ORIGINAL RESEARCH ARTICLE

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

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

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

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Abstract

Background: There is a linear correlation between piglet weaning weight and average daily gain in the post nursery period. A key factor that influences piglet weight gain during lactation is milk intake, and the variation that results in piglet weaning weight is hypothesized to be to some degree a result of differences in milk production by individual mammary glands. **Objective:** The objective was to evaluate the impact of piglet nursing location throughout lactation and its impact on piglet weaning weight, with a secondary objective determining the impact of piglet birthweight 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 timepoints, typically within the same day to verify each piglet's nursing location during the lactation period. All data was analyzed with the individual piglet as the experimental unit. **Results:** The teat pair that 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 pigs located at teat pair 7 (5.171 kg; teat pairs 5-7: 5.745-5.171 kg). Piglet 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 weight, after the piglet birthweight was accounted for to examine actual weight gain, the first four pairs of teats remained the most productive but the magnitude of advantage for teat pair 4 was reduced. Additionally, the piglets nursing teat pair seven represented the lowest birthweight and had overall reduced weight gain. **Conclusion:** Piglet weaning weight clearly differs along the udderline and is somewhat a function of birthweight of the pigs nursing at the particular location and, presumably, the milk production and composition at each location.

Keywords: *behavior; lactation; litter size; milk; nursing; piglet; sow; 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 post destete. Un factor clave que influye en el aumento de peso de los lechones durante la lactancia es la ingesta de leche, y se plantea la hipótesis de que la variación que da lugar al peso al destete es, hasta cierto punto, resultado de diferencias en producción de leche por las glándulas mamarias individuales. **Objetivo:** El objetivo fue evaluar el impacto de la ubicación de amamantamiento de los lechones durante la lactancia y su efecto sobre el peso al destete, con el objetivo secundario de determinar la influencia del peso al nacimiento en la selección del lugar de amamantamiento. **Métodos:** Los pares de pezones fueron marcados desde los anteriores a los posteriores (1-7). Se observaron un total de 1.078 lechones individuales provenientes de 108 camadas. Las observaciones de amamantamientos se registraron en tres momentos temporales, generalmente dentro del mismo día, para identificar el lugar preferido de amamantamiento de cada lechón durante el período de lactancia. Todos los datos se analizaron considerando al lechón individual como unidad experimental. **Resultados:** El par de pezones del que los lechones se amamantaron 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 destetados del par 4 (6.129 kg), y los más ligeros destetados del par 7 (5.131 kg; pares de pezones 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 respecto a lo largo de la línea de pezones. En este estudio, se observa que los cuatro primeros pares anteriores de pezones produjeron 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 se amamantaron 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 claramente varia a

lo largo de la línea de la ubre y es, en cierta medida, una función del peso al nacer de los lechones que amamantan en una ubicación particular y, presumiblemente, de la producción y composición de la leche en cada ubicación.

Palabras clave: *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-creche. Um fator-chave que influencia o ganho de peso dos leitões durante a lactação é o consumo de leite, e hipotetiza-se que a variação que resulta no peso dos leitões ao desmame seja, em parte, resultado de diferenças na produção de leite por glândulas mamárias individuais. **Objetivo:** Avaliar o impacto do local de amamentação dos leitões ao longo da 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 amamentação. **Métodos:** Os pares de tetos foram marcados de anterior para posterior (1-7). Foram observados 1.078 leitões individuais de 108 leitegadas; as observações de amamentação foram registradas em três momentos, normalmente no mesmo dia, para identificar o local preferido de amamentação 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 tetos utilizados pelos leitões durante a lactação influenciou significativamente o peso total ao desmame ($P < 0.01$). Leitões numericamente mais pesados foram desmamados dos tetos anteriores (pares 1-4: 5.915-6.129 kg), sendo os mais pesados desmamados do par de 4 (6.129 kg) e os mais leves desmamados no par 7 (5.131 kg; pares de tetos 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 leitões e o subsequente peso ao desmame foram impactados pelo local de amamentação preferido ao longo da linha do úbere. Dentro deste estudo, verifica-se que os quatro primeiros pares anteriores produziram os maiores pesos ao desmame, mas, ao contabilizar 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

amamentaram nos pares posteriores (5 -7) apresentaram características gerais de crescimento reduzidas, o que pode indicar que leitões mais leves ao nascimento são empurrados para tetos posteriores. **Conclusão:** O peso ao desmame dos leitões claramente varia ao longo da linha do úbere e é em certa medida, uma função do peso ao nascimento dos leitões que amamentam em uma localização específica e, presumivelmente, da produção e composição do leite em cada localização.

