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RESPONSE OF DIFFERENT GENETIC LINES OF BOARS TO VARYING LEVELS OF DIETARY CALCIUM AND PHOSPHORUS[1]

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Summary

Two experiments were conducted to determine the effect of various levels of dietary calcium (Ca) and phosphorus (P) on performance, soundness and blood and bone parameters of different genetic lines of boars fed under variable environmental conditions. The first experiment compared different genetic lines of boars fed two levels of dietary Ca and P. Forty purebred (Large White) and Nebraska Gene Pool boars were allotted by breed and initial weight to two levels of dietary Ca and P (.65 Ca/.50% P and 1.3% Ca/1.0% P). The dietary levels of Ca and P had no significant effect on gains when compared by breed (.72 *vs* .74 kg) and treatment (.74 *vs* .72 kg). Also, none of the differences in feed intake (2.32 *vs* 2.31) and feed to gain ratio (3.09 *vs* 3.27) between Ca-P treatments was significant. No breed x bone interactions were found for bone-breaking parameters such as peak force (kilograms), stress (kilograms/square centimeters) and stress: strain (kilograms/square centimeters/millimeters). Peak force and stress required to break bones were higher (P<.005) for bones from pigs on the high Ca-P treatments than for those from pigs on the low Ca-P treatments (206.1 kg *vs* 167.8 kg and 54.39 kg/cm^2 *vs* 42.88 kg/cm^2, respectively). Stress:strain responded in a similar fashion. Percentage ash was higher (P<.001) for boars fed the diet with 1.3% Ca and 1.0% P. No significant differences were observed in serum Ca and P levels between either breeds or treatments, but serum alkaline phosphatase levels were higher (P<.001) in boars on .65% Ca and .50% P when analyzed for differences in enzyme level between the termination of the trial and 2 days afterward. A second trial was conducted to evaluate performance and soundness scores of 180 Duroc boars fed various levels of dietary Ca and P and raised under commercial conditions. Treatments were: A, .65% Ca, .50% P; B, .975% Ca, .75% P, and C, 1.3% Ca, 1.0% P. No differences in average daily gains (.90, .90, .90 kg) were observed among the three treatments. There was a tendency for higher (P<.1) average daily feed intake (2.33, 2.33, 2.47) and (P<.01) feed to gain requirements (2.60, 2.58, 2.74) for pigs fed treatment C than for those fed treatments A and B. No differences in feet and leg scores were observed among boars fed different Ca-P treatments.

(**Key Words:** Calcium, Phosphorus, Boars, Performance, Bone-Breaking Strength.)

Introduction

Feet and leg unsoundness problems plague approximately 35% of the purebred boars tested today (Smith and Smith, 1965). Many believe that the past 10 years of intensive selection pressure, changing management ideas and widespread confinement rearing of pigs are responsible for the feet and leg unsoundness problem that troubles the swine industry. However, inadequate mineral nutrition, particularly calcium (Ca) and phosphorus (P), may share in the structural unsoundness problem.

The 1973 NRC requirements for Ca and P for young growing boars are based largely on performance parameters of growing-finishing swine. Optimum performance with maximum skeletal development is an essential factor in the determination of Ca-P requirements for the boar. In one of the few pertinent studies, Liptrap *et al.* (1970) concluded that the Ca requirement of boars was not greater than .60% when P was maintained at .50%. Tanksley (1974) found that the maximum bone-breaking

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load of boar femurs was attained with 1.2% Ca, 1.0% P but that gains and feed conversion were reduced at these levels. Irlam *et al.* (1974) noted increased breaking strength of the fourth metacarpal with 1.03% Ca, .85% P but indicated that performance was similar to that obtained with .72% Ca, .61% P.

The objective of this study was to determine the effect of various levels of dietary Ca and P on performance, bone and blood parameters of different genetic lines of boars. A second trial was conducted in the field to evaluate the effects of various levels of dietary Ca and P on performance and structural soundness of SPF Duroc boars raised under different housing conditions.

