Evaluating Calcium Administration Protocols Around Farrowing on Sow Performance

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Summary
A total of 933 mixed-parity sows (Line 1050, PIC) and their litters were used to evaluate the effect of calcium administration protocols around farrowing on sow performance. Sows were blocked by parity category and past stillbirth record, then allotted to one of three treatments with 310 to 312 replications per treatment. Treatments included: 1) control in which sows received no intervention; 2) 25 g of a calcium chloride-based product (CaCl; TRIAD, Alltech, Inc., Nicholasville, KY) top-dressed daily at the morning feeding from the time of entry (approximately d 112 of gestation) until the sow farrowed; or 3) calcium gluconate injection (CaG; VetOne; Boise, ID) where multiparous and primiparous sows received a 20 or 15 mL injection, respectively, if a sow had more than 16 piglets, longer than 1 h since the birth of the last piglet, the litter had two or more stillbirths, or farrowing duration exceeded 4 h. On a subset of females (n = 74/treatment), farrowing duration, sow blood metabolite analysis, sow urine pH, and piglet blood immunocrit were analyzed. Sow blood and urine were collected within 4 and 6 h of the end of farrowing, and piglet blood was collected within 24 h of the beginning of farrowing. Females were categorized in parity groups of P1 (n = 194), P2-P4 (n = 489), or P5+ (n = 250). Parity category, treatment, and their interaction were included as fixed effects, while the previous stillbirth category (< 0.5, ≥ 0.5 and ≤ 1, or > 1 average stillborn pigs per litter) was a random effect in the model. There were no differences in total born, percentage born alive, or percentage stillbirths between treatments; however, when at-risk sows (sows with > 16 piglets, > 1 hour since the last birth, ≥ 2 stillbirths, or farrowing lasting > 4 hours) were compared, administration of a CaG injection decreased stillbirths, increasing the percentage of pigs born alive. There was an interaction between farrowing calcium protocol and parity category for birth to cross-foster mortality ($P = 0.035$), where mortality was lowest in P1 control sows ($P < 0.05$) compared to all other combinations of treatment × parity category except for P1 CaG sows, which were intermediate. Sows fed CaCl had increased blood Cl and ionized Ca ($P < 0.05$) compared to control or CaG sows. Sows injected with CaG

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had increased blood glucose levels ($P < 0.05$) compared to control sows, with sows fed CaCl intermediate. Sows provided CaCl or CaG had decreased urine pH ($P < 0.05$) compared to control sows. There was a tendency for a farrowing Ca protocol effect on piglet immunocrit ($P = 0.068$), where offspring from CaG sows had a numeric increase in immunocrit ratios. In conclusion, in the overall population, top-dressing CaCl before farrowing or injecting CaG peripartum altered sow metabolites during farrowing but did not influence farrowing performance. However, when comparing at-risk sows among the three treatments, administration of a CaG injection decreased stillbirths, leading to an increase in the percentage of pigs born alive.

Introduction

Stillbirths are estimated to account for up to 8.4% of the total pigs born in the United States,[4] representing a substantial economic loss to producers as this translates to fewer pigs weaned. Prolonged farrowing is one of the biggest risk factors for increased stillbirths in a litter. Prolonged farrowing also leads to more hypoxic pigs, which are ineffective at obtaining colostrum, thus making them more susceptible to crushing deaths.[5] Past research investigating the effects of top-dressing calcium chloride (CaCl) for approximately 5 d prior to farrowing found a reduction in stillbirths and farrowing intervention.[6] Other research has shown that CaCl led to a decrease in stillbirths in mid-parity sows but not in primiparous or older parity sows.[7] Conversely, others have shown no improvement in percentage of stillbirths or percentage born alive when a CaCl top-dress was utilized prior to farrowing.[8] The proposed mechanism of action for reducing stillbirths is the increase in calcium supplied to the sow's uterine muscles. It has also been hypothesized that the CaCl top-dress may improve the cation/anion balance and lower the pH in the GI tract and urine. Much like CaCl, calcium gluconate (CaG) is a calcium salt. Calcium gluconate is used on many swine farms during the farrowing process. However, there is no existing literature published on the efficacy of administering CaG around parturition on improving farrowing performance. Therefore, the objective of this trial was to evaluate two calcium administration protocols around farrowing on sow performance prior to cross-fostering and sow and piglet blood parameters under commercial conditions.

