire, and Landrace barrows have a greater association between days to 230 pounds and length, suggesting that longer barrows tend to grow faster.

CHAPTER V

SUMMARY

The purpose of this study was to determine differences between littermate boars and barrows for performance and carcass traits in the Iowa and Northeast Iowa Swine Testing Stations. Data were obtained from 917 litters including 1,804 boars and 917 barrows. The data included 1,086 boars and 581 barrows from the Iowa Station at Ames, Iowa, and 718 boars and 336 barrows from the Northeast Iowa Station at New Hampton, Iowa. The Iowa Station data were obtained over a period of 12 seasons from the fall of 1979 through the fall of 1985, and the data from the Northeast Iowa Station were collected in eight seasons from the fall of 1981 through the spring of 1985. The spring testing season included pigs born from November through March, and the fall testing season included pigs born from May through September. Littermate boars and barrows from the following purebred breeds were used: Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland China, Spotted, and Yorkshire.

Boars grew .03 (2.21$\pm$.20 vs. 2.18$\pm$.21) and .10 (2.21$\pm$.18 vs. 2.11$\pm$.22) pounds/day faster ($P<.01$) than littermate barrows in the Iowa and Northeast Iowa Stations. Boars had .58 (.80$\pm$.08 vs. 1.38$\pm$.20) inches less ($P<.01$) backfat than littermate barrows (N=581) in the Iowa Station. In the Northeast Iowa Station, boars were significantly ($P<.01$) leaner than barrows when comparing average backfat of boars with carcass backfat measurements of littermate barrows at the tenth rib (.76$\pm$.06 vs. 1.06$\pm$.21) or the average of three carcass backfat measurements (.75$\pm$.08 vs. 1.29$\pm$.18

and .79±.05 vs. 1.31±.19). Boars had .67 (5.49±.42 vs. 4.82±.67) and .66 (5.62±.28 vs. 4.96±.65) square inches larger (P<.01) loin eye areas than littermate barrows in the Iowa and Northeast Iowa Stations, respectively.

The t test revealed no significant (P>.05) differences between boars and barrows for average daily gain among the eight major breeds in the Iowa Station. However, at the Northeast Iowa Station, the Duroc (2.39±.19 vs. 2.12±.21) and Hampshire (2.16±.17 vs. 2.07±.24) boars grew significantly faster (P<.01) than littermate barrows. The t test also revealed that boars averaged seven days (156.00±10.78 vs. 163.00±12.90) younger (P<.01) at 230 pounds than barrows in the Northeast Iowa Station. Although the sample size was small and the differences nonsignificant, there were some breeds in which barrows appeared to grow faster than boars. The t test for boar-barrow differences among breeds revealed that boars had significantly (P<.01) less average backfat than littermate barrows for eight major breeds in the Iowa Station and for seven breeds in the Northeast Iowa Station. For both stations, the differences in backfat thickness between boars and barrows was lowest for the Hampshire breed and the greatest differences were between boars and barrows in the Chester White, Yorkshire, Berkshire and Landrace breeds. The t test for loin eye area revealed that boars had significantly (P<.01 or .05) greater loin eye area than barrows for all breeds except Poland China in the Iowa Station and Landrace in the Northeast Iowa Station. The sex differences between littermate boars and barrows for backfat and loin eye area were significantly different (P<.01) for all years and seasons in the Iowa and Northeast Iowa Stations. The sex differences between littermate boars and barrows for backfat and loin eye area have been increasing in both stations with the largest increase occurring during the last five years. The differences between boars and barrows for days to 230 pounds were significantly different (P<.01) in all years and seasons for both stations. In comparing data for 1981 and 1985, both boars and barrows averaged ten days younger at 230 pounds in 1985 than in 1981.

Coefficients of correlation for various measurements of performance and carcass cutability between littermate boars and barrows were determined. In general, there were positive associations between boar and barrow data; however, the correlations were relatively low. The predictive value of the barrow data appears to be of little use in estimating breeding values for boars.

