Evaluation of Split Suckling Strategies on Pre- and Post-Weaning Piglet Growth and Mortality

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Summary

A total of 1,513 sows, approximately 505 sows per treatment, and their litters were used in a 20-d lactation study to determine the effects of split-suckling strategies on litter growth, pre-weaning mortality, and post-weaning performance. Sows were blocked by parity, and sows and their litters were allotted to one of three treatments consisting of a control treatment with no split-suckling, or one of two treatments using different split-suckle protocols. For split-suckle treatment 1, litters were split-suckled based on birth order, with the first eight pigs born marked at birth, and upon the completion of farrowing, the eight marked pigs were removed from the sow for 45 min. After 45 min, the eight marked pigs were placed back on the sow, and the unmarked pigs born later in the birth order were removed from the sow for 45 min, and then all pigs were returned to the sow. For split-suckle treatment 2, after farrowing was completed, the eight heaviest pigs in the litter were removed from the sow for 1.5 h and then returned to the sow, completing the split-suckle treatment. Litters on split-suckle strategies 1 and 2 were split-suckled within 18 h of birth. Cross-fostering occurred within treatment 24 h after the completion of farrowing and after the split-suckling treatment was applied. Fallback pigs were identified from d 2 to 12 after birth, pulled, and placed on a nurse sow. There were no differences ($P > 0.10$) in litter size at d 1 or weaning. Piglet weights on d 1 and weaning were not different ($P > 0.10$) among treatments. No differences ($P > 0.10$) in pre-weaning mortality from d 1 to d 2, d 2 to weaning, or overall were observed. There was no difference ($P > 0.10$) in the percentage of fallback pigs fostered to a nurse sow. Pre-weaning mortality was analyzed by body weight category at birth within treatment, light (≤ 2.6 lb), medium (2.7 < × ≤ 3.2 lb), and heavy (≥ 3.3 lb) pigs; with no differences ($P > 0.10$) in pre-weaning mortality from d 1 to weaning observed. A subset of pigs was followed into the nursery and finisher to track post-weaning growth performance and mortality, with no differences ($P > 0.10$) in ADG, ADFI, F/G, or mortality observed in the nursery or finisher. Overall, the split-suckle strategies

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used in this study did not affect pig growth performance or mortality pre- or post-weaning compared to not split-suckling.

Introduction

Litter size in the swine industry has been increasing due to genetic selection for high-producing sows.[5] Large litter sizes result in increased competition, especially where litter size is greater than the number of functional teats, resulting in reduced colostrum consumption. Split-suckling is a strategy designed to help ensure all pigs in a litter consume colostrum, specifically in large litters. However, split-suckling protocols vary between commercial production systems based on the timing of split-suckling, which pigs should be removed, and how long pigs should be removed from the sow. Split-suckling strategies also vary within the literature, and there is not one specific protocol that appears to give the best results. Therefore, more research is needed to compare different split-suckling strategies and their effect on lifetime pig growth and mortality.

We hypothesized that split-suckling litters by removing the eight heaviest pigs in each litter for 1.5 h would result in reduced pre-weaning and lifetime mortality compared to litters that were not split-suckled, as well as split-suckling by pulling off the first eight pigs born for 45 min and then removing pigs born later in the birth order for 45 min. We also hypothesized that there would be no differences in pre-weaning growth performance among treatments.

Materials and Methods

The Kansas State University Institutional Care and Use Committee approved the protocol used in this experiment. The study was conducted at a commercial sow farm in Nebraska (Pillen Family Farms, Columbus, NE). Sows and their litters were housed in individual farrowing stalls. Creep feed was offered to all litters from d 10 post-farrowing until weaning.

Animals

A total of 1,513 sows (average parity 3.6; DNA 241, Columbus, NE) and litters (DNA 241 × 600) were used in a lactation study. Sows were moved from gestation to farrowing on approximately d 110 of gestation. Sows and their litters were allotted to one of three treatments. Litters on the control treatment were not split-suckled. For split-suckle treatment 1, litters were split-suckled based on birth order. The first eight pigs born were marked at birth as the sow was farrowing. Upon the completion of farrowing, which was determined by the passing of afterbirth, the eight marked pigs were removed from the sow for 45 min and placed in the crate under a heat lamp using a board to separate them from the sow. After 45 min, the marked pigs were placed back with the sow, and the unmarked pigs born later in the birth order were pulled off the sow for 45 min, and then all pigs were placed back with the sow. For split-suckle treatment 2, after farrowing was completed, the eight heaviest pigs in the litter were removed from the sow and placed under a heat lamp in the crate for 1.5 h. After 1.5 h, all pigs were returned to the sow, completing the split-suckle treatment. Split-suckle treatments 1 and 2 were applied within 3 h of the end of farrowing if a sow farrowed during the day and within 18 h of the start of farrowing if a sow farrowed in the evening or overnight. The completion of farrowing was defined as when the afterbirth was passed. After the

