RELATIONSHIP OF EXTERNAL BODY MEASUREMENTS
AND PERFORMANCE PARAMETERS OF BOARS

by

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B. S., Oklahoma State University, 1949

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A MASTER'S THESIS

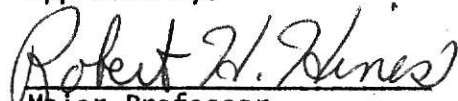submitted in partial fulfillment of the

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MASTER OF SCIENCE

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Robert H. Hines
Major Professor

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INTRODUCTION

Since the earliest domestication of animals, man has sought methods to accurately determine which ones possess superiority in certain traits. Livestock exhibitions, feeding trials, racing, and testing stations, are just a few examples of man's search for methods to determine which animals most nearly meet his requirements for traits he feels are important.

Over the years, "type" has run the gauntlet from one extreme to the other. Probably one of the best examples of this is swine type, where animals have been bred to produce from as much fat as possible, to as lean as could be selected. Of course, as need changed, breeders have attempted to select animals which excelled in those traits.

One method of selection has been the appraising or judging of the live animal and then slaughtering and measuring for certain carcass characteristics that have been predetermined as being important. While this has been a valuable tool to aid in the selection of animals possessing superior carcass qualities it has some limitation, mainly that the animals, by being slaughtered, are lost for reproduction. To offset this limitation the development of equipment to evaluate carcass qualities of live animals has been produced, such as the backfat probe, sonoray, the K40 counter, scanogram, etc.

To satisfy all segments of the livestock industry, the animal of today should not only exhibit superior muscling and carcass quality but also have faster and more efficient rate of gain. In recent times

there has been increased emphasis placed on selecting big-headed, large tailed, deep jawed and heavier boned boars on the theory that these traits contribute to superiority in rate of gain, feed efficiency, and improved carcass characteristics.

The purpose of this study is an attempt to evaluate some of these theories to see if there is any validity that certain physical character-istics of the boar indicate a correlation between body measurements and muscling, leanness, rate of gain, and/or feed efficiency.

REVIEW OF LITERATURE

Phillips and Dawson (1936) studied three methods of taking body measurements on pigs: (a) calipers and a steel tape, (b) a livestock scaling instrument, (c) measurements of photographs projected to life size for measuring purposes. Method (a) gave more accurate results than either methods (b) or (c) in all but two of the 14 measurements taken. The two exceptions were length from shoulder to tail and length from ear to tail. Method (a), besides being more accurate, required less time than either of the other two methods. This was in agreement with Phillips and Stoehr (1945) who reported that taking measurements from photographs of sheep was not as accurate as making actual measurements from the live animal.

Orme et al. (1959) studied the relationship between live animal measurements and various carcass measurements to ascertain their re-lationship to weight and percentages of wholesale cuts. Twelve live animal measurements and 12 carcass measurements from 31 long yearling

steers were determined to be highly repeatable with the exception of spring of ribs, width of pins and length from the 13th rib to hooks. However, only two relationships between live animal measurements and percent primal cuts were significant at the one percent level. These were: circumference of body at the foreflank which had a correlation of 0.46 and circumference of middle with a correlation of 0.53. The majority of the correlation coefficients were negative thus showing a slight tendency for the steers having the larger live animal measurements to have a lower percent of primal cuts.

Using live animal measurements to determine the relative value for predicting certain carcass characteristics of cattle, Hetzer et al. (1950) reported that most of the simple correlations between body measurements and conformation scores with steers were low or insignificant. They noted that none of the measurements were separated into distinct groups by either feeder or slaughter grade.

Holland and Hazel (1958) reported that the average of three backfat probes was a more accurate indicator of percent lean cuts and percent fat cuts than the body measurements of jowl, flank, middle or chest circumference and body length.

To predict edible portion of beef carcasses, Bush, Dinkel and Minyard (1960) evaluated 745 grade Hereford steers by slaughter weight, 18 body measurements, 16 subjective scores and five estimates of carcass traits. They concluded that body measurements were of little value in predicting edible portions of slaughter weight and all measurements accounted for only 2 to 4% more variation than slaughter weight alone.

