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Impact of Teat Order on Feed Consumption in Swine from Birth to Nursery

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Cover Page Footnote

Callan Lichtenwalter is a 2018 graduate with a major in Animal Science with a pre-professional concentration. Jason Apple is the honors mentor and a professor in the Department of Animal Science. Elizabeth Kegley is a professor in the Department of Animal Science. T.C. Tsai is a program associate in the Department of Animal Science.

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Meet the Student-Author

Callan Lichtenwalter

I grew up in Conway, Arkansas, and graduated from Conway High School in 2014. Since pursuing a degree in Animal Science I have been able to become very involved within the department as a member of Block and Bridle, Pre-Vet Club, and the Meats Quiz Bowl team and also as a staff member in the equine program and in the animal science nutrition lab.

Thanks to the Bumpers College and the Honors College I have had the opportunity to study abroad twice. My first time was for four weeks in the summer after my sophomore year in Scotland attending an equine science program. My second time was during the spring semester of my junior year when I attended the University of Sussex in Brighton, England. These experiences allowed me to take courses not offered here and travel all over Europe.

I would like to thank all of my coauthors and Liz Palmer, Josh Knapp, Jase Ball, and Doug Galloway. Thank you also to Bumpers College and the Honors College for their financial support of my research.

Research at a Glance

- Swine producers have assumed that pigs that nurse from the cranial portion of the udder will be more dominant and consume more milk, and later more feed.
- Using growth performance values and blood hormone levels that assess satiety, ther was no no observed relationship between teat order and feed consumption except during the beginning of the nursery phase of production.
- Accommodating the needs of pigs based on the time it takes them to adjust to a new environment seems to be a viable option in feeding pigs. Since the cranial pigs take more time to adjust, they struggle with average daily gain while eating the same amount of feed, so allowing them access to more feed could remedy their poor gains.

Callan holding the first of many pigs born for her research project.

Impact of teat order on feed consumption in swine from birth to nursery

*Callan A. Lichtenwalter**, *Jason K. Apple*[†], *Elizabeth B. Kegley*[§], *and Tsung Cheng Tsai*[‡]

Abstract

A relationship between teat order and feed consumption has been assumed in pigs, but no study has looked at this exact relationship. Pigs were observed shortly after birth to be in either a cranial, middle, or caudal teat positon. Growth performance data and active and total plasma ghrelin concentrations were analyzed at birth, weaning, and at the end of the nursery stage of production to see if a relationship with teat order was present. Overall, no effect of teat order was found on average daily gain, average daily feed intake, gain-to-feed ratio, or body weight among pigs from each section of the udder. Differences did occur during certain stages of nursery, which can be of economic importance to producers. Ghrelin was measured so a consistent measure of satiety could be observed throughout the study. No difference was seen in active or total ghrelin levels or the active-to-total ghrelin ratio in relation to teat order, although there were differences in active and total ghrelin concentrations among the sampling days. Further research should be carried out to investigate what factors would contribute to these data contradicting previous inferences about the relationship of teat order and feed consumption in pigs.

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Introduction

The goal of this experiment was to observe whether there was connection between teat order and feed consumption from birth through the end of the nursery phase of production. Teat order, the dominance hierarchy established just after birth and maintained throughout life, has been assumed by people in the industry to lead to an increase in feed consumption past the suckling stage.

The percentage of nursery-only sites in the U.S. increased from 0.4% in 1995 to 8.2% in 2012 (USDA, 2012). The all-in/all-out by room management style (all pigs come in at once and leave at once) increased from 24.4% in 2000 to 31.7% in 2012, and all-in/all-out by building increased from 32.3% in 2000 to 41.2% in 2012 (USDA, 2012). With a shift in the industry to more specified production, it is important for producers to know how their pigs are likely to perform so the pigs' needs can be met and the producer can realize the largest economic return. With an all-in/all-out system, if there is a variance in pig's weight at the end of nursery, the producers will not optimize their economic return per pig. If producers know how to feed individuals within the whole herd so that each animal reaches its maximum potential, greater profits could be realized.

