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Piglet nursing location along the sow's udder line affects piglet weight gain and subsequent weaning weight

La ubicación de los lechones lactantes a lo largo de la línea mamaria de la cerda afecta la ganancia de peso del lechón y su peso al destete

A localização dos leitões ao longo da linha mamária da porca afeta o ganho de peso dos leitões e o peso ao desmame

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Abstract

Background: There is a linear correlation between piglet weaning weight and average daily gain during the post-nursery period. A key factor that influences piglet weight gain during lactation is milk intake. Thus, the variation in piglet weaning weight is hypothesized to be, to some extent, a result of differences in milk production among individual mammary glands. **Objective:** The objective of this study was to evaluate the impact of piglet nursing location throughout lactation on piglet weaning weight, with a secondary objective of determining the impact of piglet birth weight on nursing location selection. **Methods:** Teat pairs were labeled from anterior to posterior (1–7). A total of 1,078 individual piglets from 108 litters were observed; nursing observations were recorded at three time points, typically within the same day, to verify each piglet's nursing location during the lactation period. All data were analyzed using the individual piglet as the experimental unit. **Results:** The teat pair on which piglets nursed during lactation impacted their overall weaning weight ($P < 0.001$). Numerically heavier piglets were weaned from the anterior teats (teat pairs 1–4: 5.906–6.121 kg), with the heaviest piglets weaned from teat pair 4 (6.1219 kg), and the lightest weaned piglets located at teat pair 7 (5.171 kg; teat pairs 5–7: 5.745–5.171 kg). Piglet weight gain and, thus, subsequent weaning weight was ultimately impacted by their chosen nursing location along the udder line. While the first four pairs of anterior teats produced the heaviest weaning weights, after accounting for piglet birth weight to examine actual weight gain, the first four pairs of teats remained the most productive, but the magnitude of the advantage for teat pair 4 was reduced. Additionally, piglets nursing at teat pair 7 represented the lowest birth weight and had overall lower weight gain. **Conclusion:** Piglet weaning weight differs according to the suckling position along the udder line, and it is partially a function of both the birth weight of the pigs nursing at a particular location and, presumably, the milk production and composition at that location.

Keywords: *behavior; lactation; litter size; milk; nursing; piglet; sow; suckling; teat; weaning weight.*

Resumen

Antecedentes: Existe una correlación lineal entre el peso al destete de los lechones y su ganancia media diaria durante el período posdestete. Un factor que influye en el aumento de peso de los lechones durante la lactancia es la ingesta de leche. Por lo tanto, se plantea la hipótesis de que la variación en el peso al destete se debe, en cierto modo, a diferencias en producción de leche entre las glándulas mamarias individuales. **Objetivo:** El objetivo de este estudio fue evaluar el impacto de la ubicación de los lechones durante la lactancia y su efecto sobre el peso al destete; adicionalmente, determinar la influencia del peso al nacimiento sobre la escogencia del sitio de amamantamiento por parte del lechón. **Métodos:** Los pares de pezones se marcaron, de anteriores a posteriores (1–7), según su ubicación sobre la línea mamaria. Se observaron un total de 1.078 lechones individuales provenientes de 108 camadas. La conducta de amamantamiento de los lechones se observó y registró en tres momentos diferentes, generalmente dentro del mismo día, identificando la glándula mamaria preferida de cada lechón durante la lactancia. Todos los datos se analizaron considerando al lechón individual como la unidad experimental. **Resultados:** El par de pezones del que los lechones mamaron durante la lactancia influyó en su peso total al destete ($P < 0,01$). Numéricamente, los lechones más pesados fueron destetados de los pezones anteriores (pares 1–4: 5.915–6.129 kg), siendo los más pesados los del par 4 (6.129 kg) y los más ligeros los del par 7 (5.131 kg; pares 5–7: 5.764–5.131 kg). El tamaño de la camada al destete se utilizó como covariable en el modelo estadístico, influyendo en el peso de los lechones al destete ($P < 0.01$). La ganancia de peso de los lechones y su peso al destete se vieron afectados por la ubicación de amamantamiento a lo largo de la línea mamaria. En este estudio, se observó que los cuatro primeros pares anteriores de pezones estuvieron asociados con los mayores pesos al destete, pero, al considerar el peso al nacimiento, la producción y el valor nutricional de la leche pueden ser similares, dado que la ganancia promedio no fue diferente entre los primeros cuatro pares de pezones. En contraste, los lechones que mamaron de los pares posteriores (5–7) presentaron un crecimiento reducido, lo que puede indicar que los lechones más ligeros al nacimiento fueron empujados a los pezones posteriores. **Conclusión:** El peso al destete de los lechones varía con la ubicación de amamantamiento a lo largo de la línea mamaria y es, en cierta medida, una función del peso al nacimiento de los lechones que se alimentan en una ubicación particular y, presumiblemente, de la producción y composición de la leche en esa ubicación.