[5] Kemp, B., C. L. A. Da Silva, and N. M. Soede. 2018. Recent advances in pig reproduction: Focus on impact of genetic selection for female fertility. Reprod. Domestic Animals. 53:28–36. doi:10.1111/rda.13264.

split-suckling treatment was applied, litters were cross-fostered within the treatment within 24 h after the completion of farrowing.

Individual pig weights were taken prior to split-suckling and cross-fostering. At the time of d 1 weights, pigs were given an ear tag for individual identification. Fallback pigs were identified from d 2 to 12 post-weaning, weighed, removed from the litter, and placed on a nurse sow. At weaning, individual pig weights were taken again. All pre-weaning mortalities were recorded, including the date and reason for death. Litter size was recorded at d 1, after litter equalization, and at weaning. Pig count at d 1 included only pigs alive at the time of tagging and weighing. Pre-weaning mortality was tracked only on pigs weighed on d 1 and does not include pigs that died before d 1 weights or fallback pigs removed from the litter and placed on a nurse sow.

On a subset of litters, 45 per treatment, a 3 mL blood sample was taken from each pig in the litter approximately 24 h after the birth of the first pig. Blood samples were taken from the jugular vein. At the time of blood sample collection, piglet BW was also collected. Serum was separated from whole blood through centrifugation and stored at -112°F (-80°C) until analysis for immunocrit ratio. Immunocrit ratio is a ratio of the length of precipitated immunoglobulins in the serum sample relative to the total length of the serum sample. Fifty µL of serum was mixed with a 40% ammonium sulfate solution and centrifuged (12,000 × g in a hematocrit centrifuge tube) for 10 min.[6] The immunocrit ratio was calculated by taking the ratio of the precipitate to the length of the serum tube.

On a subset of 2,208 pigs, growth performance and mortality were evaluated post-weaning through the nursery and finisher periods in a research facility. Pigs chosen to be followed into the nursery were selected because they were born the week of intensive blood collection to measure the immunocrit ratio. In both the nursery and finisher phases, pigs were penned by treatment. In the nursery, all pigs were fed in three dietary phases, with all pigs receiving the same diets. Feed intake was measured on a pen basis during the nursery period. (Gestal Evo feeding system, Jyga Technologies, St-Lambert-de-Lauzon, Quebec, Canada). Pig weights were taken at the end of the nursery period (48 to 52 d post-weaning). Of the 2,208 pigs that started in the nursery, a subset of 882 pigs was then followed into the finisher. Pigs with blood samples collected at the sow farm were selected to be followed into the finisher. During the finishing period, pigs were fed in six dietary phases, with all pigs receiving the same diets. Individual pig feed intake was measured during the grow-finish period (Nedap Feeders, Nedap, Groenlo, Netherlands). Individual pig weights were taken at d 81 post-nursery, which was at the first marketing (topping) event.

Statistical analysis

Performance data were analyzed using the lmer function of R software, version 1.4.171, as a randomized complete block design. Sow and litter were considered the experimental unit depending on the response variable. Treatment was a fixed effect. Block (sow parity) and farrowing room were considered random effects. Pre-weaning mortality and percentage of pigs fostered to nurse sows were analyzed using a binomial distribution. Pre-wean mortality was also analyzed by BW category (light, medium, or heavy) using a binomial distribution. To create the light, medium, and heavy BW cate-

[6] Vallet, J.L., J.R. Miles and L.A. Rempel. 2013. A simple novel measure of passive transfer of maternal immunoglobulin Is predictive of preweaning mortality in piglets. Vet. J. 195: 91-97.

gories, the distribution of piglet BW at d 1 was broken down into roughly three equal categories. Litter growth performance and mortality were also analyzed on a subset of the population, where litter size at d 1 was greater than the sow's functional teat count. Treatment comparisons were determined considering the interaction of the split-suckle treatment and parity, and the interaction between split-suckle treatment and timing of split-suckling and sow functional teat count. For the analysis of immunocrit ratio, treatment was a fixed effect, and sow was considered a random effect. The nursery and finisher data were analyzed using treatment as a fixed effect, with nursery or finisher room included in the model as a random effect. Pen was considered the experimental unit. Results are considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results