Brown, Brown and Butts (1974) took 10 skeletal measurements on 550 individually fed Hereford and Angus bulls at four and eight months of age. These measurements were used in stepdown regression models to predict post-weaning gain, feed conversion, feed consumption and final test weight. The coefficients of multiple determination indicated approximately 25% of the variation in test gain could be explained by combinations of skeletal measurements. Nearly 65% of the variation in final test weight was accounted for by variation in preweaning body measurements. Approximately 45% of the variation in feed consumption was explained using preweaning body measurements.

Measurements of body length, width of loin, depth and width back of the shoulders were used by Comstock and Winters (1944) to determine the correlation between conformation and such elements of productivity as fertility, rate of gain and feed efficiency. They concluded that improvement of economically important swine characteristics would be more rapid if conformation was considered only at market weight and emphasis on type at other ages directed to performance. This is in agreement with Molin (1942) who reported a partial correlation of only 0.13 between type score and 180-day weight when scoring weight was held constant.

Galal, Cartwright and Shelton (1936) studied relationships among weights and linear measurements in lambs. Measurements and weights investigated were: metacarpus and metatarsus width and breadth, hook width, birth weight, adjusted 30-day weight and adjusted weaning weight. Of these relationships, birth weight was the most valuable for predicting

daily gain. This may be in agreement with Cole's (1943) report that length of leg was of no value in predicting daily gain.

An extensive study conducted by Flock, Carter and Priode (1962) evaluated seven linear body measurements taken at birth to predict the preweaning growth rate and weaning type score of 1,425 calves. They concluded that neither linear body measurements nor type score at birth could be recommended as selection criteria to improve weaning performance.

Boylan, Rahnefeld and Seal (1966) examined the relationship between ear measurements, ear type and performance of swine and found that longer and wider ears at weaning were favorably associated with post-weaning growth rate. They also concluded that backfat thickness appeared to be independently associated with ear type, ear length and width, both at weaning and at market weight. Ear size increased only 1.5 to 2 times from weaning age to market weight, whereas body weight, over the same period, increased nearly 6 to 8 times.

EXPERIMENTAL PROCEDURE

This study involves external body measurements of boars and their relationship to such performance parameters as rate of gain and feed efficiency. Also investigated was feed usage and growth patterns of boars at specified stages of development between 30 and 114 kg.

Boars used in this study were those entered by purebred swine breeders of Kansas at the Kansas Pork Producers Test Station, located at Manhattan, Kansas, and supervised by Kansas State University. A total of 127 boars of the following breeds were represented: Berkshire,

Chester White, Duroc, Hampshire, Spotted Swine and Yorkshire. Data were collected from 55 boars tested the fall and winter test of 1973-74 and 72 the following spring and summer test of 1974.

Two littermate boars were housed in a pen 1.2 x 4.3 m which had a solid concrete floor, a one hole self-feeder and an automatic waterer. The two boars were weighed on test at an average weight of 30 kg and were tested to a weight of 114 kg. Boars were fed 45 kg of TS-46 and then fed TS-51 until completion of the trial (Table 1). These rations were fed in pelleted form. Feed and water was supplied ad libitum.

Records analyzed for this study included: age and weight of the pigs entering the test station; age when weighing 30 kg (the on test weight); age, weight and feed efficiency 35 days after going on test; age and feed efficiency at 100 kg (boars were scanogrammed at this weight using the Model 721 scan-o-gram to estimate both loineye area and backfat thickness); and age and feed efficiency at 114 kg when the test was completed.

For the fall and winter test (1973-74) 13 body measurements were made on each boar at the weight of 29 to 32 kg, and again at 112 to 115 kg. This same procedure was followed for the spring and summer test (1974) including an additional measurement on width of jaws.

Equipment used in taking measurements of the boars was a hog holder, a flexible steel measuring tape, wooden calipers, measuring cord and a ruler. All measurements were taken to the nearest one-tenth of an inch.

Of the 14 measuring sites (refer to diagrams), three were included about the head, five on the body, four on the legs and the final two on the tail.

Head measurements included width between the eyes from the inside corner of one eye to the inside corner of the other eye, width of skull at the top of the head between the ears and width of jaws at their widest portion directly below the back junction of the ear.