Palabras clave: *amamantamiento; cerda; comportamiento; lactancia; leche; lechón; peso al destete; pezón; tamaño de la camada.*

Resumo

Introdução: Existe uma correlação linear entre o peso ao desmame dos leitões e o ganho médio diário no período pós-desmame. Um fator-chave que influencia o ganho de peso dos leitões durante a lactação é o consumo de leite, e supõe-se que a variação no peso dos leitões ao desmame seja, em parte, um reflexo das diferenças na produção de leite entre as glândulas mamárias individuais. **Objetivo:** Avaliar o impacto do local de aleitamento (teta) dos leitões durante la lactação e seu efeito no peso ao desmame, com um objetivo secundário de determinar a influência do peso ao nascimento na seleção do local de aleitamento. **Métodos:** Os pares de tetas foram marcados do anterior ao posterior (1–7). Foram observados 1.078 leitões individuais de 108 leitegadas; as observações de aleitamento foram registradas em três momentos, normalmente no mesmo dia, para identificar o local preferido de aleitamento de cada leitão ao longo do período de lactação. Todos os dados foram analisados considerando o leitão individual como unidade experimental. **Resultados:** O par de tetas utilizados pelos leitões durante a lactação influenciou significativamente o peso total ao desmame ($P < 0.01$). Leitões numericamente mais pesados foram desmamados das tetas anteriores (pares 1–4: 5.915–6.129 kg), sendo os mais pesados desmamados no par 4 (6.129 kg) e os mais leves desmamados no par 7 (5.131 kg; pares 5–7: 5.764–5.131 kg). O tamanho da leitegada ao desmame foi utilizado como covariável no modelo estatístico, influenciando o peso dos leitões ao desmame ($P < 0.01$). O ganho de peso dos leitões e o subsequente peso ao desmame foram impactados pelo local de aleitamento preferido ao longo da linha mamária. Neste estudo, observou-se que os quatro primeiros pares anteriores estiveram associados aos maiores pesos ao desmame, mas, ao considerar o peso ao nascimento, a produção e o valor nutricional do leite podem ser semelhantes, uma vez que o ganho médio não foi diferente entre os quatro primeiros pares.

Em contraste, os leitões que mamaram nos pares posteriores (5–7) apresentaram crescimento reduzido, o que pode indicar que leitões mais leves ao nascimento foram deslocados para as tetas posteriores. **Conclusão:** O peso ao desmame dos leitões claramente varia ao longo da linha mamária e é, em certa medida, uma função do peso ao nascimento dos leitões que se alimentam em uma localização específica e, presumivelmente, da produção e composição do leite nessa localização.

Palavras-chave: *aleitamento; comportamento; lactação; leite; leitão; porca; peso ao desmame; tamanho da leitegada; tetas; mamilo.*

Introduction

Piglet weaning weight (WW) is a critical factor for success within the swine industry and is logically linked to varying piglet birth weight (BW) within a litter. Piglet birth weight is negatively correlated with litter size (Roehe, 1999), with lighter piglets at birth experiencing lower preweaning weight gain and reduced survivability (Gondret et al., 2005).

Previous research (Cabrera et al., 2010) identified a linear relationship between piglet WW and average daily gain (ADG) during the post-nursery period. Lighter piglets at weaning raised in a typical production system may achieve some degree of compensatory growth during postweaning periods but ultimately remain lighter at the end of the nursery period (Smith et al., 2007) and take longer to reach market weight than their heavier counterparts (Mahan and Lepine, 1991).

A key factor that influences piglet weight gain during lactation is milk intake. While piglet BW varies, the variation in WW has been hypothesized to result from differences in milk production among individual mammary glands (Fraser and Jones, 1975; Fraser et al., 1979). Whether milk production varies across the sow's udder line remains inconclusive; Donald (1937) reported that anterior mammary glands are typically larger and produce more milk, but this was contradicted by others (Hartman et al., 1962; Pond et al., 1962), who found no difference in milk production among teat glands.