There were no differences in functional teat count or wean age among treatments ($P > 0.10$; Table 1). Litter size on d 1, after equalization, and at weaning were not different ($P > 0.10$) among treatments. No differences ($P > 0.10$) were observed for litter or piglet BW at d 1 or at weaning, as well as piglet ADG. Pre-weaning mortality was analyzed from d 1 to 2, d 2 to weaning, and overall, and no differences ($P > 0.10$) were observed among treatments. The percentage of fallback pigs removed and placed on nurse sows was not different ($P > 0.10$) among treatments. Pre-wean morality was also analyzed based on BW category, light: ≤ 2.6 lb, medium: 2.7 to 3.2 lb, or heavy: ≥ 3.3 lb. When mortality was analyzed by BW category, there was no difference ($P > 0.10$) among treatments for each BW category.

Immunocrit ratio measures the immunoglobulin levels in serum and can be used as an indicator of colostrum intake in piglets. Thus, a higher immunocrit ratio indicates high colostrum intake. No differences ($P > 0.10$; Table 2) were observed among treatments for immunocrit ratio, indicating that split-suckling did not have an impact on colostrum intake. When considering only the pigs that blood samples were collected from, there were no differences ($P > 0.10$) in piglet BW at d 1, d 2, or at weaning, as well as pig gain from d 1 to 2, d 2 to weaning, or d 1 to weaning. There were also no differences ($P > 0.10$) in mortality from d 1 to weaning.

Litter performance and pre-weaning mortality were analyzed on a subset of litters, where litter size at d 1 was higher than functional teat count to determine if split-suckling had a positive effect on larger litters (Table 3). There was no difference ($P > 0.10$) in litter size or growth performance among treatments based on litter size at d 1. A difference ($P < 0.05$) in pre-weaning mortality from d 1 to 2 was observed among treatments, with litters not split-suckled having a higher mortality from d 1 to 2 compared to litters split-suckled based on birth order, with litters split-suckled based on body weight being intermediate. However, there was no difference in pre-weaning mortality from d 2 to weaning. Overall, pre-weaning mortality, as well as the percentage of fallback pigs removed onto nurse sows, was not different ($P > 0.10$) between treatments.

Additional analyses were conducted to try to identify if there was a subset of the population where split-suckling had a positive impact on growth performance or on reducing pre-wean mortality. Additional analyses included determining if there were differences in split-suckle treatment based on sow parity, timing of split-suckle application, or teat count. Sow parity was divided into four groups: parity 1, parity 2, parity 3 and 4, and parity 5+ sows. No interactions ($P > 0.10$) were observed between treatment and parity group, indicating there were no differences in split-suckle treatment response based on parity. The timing of split-suckling was analyzed by comparing litters that were split-suckled the same day they were born to those that were split-suckled the day after farrowing. There were no interactions observed ($P > 0.10$) between treatment and split-suckle timing. Sow functional teat count was divided into two groups, 14 or fewer and 15 or more, and no interactions ($P > 0.10$) were observed between split-suckle treatment and functional teat count.

A subset of pigs was followed into the nursery to evaluate post-weaning growth and mortality (Table 4). There was a difference ($P < 0.05$) in starting BW at the nursery, with pigs split-suckled by BW having heavier BW compared to pigs not split-suckled, with pigs split-suckled by birth order intermediate. However, because there was no difference in BW at weaning for the overall data when including all piglet weights at weaning, this difference was due to chance. There were no differences ($P > 0.10$) in ADG, ADFI, F/G, or final BW at d 48 to 52 post-weaning at the end of the nursery period. Mortality during the nursery period was not different ($P > 0.10$) among treatments.

A subset of pigs that were followed into the nursery were also followed into the finisher (Table 5). In the finisher, on d 81 post-nursery, there were no differences ($P > 0.10$) in BW, ADG, ADFI, or F/G. The percentage of removals and mortality was not different ($P > 0.10$) among treatments.

In conclusion, split-suckling by birth order or body weight did not result in significant differences in pre-weaning growth performance or mortality compared to no split-suckling. The split-suckle treatments evaluated in this study did not affect post-weaning growth performance or mortality in the nursery or the finisher. The data would suggest that the split-suckling strategies evaluated in this study did not have a meaningful effect on mortality or litter performance.