Experimental Procedure

Trial 1. Forty boars were randomly assigned by genetic line and weight to two levels of dietary Ca and P for determination of the effects of the different levels on average daily gain, average daily feed intake, feed to gain ratio and blood and bone parameters. Treatment A (.65% Ca and .50% P) met NRC (1973) requirements for young growing pigs. Treatment B contained 1.3% Ca and 1.0% P (NRC requirements plus 100%). The Ca:P ratio was maintained at 1.3:1 for both treatments. Experimental diets (table 1) were corn-soybean meal based and were formulated to contain 17% crude protein. The diets were fed in meal form. The levels of Ca and P were attained by adjustment of the proportions of dicalcium phosphate and calcium carbonate in the diets. Zinc was added to supply 200 ppm in an attempt to avoid any possible onset of parakeratosis with the high Ca/P levels. Vitamin D_3 was supplemented at 440 IU/kg.

Because of slight age differences, boars were allotted to blocks by weight. Boars fed in block 1 were started on the experimental diets at approximately 23.8 kg and fed for 14 weeks until termination at approximately 100.5 kilograms. Boars in block 2 were started at 21.3 kg and fed for 16 weeks until termination at approximately 90.7 kilograms. Boars were group-fed *ad libitum* in outside dirt lots; each treatment per block contained four purebred (Large White) boars and six Nebraska Gene Pool (Zimmerman and Cunningham, 1975) boars (considered as crossbred boars). Individual boar weights and pen feed consumption were measured biweekly.

All boars were slaughtered 2 days after termination of the test, with the left ham and foot excised for recovery of the femur and third and fourth metatarsals. The ham and foot were chilled for 1 week at 2 C, after which bones were removed and frozen at −18 C in moisture-proof plastic bags. In preparation for analysis, bones were thawed at 22 C for 6 hr, then autoclaved for 10 min at 110 C to aid in removal of external fat and muscle tissue. The femur was drilled at the trochanteric and intercondyloid fossa with a 4.76-mm carbon steel bit for extraction of fat from the internal matrix of the bone. Metatarsals were prepared in the same manner. All bones were then extracted for 24 hr with anhydrous ethyl ether in a side-arm ether extraction apparatus to standardize the bones to a fat-free basis. After 24 hr of air drying at 22 C and 12 hr of oven drying at 100 C, all femurs and metatarsals were weighed on a moisture-free, fat-free basis and measured for total length. Two shaft diameter measurements (a, b) were taken at the midpoint of the bone, perpendicular to each other. These two measurements (a and b) were utilized in the calculation of cross-sectional area of the bone.

For objective estimates of the degree of mineralization of individual bones, the bones were broken with an Instron[4] testing machine. Bone test formulas used for determining relative strength and physical characteristics were: Deformation = extension measurement of the cross head when force is applied to the bone, measured in millimeters; length = centimeters; weight = grams; peak force = kilograms of force applied to the midpoint of the shaft; stress = peak force (kilograms)/cross-sectional area (square centimeters); stress:strain = peak force (kilograms)/length (square centimeters)/deformation (millimeters); cross-sectional area = midshaft diameters (centimeters) $(a + b/2/2)^2 \times \pi$.

Bone ash determinations were made on the entire metatarsal bones, whereas only 2.54-cm sections were taken from the midpoint of the shaft of the femur. Determination of percentage of bone ash was conducted according to AOAC (1965) procedures.

Blood samples were obtained from the brachial region in all boars just before termina-

[4]Model TM 1123, Instron Corp., Canton, MA.

tion (T) of the trial and 2 days later (T+2), just before slaughter. At the end of the trial, boars fed treatment B were switched to diets containing .65% Ca and .50% P for 2 days for evaluation of changes, if any, in serum Ca, P or alkaline phosphatase. Special care was taken during blood collection and handling to prevent hemolysis; blood was collected quickly and restraining techniques were used to minimize struggling by the animal. Serum Ca levels were determined by atomic absorption spectrophotometry. Serum inorganic P was determined by the colorimetric method of Goldenberg and Fernandez (1966). Serum alkaline phosphatase was determined by a procedure outlined by the Sigma Chemical Co. (1975).

Statistical analysis was conducted by an appropriate application of least-squares analysis as designed and implemented by Barr and Goodnight (1972) and Steel and Torrie (1960).