Therefore, the primary objective of this study was to evaluate whether piglet nursing location impacts WW. A secondary objective was to determine whether piglet BW influences their choice of nursing location. Current knowledge in this area of behavior and physiology is limited; thus, expanding this understanding may contribute to improved management of lactation in swine farms.

Materials and Methods

Ethical Considerations

The experiment was conducted in accordance with the husbandry guidelines for the care and use of agricultural animals in research and teaching, commonly called the Ag Guide (2020). The experiment was carried out in environmentally controlled farrowing rooms at the University of Kentucky Swine Research Center.

Animals and Sample Collection

Over the course of one year, 114 sows and litters (Yorkshire × Landrace) that farrowed at the University of Kentucky Swine Research Center were utilized as part of the lactation/nursing observation process. Characteristics of the sows and litters varied with regard to sow parity ($\bar{X}$ = 2.8, range = 2–9), litter size at birth ($\bar{X}$ = 11.1, range = 6–17), piglet birth weight ($\bar{X}$ = 1.53 kg, range = 0.71–2.20), litter size at weaning ($\bar{X}$ = 10.3, range = 7–14), and age at weaning ($\bar{X}$ = 21.0 d, range = 17–25 d).

Piglets were processed within 24 hours of birth, which included clipping of needle teeth, ear notching, weighing, injection of 150 mg of iron dextran, and navel trimming if needed. Pigs were castrated at days 6–8 and weighed again at

weaning. Cross-fostering did not occur during this experiment, and creep feed was not offered to the piglets.

A total of 1,078 individual piglets were observed while nursing their dam. Nursing observations were recorded at three time points for each litter between days 7–11 to verify each piglet's nursing location. Before each observation, piglets were marked with a number on their back for easy identification to facilitate data collection. Numbers and ear-notch identification were recorded. After being marked, the entire litter was returned to the sow.

During each nursing bout observation, the teat at which the piglet nursed and its assigned number were recorded. A nursing observation began when a sow laid down exposing her udder and allowing piglets to approach a teat; it was considered complete when the sow rolled over onto her stomach or when all piglets moved away from her and stopped nursing, or when the sow stood up. If a piglet began the nursing bout at one teat and then switched to another, it was recorded, and at the end of the bout the piglet was assigned to the teat where it spent the most time. Teat pairs were labeled from anterior to posterior (1–7). A teat pair was excluded from the analysis if only one teat within the pair was nursed; thus, for litters with an odd number of pigs there was always at least one pig that was not included in the final data set due to the absence of a littermate nursing at the same teat pair location. Prior to analysis, observations for teats that had more than one piglet nursing throughout the individual observation period were also removed from the data set. Observations from litters with six or fewer piglets at weaning (n = 6 litters) were removed to avoid overrepresentation of exceptionally heavy pigs in the data set, which would not be representative of normal litters. Following these exclusions, 996 piglets remained, yielding a total of 498 teat pair observations.

Statistical Analysis

All data were analyzed using ANOVA with the teat pair as the experimental unit.

The following dependent variables were evaluated: birth weight (BW), weaning weight (WW), and lactation weight gain (WW – BW). The effect of teat location on piglet growth rate was analyzed using polynomial regression within the PROC GLM procedure in SAS (v 9.4; SAS Institute, Cary, NC). Litter size at weaning was included as a covariate for WW and lactation weight gain to determine whether it affected the interpretation of the data; live-born litter size was included as a covariate for piglet BW in relation to teat location for the same purpose. Values are reported as least-squares means (LSMeans), with statistically significant differences established at $P \leq 0.05$, and tendencies identified at $P \leq 0.10$.

Results

Effect of teat location on piglet weaning weight

The teat pair at which piglets nursed during lactation impacted their WW ($P < 0.0001$; Table 1), and there was a linear (L) and quadratic (Q) effect of location (L: $P < 0.0001$; Q: $P < 0.001$). Numerically heavier piglets were weaned from the more anterior teat pairs (1-4). Surprisingly, the numerically heaviest pigs were not weaned from teat pair 1, but from teat pair 4 (6.121 kg). After teat pair 4, there was a gradual decrease in weight, with the lightest pigs located at teat pair 7, weighing approximately 1 kg less than pigs from teat pair 4. Litter size at weaning was added as a covariate in the statistical model to account for nursing competition in larger litters, and it significantly influenced WW (P < 00001).

