Effect of Level of Dietary Calcium-Phosphorus During Growth and Gestation on Calcium-Phosphorus Balance and Reproductive Performance of First-Litter Sows

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EFFECT OF LEVEL OF DIETARY CALCIUM - PHOSPHORUS DURING GROWTH AND GESTATION ON CALCIUM - PHOSPHORUS BALANCE AND REPRODUCTIVE PERFORMANCE OF FIRST - LITTER SOWS[1]

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Summary

Twenty-four bred gilts were used in a Ca-P metabolism trial. Twelve gilts were fed gestation treatment A (13 g Ca, 10 g/day), while the other 12 were fed gestation treatment B (19.5 g Ca, 15 g P/day). One-half of the gilts in each treatment group were fed .65% Ca, .50% P from 7 to 94 kg, and half were fed .975% Ca, .75% P for the same period. Treatment B gilts excreted more (P<.005) fecal and urinary P. Twenty-four first litter sows fed the same treatment diets during growth and gestation and given .75% Ca, .50% P during lactation were used in a Ca and P balance trial conducted from day 38 to 42 of lactation. No differences in fecal, urinary or milk Ca or P were noted between sows fed the different diets during growth or gestation. A higher (P<.05) value for Ca balance during lactation was observed for sows fed treatment diet B during gestation than for those fed gestation diet A. There were growth treatment × gestation treatment interactions (P<.05) for both Ca and P balance. No differences were noted in total pigs farrowed, total pigs farrowed alive, average weaning weight or number of pigs weaned. Birth weights were higher (P<.05) for pigs from sows fed diet B during gestation than for pigs from sows fed diet A. Pre- and postfarrowing weights, weaned sow weight and lactation gain were similar regardless of treatment fed during growth or gestation.

(Key Words: Sow, Gilt, Calcium, Phosphorus, Gestation, Lactation.)

Introduction

The Ca and P requirements of gestating gilts are based on limited research. The NRC (1968, 1973) suggested requirements for gestating gilts were 15 g Ca and 10 g P/day, but redefined the requirements in 1979 (NRC, 1979) to 13.5 g Ca and 10.8 g P/day. Harmon *et al.* (1974) reported that gilts fed diets containing .31% P (5.58 g/day) during gestation farrowed normally and showed no consistent effects during lactation that could be attributed to P feeding level during gestation. Still, the authors noted a high incidence of posterior paralysis among sows fed .31% P and suckled for 8 weeks. Harmon *et al.* (1975) also reported that sows fed a gestation P level of .33% with various P levels during lactation produced litters of similar size and weight to those produced by sows fed .68% P during gestation. Nimmo *et al.* (1981) reported lower bone peak force values and less bone strength per unit area for gilts that had been fed .65% Ca and .50% P. They also found that 30% of the gilts on the lower Ca-P treatments had to be removed from the trial because they were unable to stand, whereas the removal rate for the gilts given .975% Ca, .75% P was negligible. Kornegay *et al.* (1973) reported similar farrowing and weaning performance and tissue parameters for sows fed either 10.3 g Ca and 11.0 g P or 15.5 g Ca and 15.0 g P daily for five reproductive cycles. The data presently available are inconsistent and inconclusive for a wide variety of response criteria that must be considered in the estimation of Ca-P requirements of gilts during gestation.

This study was conducted to determine the effects of various levels of dietary Ca and P fed to gilts during growth and gestation on

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Ca-P balance in the dam during gestation and lactation.

Experimental Procedure

Phase 1. Twenty-four gilts, all bred within a 5-day period, were used in a Ca-P metabolism trial conducted during gestation. Twelve of the gilts were fed .65% Ca and .50% P (growth treatment A) from 7.25 to 92.8 kg, while the other 12 were fed .975% Ca and .75% P (growth treatment B). At 92.8 kg, one-half of the gilts on growth treatment A were assigned to gestation treatment A (13.0 g Ca and 10.0 g P/day) and half were assigned to gestation treatment B (19.5 g Ca and 15.0 g P/day). The same assignment of gestation treatments was carried out for the 12 gilts on growth treatment B, creating four outcome growth-gestation treatment groups (six gilts/group): growth A-gestation A, growth A-gestation B, growth B-gestation A and growth B-gestation B. A detailed description of diets, feeding procedures, housing and breeding procedures has been given by Nimmo *et al.* (1981). Gilts were placed in metabolism crates at an average of 38 days of gestation and continued on their respective gestation diets for 3 days before the initiation of the collection period. All urine and feces were collected for 96 hours. Gilts had been catheterized with either 18- or 20-gauge 5-cc foley catheters for urine collection. Urine was collected in 22-liter plastic containers, with volume determined daily, and diluted to the nearest 500 ml volume with redeionized distilled water. After dilution, 5% of the sample was kept for analysis. Feces were collected at least three times daily, frozen and pooled over the 4-day period. Analysis of urine and feces for Ca and P was performed by an automated procedure adapted from Kessler and Wolfman (1964).