Acknowledgements

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Table 1. The effect of split-suckling on litter and piglet growth performance and pre-weaning mortality[1]

	Control[2]	Split-suckle 1- First eight	Split-suckle 2- Heaviest eight	SEM	*P* =
Sows and litters, n	506	504	503	---	---
Parity	3.6	3.6	3.6	0.88	0.995
Teat count, n[3]	14.7	14.5	14.6	0.06	0.121
Wean age, d	20.0	20.0	20.0	0.13	0.980
Litter size, n					
d 1	14.9	15.0	15.0	0.46	0.889
Equalization	14.5	14.6	14.6	0.17	0.638
Weaning	12.3	12.2	12.4	0.25	0.733
Litter weight, lb					
d 1	44.5	44.7	44.9	2.19	0.704
Weaning	149.2	148.5	150.6	6.11	0.436
Mean piglet BW, lb					
d 1	3.00	3.00	3.01	0.087	0.849
Weaning	12.12	12.15	12.14	0.359	0.942
Piglet ADG, lb	0.48	0.48	0.48	0.02	0.925
Pre-weaning mortality, %					
d 1 to d 2	2.5	2.0	2.2	0.37	0.178
d 2 to weaning	8.3	8.9	8.4	0.62	0.563
d 1 to weaning	10.6	10.6	10.4	0.75	0.922
Fallback pigs, %[4]	6.1	7.1	6.5	0.93	0.145
Total mortality and fallback pigs, %	17.2	18.2	17.3	1.56	0.498
Pre-weaning mortality by BW category, %					
d 1 to weaning					
Light, ≤ 2.6 lb	15.7	17.3	16.3	1.30	0.411
Medium, 2.7 < × ≤ 3.2 lb	8.8	8.4	8.7	0.68	0.871
Heavy, ≥ 3.3 lb	7.2	6.4	6.6	0.56	0.550

[1]A total of 1,513 mixed-parity sows (Line 241, DNA, Columbus, NE) and litters were used from birth until weaning.
[2]Sows and their litters were allotted to one of three treatments. Control litters were not split-suckled. For split-suckle treatment 1, litters were split-suckled based on birth order, with the first eight born pigs removed from the sow for 45 min and then swapped with the remaining pigs that were pulled off the sow for 45 min. For split-suckle treatment 2, the eight heaviest pigs were removed from the sow for 1.5 h and then placed back with the sow.
[3]Teat count includes only functional teats.
[4]Fallback pigs were removed from the litter and placed on nurse sows.

Table 2. The effect of split-suckling on piglet immunocrit ratio[1]

	Control[2]	Split-suckle 1- First eight	Split-suckle 2- Heaviest eight	SEM	*P* =
Sows and litters, n	45	45	44	---	---
Parity	3.6	3.8	3.6	0.33	0.862
Immunocrit ratio	0.076	0.079	0.078	0.0028	0.784
Mean piglet BW, lb					
d 1	2.91	3.03	3.00	0.060	0.346
d 2	3.04	3.12	3.11	0.068	0.636
Weaning	11.63	11.39	11.77	0.192	0.426
Piglet gain, lb					
d 1 to 2	0.12	0.09	0.09	0.022	0.555
d 2 to weaning	8.51	8.21	8.60	0.174	0.316
d 1 to weaning	8.66	8.31	8.70	0.176	0.282
Mortality, d 1 to weaning, %	10.7	9.0	10.3	1.71	0.142

[1]Blood samples were collected on 134 whole litters, approximately 45 litters per treatment, to determine immunocrit ratio. A 3 mL blood sample was collected from each pig, and serum was separated from whole blood and used to determine immunocrit ratio.

[2]Sows and their litters were allotted to one of three treatments. Control litters were not split-suckled. For split-suckle treatment 1, litters were split-suckled based on birth order, with the first eight born pigs removed from the sow for 45 min and then swapped with the remaining pigs that were pulled off the sow for 45 min. For split-suckle treatment 2, the eight heaviest pigs were removed from the sow for 1.5 h and then placed back with the sow.