Materials and Methods

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. This study was conducted at a commercial sow farm in northwest Texas (JBS Live Pork, Dalhart, Texas). Sows were individually housed in farrowing stalls equipped with a SowMax sow feed hopper (HogSlat, Newton Grove, NC) with a nipple waterer.

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Animals

A total of 933 sows (average parity 3.3, Line 1050, PIC, Hendersonville, TN) and their litters were used from May to August 2024. On approximately d 112 of gestation, sows were moved into the farrowing house, weighed, blocked by parity and past stillbirth record, and assigned to one of three calcium administration protocols. Parity categories were: first parity (n = 194), parities 2-4 (n = 489), and parity 5 and above (n = 250). Average past stillbirth categories of multiparous sows (n = 739) were: < 0.5 (n = 326), 0.5 ≥ × ≤ 1.0 (n = 278), and > 1.0 (n = 135). Within the block, females were randomly assigned to a treatment to equalize parity and average past stillbirths. Treatments included: 1) control in which sows received no intervention; 2) 25 g of a calcium chloride-based product (CaCl; TRIAD, Alltech, Inc., Nicholasville, KY) top dressed daily at the morning feeding from the time of entry (approximately d 112 of gestation) until the sow farrowed; or 3) calcium gluconate injection (CaG; VetOne; Boise, ID) where multiparous and primiparous sows received a 20 or 15 mL, respectively, injection intramuscularly in the neck if a sow had more than 16 piglets, it had been longer than 1 h since the birth of the last piglet, the litter had 2 or more stillbirths, or farrowing duration exceeded 4 h. All sows were fed approximately 4 lb/day (2 lb each morning and afternoon) from d 112 of gestation until farrowing. All sows were hand-fed prior to farrowing, and after farrowing, sows had *ad libitum* access to a common lactation diet.

Farrowing was monitored from 6 a.m. until 3 p.m. daily. All sows, regardless of farrowing timing, were included in the analysis of this study. For each sow, litter characteristics (live-born, stillborn, and born mummified) were recorded on a sow card by a member of the farm farrowing team during each pass of the farrowing house (approximately every 15 min). If it had been longer than 30 min since the birth of the last piglet or if it was clear the sow was in distress, farrowing assistance (sleeving) occurred, and if a piglet was present in the birth canal, it was manually removed. Any instances of sleeving were recorded on the sow card, regardless if a piglet was removed or not. Oxytocin was utilized sparingly in this trial and only after agreed upon by two independent parties of the research team. A total of eight sows received oxytocin (VetOne; Boise, ID) during this trial, with four from the CaG treatment and four from the CaCl treatment. Sows were only induced to farrow if gestation length exceeded 117 days. A total of 28 sows were induced using Lutalyse (Zoetis Inc., Kalamazoo, MI), with 13 from the control treatment, eight from the CaCl treatment, and seven from the CaG treatment.

Any piglet mortalities that occurred prior to cross-fostering (at approximately 24 h of age) were recorded. The cause of mortality was also recorded. The wean-to-service interval was analyzed for each sow that remained in the herd after weaning. Females that were culled from the herd were recorded, and the reasoning for culling was recorded as well.