Starvation is the second leading cause of death during the nursery phase, with producers reporting that starvation accounted for 22.1% of their losses (USDA, 2012). One way to decrease this loss is to understand if the needs of pigs vary based on factors such as dominance, or teat order, and then accommodate for individuals who would normally experience a decrease in feed intake. Having strong early growth rates is extremely important in pigs. For every one pound under the ideal weight a pig is at 10 weeks old, it may take up to an additional 5 days to reach ideal market weight later in life (Pitcher and Springer, 1997). Pigs that are lighter at weaning can be more labor intensive to manage in the nursery, and have a greater risk of death than pigs that weigh more at weaning (Drits, 1998). With a variation in weaning weight comes the need to divide pigs into pens and feed them based on their needs. When producers better understand the divisions within their nursery pigs, each pig can be fed to match its own needs and reach an appropriate weight along with all the other pigs in the nursery (Drits, 1998).

Total feed cost is the largest production cost per pig sold in most nurseries, and it is influenced heavily by feed efficiency (DeRouchey et al., 2014). The goal of the nursery phase is to adjust pigs to the dry feed they will be consuming in the grow-finish stage of production. The faster this diet can be introduced, the lower feed costs will be overall. One feeding strategy is for pigs that are heavier at weaning to be fed less once in the nursery so that their smaller litter mates have the opportunity to catch up in body weight. This saves costs and prevents over-feeding larger pigs, so all pigs end nursery at a more consistent weight (DeRouchey et al., 2010).

Understanding how best to feed pigs during the nursery stage is vital for both production efficiency and costs. Knowing if there is a relationship between teat order and feed efficiency and weight gain in the nursery can help producers to best divide their pigs and allocate rations for each nursery phase. When each pig is fed appropriately, pigs will end nursery and enter the grow-finish stage at a more consistent weight in an all-in/all-out system.

Materials and Methods

Observational Study

All sows used farrowed (gave birth) on 10 November 2017 between 10:00 and 19:30 h. Sows were individually housed in farrowing crates (1.22 m × 2.13 m). Seven second-parity sows (sows on their second litter of piglets), that had at least 8 piglets by the end of parturition (process of giving birth), were observed in this experiment. Piglets were observed during birth and individually marked with a non-toxic, permanent marker identifying them and approximately denoting birth order. This was their primary identification until processing occurred. Teat order was observed in litters 2 to 4 hours after birth and recorded as a preliminary teat order. Processing occurred 24 ± 4 hours after birth, and at this time pigs were assigned a unique identification number (ears were notched) that was recorded with their corresponding birth order. Processing also included docking of pig's tails and receiving an injection of hydroxydextran at this time, while males were surgically castrated 7 days after birth. A birth weight was recorded at processing as well. Teat order was again assessed at 24 ± 4 and 48 ± 4 hours after birth. By 48 hours, the teat order had stabilized (86% of pigs consistently remained on the same teat pair during feedings), and this was regarded as the final teat order. From this final order, 6 pigs from 6 litters were selected (1 sow lost a pig, resulting in fewer than 8 pigs and was removed from the study). The 6 pigs from each litter were chosen based on their position along the udder. Two pigs were chosen from the cranial portion of the udder, 2 from the middle portion, and 2 from the caudal portion. When all 36 piglets were identified, 33 were selected for blood sampling. Ghrelin was measured throughout so a consistent measure of satiety could be observed throughout the study. In the 3 litters where only 5 piglets were selected for a blood sample, a single pig from the caudal portion of the udder was chosen for sampling. Blood was sampled via anterior vena cava puncture using a 23 gauge (2.54 cm) needle and transferred into tubes containing Ethylenediamine tetraacetic acid (EDTA) and aprotinin before being placed on ice until centrifuged (2000 × g, 20 minutes, 4 °C). Plasma was then transferred into duplicate aliquots. Half of the aliquots for each individual sample contained 50 µL of 10 M HCl. All aliquots contained 500 µL of plasma. Aliquots containing acid were vortexed, and then all samples were stored at -80 °C until assayed. This process was repeated at weaning (21 days), and at the end of the nursery phase (62 days).

Performance Data

At weaning (21 days of age), pigs were weighed before being moved to off-site housing and placed in 1.6 m × 1.2 m nursery pens. There were 2 pigs per pen, and each pig was placed with a litter mate that suckled from the same region of the udder. The pigs chosen for the study (n = 36) were thus divided into 18 pens. Feed consumption was monitored during the 6 weeks of the nursery period. Nursery was divided into 3 two-week phases. Phase-1 feed was offered after weaning and feed was weighed for each pen before placing in feeders. Pigs had ad libitum access to feed and water. Records of any feed added to feeders before the end of the two week phase were kept. At the end of the two weeks, the feed remaining for each pen was weighed and subtracted from the total feed added. The pigs then received a phase-2 diet, followed by the phase-3 diet for the last two weeks of the trial, and feed disappearance was recorded at the end of each phase. Average daily feed intake was calculated by dividing the amount of feed consumed by the number of pigs in the pen and the number of days in the phase. Pigs were also

Table 1. Growth performance data.