Phase 2 Twenty-four lactating first-litter sows were used in a Ca-P balance trial. All sows were offered 4.53 kg of a lactation diet containing .75% Ca and .50% P daily (for complete description, see Nimmo *et al.*, 1981). Sows and their litters were placed in metabolism crates at an average of 35 days postpartum and allowed to adjust for 3 days before collections were begun. During the adjustment and collection periods, litters were separated from their dams because the dams were catheterized, but the piglets were allowed to suckle three times at 4-hr intervals and twice at 6-hr intervals each day. Collection and analysis of feces and urine were carried out as in phase 1. Milk production, measured as litter weight gain over a 24-period, was determined on the fourth day of collection; the litters were weighed before and immediately after each suckling and the gains summed. Milk samples were collected 1 day thereafter for subsequent Ca-P analysis by the procedure of Kessler and Wolfman (1964). Since endogenous losses of Ca and P were not determined, all retention and balance data are "apparent" values.

All gilts were weighed at 109 days of gestation, immediately after farrowing, and at weaning. Data were collected on 67 litters from the four outcome growth-gestation treatment groups (A-A, A-B, B-A, B-B).

Analysis of treatments was carried out to evaluate responses during the growth and gestation periods on gestation and lactation Ca-P balance. Groups growth A-gestation-A and growth A-gestation-B (A-A, A-B) were pooled to create pooled growth group A (p-grow A) while groups B-A and B-B were pooled to create growth group B. Similar procedures were followed to create p-gest A and p-gest B (A-A, B-A = p-gest A; A-B, B-B = p-gest B). Comparisons of p-grow A *versus* p-grow B and p-gest A *versus* p-gest B were made in both phrases. The growth × gestation interaction was also tested. Statistical analysis was conducted by least-squares procedures designed and implemented by Barr *et al.* (1976) and Steel and Torrie (1960).

Results and Discussion

In phase 1, no differences (P>.05) between pooled growth groups were found in Ca or P losses from the feces or urine or in the amount of Ca or P retained (table 1). However, gilts fed p-gest A (13.0 g Ca and 10.0 g P/day) excreted less fecal Ca daily than gilts fed p-gest B (19.5 Ca and 15.0 g P/day); 12.2 *vs* 16.2 g). Only a small amount of urinary Ca was excreted daily by the gilts and there were no differences due to treatment. More Ca was retained daily by gilts fed p-gest B diets (P<.005) than by those fed p-gest A (3.15 *vs* .68 g). Gestating gilts fed 13.5 g Ca/day excreted 91.1% of their intake, or 12.3 g, while gilts fed 19.5 g Ca/day excreted only 83.8% of their intake, or 16.3 grams. The net increase in Ca retained for gilts fed 19.5 g

TABLE 1. EFFECT OF DIETARY CALCIUM-PHOSPHORUS LEVELS DURING GROWTH AND GESTATION ON CALCIUM-PHOSPHORUS BALANCE OF GESTATING GILTS

Item	Treatment means ± SE[a]				Treatment means ± SE pooled by growth and gestation treatments[b]			
	AA	AB	BA	BB	p-grow A	p-grow B	p-gest A	p-gest B
Fecal Ca, g[c]	12.10 ± .31	16.80 ± .71	12.29 ± .46	15.59 ± 1.01	14.44 ± .80	13.94 ± .73	12.19 ± .27	16.19 ± .62
Urinary Ca, g	.14 ± .04	.17 ± .02	.10 ± .02	.13 ± .04	.15 ± .02	.12 ± .02	.12 ± .02	.15 ± .02
Ca retention, g[d]	.76 ± .30	2.53 ± .71	.60 ± .47	3.78 ± 1.04	1.65 ± .45	2.19 ± .72	.69 ± .27	3.15 ± .63
Fecal P, g[d]	5.26 ± .40	7.94 ± .59	5.45 ± .46	7.47 ± .58	6.61 ± .53	6.46 ± .46	5.36 ± .29	7.71 ± .40
Urinary P, g[d]	1.35 ± .18	1.93 ± .15	.94 ± .13	1.79 ± .19	1.64 ± .14	1.36 ± .17	1.15 ± .12	1.86 ± .12
P retention, g[d]	3.38 ± .50	5.12 ± .58	3.60 ± .51	5.74 ± .56	4.25 ± .45	4.67 ± .48	3.49 ± .34	5.43 ± .40