Trial 2. After the analyses for trial 1 were completed, a cooperative experiment was developed with Waldo Duroc Farms, DeWitt, Nebraska, to evaluate the diets utilized in trial 1 under field conditions. One hundred and eighty purebred SPF Duroc boars were randomly allotted by house and weight to three dietary levels of Ca and P. Treatment A consisted of .65% Ca and .50% P, which met NRC (1973) requirements for growing pigs. Treatment B contained .975% Ca and .75% P (NRC requirements plus 50%), and Treatment C contained 1.3% Ca and 1.0% P (NRC requirements plus 100%). The Ca to P ratio was maintained at 1.3:1 for all dietary treatments. Experimental diets were commercially prepared corn-soybean meal-based (table 1) diets containing 17% crude protein. They were fed in meal form.

Boars were started on the experimental diets at 31 kg and fed *ad libitum* to an average weight of 102 kilograms. Average daily gain, average daily feed intake and feed to gain ratio were measured at 3-week intervals. Soundness scores were recorded by three independent evaluators just before termination of the trial. Soundness criteria scores were total movement, structure and toe length of front and rear feet and legs. A score of 3 meant there were no major or minor structural weaknesses; 2 signified structural abnormality, but not serious enough to create risks in handling or movement, and 1 indicated severe structural or other abnormality that obviously restricted the movement or value of the pig (Hormel Farmer, 1976).

Boars used in the study were housed in (1) a modified open-front building with total concrete floors with an open-pit flush system,

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS (TRIALS 1 AND 2)

Ingredient	Internat'l Ref. No.	Trial 1		Trial 2		
		Diet A	Diet B	Diet A	Diet B	Diet C
Corn, yellow	4-02-931	72.84	69.46	72.84	71.15	69.46
Soybean meal (44%)	5-04-612	23.74	24.42	23.74	24.07	24.42
Dicalcium phosphate	6-01-080	.81	3.51	.81	2.20	3.51
Limestone, ground	6-02-632	1.01	1.01	1.01	.98	1.01
Salt	6-04-152	.50	.50	.50	.50	.50
Trace minerals[a]		.10	.10	...	...	...
Vitamin and antibiotic mix[b]		1.00	1.00	...	...	...
Trace minerals[c]		...	...	.10	.10	.10
Vitamin premix[c]		...	...	1.00	1.00	1.00
		100.0	100.0	100.0	100.0	100.0

[a]Calcium Carbonate Company, IL. Contributed the following in ppm in trial 1: Zn, 200; Fe, 100; Mn, 55.0; Cu, 10.0; Co, 1.0; I, 1.5.

[b]Contributed the following per kilogram of diet: vitamin A, 3,306 USP; vitamin D_3, 440 IU; riboflavin, 220 mg; pantothenic acid, 13.23 mg; niacin, 17.64 mg; choline chloride, 110.23 mg; vitamin B_{12}, 22.05 g; ethoxyquin, 4.41 mg; menadione sodium bisulfite, 2.20 mg; vitamin E, 22.05 IU. Antibiotic portion contained chlortetracycline 4.4%, sulfamethazine 4.4% and procaine penicillin 2.2%.

[c]Commercially prepared by Master Mix Feed Co. for Waldo Farms. Trace mineral and vitamin premix not identified.

(2) a modified open-front building with partially-slotted concrete floors or (3) a total confinement building with partially-slotted floors. All treatments were imposed on replicate pens of boars within each housing system.

Results and Discussion

A summary of average daily gains, average daily feed intake and feed to gain ratio by breed and treatment (trial 1) is presented in table 2. No differences between genetic lines or treatments were noted for average daily gain (.72 *vs* .74 kg and .74 *vs* .72 kg, respectively). These results agree with those reported by Doige *et al.*, (1975), who found no differences in performance of purebred and crossbred swine fed various Ca and P levels. No differences in average daily feed intake (2.32, 2.31) and feed to gain ratio (3.09, 3.27) were observed between treatments, although feed to gain ratio was numerically different. These results indicate that no differences exist between purebred and crossbred boars in performance parameters when the animals are fed diets containing either the NRC (1973) suggested requirements of .65% Ca and .50% P or 1.3% Ca and 1.0% P.

A summary of the effects of dietary treatment and genetic line on bone characteristics is presented in table 3. Peak force and stress re-

TABLE 2. EFFECT OF TREATMENT AND GENETIC LINE ON PERFORMANCE PARAMETERS. TRIAL 1

	Variable[a]			
	Treatment		Genetic line	
Criterion[b]	A	B	1	2
ADG, kg[c]	.74	.72	.72	.74
ADFI[c], kg[cd]	2,32	2.31	...	...
Feed to gain ratio[cdc]	3.09	3.27	...	...