On a subset of females (n = 74/treatment), more extensive data collection was performed. Farrowing duration was collected, in which the beginning of farrowing is denoted as the birth of the first piglet, and the end of farrowing is denoted as the birth of the last piglet. The first five pigs born were marked for split-suckling purposes. Within 4 h of the end of farrowing, blood was collected from the ear vein of the sow. Using the iSTAT CHEM8+ cartridge (Zoetis, Parsippany, NJ), sow blood metabolites, including ionized calcium, glucose, blood urea nitrogen, sodium, potassium, chloride, total carbon dioxide, anion gap, creatinine, hematocrit, and hemoglobin were determined. Within 6 h of the end of farrowing, sow urine was collected and analyzed for pH. At approximately 24 h after the beginning of farrowing, blood was taken for determination of immunocrit ratio from one of the first five pigs born, visually selecting the pig closest to the average birth weight of the litter. Immunocrit ratio is a ratio of the length of precipitated immunoglobulins in the serum sample relative to the total length of the serum sample. Ammonium sulfate was utilized to precipitate the immunoglobins in the serum sample, and the immunocrit ratio was utilized as an estimation of colostrum consumption.

Statistical analysis

Continuous data were analyzed using the lme4 package of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) as a randomized complete block design. Blocking structure accounted for parity and the average past stillbirth record. Sow served as the experimental unit. Treatment, parity category, and their interaction were included as fixed effects. Past stillbirth category was included in the model as a random effect. Count data were analyzed using a negative binomial distribution using a logit link function. Proportion data, including birth-cross foster mortality and litter characteristics, were analyzed using a binomial distribution using a logit link function. Percentage data, including percentage culled and percentage sleeved, were analyzed using a binary distribution. Differences were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$. All treatment × parity interactions were $P > 0.05$ unless otherwise indicated.

Sows were also categorized into two subsets: at-risk (n = 411) or non-at-risk (n = 522) across the three treatments for additional statistical analysis. At-risk sows were those that met the criteria to receive calcium gluconate injection (sows with > 16 piglets, > 1 hour since the last birth, ≥ 2 stillbirths, or farrowing lasting > 4 hours) and farrowed between the hours of 6 a.m. and 3 p.m. Because sows were assigned to treatment before farrowing, there were also sows assigned to the calcium gluconate treatment that were not later classified as at-risk sows and, thus, did not receive an injection of calcium gluconate. These females would be deemed non-at-risk. The same statistical analyses were performed with the same statistical models, but within the risk group for the three treatments.

Results and Discussion

Overall population

There was a treatment × parity interaction for the proportion of mummies in the litter ($P = 0.019$; Table 1), where within parity 1 females, there was a numeric increase in mummies in CaCl sows compared to the other two treatments, whereas in parity 5+ sows there was a numeric increase in mummies in CaG sows compared to the other two calcium administration protocols. However, it should be noted that the earliest calcium-administration protocols began at d 112 of gestation, so this difference in mummies was likely due to chance. There was a treatment × parity interaction in birth-to-cross-foster mortality ($P = 0.035$), where parity 1 control sows had the lowest birth to cross-foster mortality compared to all other parity by treatment categories ($P < 0.05$) with the exception of parity 1 calcium gluconate sows, which were intermediate.

In the overall population, there was no difference in total born, the proportion of the litter born alive, or the proportion of stillbirths in the litter due to calcium administration protocol ($P > 0.10$; Table 2). There were no differences in the percentage of females who needed to be sleeved, the number of times that females needed to be sleeved, or farrowing duration due to calcium administration protocol ($P > 0.10$). Birth-to-cross-foster mortality was increased in CaCl sows ($P < 0.05$) compared to control sows, with CaG sows intermediate. Wean-to-service interval, the percentage of females culled, and the percentage of females culled due to being open were not different due to calcium administration protocol ($P > 0.10$).

Anion gap, blood urea nitrogen, creatinine, potassium, and sodium in the blood did not differ based on calcium administration protocol ($P > 0.10$; Table 3). Chloride was greater in the blood from CaCl sows ($P < 0.05$) compared to control and CaG sows. Blood glucose levels were greater in CaG sows ($P < 0.05$) compared to control and CaCl sows. There was a tendency for a difference in hematocrit and hemoglobin levels based on calcium administration protocol ($P \leq 0.067$), where CaCl sows had a numeric increase in both criteria, followed by CaG sows, and then by control sows. Circulating ionized calcium levels were increased in CaCl sows ($P < 0.05$) compared to both CaG and control sows. Total carbon dioxide in the blood was decreased in CaCl sows ($P < 0.05$) compared to control sows, with CaG sows intermediate. Urine pH was decreased in CaG and CaCl treatment sows ($P < 0.05$) compared to control sows. There was a tendency for a difference in piglet immunocrit ratio based on calcium administration protocol ($P = 0.068$), where pigs from CaG sows had a numeric increase in immunocrit ratio compared to pigs from control sows.