Table 3. The effect of split-suckling on litter and piglet growth performance and pre-weaning mortality for sows that had higher pig count at d 1 than teat count[1]

	Control[2]	Split-suckle 1-First eight	Split-suckle 2-Heaviest eight	SEM	*P* =
No. of sows and litters, n	237	252	240	---	---
Parity	4.0	3.8	3.9	0.87	0.999
Teat count, n[3]	14.4	14.2	14.2	0.07	0.092
Litter size, n					
d 1	16.8	16.8	17.0	0.32	0.829
Equalization	15.0	15.1	15.3	0.26	0.716
Weaning	12.3	12.3	12.4	0.28	0.902
Litter weight, lb					
d 1	48.9	48.6	49.6	1.66	0.219
Weaning	148.3	149.5	151.5	6.23	0.403
Mean piglet BW, lb					
d 1	2.9	2.9	2.9	0.06	0.490
Weaning	12.0	12.0	12.1	0.35	0.851
Piglet ADG, lb/d	0.45	0.46	0.46	0.02	0.656
Pre-weaning mortality, %					
d 1 to d 2	3.3[a]	2.4[b]	2.5[ab]	0.47	0.025
d 2 to weaning	9.2	9.3	9.2	0.74	0.817
d 1 to weaning	12.5	11.6	11.7	0.97	0424
Fallback pigs, %[4]	7.5	8.6	8.4	0.93	0.185
Total mortality and fallback pigs, %	20.1	20.4	20.1	1.56	0.498

[a,b]Means in the same row that do not have a common superscript differ ($P < 0.05$).

[1]A total of 729 mixed-parity sows (Line 241, DNA, Columbus, NE) and litters were used from birth until weaning.

[2]Sows and their litters were allotted to one of three treatments. Control litters were not split-suckled. For split-suckle treatment 1, litters were split-suckled based on birth order, with the first eight born pigs removed from the sow for 45 min and then swapped with the remaining pigs that were pulled off the sow for 45 min. For split-suckle treatment 2, the eight heaviest pigs were removed from the sow for 1.5 h and then placed back with the sow.

[3]Teat count includes only functional teats.

[4]Fallback pigs were removed from the litter and placed on nurse sows.

Table 4. The effect of split-suckling on nursery pig performance[1]

	Control[2]	Split-suckle 1- First eight	Split-suckle 2- Heaviest eight	SEM	*P* =
Pens, n	32	32	32	---	---
Starting BW, lb	11.2[b]	11.3[ab]	11.7[a]	0.14	0.020
Final BW (48-52 d post-weaning), lb	55.6	55.1	55.4	0.64	0.839
ADG, lb	0.88	0.88	0.87	0.013	0.700
ADFI, lb	1.13	1.14	1.14	0.020	0.940
F/G	1.29	1.31	1.31	0.018	0.571
Mortality, %	4.5	3.1	4.1	0.008	0.400

[a,b]Means in the same row that do not have a common superscript differ ($P < 0.05$).
[1]A subset of pigs, 2,208, was used to evaluate nursery growth performance and mortality.
[2]Sows and their litters were allotted to one of three treatments. Control litters were not split-suckled. For split-suckle treatment 1, litters were split-suckled based on birth order, with the first eight born pigs removed from the sow for 45 min and then swapped with the remaining pigs that were pulled off the sow for 45 min. For split-suckle treatment 2, the eight heaviest pigs were removed from the sow for 1.5 h and then placed back with the sow.

Table 5. The effect of split-suckling on finisher pig performance[1]

	Control[2]	Split-suckle 1- First eight	Split-suckle 2- Heaviest eight	SEM	*P* =
Pens, n	14	14	14	---	---
Starting BW, lb	56.3	54.7	56.8	1.18	0.137
Final BW (77 d post-weaning), lb	226.0	226.8	229.9	2.38	0.332
ADG, lb	2.14	2.14	2.22	0.046	0.148
ADFI, lb	5.31	5.27	5.38	0.068	0.316
F/G	2.49	2.46	2.42	0.056	0.551
Mortality, %	3.7	4.1	1.7	0.012	0.200
Removals, %	2.7	3.4	2.7	1.057	0.800
Mortality + Removals, %	6.4	7.7	4.5	1.824	0.300

[1]A subset of pigs, 882, was used to evaluate finishing growth performance and mortality.
[2]Sows and their litters were allotted to one of three treatments. Control litters were not split-suckled. For split-suckle treatment 1, litters were split-suckled based on birth order, with the first eight born pigs removed from the sow for 45 min and then swapped with the remaining pigs that were pulled off the sow for 45 min. For split-suckle treatment 2, the eight heaviest pigs were removed from the sow for 1.5 h and then placed back with the sow.