Length of body was measured from the atlanto accipital joint to the base of the tail with the steel measuring tape. Heart girth was measured immediately behind the shoulders. Width of the floor of the chest was taken immediately back of and parallel to the elbows, and depth of chest just back of the elbow from the backbone to the sternum. Width of ham was determined by measuring the widest point of the stifle.

Length of front leg was measured from the base of the hoof, vertically to the top of the elbow. Circumference of the forearm was measured with the steel tape by encircling the forearm, keeping the tape parallel to the floor and as close to the body as possible. The final front leg measurement was made from the smallest portion of the cannon bone equa-distant between the knee and pastern. The circumference of the cannon, located mid-way between the hock and pastern was taken on the back leg.

Length of tail was measured from base to tip and circumference measured as close to the body as possible.

Table 1. Composition of Test Station Diets.

Ingredient	TS-46 (Percent)[a]	TS-51 (Percent)[b]
Sorghum grain	34.25	35.65
Yellow corn	35.08	36.25
Soybean meal (44%)	25.00	22.00
Molasses	2.00	2.50
Dicalcium phosphate	1.60	1.60
Ground limestone	0.70	0.70
Salt	0.50	0.50
Vitamin premix[c]	0.50	0.10
Trace minerals[d]	0.10	0.50
Antibiotic premix[e]	0.27	0.20

[a] Crude protein in ration TS-46 = 18.4%.

[b] Crude protein in ration TS-51 = 17.4%.

[c] Amount per killogram: 880,000 USP units of vitamin A, 66,000 USP units of vitamin D_3, 990 mg of riboflavin, 2,640 mg of d-Pantothenic acid, 66,000 mg of Choline, 5,500 mg of Niacin, 4,400 I.U. vitamin E, 4.84 mg of vitamin B_{12} and 12.54 g preservative (BHT).

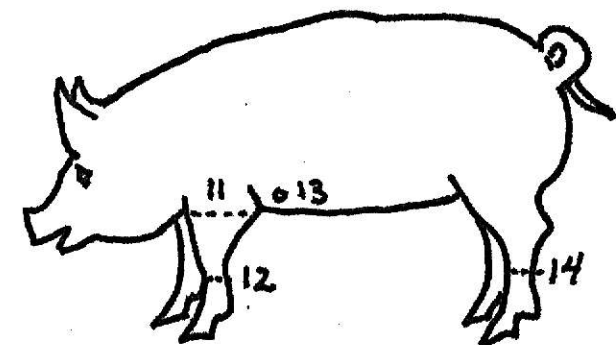[d] Containing 0.1% cobalt, 1.1% copper, 0.15% iodine, 10% iron, 5.5% manganese and 20% zinc.

[e] Supplied as Tylan-10.

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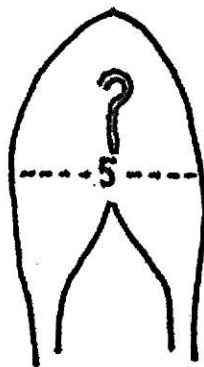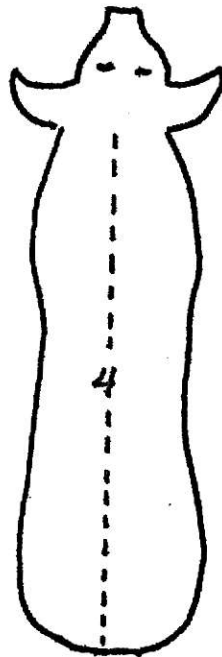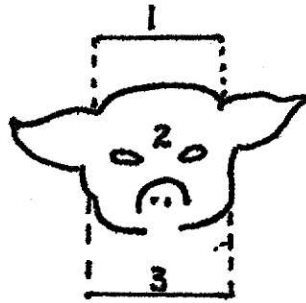
1. Width between the ears.