[a]Treatment means represent four groups of six gilts each, fed AA, BB, BA or BB. First letter denotes growth treatment (A = .65% Ca, .50% P; B = .975% Ca, .75% P), second letter denotes gestation treatment (A = 13.0 g Ca, 10.0 g P/day; B = 19.5 g Ca, 15.0 g P/day). Means are expressed as grams per day.

[b]Treatment means are derived from data from pooled growth groups A and B and pooled gestation group A and B (12 observations/treatment). Means are expressed as grams per day.

[c]p-gest A *versus* p-gest B (P<.001).

[d]p-gest A *versus* p-gest B (P<.005).

Ca/day was 2.47 grams. More fecal and urinary P was excreted (P<.005) by gilts fed p-gest B than by those fed p-gest A. More P was retained (P<.005) by gilts fed p-gest B. Although 5 g more P (10.0 *vs* 15.0 g) was fed to the p-gest B gilts, they retained only 1.94 g more.

The results of the gestation metabolism trial indicate that more Ca and P were retained when 19.5 g Ca and 15.0 g P/day were fed than when 13.5 g Ca and 10.0 g P/day were fed. The latter levels are similar to the NRC (1979)-suggested requirements for gestating gilts and sows. This suggests that the NRC-suggested levels might be too low if greater retention of Ca and P during gestation is important. Although the data reflect a 4-day period at approximately 40 to 45 days of gestation, an appreciable net increase in Ca and P retained probably existed throughout gestation for the gilts fed 19.5 g Ca and 15.0 g P/day.

Bone data obtained on these gilts following one lactation (Nimmo *et al.*, 1981) suggested that because the bones were stronger per unit area, they were more dense. This supports the hypothesis that more resorption of Ca and P from the skeleton had occurred during lactation in gilts fed p-gest A so that the animals could meet lactation Ca and P demands.

No differences (P>.05) in fecal, urinary or milk Ca and P were observed between p-grow and p-gest groups (table 2). In addition, no differences were noted between p-grow A and p-grow B or between p-gest A and p-gest B in retention, balance or intake of Ca or P. A higher (P<.05) value for Ca balance during lactation was observed for gilts fed p-gest B than for those fed p-gest A (14.45 *vs* 11.99). In addition, there was a p-grow × p-gest interaction (P<.05) for both Ca and P balance. Some trends concerning Ca and P balance may be more evident when the means for the outcome growth-gestation groups (table 2) are evaluated (A-A, A-B, B-A, B-B). Although Ca and P intake was the same for all lactating sows (.75% Ca and .50% P), some variation existed because of different rates of feed consumption. There was also variation in milk volume and grams of Ca and P excreted in the milk daily, although no differences existed within pooled growth and pooled gestation treatment groups. Milk volume may have been affected by the periodic

TABLE 2. EFFECT OF DIETARY CALCIUM-PHOSPHORUS LEVELS DURING GROWTH AND GESTATION ON CALCIUM-PHOSPHORUS BALANCE OF LACTATING FIRST-LITTER SOWS