Although a limited number of Chester White pens were included in this study, the coefficients of correlation between littermate boars and barrows suggest that castration may have a different effect upon performance and carcass cutability of Chester White than for other breeds. Unfortunately for Chester White breeders, there appears to be a much higher positive correlation between average daily gain and backfat thickness for Chester White boars and barrows than for other breeds. In other breeds, the correlation between growth rate and backfat is low enough to allow simultaneous progress for improving both traits. A similar desirable low correlation was found between growth rate and loin eye area for other breeds.

The coefficients of correlation between backfat and loin eye area were greater for barrows than boars, suggesting that errors of measurement may have been prevalent in the boar data. Large errors in measurement of boar backfat could account for some or all of the increased difference in backfat thickness observed between littermate boars and barrows during recent years.

APPENDIX

TABLE 18. SUMMARY OF COMPARATIVE RESULTS OF EXPERIMENTS WITH BOARS, BARROWS, AND GILTS

Investigator	Breed	No. of Animal	Sex[a]	FM[b]	Trait[c]					
					IW (lb)	FW (lb)	ADG (lb/day)	FE	ABF (in)	LEA (sq in)
Winters et al.	Poland China	67	B		34.0	198	1.47			
(1942)		67	b		33.0	195	1.45			
U.S.A.	Minnesota	19	B		36.2	181	1.29[r]			
	Number 1	19	b		34.0	203	1.50[q]			
Pearson et al.	Duroc	4	B	ALF	36.0	225	1.80[q]	3.22	[e]1.66	
(1952)		4	b	ALF	35.3	190	1.46[r]	3.55	[e]1.56	
U.S.A.		5	G	ALF	35.3	187	1.43[r]	3.48	[e]1.66	
		4	ISB	ALF	34.6	194	1.50[r]	3.25	[e]1.44	
		5	ISb	ALF	34.8	187	1.43[r]	3.29	[e]1.71	
		5	ISG	ALF	33.3	182	1.40[r]	3.38	[e]1.58	
Bratzler et al.	Poland China x	4	B	ALF	40.0	224	1.31	3.84	[e]1.06[q]	
(1954)	Hampshire x Duroc	4	b	ALF	41.4	220	1.41	3.81	[e]1.75[r]	
U.S.A.		4	ITb	ALF	40.3	220	1.52	3.80	[e]1.68[r]	
		4	BC100	ALF	41.4	216	1.46	3.96	[e]1.74[r]	
		4	BC140	ALF	40.6	217	1.57	3.58	[e]1.43[s]	
		4	BC180	ALF	39.2	227	1.42	3.67	[e]1.43[s]	
Hetzer et al.	Landrace and	45	B	ALF	87.0	212			[f]1.37[n]	
(1956)	crossbred lines	30	b	ALF	87.0	211			[f]1.57[o]	
U.S.A.		65	G	ALF	87.0	213			[f]1.55[o]	
Charette	Canadian	14	B	IALF	3.31	203	1.34	3.19[n]	[g]1.14	4.50[q]
(1961)	Yorkshire	16	BCB	IALF	3.31	203	1.35	3.53[o]	[g]1.34	4.07[r]
Canada		15	BC6	IALF	3.09	203	1.34	3.61[o]	[g]1.34	4.02[r]
		15	BC12	IALF	3.31	203	1.34	3.54[o]	[g]1.26	4.21[r]
		16	BC16	IALF	3.09	203	1.34	3.56[o]	[g]1.30	4.16[r]
		9	BC20	IALF	3.09	202	1.34	3.28[o]	[g]1.22	4.04[r]
		16	G	IALF	3.31	205	1.32	3.44[o]	[g]1.22	4.40[q]
Lidvall et al.		8	B		50.0	230	Sex=P> .05	B<b[q]	[e]B<b[n]	Sex=P> .05
(1964)		8	b		50.0	230		B<G[n]	[e]b=G	
U.S.A.		8	G		50.0	230		G<b[n]	[e]G=B	
Prescott and	Large White	7	B	GALF	50.0	250	1.72		[g]1.69[q]	[k]4.98
Lamming		7	b	GALF	50.0	250	1.81		[g]2.05[r]	[k]4.87
(1964)										
Great Britain										