	Treatment			*P*-value			
	Cranial	Middle	Caudal	SE	Treatment	Linear	Quadratic
Average daily gain, grams/day							
Birth to Weaning	258	258	247	27.7	0.96	0.80	0.88
Nursery Phase 1	116	149	168	21.2	0.25	0.11	0.77
Nursery Phase 2	481	536	458	32.0	0.25	0.63	0.11
Nursery Phase 3	770	725	771	27.8	0.43	0.97	0.20
Nursery	457	473	465	22.0	0.87	0.79	0.66
Overall	394	405	396	19.2	0.91	0.92	0.68
Average daily feed Intake, grams/day							
Nursery Phase 1	258	236	249	22.0	0.79	0.79	0.53
Nursery Phase 2	737	725	606	42.7	0.09	0.05	0.32
Nursery Phase 3	1077	1129	1128	65.9	0.82	0.59	0.75
Nursery	693	698	658	33.3	0.67	0.48	0.59
Gain to feed							
Nursery Phase 1	0.428	0.634	0.648	0.06	0.02	0.01	0.18
Nursery Phase 2	0.661	0.744	0.771	0.05	0.34	0.17	0.68
Nursery Phase 3	0.720	0.650	0.691	0.03	0.22	0.46	0.12
Nursery	0.661	0.682	0.707	0.02	0.33	0.14	0.95
Weight, kilograms							
Birth	1.44	1.39	1.45	0.11	0.91	0.96	0.66
Weaning	6.40	6.28	6.15	0.54	0.95	0.75	0.99
Nursery Phase 1	7.91	8.23	8.33	0.60	0.87	0.62	0.88
Nursery Phase 2	15.1	16.3	15.2	0.95	0.65	0.95	0.36
Nursery Phase 3	25.1	25.7	25.2	1.21	0.94	0.95	0.74

weighed at the transition of every phase change and at the end of the nursery period to calculate average daily gain and gain-to-feed ratio.

Plasma Analysis

Active ghrelin was assessed from the acidified plasma samples using a commercial RIA kit (GHRA-88HK; Active Ghrelin; EMD Millipore, Billerica, Massachusetts, U.S.). This kit uses a specific antibody for the biologically active form of ghrelin with the octanoyl group on Serine 3. The assay has successfully tested for active ghrelin in previous studies (Brown-Brandl et al., 2015). Whereas total ghrelin was assessed from the acidified plasma samples using a commercial RIA kit (GHRA-89HK; Total Ghrelin; EMD Millipore, Billerica, Massachusetts, U.S.). This kit has also been successfully utilized in the same study as the active ghrelin (Brown-Brandl et al., 2015). To better fit a normal distribution, plasma data is presented using log-transformed means.

Statistical Analysis

Data were analyzed as a randomized complete block design, with sow/litter as the blocking factor (random effect), and piglet as the experimental unit. To better fit a normal distribution, plasma data are analyzed and presented using log-transformed means. The analysis of variance was generated with PROC GLIMMIX, with teat order as the lone fixed effect in the model. Least square means were calculated and separated using the PDIFF option when a significant ($P \leq 0.05$) F-test occurred. In addition, contrasts were included in the analysis to determine the linear or quadratic effect of teat order on pig performance.

Results and Discussion

No difference in body weight was observed at birth ($P = 0.91$), at weaning ($P = 0.95$), or at the end of any nursery stage ($P \geq 0.65$; Table 1). Furthermore, no effect of teat order was found on average daily gain (ADG) overall ($P = 0.91$) or throughout the nursery phase ($P = 0.87$). However, in nursery phase 1 (N1), there appeared to be a linear relationship ($P = 0.11$) between teat order and ADG. Although not significantly different, pigs in the cranial teat position had the lowest ADG, and pigs in the caudal teat position had the greatest ADG.

There was no effect of teat order ($P = 0.67$) on average daily feed intake (ADFI) of pigs for the overall nursery period (Table 1). During nursery phase 2 (N2), however, a linear relationship ($P = 0.05$) between teat order and feed intake was observed, with pigs in the cranial teat position having had the greatest ADFI, and pigs in the caudal teat position had the lowest ADFI ($P = 0.09$).