Item	Treatment means ± SE[a]				Treatment means ± SE pooled by growth and gestation treatments[b]			
	AA	AB	BA	BB	p-grow A	p-grow B	p-gest A	p-gest B
Fecal Ca, g	12.86 ± 1.38	13.80 ± .82	13.40 ± 1.41	13.45 ± .94	13.33 ± .78	13.42 ± .81	13.13 ± .95	13.62 ± .60
Urinary Ca, g	.31 ± .09	.45 ± .10	.29 ± .08	.52 ± .11	.38 ± .07	.41 ± .08	.30 ± .06	.48 ± .07
Milk Ca, g	4.51 ± 1.37	3.12 ± .52	3.64 ± .70	3.34 ± .68	3.82 ± .73	3.49 ± .47	4.07 ± .75	3.23 ± .41
Ca retention, g	14.12 ± 1.77	18.19 ± 1.13	18.01 ± 1.27	17.18 ± .78	16.16 ± 1.17	17.59 ± .72	16.06 ± 1.19	17.68 ± .67
Ca balance, g[cd]	9.61 ± 1.30	15.07 ± .69	14.37 ± 1.29	13.83 ± .83	12.34 ± 1.08	14.10 ± .73	11.99 ± 1.13	14.45 ± .55
Ca intake, g	27.29 ± 2.62	32.44 ± 1.40	31.69 ± 2.44	31.15 ± .75	29.86 ± 1.62	31.42 ± 1.22	29.49 ± 1.83	31.79 ± .78
Fecal P, g	16.17 ± 1.56	17.66 ± 1.58	18.62 ± 1.46	19.19 ± .97	17.40 ± 1.12	18.42 ± .87	16.91 ± 1.04	18.91 ± .89
Urinary P, g	.40 ± .12	.53 ± .12	.46 ± .17	.51 ± .14	.43 ± .08	.52 ± .10	.47 ± .10	.48 ± .09
Milk P, g	4.23 ± 1.18	2.99 ± .40	2.81 ± .49	3.23 ± .45	3.52 ± .63	3.11 ± .32	3.61 ± .65	3.02 ± .29
P retention, g	1.25 ± .70	2.57 ± 1.25	2.13 ± .54	.66 ± .83	1.69 ± .70	1.62 ± .55	1.91 ± .47	1.40 ± .75
P balance, g[d]	−2.98 ± .72	−.41 ± 1.30	−.68 ± .58	−2.57 ± .66	−1.83 ± .79	−1.49 ± .53	−1.69 ± .59	−1.62 ± .75
P intake, g	17.83 ± 1.71	20.76 ± .97	21.21 ± 1.69	20.36 ± .54	19.52 ± 1.07	20.56 ± .85	19.29 ± 1.23	20.79 ± .54
Milk volume, ml	1,266 ± 312	913 ± 137	872 ± 125	1,028 ± 179	1,069 ± 173	970 ± 106	1,089 ± 169	950 ± 110

[a]Treatment means represent four groups of six gilts each, fed AA, BB, BA or BB. First letter denotes growth treatment (A = .65% Ca, .50% P; B = .975% Ca, .75% P), second letter denotes gestation treatment (A = 13.0 g Ca, 10.0 g P/day; B = 19.5 g Ca, 15.0 g P/day).

[b]Treatment means are derived from data for pooled growth groups A and B and pooled gestation groups A and B (12 observations/treatment).

[c]p-gest A *versus* p-gest B ($P<.05$).

[d]p-grow × p-gest interaction ($P<.05$).

TABLE 3. EFFECT OF DIETARY CALCIUM-PHOSPHORUS LEVELS DURING GROWTH AND GESTATION ON REPRODUCTIVE PERFORMANCE

Item	Treatment means ± SE[a]				Treatment means ± SE pooled by growth and gestation treatments[b]			
	AA	AB	BA	BB	p-grow A	p-grow B	p-gest A	p-gest B
Total farrowed	9.5 ± .75	9.4 ± .49	8.8 ± .58	8.9 ± .46	9.1 ± .46	9.1 ± .34	9.4 ± .42	8.9 ± .36
Total farrowed alive	9.2 ± .79	9.2 ± .51	8.4 ± .60	8.7 ± .50	8.8 ± .48	8.9 ± .35	9.2 ± .44	8.5 ± .38
Stillborn	.28 ± .29	.16 ± .09	.41 ± .15	.22 ± .10	.35 ± .15	.19 ± .07	.22 ± .13	.31 ± .09
Mummies	.14 ± .14	.16 ± .09	.17 ± .13	.27 ± .18	.16 ± .09	.22 ± .10	.16 ± .08	.23 ± .11
Birth weight, kg[c]	1.3 ± .04	1.4 ± .03	1.4 ± .05	1.5 ± .05	1.4 ± .04	1.4 ± .03	1.3 ± .03	1.4 ± .04
Avg weaning weight, kg	10.0 ± .90	10.8 ± .60	9.5 ± .63	9.1 ± .60	10.4 ± .53	9.3 ± .42	9.7 ± .51	10.0 ± .45
No. of pigs weaned	7.3 ± .77	7.4 ± .58	7.1 ± .50	6.9 ± .63	7.2 ± .43	7.2 ± .43	7.4 ± .46	7.0 ± .40
Prefarrow gilt weight, kg[d]	165 ± 2.67	164 ± 1.90	157 ± 2.32	165 ± 2.08	161 ± 1.85	164 ± 1.39	164 ± 1.55	161 ± 1.67
Postfarrow gilt weight, kg[d]	153 ± 2.73	152 ± 1.75	145 ± 2.03	153 ± 2.05	148 ± 1.79	152 ± 1.52	148 ± 1.52	148 ± 1.58
Weaned sow weight, kg	141 ± 4.82	141 ± 2.93	134 ± 2.43	144 ± 2.58	137 ± 2.58	143 ± 1.94	141 ± 2.63	139 ± 1.96
Lactation gain, kg	−11.7 ± 3.32	−10.9 ± 2.84	−10.4 ± 2.43	−8.2 ± 2.68	−11.0 ± 1.97	−9.6 ± 1.94	−11.2 ± 2.12	−9.3 ± 1.80