TABLE 18. (continued)

Investigator	Breed	No. of Animal	Sex[a]	FM[b]	Trait[c] IW (lb)	FW (lb)	ADG (lb/day)	FE	ABF (in)	LEA (sq in)
Blair and English (1965) Great Britain	Large White	24	B	IRF	41.0	195	1.44^{v}	3.06^{tq}	$^{h}.98^{tq}$	$^{m}3.84^{t}$
		24	b	IRF	41.0	195	1.33^{w}	3.45^{u}	$^{h}1.22^{un}$	$^{m}3.36^{u}$
		24	G	IRF	37.3	195	1.33^{w}	3.24^{tr}	$^{h}1.10^{ro}$	$^{m}3.88^{tv}$
Burgess (1965) U.S.A.	Duroc (24) and Hampshire (12)	12	B	ALF	68.6	200	1.92^{ps}	2.94^{q}	$^{e}1.34^{q}$	$^{l}4.85^{n}$
		12	b	ALF	69.0	200	1.82^{q}	3.34^{r}	$^{e}1.54^{rn}$	$^{l}4.51^{oq}$
		12	G	ALF	70.1	200	1.78^{t}	3.23^{s}	$^{e}1.42^{o}$	$^{l}5.03^{nr}$
McCampbell and Baird (1965) U.S.A.	Poland China	Total 58	B	ALF	41.0	200	B G[s]	3.06	^{e}B<b[n]	B>b[n]
			b	ALF	41.0	200	b G[s]	3.06	^{e}G<b[n]	G>b[q]
			G	ALF	41.0	200		2.93		
Jones (1971) U.S.A.	Duroc	6	B	ALF	76.5	219	1.98^{s}	2.77^{q}	$^{e}1.10^{q}$	$^{l}4.90^{q}$
		6	b	ALF	74.7	225	1.80^{t}	3.18^{r}	$^{e}1.26^{r}$	$^{l}5.35^{r}$
		6	G	ALF	72.5	225	1.70^{u}	3.03^{r}	$^{e}1.22^{r}$	$^{l}5.84^{s}$
	Duroc	6	B	ALF	75.4	298	2.02^{s}	2.93^{q}	$^{e}1.38^{q}$	$^{l}6.32^{q}$
		6	b	ALF	75.0	296	1.63^{t}	3.64^{r}	$^{e}1.65^{r}$	$^{l}6.06^{r}$
		6	G	ALF	71.4	294	1.60^{t}	3.39^{s}	$^{e}1.50^{s}$	$^{l}6.88^{s}$
Newell and Bowland (1972) Canada	(overall period)	16	B	ALF (18, 16, and 13 protein)	20.9	198	1.59	3.01^{n}	$^{g}1.26^{q}$	4.19^{q}
		16	b		20.9	198	1.61	3.40^{o}	$^{g}1.59^{r}$	4.00^{q}
		16	G		24.0	198	1.59	3.31^{o}	$^{g}1.42^{s}$	4.56^{r}
	(finishing period)	16	B		110.0	198	1.92^{n}	3.46^{n}		
		16	b		110.0	198	1.79^{o}	4.06^{o}		
		16	G		110.0	198	1.76^{o}	3.86^{o}		
Newell et al. (1973) Canada	Yorkshire x Hampshire x Landrace x Lacombe	8	B	ALF	29.0	198	1.70	2.88^{n}		
		8	b	ALF	29.0	198	1.72	3.29^{o}		
		16	IDB	ALF	29.0	198	1.74	2.78^{n}		
		16	BC154	ALF	29.0	198	1.72	3.05^{n}		
		8	G	ALF	29.0	198	1.68	3.04^{n}		

TABLE 18. (continued)