2. Width between the eyes.

3. Width of jaws.

4. Length of body.

5. Width of stifle.
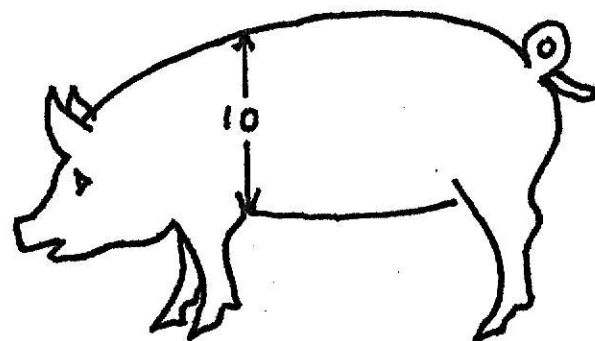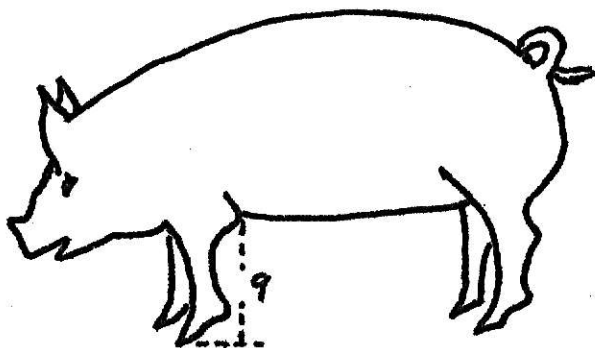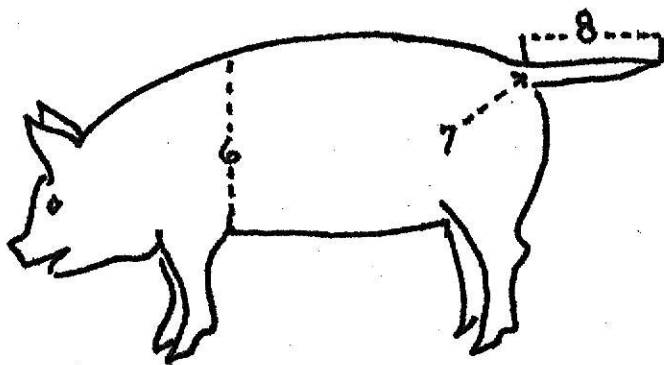
6. Heart girth.

7. Tail circumference.

8. Tail length.

9. Front leg length.

10. Depth of chest.

11. Forearm circumference.

12. Front cannon circumference.

13. Floor of chest width.

14. Back cannon circumference.

RESULTS AND DISCUSSION

Breed Difference. Breed differences are presented in Table II. A significant ($p < .05$) difference in test age, 100 kg age and 114 kg age was found between breeds. Breed influence was also significant ($p < .05$) for 35-day weight, backfat thickness, loineye area and index score. Breeds did not affect the 35-day F/G or the 100 to 114 kg F/G ratio; however, they did influence the 35-day to 100 kg F/G ratio at a statistically significant level ($p < .05$).

The average performance of the six breeds is given in Table III. Chester Whites and Yorkshires are generally recognized as the heaviest milking breeds and they had the youngest pigs entering the test. The Yorkshire maintained this age advantage being the youngest at both the 100 and 114 kg weights.

Hampshires were the most efficient breed in F/G ratio, largest loineye and least backfat at 100 kg. They were also the highest indexing breed with an average of 178 points. They were closely followed by the Yorkshire with 177 index and the Duroc with 176.

Test Difference. Test differences are presented in Table II. Tests 1 and 3 were under fall and winter conditions. Tests 2 and 4 were spring and summer test. Under different climatic conditions there was a significant difference ($p < .05$) in 100 kg age, 114 kg age and 100 to 114 kg F/G. Part of the test differences were due to different bloodlines and boars, partially accounting for significant ($p < .05$) differences in backfat, loineye and index in the four tests.

Initial Age. For each increase of a day's age of the boars entering the test station, age on test was a significant (p < .05) 0.79 days older. This was also true for boars weighing 100 kg and 114 kg as they were 0.72 and 0.60 days older respectively. No significant differences was found in 35-day age or index due to initial age. However, there was a significant difference (p < .05) in 35-day F/G, 2nd F/G (from 35 days on test to 100 kg) and 3rd F/G (100 kg to 114 kg).

Initial Weight. Test age, 100 kg age and 114 kg age were all significantly influenced (p < .05) by the initial weight of the boars entering the test station. For each decrease of 0.22 kg of initial weight the boars were one day younger going on test. This was also true for them when weighing 100 kg and 114 kg as they were 0.23 and 1.21 days younger. The 35-day F/G was influenced (p < .20) by the initial weight of the boars entering the station. For each kg of body weight they required .003 kg additional feed to produce 1 kg gain. This trend was also noted for the 100 to 114 kg F/G ratio with .006 kg of additional feed required to produce 1 kg gain. Initial weight did not significantly influence backfat thickness, loineye area, or 35-day to 100 kg F/G ratio.