[a]Treatment A = .65% Ca, .50% P; treatment B = 1.3% Ca, 1.0% P; genetic line 1 = Large White; genetic line 2 = gene pool.

[b]ADG = average daily gain; ADFI = average daily feed intake.

[c]Standard error of treatment means: ADG = .04; ADFI = .30; F:G = .12.

[d]ADFI and feed to gain parameters were the result of group feeding by treatment; thus, no genetic line results were possible.

TABLE 3. EFFECT OF TREATMENT AND GENETIC LINE ON PEAK FORCE, STRESS AND STRESS:STRAIN PARAMETERS OF BONES. TRIAL 1

	Criterion									
	Peak force, kg[a]				Stress, kg/cm^2[a]			Stress:strain, kg/cm^2/mm^2		
Variable[b]	Femur	3rd meta	4th meta	Avg	Femur	3rd meta	4th meta	Avg	Femur	3rd meta	4th meta	Avg
Treatment A	289.2	115.2	98.8	167.8[c]	62.00	36.34	30.30	42.88[c]	54.21	34.69	30.42	39.77[c]
Treatment B	355.7	129.3	141.2	206.1[c]	75.84	43.20	45.25	54.39[c]	68.91	52.45	46.60	55.76[c]
Genetic line 1	320.3	115.0	119.0	181.7	66.60	36.90	36.49	46.24	57.80	38.63	34.05	43.19
Genetic line 2	321.0	127.0	120.0	189.3	69.83	41.62	38.35	50.05	63.38	46.62	41.25	50.42

[a]Standard error of treatment means; peak force = 8.31, stress = 1.67, stress:strain = 2.69.

[b]Treatment A = .65% Ca, .50% P; treatment B = 1.3% Ca, 1.0% P; genetic line 1 = Large White; genetic line 2 = gene pool.

[c]Significance ($P<.005$) within each criterion comparison.

quired to break bones from pigs on treatment A were less (P<.005) than those required to break bones from pigs on treatment B (167.8 kg *vs* 206.1 kg and 42.88 kg/cm^2 *vs* 54.39 kg/cm^2, respectively). Stress:strain values showed a similar pattern; stress:strain required to break bones from pigs on treatment A (the low Ca:P treatment) was less (P<.005) than that necessary to break bones from pigs on treatment B (39.77 kg/cm^2/mm *vs* 55.76 kg/cm^2/mm). These findings contrast with those reported by Tanksley (1974), who indicated that femurs responded to higher Ca and P levels, as shown by increased bone-breaking load, whereas metatarsals did not. The results suggest that the degree of mineralization of bone was greater for boars fed diets containing 1.3% Ca and 1.0% P than it was for those fed the lower level of Ca and P. The stress:strain parameter—which is a function of three different measurements, including peak force (kilograms), cross-sectional area (centimeters) $(a + b)/2/2 \times \pi$ and deformation (millimeters), appears to be a fairly precise estimate for assessing the degree of mineralization of bones. The largest percentage difference between dietary treatments was observed for this parameter.

Results analyzed by genetic line revealed no breed × bone interaction for the femur and third and fourth metatarsals when pooled across dietary treatments. As expected, peak force, stress and stress:strain values for femurs were much greater than those for metatarsals simply because of differences in the physical characteristics of the bones.

Deformation is defined as the length of extension measurement (millimeters) downward that is required to break test bones. A summary of deformation (millimeter) and percentage ash for individual bones evaluated by treatment is presented in table 4. Higher deformation values were obtained when femurs were broken than when metatarsals were broken because of the increased width of fulcra points for femurs and physical differences in the bones. Percentage ash values for femur sections were higher than those for metatarsals, probably because of the higher percentage of organic cartilage in the intact metatarsal. A higher deformation value (P<.001) was observed for bones from pigs on treatment A (.65% Ca and .50% P), (1.22 mm *vs* 1.00 mm); this finding suggests that bones with apparently less mineralization will bend more before breaking. Bones with higher mineralization characteristics will not bend as much before breaking. Percentage ash was greater (P<.001) for bones from pigs on treatment B, indicating that more mineralization of bones had occurred in boars fed 1.3% Ca and 1.0% P. These results do not agree with those reported by Tanksley (1974), who found no differences in percentage ash as dietary Ca and P increased. There were no significant differences between genetic lines for deformation and percentage ash.