Non-at-risk sows

Litter characteristics, including total born, percentage born alive, percentage stillborn, and percentage of mummies, did not differ based on calcium administration protocol within non-at-risk sows ($P > 0.10$; Table 4). Calcium administration protocol did not affect the percentage of females sleeved, the number of times females were sleeved, farrowing duration, or wean-to-service interval in non-at-risk sows ($P > 0.10$). Birth-to-cross-foster mortality was increased in CaG and CaCl sows ($P < 0.05$) compared to control sows. Blood chloride, ionized calcium, and total carbon dioxide were greater in calcium chloride sows compared to control sows ($P \leq 0.044$; Table 5). Blood sodium tended to be higher in CaCl sows ($P = 0.054$) compared to control sows.

At-risk sows

In at-risk sows, the percentage of stillbirths was decreased in CaG sows ($P < 0.05$) compared to control and CaCl sows. This led to an improvement in percentage born alive in CaG sows ($P < 0.05$) compared to control and CaCl sows. The percentage of sows sleeved, the number of times sows were sleeved, and the wean-to-service interval did not differ based on calcium administration protocol ($P > 0.10$). Birth-to-cross-foster mortality was decreased in CaG sows ($P < 0.05$) compared to CaCl sows, with control sows intermediate. Blood chloride was increased in CaCl sows ($P < 0.05$) compared to control and CaG sows. Blood glucose was increased in CaG sows ($P < 0.05$) compared to control and CaCl sows. Circulating ionized calcium was increased in CaCl sows ($P < 0.05$) compared to control sows, with CaG sows intermediate. Total carbon dioxide in the blood was lower in CaCl sows ($P < 0.05$) compared to control sows, with CaG sows intermediate.

Parity effects

As expected, parity 5+ sows were heavier ($P < 0.05$) at entry in the farrowing house compared to parity 2-4 sows; similarly, parity 2-4 sows were heavier ($P < 0.05$) than parity 1 sows at entry into the farrowing house. These differences in entry BW due to parity category were seen when sows were broken into non-at-risk and at-risk sows as well. Parity 5+ sows had a lower percentage of pigs born alive, a higher percentage of stillbirths, and were culled at a higher rate ($P < 0.05$) compared to parity 2-4 sows and parity 1 sows. Similarly, in both non-at-risk and at-risk sows, stillbirths were highest in parity 5+ sows ($P < 0.05$) and, in non-at-risk sows, parity 5+ sows had a lower percentage of pigs born alive ($P < 0.05$) compared to parity 2-4 and parity 1 sows. Parity 5+ sows were sleeved at the highest frequency ($P < 0.05$), followed by parity 2-4 sows, and then by parity 1 sows. Birth-to-cross-foster mortality was lower in parity 1 sows ($P < 0.05$) compared to parity 2-4 sows and parity 5+ sows. A similar relationship between parity and mortality was seen in birth-to-cross-foster mortality in non-at-risk females. There was a tendency for a difference in wean-to-service interval based on parity category ($P = 0.053$), where parity 5+ sows had a numeric decrease in wean-to-service interval compared to parity 2-4 sows and parity 1 sows. Blood creatinine was higher in parity 5+ and parity 2-4 sows ($P < 0.05$) compared to parity 1 sows. A similar relationship between parity and blood creatinine was seen in non-at-risk sows; however, in at-risk sows, blood creatinine was higher only in parity 5+ sows ($P < 0.05$) compared to parity 2-4 and parity 1 sows. There was a tendency for an effect of parity category on blood glucose level ($P = 0.059$) where glucose was numerically highest in parity 1 sows and decreased as parity increased. Circulating ionized calcium was decreased in parity 5+ sows ($P < 0.05$) compared to parity 1 and parity 2-4 sows. A similar relationship between parity and circulating ionized calcium was seen in both non-at-risk and at-risk sows. Blood potassium tended to be different based on parity ($P = 0.058$), where there was a numeric decrease in potassium in parity 2-4 sows compared to parity 1 and parity 5+ sows. A similar trend in blood potassium levels based on parity was seen in at-risk sows ($P = 0.092$). In at-risk sows, blood sodium tended to be different based on parity ($P = 0.066$), where parity 1 sows had a numeric increase in sodium compared to parity 2-4 and parity 5+ sows.