Investigator	Breed	No. of Animal	Sex[a]	FM[b]	Trait[c] IW (lb)	FW (lb)	ADG (lb/day)	FE	ABF (in)	LEA (sq in)
Pay and Davies (1973) Great Britain	Large White/ Landrace x Large White	12	B	ISALF	48.5	198	1.70	2.81	[i]1.50[†]	[m]5.24
		12	b	(16% protein)	48.5	198	1.79	2.98	[i]1.89[u]	[m]5.16
		12	B	ISALF	48.5	198	1.76	2.81	[i]1.42[†]	[m]5.58[†]
		12	b	(18% protein)	48.5	198	1.74	3.06	[i]1.77[u]	[m]4.99[u]
		12	B	ISALF	48.5	198	1.74	2.90	[i]1.38[†]	[m]5.50[†]
		12	b	(20% protein)	48.5	198	1.74	3.05	[i]1.57[u]	[m]4.98[u]
	(overall average)	36	B		48.5	198	1.74	2.84[†]	[i]1.42[†]	[m]5.44[†]
	(overall average)	36	b		48.5	198	1.76	3.03[u]	[i]1.73[u]	[m]5.05[u]
Hansson[d] (1974) Sweden and Hansson et al. (1975) Sweden	Swedish Landrace	12	B	IRF	55.1	154	1.42	8.5	[j].63[n]	[m]4.42
		12	b	IRF	55.1	154	1.46	8.6	[j].71[o]	[m]4.22
		12	G	IRF	55.1	154	1.42	8.7	[j].67	[m]4.36
	Swedish Landrace	12	B	IRF	55.1	198	1.56	9.0	[j].79[n]	[m]4.96
		12	b	IRF	55.1	198	1.51	9.5	[j].94[o]	[m]4.65
		12	G	IRF	55.1	198	1.52	9.4	[j].83	[m]5.35
	Swedish Landrace	20	B	IRF	55.1	243	1.63[†]	9.4[†]	[j].94[n]	[m]5.60
		22	b	IRF	55.1	243	1.49[u]	10.6[u]	[j]1.10[o]	[m]5.18
		21	G	IRF	55.1	243	1.48[u]	10.6[u]	[j]1.02	[m]5.60
	Swedish Landrace	12	B	IRF	55.1	287	1.58[q]	10.1[†]	[j].98[n]	[m]6.70[n]
		11	b	IRF	55.1	287	1.48[r]	11.2[u]	[j]1.22[o]	[m]5.92[o]
		11	G	IRF	55.1	287	1.48[r]	11.1[u]	[j]1.18	[m]6.29
Hansson[d] (1974) Sweden and Hansson et al. (1975) Sweden	Swedish Yorkshire	15	B	IRF	55.1	154	1.42	8.7	[j].63[n]	[m]3.89
		12	b	IRF	55.1	154	1.35	9.1	[j].83[o]	[m]3.70
		16	G	IRF	55.1	154	1.41	8.9	[j].79	[m]4.22
	Swedish Yorkshire	15	B	IRF	55.1	198	1.54	9.0[n]	[j].75[n]	[m]4.59[n]
		12	b	IRF	55.1	198	1.48	9.5[o]	[j].98[o]	[m]3.94[o]
		18	G	IRF	55.1	198	1.48	9.7[o]	[j].91	[m]4.46

TABLE 18. (continued)