A summary of the physical measurement parameters of individual bones evaluated by treatment and genetic line is presented in table 5. Results of physical measurement parameters analyzed by treatments pooled across bones revealed a difference (P<.001) in length between bones from pigs fed treatment A and bones from pigs fed treatment B (12.61 cm *vs* 12.31 cm). An interesting phenomenon was

TABLE 4. EFFECT OF CA/P LEVELS ON DEFORMATION AND PERCENTAGE OF ASH OF BONES

	Treatment[a]			
	A[b]		B[b]	
Bone	Def, mm	Ash, %	Def, mm	Ash, %
Femur	1.30	64.64	1.15	66.54
Third metatarsal	1.19	58.63	1.01	60.59
Fourth metatarsal	1.17	58.70	.85	61.04
Avg	1.22[c]	60.65[c]	1.00[c]	62.65[c]

[a]Treatment A = .65% Ca, .50% P; Treatment B = 1.3% Ca, 1.0% P.

[b]Standard error of treatment means: def = .06; ash = .16.

[c]Significance (P<.001) within each criterion comparison.

TABLE 5. EFFECT OF TREATMENT AND GENETIC LINE ON WEIGHT, LENGTH AND CROSS-SECTIONAL AREA PARAMETERS OF BONES. TRIAL 1

Variable[bc]	Weight, g[a]				Length, cm[ab]				Cross-sectional area[a], (cm) (a+b)/2/2 × π			
	Femur	Third meta	Fourth meta	Avg	Femur	Third meta	Fourth meta	Avg	Femur	Third meta	Fourth meta	Avg
Treatment A	149.5	16.72	17.66	61.31	19.43	8.93	9.48	12.61[d]	4.75	3.18	3.28	3.74[e]
Treatment B	154.1	16.44	17.70	61.11	19.25	8.82	9.24	12.31[d]	4.71	2.99	3.11	3.58[e]
Genetic line 1	153.5	16.22	17.72	60.56	19.60	8.86	9.43	12.48[d]	4.85	3.11	3.27	3.72
Genetic line 2	150.5	16.83	17.64	61.65	19.18	8.88	9.31	12.45[d]	4.65	3.07	3.14	3.62

[a]Standard error of treatment means: weight = 15.35, length = 1.17, cross-sectional area = .18.

[b]Genetic line × bone interaction (P<.05).

[c]Treatment A = .65% Ca, .50% P; treatment B = 1.3% Ca, 1.0% P; genetic line 1 = Large White; genetic line 2 = gene pool.

[d]Significance (P<.005) for treatment and genetic line comparisons.

[e]Significance (P<.05) for treatment comparison.

noted for bones from boars on treatment B. Percentage ash values of bones from these boars were lower, yet measurements revealed the bones were longer. Trabecular bones in the metaphysis support the epiphyseal plate, which adds to the length of the bone. Therefore, the decrease in percentage ash and increase in length was probably due in part to the higher percentage of organic cartilage of the epiphyseal plate. Finally, bones from pigs on treatment A had larger cross-sectional area (P<.05) than did those from pigs on diet B (3.74 cm^2 *vs* 3.58 cm^2).

Bone weight and cross-sectional area measurements did not differ between genetic lines, but genetic line 1 (Large Whites) had longer (P<.005) bones than genetic line 2 (Gene Pool). A genetic line × bone interaction (P<.005) was also noted. The largest difference between genetic lines in individual length of bones was for femurs (19.60 cm for genetic line 1 *vs* 19.18 cm for genetic line 2).

Results of (T) and (T+2) bleedings for serum parameters are presented in table 6. No differences in serum Ca and P were observed between genetic lines or dietary treatments. Genetic line 1 had higher (P<.001) alkaline phosphatase levels than genetic line 2 during the (T) and (T+2) bleeding. When analyzed by treatment, higher (P<.005) akaline phosphatase levels for the (T) bleeding were observed for boars fed treatment A. These findings, along with lower percentage ash, increased bone length and increased diameter, suggest that Ca and P levels may have retarded normal bone growth and mineralization patterns in pigs fed treatment A. Also, genetic line 1 may have had a higher Ca and P requirement for normal bone mineralization patterns when assessed by these parameters. Increases in serum alkaline phosphatase activity have been reported in animals affected by diseases such as osteomalacia and rickets (Kay, 1930). Also, early bone growth patterns are associated with elevated serum alkaline phosphatase levels (Clark and Beck, 1950). Therefore, the decreases observed as the pig matures may be a result of decreased bone formation and reduced osteoblastic activity.