Palavras-chave: *amamentação; comportamento; lactação; leite; leitão; porca; peso ao desmame; tamanho da leitegada; teto.*

Introduction

Piglet weaning weight (WW) is a critical component for success within the swine industry and is logically related to varying piglet birthweight (BW) within a litter. Piglet birthweight is negatively correlated with litter size (Roehe, 1999), with lighter birthweight piglets experiencing less preweaning weight gain and a decrease in survivability (Gondret et al., 2005). Previous research (Cabrera et al., 2010) identified a linear relationship between piglet WW and average daily gain (ADG) in the post-nursery period. Lighter piglets at weaning reared in a typical production system may achieve compensatory growth rates to some degree during postweaning periods but ultimately are 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 differs, the variation in WW has been hypothesized to be a result of differences in milk production by individual mammary glands (Fraser and Jones, 1975; Fraser et al., 1979)Whether or not milk production varies across the sow udder line is inconclusive; Donald (1937) reported that anterior mammary glands are typically larger and produce more milk, but this is contradicted by others (Hartman et al., 1962; Pond et al., 1962) that found there is no difference in milk production among teat glands.

Therefore, the primary study objective was to evaluate whether piglet nursing location impacts WW. The second study objective was to determine whether piglet BW influences their selected nursing location. Information about this area of behavior and physiology is

currently limited, thus increasing this area of knowledge may result in improved lactation management.

Materials and methods

Ethical considerations

The experiment was conducted within 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 1 year, 114 sows and litters (Yorkshire x 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 born ($\bar{X}$ = 11.1, range = 6-17), piglet birthweight ($\bar{X}$ = 1.53 kg, range = 0.71-2.20), litter size weaned ($\bar{X}$ = 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 as iron dextran, and navel clipping if needed. Pigs were castrated at d 6-8 and were 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 during d 7 – 11 to verify each piglet's nursing location. Prior to each observation piglets received a number on their back for ease of identification to facilitate data collection. Numbers and the piglet identification (ear-notch) was recorded. After being numbered, the entire litter was returned to the sow. During each nursing bout observation, the teat the piglet nursed, and their assigned number were recorded. A nursing observation began when a sow laid down, exposed her udder and underline, and piglets approached to nurse 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 the sow stood up. If a piglet started the nursing bout

at one teat and then switched to another one, it was noted 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). The teat pair was not included in the analysis if only one teat in that pair was nursed; thus, for litters with an odd number of pigs, there would always be at least one pig that was not included in the final set of data because of the lack of a littermate also nursing at that 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 a litter with a total number of 6 pigs or fewer at weaning (n = 6 litters) were removed to avoid extremely heavy pigs in the data set that would not be representative of normal litters. Following these observation removals, 996 piglets remained for a total of 498 teat pair observations.

Statistical analysis

All data were analyzed by ANOVA with the teat pair as the experimental unit. The following dependent variables were evaluated: birthweight (BW), weaning weight (WW), and lactation weight gain between day 1 and weaning (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 utilized as a covariate for WW and lactation weight gain to ascertain if that affected the interpretation of the data; live born liter size was utilized as a covariate for piglet birthweight in relation to teat location for the same purpose. Values are reported as LSMeans and statistically significant differences were established at $P \leq 0.05$, tendencies were established at $P \leq 0.10$.

Results

Effect of teat location on piglet weaning weight

The teat pair that 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

weight pigs located at teat pair 7, being about 1 kg smaller than pigs from teat pair 4. Litter size at weaning was added as a covariate to the statistical model to account for nursing competition that larger litters may experience and it did impact WW ($P < 0.0001$).

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 numbered anterior to posterior.
[2]Linear and quadratic effect of location (L: $P < 0.0001$; Q: $P < 0.001$) ; the greatest weaning weight is denoted by an *. Litter size was used as a covariate and impacted 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 the 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 ($P < 0.0001$;). The piglets that weaned from teat pair 4 had the greatest gain throughout lactation. Teat pairs 5-7 had a decrease in lactation gain, and teat pair seven was associated with the smallest gain.

Table 2. Average piglet gain (kg) in relation to teat pair location using litter size at weaning 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 - birthweight.
[3]Linear and quadratic effect of location (L: $P < 0.0001$; Q: $P = 0.005$) ; the greatest weaning weight is denoted by an *. Litter size was used as a covariate and impacted piglet gain ($P < 0.0001$).

Effect of piglet birthweight 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 birthweight (BW, kg) in relation to 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 birthweight is denoted by an *.