[a]Treatment means represent four groups; AA = 14, AB = 17, BA = 18, BB = 18. First letter denotes growth treatment (A = .65% Ca, .50% P; B = .975% Ca, .75% P), second letter denotes gestation treatment (A = 13.0 g Ca, 10.0 G P/day; B = 19.5 g Ca, 15.0 g P/day).

[b]Treatment means are derived from pooled growth groups A and B and pooled gestation groups A and B (12 observations/treatment).

[c]p-gest A *versus* p-gest B ($P<.05$).

[d]p-grow × p-gest interaction ($P<.05$).

suckling procedure used for piglets, although milk volumes did represent a total 24-hr collection rather than estimates, as have been reported by other workers (Wells *et al.*, 1940; Lodge, 1959; Mahan *et al.*, 1971).

Since the Ca and P levels (.75% Ca and .50% P) were the same for all sows during lactation, a wider range of Ca-P levels during gestation may have resulted in detectable treatment differences in Ca and P balance during lactation, although all outcome treatment groups (A-A, A-B, B-A, B-B) were in negative P balance. These results are in contrast with those reported by Harmon *et al.* (1975), who indicated that all but one group of sows fed 5.94 or 13.24 g of P during gestation and 13.5, 16.5 or 19.5 g P during a 28-day lactation period remained in positive P balance.

A summary of reproductive performance is presented in table 3. No differences (P>.05) were noted in total pigs farrowed, total pigs farrowed alive, stillborn pigs, mummies, average weaning weight or number of pigs weaned. Harmon *et al.* (1975) reported no difference in litter size and litter weight among first-litter sows fed a corn-soybean meal diet with or without supplemental P during gestation. Harmon *et al.* (1975) reported that sows fed .65% P during lactation weaned lighter pigs than sows fed .45% P, although the numbers of pigs weaned were similar. Birth weights were greater (P<.05) for pigs from sows given p-gest B during gestation than for those from sows on p-gest A (1.4 *vs* 1.3 kg). Kornegay *et al.* (1973) reported no differences in farrowing or weaning performance traits, except average weaning weight, between pigs from sows fed low Ca-P levels (10.3 g Ca and 11.0 g P) and pigs from sows fed high levels (15.5 g Ca and 15.0 g P). In this trial, weaning weight was higher for pigs from sows fed the lower Ca and P levels. The standard errors for all pig response criteria were large because of the normal variation found in litter data. Regardless, any trends that may have occurred were difficult to interpret because of the magnitude of the standard error for treatment means. Pre- and postfarrowing gilt weights, weaned sow weights and lactation gains were similar for the p-grow and p-gest treatment groups. Also, although a p-grow × p-gest interaction (P<.05) was observed for pre- and postfarrowing gilt weights, the average lactation weight loss was 1.02 kg for the 42-day lactation period. Kornegay *et al.* (1973) reported an 11.4 kg weight loss during five reproductive cycles of 42 days each, while Harmon *et al.* (1975) noted a 17-kg weight loss over a 28-day lactation. Dietary Ca-P treatment during gestation and subsequent lactation appears to have little if any effect on sow weight loss during lactation.

The results of the studies of Ca and P balance during gestation and lactation, in conjunction with data on bone characteristics and the number of gilts failing to complete gestation because of their inability to stand (Nimmo *et al.*, 1981), do not agree with the level of P reported by Harmon *et al.* (1975) as satisfactory for first-litter gestating gilts. One of the levels of dietary Ca and P utilized for gestating gilts in this study (13.5 g Ca and 10.0 g P/day) was similar to the NRC (1979)-suggested requirements (13.5 g Ca and 10.8 g P/day). When consideration is given to maximal skeletal development and the ability of gestating gilts to withstand the rigors of being reared in confinement, the data indicate that 13.5 g Ca and 10.0 g P/day was not adequate while 19.5 g Ca and 15 g P appeared quite adequate for gestating gilts. Thus, the results reported herein do not support the 1979 NRC requirements for Ca and P for gestating gilts.

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