In conclusion, for the overall population, top-dressing the CaCl-based product before farrowing or administering CaG injections peripartum altered sow metabolites during farrowing but did not influence farrowing performance. However, when the population was further broken down into non-at-risk and at-risk (sows with > 16 piglets, > 1 hour since the last birth, ≥ 2 stillbirths, or farrowing lasting > 4 hours), administration of a CaG injection decreased stillbirths in at-risk sows, leading to an increase in the percentage of pigs born alive.

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Table 1. Interactive effects of farrowing calcium protocol and parity on sow farrowing performance[1]

Item	Farrowing protocol[2]:	None			Calcium chloride			Calcium gluconate				*P* =		
	Parity Category[3]:	P1	P2-P4	P5+	P1	P2-P4	P5+	P1	P2-P4	P5+	SEM	TRT × Parity	TRT	Parity
Count, n		65	163	83	65	164	83	64	162	84	---	---	---	---
Mummy, %		2.0	3.0	2.7	3.6	3.0	2.9	2.2	2.1	3.7	0.56	0.019	0.035	0.228
Birth-cross foster mortality, %		3.9[b]	6.9[a]	7.8[a]	8.0[a]	7.4[a]	8.3[a]	6.1[ab]	7.2[a]	8.2[a]	0.85	0.035	< 0.001	< 0.001

[a,b]Means within row with different superscripts differ (*P* < 0.05).
[1]A total of 933 mixed-parity sows (PIC, Line 1050) and litters were used from the time of load-in into the farrowing house (approximately d 112 of gestation) until cross-fostering at approximately 24 h after farrowing.
[2]Farrowing protocol consisted of a control with sows receiving no intervention (None), 25 g of a calcium chloride based product (TRIAD, All-Tech, Lexington, KY) top-dressed on the morning feeding of each sow, from load-in into the farrowing house until each female farrowed (Calcium chloride), and a calcium gluconate protocol in which multiparous sows received a 20 mL injection and primiparous sows received a 15 mL injection of calcium gluconate if a litter had more than 16 piglets, it had been longer than 1 hour since the birth of the last piglet, the litter had two or more stillbirths, or farrowing duration exceeded four hours (Calcium gluconate).
[3]Parity was included as a fixed effect in the data analysis model. Sows were classified as P1 (n = 194), P2-P4 (n = 489), or P5+ (n = 250).

Table 2. Effect of farrowing calcium protocol on sow farrowing performance[1]