Table 1. Average weaning weight (WW, kg) using litter size at weaning as a covariate in relation to teat pair location.

Location[1]	WW (kg)[2]	S.E.	n
1	5.946	0.125	96
2	5.906	0.125	92
3	5.985	0.126	88
4	6.121*	0.127	84
5	5.745	0.128	66
6	5.387	0.137	46
7	5.171	0.155	26

[1]Teat pair location numbering follows an anterior-to-posterior sequence.
[2]Linear and quadratic effects of location (L: $P < 0.0001$; Q: $P < 0.001$); the greatest weaning weight is denoted by an asterisk (*). Litter size was used as a covariate and significantly influenced weaning weight (P < 0.0001).

Effect of teat location on piglet weight gain

To confirm that differences in piglet WW were impacted by their nursing location and not simply BW, an additional analysis evaluated the actual weight gain of the individual piglet. There was a linear and quadratic effect of location (Table 2; L: P < 0.0001; Q: P = 0.005). Like piglet WW, teat pairs 1-4 had the greatest lactation gain ($P < 0.0001$;). Piglets weaned from teat pair 4 had the greatest weight gain throughout lactation. Teat pairs 5-7 had a decrease in lactation gain, and teat pair 7 was associated with the smallest gain.

Table 2. Average piglet gain (kg) by teat pair location, with litter size at weaning included as a covariate.

Location[1]	Gain[2,3]	S.E.	n
1	4.406	0.113	96
2	4.404	0.114	92
3	4.465	0.115	88
4	4.489*	0.115	84
5	4.175	0.117	66
6	3.909	0.125	46
7	3.756	0.141	26

[1]Teat pair location numbered anterior to posterior·
[2]Piglet gain = piglet weaning weight – birth weight·
[3]Linear and quadratic effect of location (L: $P < 0.0001$; Q: $P = 0.005$); the greatest weaning weight is denoted by an asterisk (*). Litter size was used as a covariate and significantly influenced piglet gain ($P < 0.0001$).

Effect of piglet birth weight on nursing location

Within our study, we observed that piglets with the heaviest BW selected teats from the fourth to sixth pair (depending on whether litter size at birth was used as a covariate in the analysis, Q: $P < 0.05$; Tables 3 and 4), instead of the first or second teat pair.

Table 3. Average piglet birth weight (BW, kg) by teat pair location.

Location[1]	BW (kg)[2]	S.E.	n
1	1.542	0.031	96
2	1.506	0.032	92
3	1.531	0.032	88
4	1.581*	0.032	84
5	1.537	0.035	66
6	1.498	0.034	46
7	1.443	0.038	26

[1]Teat pair location numbered anterior to posterior.
[2]Quadratic effect of location ($P = 0.05$); the greatest birth weight is denoted by an asterisk (*).

Within this dataset, litter size at birth impacted teat selection in relation to piglet BW ($P < 0.001$), and a quadratic effect of location remained ($P = 0.03$; Table 4).

Table 4. Average piglet birth weight (BW, kg) in relation to teat pair location using litter size at birth as a covariate.

Location[1]	BW (kg)[2]	S.E.	n
1	1.538	0.029	96
2	1.506	0.029	92
3	1.546	0.031	88
4	1.551	0.029	84
5	1.562	0.035	66
6	1.580*	0.052	46
7	1.395	0.057	26

[1]Teat pair location numbered anterior to posterior.
[2]Quadratic effect of location ($P = 0.03$); the greatest birth weight is denoted by an asterisk (*). Litter size was used as a covariate and significantly influenced BW in relation to location ($P < 0.001$).