The differences in the (T) and (T+2) bleeding serum Ca, P and alkaline phosphatase values were not surprising. No differences were found in serum Ca and P. The treatment × genetic line interaction (P<.05) that was observed appears to suggest that boars of genetic line 1 responded more to the decreased Ca level than did boars

TABLE 6. EFFECT OF TREATMENT AND GENETIC LINE ON SERUM CALCIUM, PHOSPHORUS AND ALKALINE PHOSPHATASE. TRIAL 1. (T) *vs* (T + 2)

Treatment[b]	Genetic line[c]	T[a]			T + 2[a]			Difference		
		Ca	P	Alk. PO_4	Ca	P	Alk. PO_4	Ca	P	Alk. PO_4
		mg/100 ml		IU/ml	mg/100 ml		IU/ml	mg/100 ml		IU/ml
A	1	11.29	8.80	.084[d]	10.40	8.69	.077[e]	.89	.11	.007[f]
A	2	11.07	8.67	.057[d]	11.05	8.64	.051[e]	.02	.03	.006[f]
Avg		11.15	8.72	.068[g]	10.79	8.66	.062	.36	.06	.006[h]
B	1	11.09	8.90	.061[d]	11.25	8.78	.077[e]	−.16	.12	−.016[f]
B	2	11.18	8.92	.048[d]	10.98	8.84	.048[e]	.20	.08	.000[f]
Avg		11.14	8.91	.053[g]	11.09	8.81	.060	.50	.10	−.007[h]

[a]Standard error of treatment means: T: Ca = .18, p = .11, Alk. PO_4 = .003; T + 2: Ca = .20, P = .10, Alk. PO_4 = .003.

[b]Treatment A = .65% Ca, .50% P; Treatment B = 1.3 Ca, 1.0% P.

[c]Genetic line 1 = Large White; genetic line 2 = gene pool.

[d]Genetic line 1 *vs* genetic line 2 ($P<.001$).

[e]Genetic line 1 *vs* genetic line 2 ($P<.001$).

[f]Genetic line X treatment interaction ($P<.05$).

[g]Treatment A *vs* treatment B ($P<.005$).

[h]Treatment A *vs* treatment B ($P<.01$).

TABLE 7. EFFECT OF TREATMENT AND HOUSING CONDITION ON AVERAGE DAILY GAIN, AVERAGE DAILY FEED INTAKE, FEED TO GAIN RATIO AND SOUNDNESS SCORES. TRIAL 2

Item	ADG[ab], kg	ADFI[ab], kg	F:G[ab]	Front score[b]	Rear score[b]
Treatment[c]					
A	.90	2.33	2.60	2.13	2.11
B	.90	2.33[d]	2.58[e]	2.24	2.09
C	.90	2.47[d]	2.74[e]	2.14	2.15
House[f]					
1	.89	2.42	2.70[g]	1.97[h]	2.08
2	.90	2.37	2.63[gi]	2.24[hj]	2.00
3	.91	2.27	2.50[gi]	2.61[hj]	2.31

[a]ADG = average daily gain; ADFI = average daily feed intake; F:G feed per gain.

[b]Standard error of treatment means: ADG = .02, ADFI = .06, F:G = .03, front score = .08, rear score = .08.

[c]Treatment A = .65% Ca, .50% P; treatment B = .975% Ca, .75% P; treatment C = 1.3% Ca, 1.0% P.

[d]Treatment 2 *vs* 3 (P<.1).

[e]Treatment 2 *vs* 3 (P<.05).

[f]1 = modified open-front (flush system); 2 = modified open-front (partially-slotted floors); 3 = total confinement (partially-slotted floors).

[g]House 1 *vs* 2, 3 (P<.05).

[h]House 1 *vs* 2, 3 (P<.001).

[i]House 2 *vs* 3 (P<.1).