Farrowing protocol[2]:	None	Calcium chloride	Calcium gluconate	SEM	*P* = TRT × Parity	TRT	Parity
Count, n	311	312	310	---	---	---	---
Sow entry BW, lb	593.0	595.0	592.7	5.40	0.478	0.891	< 0.001
Gestation length, d	116.1	116.1	116.0	0.08	0.310	0.679	0.362
Litter characteristics							
Total born, n	16.7	16.7	16.9	0.25	0.907	0.963	0.600
Born alive, %	90.8	90.1	91.4	0.88	0.190	0.145	< 0.001
Stillborn, %	6.7	6.7	6.1	0.87	0.462	0.226	< 0.001
Mummy, %	2.5	3.1	2.6	0.26	0.019	0.035	0.228
Farrowing characteristics							
Percentage of females sleeved	45.0	48.7	51.3	3.32	0.278	0.381	< 0.001
Number of times sleeved	1.1	1.1	1.3	0.39	0.970	0.901	0.458
Farrowing duration, min[3]	294.6	294.2	323.7	15.07	0.951	0.194	0.350
Birth-cross foster mortality, %	5.9[b]	7.9[a]	7.1[ab]	0.42	0.035	< 0.001	< 0.001
Wean to service interval, d	4.8	5.2	4.8	0.28	0.256	0.349	0.053
Culled, %[4]	4.8	7.1	8.6	2.63	0.427	0.256	< 0.001
Culled – Open, %	0.0	2.3	2.8	6.78	0.613	0.456	0.300

[a,b]Means within row with different superscripts differ (*P* < 0.05).
[1]A total of 933 mixed-parity sows (PIC, Line 1050) and litters were used from the time of load-in into the farrowing house (approximately d 112 of gestation) until cross-fostering at approximately 24 h after farrowing.
[2]Farrowing protocol consisted of a control with sows receiving no intervention (None), 25 g of a calcium chloride based product (TRIAD, All-Tech, Lexington, KY) top-dressed on the morning feeding of each sow from load-in into the farrowing house until each female farrowed (Calcium chloride), and a calcium gluconate protocol in which multiparous sows received a 20 mL injection and primiparous sows received a 15 mL injection of calcium gluconate if a litter had more than 16 piglets, it had been longer than 1 hour since the birth of the last piglet, the litter had 2 or more stillbirths, or farrowing duration exceeded 4 hours (Calcium gluconate).
[3]Farrowing duration was collected on a subset of females (n = 74/trt).
[4]Percentage of females culled from the time of allotment until d 30 post insemination.

Table 3. Effect of farrowing calcium protocol on sow and piglet blood and urine characteristics[1]

					P =		
Farrowing protocol[2]:	**None**	**Calcium chloride**	**Calcium gluconate**	**SEM**	**TRT × Parity**	**TRT**	**Parity**
Count, n	74	74	74	---	---	---	---
Blood characteristics							
Anion gap, mmol/L	17.6	18.0	18.2	0.25	0.761	0.236	0.561
Blood urea nitrogen, mg/dL	12.6	13.0	13.6	0.71	0.232	0.401	0.405
Chloride, mmol/L	102.9[b]	104.6[a]	103.0[b]	0.39	0.973	< 0.001	0.161
Creatinine mg/dL	3.1	3.2	3.2	0.07	0.643	0.944	0.001
Glucose, mmol/L	96.5[b]	96.4[b]	102.8[a]	2.46	0.765	0.026	0.059
Hematocrit, % PCV	31.0	32.6	31.7	0.56	0.510	0.060	0.455
Hemoglobin, g/dL	10.5	11.1	10.8	0.19	0.495	0.067	0.455
Ionized calcium, mmol/L	1.23[b]	1.29[a]	1.24[b]	0.016	0.212	< 0.001	0.001
Potassium, mmol/L	4.2	4.2	4.1	0.05	0.587	0.365	0.058
Sodium, mmol/L	142.6	143.0	142.6	0.28	0.863	0.371	0.144
Total carbon dioxide, mmol/L	27.3[a]	25.6[b]	26.5[ab]	0.34	0.452	< 0.001	0.162
Urine pH	6.96[a]	6.41[b]	6.53[b]	0.128	0.745	0.001	0.904
Piglet immunocrit ratio[3]	0.070	0.074	0.080	0.0034	0.430	0.068	0.406