Table II. Probability of Effects on Performance Parameters Being
Due to Chance.

Performance Parameters	Effects			
	Breed	Test	Initial Age	Initial Weight
Test age	0.0000	0.0813	0.0000	0.0000
100 kg ag.	0.0000	0.0000	0.0000	0.0000
114 kg ag.	0.0024	0.0000	0.0000	0.0000
35-day wt.	0.0001	0.1052	NS	0.0042
35-day F/G	NS	0.0000	0.0032	0.1487
2nd F/G	0.0496	0.0000	0.0000	NS
3rd F/G	NS	0.0000	0.0012	0.0724
Backfat	0.0000	0.0000	0.0141	NS
Loineye	0.0000	0.0000	0.0168	NS
Index	0.0109	0.0000	NS	NS

Measurements. Measurement results are presented in Table IV. Of
the 14 external body measurements taken at 29.5 kg and again at 114 kg,
the following were the only ones showing significance.

Test age was correlated with three measurements: chest depth, width
between the ears and rear cannon circumference. For each increase of
chest depth at 29.5 kg the age on-test was increased by .83 days. Boars
measuring 1 cm wider between the ears at 114 kg were 6.48 days slower
coming off test and for each cm increase of the rear cannon measurement
the test age increased 4.45 days.

The regression coefficient of stifle width was positively correlated with 35-day weight at the 29.5 kg measurement. For each 1 cm increase of stifle width the 35-day weight increased 1.15 kg. Forearm measurement was also significantly influenced (p < .05) at 114 kg weight. As the forearm circumference increased 1 cm the 35-day weight was .048 kg heavier.

A slight increase in feed efficiency from 100 kg to 114 kg indicated that as the chest depth measurement increased 1 cm the feed required to gain 1 kg decreased by .006 kg.

Body length was negatively correlated with loineye area at 29.5 kg in that each additional cm of length of body reduced the loineye area by .29 cm^2; however, the regression coefficient of stifle width was positive at 29.5 kg. As the stifle width increased 1 cm the loineye area increased by .21 cm^2.

The final parameter that showed significance was the stifle width at 114 kg. For each cm of additional stifle width the index decreased by .65 point.

On the initial analysis, only those measurements listed on Table IV showed any possibility of correlation with performance parameters. On further analysis of the data all of these were nonsignificant with the exception of those discussed above and in these the differences were quite small. This may be in agreement with a preweaning growth rate and weaning type score study conducted by Flock, Carter and Priode (1962). They took seven linear body measurements on 1,425 calves and concluded that neither linear body measurements nor type score at birth could be recommended as selection criteria to improve weaning performance.

Table III. Average Breed Responses to Specified Performance Parameters.

Breed	Berk-shire	Chester White	Duroc	Hamp-shire	Spots	York-shire
Number	7	15	89	51	12	56
Test age[a]	82.00	75.10	77.60	77.20	77.60	75.30
100 kg age	165.50	155.30	155.70	158.60	155.70	152.00
114 kg age	178.30	171.20	171.70	172.30	169.20	168.20
35-day wt.[b]	56.05	58.41	60.23	56.77	58.55	61.09
35-day F/G[c]	2.43	2.10	2.14	2.21	2.48	2.16
2nd F/G[d]	2.51	2.57	2.65	2.43	3.07	2.70
3rd F/G[e]	2.87	3.13	2.97	2.74	3.28	3.05
Backfat[f]	2.21	2.24	2.29	2.01	2.39	2.34
Loineye[g]	13.89	13.56	13.36	14.53	13.77	13.26
Index[h]	166.00	171.00	176.00	178.00	164.00	177.00

[a] Test age is days of age when going on test at 29.5 kg.

[b] 35-day weight is boars' weight 35 days after going on test.

[c] 35-day F/G is the feed-to-gain ratio of first 35 days on test.

[d] 2nd F/G is from 35 days on test to 100 kg.

[e] 3rd F/G is from 100 kg to 114 kg.