Investigator	Breed	No. of Animal	Sex[a]	FM[b]	Trait[c] IW (lb)	FW (lb)	ADG (lb/day)	FE	ABF (in)	LEA (sq in)
Hansson[d] (1974) Sweden	Swedish Yorkshire	25	B	IRF	55.1	243	1.54^{n}	9.7^{t}	$^{j}.91^{n}$	$^{m}4.84$
		21	b	IRF	55.1	243	1.47^{o}	10.7^{u}	$^{j}1.22^{o}$	$^{m}4.57$
		24	G	IRF	55.1	243	1.46^{o}	10.8^{u}	$^{j}1.10$	$^{m}5.02$
Hansson et al. (1975) Sweden	Swedish Yorkshire	10	B	IRF	55.1	287	1.67^{q}	9.6^{t}	$^{j}.98^{n}$	$^{m}5.91$
		11	b	IRF	55.1	287	1.46^{r}	11.2^{u}	$^{j}1.34^{o}$	$^{m}5.19$
		14	G	IRF	55.1	287	1.46^{r}	11.3^{u}	$^{j}1.30$	$^{m}5.41$
Siers (1975) U.S.A.	Yorkshire (Spring)	20	B	IALF	59.5	218	2.07^{n}	2.63^{n}	1.18^{q}	$^{l}5.07^{q}$
		19	b	IALF	59.5	218	2.11^{n}	2.77^{o}	1.30^{r}	$^{l}4.40^{r}$
		24	G	IALF	59.5	218	1.83^{o}	2.88	1.18	$^{l}5.36^{s}$
	Yorkshire (Fall)	16	B	IALF	59.5	219	1.97^{n}	3.07	1.22^{q}	$^{l}5.19^{q}$
		14	b	IALF	59.5	219	1.82	3.42	1.42^{r}	$^{l}4.46^{r}$
		21	G	IALF	59.5	219	1.74^{o}	3.27	1.30^{s}	$^{l}5.18^{qs}$
Cliplef and Strain (1981) Canada	Yorkshire	25	FGB	ALF		199			1.14^{q}	5.05^{q}
		25	SGB	ALF		197			1.02^{q}	5.49^{q}
		24	b	ALF		195			1.54^{rn}	4.20^{r}
		26	G	ALF		196			1.30^{ro}	4.88^{q}
Campbell and King (1982) Australia		3	B	IALF (17% protein)	44.1	154	1.81	2.77	0.91	
		3	b		44.1	154	1.75	3.10	1.06	
		3	B	IALF (21% protein)	44.1	154	1.81	2.86	0.79	
		3	b		44.1	154	1.81	3.22	1.22	
		3	B	IALF (23% protein)	44.1	154	1.70	2.93	0.91	
		3	b		44.1	154	1.75	3.20	1.10	

[a]Sex: B, b, or G = boar, barrow, or gilt; ISB, b, or G = the implantation of stilbestrol in boar, barrow, or gilt; ITb = the implantation of testosterone (193 mg) in barrow; BC100, 140, or 180 = boar castrated at 100, 140, or 180 pounds of weight; BCB, 6, 12, 16, or 20 = boar castrated at birth, 6, 12, 16, or 20 weeks of age; IDB = the implantation of diethylstilbestrol (96 mg) in boar at 154 pounds; BC154 = boar castrated at 154 pounds of weight; FGB = faster gaining boars; SGB = slower gaining boar.

[b]FM = feeding method: ALF = ad libitum feeding; IALF = individually ad libitum feeding; IRF = individually restricted feeding; ISALF = individually semi-ad libitum feeding.

TABLE 18. (continued)

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[c] IW = initial weight; FW = final weight; ADG = average daily gain; FE = feed efficiency; ABF = average carcass backfat; LEA = loin eye area.

[d] Feed efficiency was measured by energy (MCal)/kg. gain.

[e] The thickness of carcass backfat was determined by average measurements taken at the first rib, last rib, and last lumbar vertebra.

[f] The thickness of carcass backfat was determined by average measurements taken at the first and seventh thoracic vertebra and at the first, middle, and last lumbar vertebra.

[g] The thickness of carcass backfat was determined by average measurements taken at the shoulder fat, backfat, and loin fat.

[h] Loin backfat thickness (tenth rib).

[i] Intrascope measurements were taken for fat depth at 'c' and 'k' on the carcass (4.5 and 8.5 cm from the midline at the point of the last rib).

[j] The mean of the six positions, the mean of the measurements taken at lumbar region and the measurements taken at the middle and the shoulder were used in calculating the mean of backfat.

[k] The loin eye area measurement was estimated at the level of the last rib and was estimated by the following formula width/2 × depth/2 × 3.142 square inches.

[l] Loin eye area at tenth rib.

[m] Loin eye area at the last rib.

[n,o,p] Values with different superscript letters differ ($P < .05$).

[q,r,s] Values with different superscript letters differ ($P < .01$).

[t,u,v] Values with different superscript letters differ ($P < .001$).

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