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 birthweight (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 birthweight is denoted by an *. Litter size was used as a covariate and impacted BW relative 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 selected nursing location. Using a robust observational number, these objectives were accomplished. On first evaluation of the data, differences in weaning weights along the udder line suggest that there may be a difference in either the quantity of milk produced or the nutrient composition of that milk, because when individual piglet gain is assessed, teat pairs 1-4 seem to produce relatively similar weight gain but the piglets that nursed the posterior teat pairs (5-7) had reduced growth characteristics. The results from this study where the heaviest pigs were at teat pair 4 seem to disagree somewhat with Kim et al. (2000), who stated that teat pairs 1-3 (anterior), resulted in heavier piglet weight compared to teat pairs 4-6 (posterior), but this is somewhat an artifact of the methodology as different publications grouped pigs differently into anterior, midudder, or posterior in order to increase the number of observations within those groupings. Our data is presented as a continuous function from teat pair 1 to teat pair 7. Skok et al. (2007) measured milk production during 4 weeks of lactation by the weigh-suckle-weigh method and reported that piglets who nursed from anterior (teat pairs 1 and 2) or middle (teat pairs 3, 4, and 5) teat pairs did not consume a difference in milk volume to affect weight gain but consumed more than piglets who nursed from posterior (teat pairs 6 and 7) teats; the numerically heaviest piglets were from the middle teat pairs. Suport for the heaviest pigs being at the anterior position is provided both by the work of Šamanc et al. (2013), who reported that piglets that nursed anterior compared to posterior glands had higher bodyweight at d8 of age and by the work of Lannom (2018). Thus, published results differ in their conclusions.

It has been reported that individual nutrient components of both milk and colostrum are different between teat pairs; Lannom (2018) reported that dry matter and fat percentage declined from anterior to posterior teat pairs, particularly for teat pairs 6 and 7. Conversely, Šamanc et al. (2013) observed no difference between anterior teat pairs (pairs 1 to 3) compared to posterior teat pairs (pairs 4 to 6) in the dry matter or fat percentages but did observe a lower protein percentage in posterior teat pairs; while Šamanc et al. (2013) did not observe significantly lower fat percentage posteriorly, the numerical direction was lower and the much lower number of observations compared to the strong statistical power of Lannom

(2018) lead to the conclusion that milk composition does differ along the udder line. While this experiment did not measure nutrient output components of the teat pairs, it certainly demonstrates that there must be differences along the udder that result in a decrease in gain from the piglets nursing the posterior teat pairs.

Litter sizes have been increasing over the last decade and, in utero, litter size typically impacts BW, with larger litters producing lighter piglets at birth (Quiniou et al., 2002; Beaulieu et al., 2010); thus the issue of BW will continue. With regard to the selection of a nursing location after birth, nursing behavior has been previously studied (Rossillon-Warnier and Paquay, 1984; De Passillé et al., 1988; Puppe and Tuchscherer, 1999) with contradictory results. Rossillon-Warnier and Paquay (1984) observed that birth weight had no influence on teat order. Fraser and Jones (1975) observed that while anterior teats did seem to confer some advantage in weaning weight but that it was independent of the birth weight as the pigs nursing at different locations and Fraser et al,. (1979), after redistributing pigs of different weight classes, observed that differences in growth could not be explained by competition for the anterior teats. Fraser and Thompson (1986) noted that there was an expected preference for anterior teats by piglets but that the preference was more apparent in second parity sows than in first parity sows. It was hypothesized by Skok et al. (2007) that lighter BW piglets get pushed to the more posterior teats, and our results agree somewhat with this, especially at the most posterior location pair 7, as piglet weights were lower in all aspects at that location. Lannom et al. (2018) reported that piglets that select either the first or second pair of teats typically had the heaviest birthweights within their litter. However, our results differed with the heaviest birthweight pigs being midudder.

From a management perspective, this has some implications that need to be considered. If the nutritional composition or output decreases the more posterior the piglets nurse, then perhaps management practices, such as cross-fostering of pigs especially nursing teat pair 7 may need to be incorporated. Additional consideration regarding the nutrition of the sow diet to impact milk yield or components may also combat the reduced nutritional intake that lighter piglets will experience if they are nursing from a posterior teat.

Piglet gain and weaning weight are clearly impacted by their nursing location along the udder line. Future investigation may involve gathering samples from every teat during lactation, and at multiple times throughout the lactation, to gain a more complete

understanding of how, or if, milk composition changes along the udder from parturition to weaning. If nutritional composition or yield are not consistent, then equations used to calculate milk yield (Hansen et al., 2012) need to be re-evaluated. As modern sows continue to be selected for prolificacy, additional management steps will need to be implemented to provide large litters equal opportunity for teat access to provide the best opportunity for growth 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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