[f] Centimeters.

[g] Square centimeters.

[h] Index = 250 + (rate of gain x 50) - (feed efficiency x 50) - (backfat x 50).

Table IV. Regression Coefficients of Various Measurements on Performance Traits.

	Test age	35-day wt.	35-day F/G	2nd F/G	3rd F/G	100 kg age	114 kg age	Back-fat	Loin-eye	Index
Breed	***	***	NS	*	NS	***	**	***	***	*
Test	NS	NS	***	***	***	***	***	***	***	***
ln age	***	NS	**	***	**	***	***	NS	*	NS
ln wt	***	**	NS	NS	NS	***	***	NS	NS	NS
Chest depth	-.830***	NS	NS	NS	-.006*	NS	NS	NS	NS	NS
Length 1	NS	NS	NS	NS	NS	NS	NS	NS	-.290***	NS
Tail length 1[a]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Stifle 1	NS	1,150***	NS	NS	NS	NS	NS	NS	0.210*	NS
Heart girth 1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ear width 1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cannon 1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Forearm 1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Eye width 2[b]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ear width 2	6.480***	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cannon 2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Forearm 2	NS	0.048*	NS	NS	NS	NS	NS	NS	NS	NS
Rear leg 2	4.450***	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chest width 2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Stifle 2	NS	NS	NS	NS	NS	NS	NS	NS	NS	-.650***

[a] 1 indicates 29.5 kg measurement.
[b] 2 Indicates 114 kg measurement.
* P .05
** P .01
*** P .001

SUMMARY

Performance records from 230 boars (two spring-summer and two fall-winter) test periods were included in this study. Breed differences were observed. The Chester White and Yorkshire pigs were youngest entering the test station and the Yorkshire maintained this age advantage at the 100 kg and 114 kg weights. Hampshires were the most efficient breed in F/G ratio; they also had the largest loineye, least backfat and were the highest indexing breed, followed closely by the Yorkshire and Duroc.

Initial age significantly influenced age on-test, 35-day F/G, 35-day to 100 kg F/G and 100 to 114 kg F/G. Age on-test influenced 35-day weight and age at 100 kg and 114 kg.

Fourteen external live-body measurements were made on 127 boars at 29.5 kg and 114 kg to evaluate the correlations between body measurements, leanness, rate of gain and/or feed efficiency. While there was some statistically significant measurement differences there was no consistency recorded at both the 29.5 kg and 114 kg weights.

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Fourteen external live animal measurements were taken on 127 boars of six breeds at 29.5 kg and again at 114 kg to determine their relationships with ten performance parameters. Records were analyzed from two tests where measurements were taken plus performance data from two previous tests. Performance parameters included age at 29.5 kg (the on-test weight); feed per gain for the first 35 days on test and 35 day weight; and age and feed per gain at 100 kg and 114 kg. Estimated loineye area and backfat thickness, corrected to 100 kg, obtained by using the model 721 scan-o-gram were also included.

A significant (P < .05) difference in test age, 35-day to 100 kg feed per gain, and age at 100 kg and 114 kg was found between breeds. Breed influence was also significant (P < .05) on 35-day weight, backfat thickness, loineye area and index score. Performance parameters that were significantly (P < .05) influenced by test were: 100 kg age, 114 kg age and 100 to 114 kg feed per gain. Initial age significantly influenced (P < .05) age on-test, 35-day feed per gain, 35-day to 100 kg feed per gain, 100 to 114 kg feed per gain and age at 100 kg and 114 kg. Age on-test, 35-day weight, and age at 100 kg and 114 kg were significantly influenced (P < .05) by the initial weight of the boars when entering the test station.

As the body length at 29.5 kg increased by 1 cm the loineye area at 100 kg decreased by .29 cm^2 and as the stifle width at 29.5 kg increased by 1 cm the loineye area at 100 kg increased by .21 cm^2. For each increase in circumference of the rear cannon by 1 cm at 114 kg the days on-test increased by 4.45 days. When stifle width at 29.5 kg was 1 cm wider the

35-day weight was 1.15 kg heavier. As chest depth 29.5 increased by 1 cm
the feed per gain ratio narrowed by .006 kg. For each increase of 1 cm
in stifle width at 114 kg the index score decreased by .65 point.