[a,b]Means within row with different superscripts differ ($P < 0.05$).
[1]A total of 933 mixed-parity sows (PIC, Line 1050) and litters were used from the time of load-in into the farrowing house (approximately d 112 of gestation) until cross-fostering at approximately 24 h after farrowing.
[2]Farrowing protocol consisted of a control with sows receiving no intervention (None), 25 g of a calcium chloride based product (TRIAD, All-Tech, Lexington, KY) top-dressed on the morning feeding of each sow from load-in into the farrowing house until each female farrowed (Calcium chloride), and a calcium gluconate protocol in which multiparous sows received a 20 mL injection and primiparous sows received a 15 mL injection of calcium gluconate if a litter had more than 16 piglets, it had been longer than 1 hour since the birth of the last piglet, the litter had 2 or more stillbirths, or farrowing duration exceeded 4 hours (Calcium gluconate).
[3]Blood was taken from one of the first five pigs born in each litter at approximately 24 h after the start of farrowing.

Table 4. Effect of farrowing calcium protocol on sow farrowing performance for at-risk and non-at-risk sows[1]

	Non-at-risk sows					At-risk sows				
Farrowing protocol[2]:	**None**	**Calcium chloride**	**Calcium gluconate**	**SEM**	**TRT, $P =$**	**None**	**Calcium chloride**	**Calcium gluconate**	**SEM**	**TRT, $P =$**
Count, n	172	184	166	---	---	139	128	144	---	---
Sow entry BW, lb[3,4]	589.3	591.0	585.9	6.89	0.738	597.6	600.0	599.7	7.50	0.953
Gestation length, d	116.0	115.9	115.9	0.11	0.643	116.1	116.2	116.1	0.13	0.643
Litter characteristics										
Total born, n	16.6	16.6	16.4	0.35	0.869	16.9	16.9	17.6	0.44	0.559
Total born alive, n	15.5	15.3	14.8	0.34	0.655	14.9	15.0	16.1	0.42	0.181
Stillborn, n[3,4]	0.8	0.9	1.0	0.18	0.865	1.5[a]	1.4[ab]	1.0[b]	0.16	0.039
Mummy, n	0.4	0.5	0.5	0.06	0.197	0.4	0.5	0.4	0.09	0.688
Born alive, %[3]	92.9	91.3	91.0	1.08	0.163	88.2[b]	88.6[b]	92.1[a]	0.98	0.006
Stillborn, %[3,4]	4.8	5.6	6.1	1.09	0.772	9.0[a]	8.3[a]	5.9[b]	0.91	0.004
Mummy, %[5]	2.4	2.9	2.9	0.34	0.102	2.6	3.0	2.1	0.48	0.670
Farrowing characteristics										
Percentage of females sleeved	16.2	30.0	19.4	4.01	0.696	78.2	78.6	87.6	4.33	0.594
Number of times sleeved	0.2[b]	0.4[a]	0.3[ab]	0.07	0.363	2.3	2.5	2.6	0.32	0.948
Birth-cross foster mortality, %[3]	4.1[b]	6.8[a]	6.7[a]	0.54	0.003	8.1[ab]	10.1[a]	7.6[b]	0.80	0.006
Wean to service interval, d	4.6	5.6	4.9	0.47	0.152	5.4	5.0	5.1	0.53	0.733

[a,b]Means within row with different superscripts differ ($P < 0.05$).

[1]A total of 933 mixed-parity sows (PIC, Line 1050) and litters were used from the time of load-in into the farrowing house (approximately d 112 of gestation) until cross-fostering at approximately 24 h after farrowing.

[2]Farrowing protocol consisted of a control with sows receiving no intervention (None), 25 g of a calcium chloride based product (TRIAD, All-Tech, Lexington, KY) top-dressed each morning from entry into the farrowing house until each female farrowed (Calcium chloride), and a calcium gluconate protocol in which at-risk multiparous sows received a 20 mL injection and primiparous sows received a 15 mL injection of calcium gluconate. Females were categorized into two subsets: at-risk (n = 411) or non-at-risk (n = 522). At-risk sows were those that met the criteria to receive calcium gluconate injection (sows with > 16 piglets, > 1 hour since the last birth, ≥ 2 stillbirths, or farrowing lasting > 4 hours). Because sows were assigned to treatment before farrowing, there were also sows assigned to the calcium gluconate treatment that were not later classified as at-risk sows and, thus, did not receive an injection of calcium gluconate.