[j]House 2 *vs* 3 (P<.05).

of genetic line 2. The resulting increase in alkaline phosphatase for (T+2) bleeding was expected. Also, boars fed treatment A were observed to have higher (P<.001) alkaline phosphatase levels than boars fed treatment B when differences between (T) and (T+2) bleedings were analyzed. This observation supports the contention that .65% Ca and .50% P seem to be inadequate for optimum mineralization of growing boars.

Trial 2. Results of trial 2 are presented in table 7. Statistical analysis revealed no treatment differences in average daily gain, as the boars gained .90 kg per day on all three treatments. Boars fed treatment C had a higher (P<.05) feed to gain ratio than did those fed treatments A and B (2.74 *vs* 2.60 and 2.58). Also, boars fed treatment C showed a tendency (P<.1) to consume more feed on a daily basis than those on treatments A and B (2.47 *vs* 2.33 and 2.33). Differences in kilocalories of energy per kilogram of diet among pigs on the three experimental treatments were minimal.

Evaluation of soundness scores for front and rear legs revealed no differences among dietary treatments. Performance and soundness scores were also analyzed by housing situations pooled across treatments. No differences were observed in average daily gain (.89, .90, .91) and average daily feed intake (2.42, 2.37, 2.27) among the three types of housing. Feed to gain ratio was greater (P<.01) for boars kept in housing type 1 than for those maintained in houses 2 and 3 (2.70 *vs* 2.63 and 2.50). Also, there was a tendency (P<.1) for feed to gain requirements to be greater for house 2 boars than for house 3 boars (2.63 *vs* 2.50). Soundness scores of front legs were lower (P<.001) for boars fed in house 1, indicating more unsoundness for them than for boars fed in houses 2 and 3. Pigs in house 2 had lower front and rear leg soundness scores (P<.05) than those in house 3. The differences in soundness scores between boars in house 1 and those in houses 2 and 3 may have been partially caused by the wet floors in house 1, which contained an open-pit flush system. There is no apparent explanation for the difference in soundness scores between boars in house 2 and those in house 3, since floor design was the same.

Literature Cited

AOAC. 1965. Official Methods of Analysis (11th Ed.). Association of Official Agriculture Chemists, Washington, DC.

Barr, A. J. and J. H. Goodnight. 1972. A user's guide

to the statistical analysis system (SAS). North Carolina State Univ., Raleigh.

Clark, L. C. and E. Beck. 1950. Plasma alkaline phosphatase activity. I. Normative data for growing children. J. Pediat. 36:335.

Doige, C. E., B. D. Owens and J.H.L. Mills. 1975. Influence of calcium and phosphorus on growth and skeletal development of growing swine. Can. J. Anim. Sci. 55:147.

Goldenberg, H. and A. Fernandez. 1966. Simplified method for the estimation of inorganic phosphorus in body fluids. Clin. Chem. 12:87.

Hormel Farmer. 1976. Production Tested Barrows 31(2):16.

Irlam, D. E., H. H. Hodson, Jr. and R. A. Synder. 1974. Calcium and phosphorus levels for boars. J. Anim. Sci. 39:977 (Abstr.).

Kay, H. O. 1930. Plasma Phosphatase II. The enzyme in disease, particularly in bone disease. J. Biol. Chem. 89:249.

Liptrap, D. O., E. R. Miller, D. E. Ullrey, K. K. Keahey and J. A. Hoefer. 1970. Calcium level for developing boars and gilts. J. Anim. Sci. 31:540.

NRC. 1973. Nutrient Requirements of Domestic Animals, No. 2. Nutrient Requirements of Swine. National Academy of Science–National Research Council, Washington, DC.

Sigma Chemical Co. 1975. The colorimetric determination of phosphatase. Tech. Bull. No. 104 (Revised Ed.), St. Louis, MO.

Smith, R.G.D. and C. Smith. 1965. Report on boar performance testing at Sterling. Anim. Prod. 7:284.

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

Tanksley, T. D. 1974. Evaluation of the dietary calcium and phosphorus requirements of developing boars. Proc. Swine Short Course. Texas Agr. Exp. Sta., College Station. P. 68.

Zimmerman, D. R. and P. J. Cunningham. 1975. Selection for ovulation rate in swine: Population, procedures and ovulation response. J. Anim. Sci. 40:61.