Discussion

The objectives of this study were to evaluate whether piglet nursing location impacts WW and to determine whether piglet BW influences their choice of nursing location. Using a robust observational dataset, these objectives were accomplished. An initial evaluation of the data showed that differences in weaning weights along the udder line suggest that there may be a difference in either the quantity or nutrient composition of milk produced. When individual piglet gain is assessed, teat pairs 1-4 appeared to produce relatively similar weight gain, whereas piglets nursing at the posterior teat pairs (5-7) exhibited reduced growth. The results from this study, where the heaviest pigs suckled at teat pair 4 disagree with Kim et al. (2000), who stated that anterior teat pairs (1-3), resulted in heavier piglet weight compared to posterior teat pairs (4-6). However, this discrepancy may be due to methodological differences, as various studies have classified teats differently (e.g., anterior,

mid-udder, or posterior) to increase sample sizes within categories. Our data are presented as a continuous function from teat pair 1 to teat pair 7. Skok et al. (2007) measured milk production over four weeks of lactation using the weigh-suckle-weigh method and reported that piglets nursing at anterior (teat pairs 1 and 2) or middle (teat pairs 3, 4, and 5) teat pairs did not consume a greater milk volume than necessary to affect weight gain, but they consumed more than piglets nursing at posterior teat pairs (pairs 6 and 7); the numerically heaviest piglets were from the middle teat pairs. Support for the heaviest pigs being located at the anterior teats is provided both by the work of Šamanc et al. (2013), who reported that piglets nursing at anterior rather than posterior glands had higher body weight at day 8 of age, and by the work of Lannom (2018). Thus, published results differ in their conclusions.

It has been reported that individual nutrient composition of both milk and colostrum varies between teat pairs. Lannom (2018) reported that dry matter and fat percentages declined from anterior to posterior teat pairs, particularly in teat pairs 6 and 7. Conversely, Šamanc et al. (2013) observed no differences in dry matter or fat percentages between anterior (teat pairs 1 - 3) compared to posterior (pairs 4 - 6) teat pairs, but did observe lower protein percentage in posterior teat pairs. While Šamanc et al. (2013) did not report significantly lower fat percentage in posterior teat pairs, a numerical trend was observed. Given the much smaller sample size compared to the strong statistical power of Lannom (2018), it can be concluded that milk composition likely differs along the udder line. While the present experiment did not measure nutrient composition across teat pairs, it certainly demonstrates that there must be differences along the udder line that result in a decrease in gain of piglets nursing at posterior teat pairs.

Litter sizes have increased over the last decade, and larger litters in utero typically result in lower BW at birth (Quiniou et al., 2002; Beaulieu et al., 2010). Thus, BW-related challenges are expected to persist. Regarding nursing location selection after birth, nursing behavior has been previously studied (Rossillon-Warnier and Paquay, 1984; De Passillé et al., 1988; Puppe and Tuchscherer, 1999) yielding contradictory results. Rossillon-Warnier and Paquay (1984) observed that BW had no influence on teat order. Fraser and Jones (1975) observed that while anterior teats appeared to provide some advantage in weaning weight, this effect was independent of birth weight. Fraser et al. (1979), after redistributing pigs of different weight classes, observed that growth differences could not be explained by competition for the anterior teats. Fraser and Thompson (1986) noted a general preference for anterior teats, but this preference was more pronounced in second-parity sows than in first-parity sows. It was hypothesized by Skok et al. (2007) that lighter BW piglets are pushed toward posterior teats, and our results agree somewhat with this, especially at the most posterior location pair 7, as piglet weights were consistently lower at that location. Lannom et al. (2018) reported that piglets nursing at the first or second teat pair typically had the highest BW within their litter. However, our results differed with the heaviest piglets nursing at mid-udder teat pairs.

From a management perspective, these findings have important implications. If milk composition or yield decline the more posterior the piglets nurse, management strategies such as cross-fostering piglets nursing at teat pair 7 may be beneficial. Additionally, sow nutrition should be optimized to enhance milk production and composition, helping compensate for reduced nutrient intake among lighter piglets nursing at posterior teats.

Piglet gain and WW are clearly influenced by nursing location along the udder line. Future research should focus on collecting milk samples from each teat, at multiple times throughout lactation, to determine whether milk composition changes along the udder from parturition to weaning. If nutrient composition

or yield are not consistent across the udder, then the equations used to estimate milk yield (Hansen et al., 2012) need to be re-evaluated. As modern sows continue to be selected for higher prolificacy, additional management strategies will be necessary to ensure equal teat access for large litters, maximizing growth potential throughout lactation.

Declarations

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Conflicts of interest

The authors declare no conflicts of interest.

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Author contributions

The study was designed by ML and SD. Field data were collected by HM and SD. The manuscript was written by SD and ML. All authors reviewed and approved the final version of the manuscript.

Use of artificial intelligence (AI)

No AI or AI-assisted technologies were used during the preparation of this work.

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