[3]Non at-risk sows: Parity, $P < 0.05$.

[4]At-risk sows: Parity, $P < 0.05$.

[5]At-risk sows: Parity, $P < 0.10$.

Table 5. Effect of farrowing calcium protocol on farrowing duration and sow and piglet blood parameters for at-risk and non-at-risk sows[1]

	Non-at-risk sows					At-risk sows				
Farrowing protocol[2]:	None	Calcium chloride	Calcium gluconate	SEM	TRT, *P* =	None	Calcium chloride	Calcium gluconate	SEM	TRT, *P* =
Count, n	26	48	0	---	---	48	26	74	---	---
Farrowing duration, min	277.1	284.3	---	23.80	0.763	307.6	307.1	328.0	31.21	0.628
Blood characteristics										
Anion gap, mmol/L	17.4	18.1	---	0.53	0.219	17.7	18.0	18.2	0.49	0.428
Blood urea nitrogen, mg/dL	12.8	12.8	---	1.15	0.989	12.6	12.7	13.6	1.20	0.411
Chloride, mmol/L	102.8	104.7	---	0.70	0.007	102.9[b]	104.9[a]	103.1[b]	0.72	0.039
Creatinine mg/dL[3,4]	3.1	3.1	---	0.15	0.701	3.2	3.3	3.2	0.13	0.809
Glucose, mmol/L	98.5	97.8	---	4.72	0.882	95.6[b]	90.7[b]	102.7[a]	4.14	0.005
Hematocrit, % PCV	30.8	32.3	---	1.18	0.205	31.0	33.3	31.7	1.05	0.168
Hemoglobin, g/dL	10.5	11.0	---	0.40	0.212	10.6	11.3	10.8	0.36	0.178
Ionized calcium, mmol/L[3,4]	1.25	1.29	---	0.019	0.044	1.22[b]	1.29[a]	1.24[ab]	0.020	0.004
Potassium, mmol/L[5]	4.2	4.2	---	0.08	0.647	4.2	4.2	4.1	0.09	0.637
Sodium, mmol/L[5]	142.1	143.1	---	0.53	0.054	142.8	143.2	142.5	0.54	0.443
Total carbon dioxide, mmol/L	27.1	25.6	---	0.73	0.026	27.6[a]	25.5[b]	26.5[ab]	0.65	0.011
Piglet immunocrit[6]	0.063	0.074	---	0.0078	0.131	0.072	0.073	0.080	0.0057	0.206

[a,b]Means within row with different superscripts differ ($P < 0.05$).

[1]A total of 933 mixed-parity sows (PIC, Line 1050) and litters were used from the time of load-in into the farrowing house (approximately d 112 of gestation) until cross-fostering at approximately 24 h after farrowing.

[2]Farrowing protocol consisted of a control with sows receiving no intervention (None), 25 g of a calcium chloride based product (TRIAD, All-Tech, Lexington, KY) top-dressed each morning from entry into the farrowing house until each female farrowed (Calcium chloride), and a calcium gluconate protocol in which at-risk multiparous sows received a 20 mL injection and primiparous sows received a 15 mL injection of calcium gluconate. Females were categorized into two subsets: at-risk (n = 411) or non-at-risk (n = 522). At-risk sows were those that met the criteria to receive calcium gluconate injection (sows with > 16 piglets, > 1 hour since the last birth, ≥ 2 stillbirths, or farrowing lasting > 4 hours). Because sows were assigned to treatment before farrowing, there were also sows assigned to the calcium gluconate treatment that were not later classified as at-risk sows and, thus, did not receive an injection of calcium gluconate.

[3]Non at-risk sows: Parity, $P < 0.05$.

[4]At-risk sows: Parity, $P < 0.05$.

[5]At-risk sows: Parity, $P < 0.10$.

[6]Blood was taken from one of the first five pigs born in each litter at approximately 24 h after the start of farrowing.