Overall feed efficiency, as measured by gain-to-feed ratio (G:F), was not affected ($P = 0.33$) by teat order (Table 1). A strong linear relationship between G:F and teat position was observed in N1 ($P = 0.01$) during NI,

Table 2. Log-transformed means of active ghrelin, total ghrelin, and active to total ghrelin ratio.

	Treatment†				*P*-value		
Item	**Cranial**	**Middle**	**Caudal**	**SE‡**	**Treatment**	**Day**	**Treatment × day**
Active	--------------picogram/mL--------------						
D 7 a†	3.66	3.71	3.49				
D 21 b	3.46	3.53	3.37				
D 62 a	3.64	3.59	3.57	0.1	0.18	0.04	0.79
Total							
D 7 a	6.94	6.89	6.76				
D 21 b	6.49	6.55	6.53				
D 62 a	6.80	6.91	6.84	0.1	0.63	<0.01	0.65
Active:Total							
D 7	-3.29	-3.19	-3.27				
D 21	-3.04	-3.00	-3.22				
D 62	-3.17	-3.32	-3.26	0.1	0.68	0.12	0.58

† Columns without common letter superscripts differ, Main effect of day, $P < 0.05$.
‡ Pooled standard error of the mean for the interaction.

and pigs in the cranial teat position had the lowest G:F; whereas pigs in the caudal teat position had the greatest G:F ($P = 0.02$).

Overall, no relationship between teat order and growth performance was found. A linear relationship between teat order and ADG in the first phase of nursery would be consistent with previous observations (Cardoso et al., 2015). The pigs that nursed on the caudal portion of the udder are perhaps more independent because the contact they had with their dam was less direct. This would make the transition of weaning easier on the piglets. Because ADFI did not differ during this phase, but the G:F linearly favored caudal piglets, the results suggest that the more caudal, less dominant pigs had the ability to better adapt to a new environment and continue growing undeterred. Cranial pigs having the greatest ADFI in nursery N2 suggests that those piglets had time to adjust to their new environment and were able to catch up to their conspecifics. Average daily gains and G:F not differing for N2 would suggest that the more cranial pigs were still adjusting during this time period, and had to consume more to stay on track with the other pigs.

No difference was observed among treatment groups for active ghrelin (AG; $P = 0.18$), total ghrelin (TG; $P = 0.63$), or active-to-total ghrelin ratio (A:T; $P = 0.68$) (Table 2). There were also no treatment by day interactions ($P \geq 0.58$) for AG, TG, or A:T. The only difference observed was when comparing values × day for AG ($P = 0.04$) and TG ($P < 0.01$). No difference was observed for A:T ($P = 0.12$) when comparing by day.

Because no difference was observed among treatment groups for AG, TG, or A:T, it can be assumed that all pigs maintained comparable levels of satiety. This is especially relevant for samples taken on day seven when pigs were nursing and no accurate way of measuring feed intake was possible. The results suggest that pigs in the cranial, middle, and caudal regions of the udder were all able to obtain an amount of milk that lead to similar hormonal levels of satiety. This strays from previous assumptions that maintained that cranial piglets consume the most milk and continue to consume the most feed in later stages of production (Cardoso et al., 2015). The only way to know if the pigs from each region of the udder were receiving a similar amount of milk would be to analyze samples from the sow. Further research could be done to analyze both quantity and quality of the milk in each region and then relate it growth of pigs nursing in each of these regions.

A difference in both AG and TG was seen over the different days, specifically on day 21 when piglets were weaned and transported to the offsite nursery. The lower levels of both forms of ghrelin at this time may indicate a decrease in appetite at weaning. The piglets were under a high level of stress at that time, which may have influenced the decrease in ghrelin levels, and thus appetite stimulation. This would be consistent with observed decreases in feed intake after weaning (Cardoso et al., 2015).

Both the growth performance and plasma results seem to suggest that the assumed relationship between teat order and feed consumption and growth does not hold true. At birth, pigs from each litter were observed competing for a spot along the udder. This suggests that there is still competition for a preferred spot and that more dominant pigs are able to obtain this position; however, the advantages of this preferred position are now questionable.

Because there has been a trend towards all-in/all-out systems recently, having a consistent drove at the end of a production stage is essential for the viability of an operation. Pigs that nursed on the cranial portion of the udder appear to have the hardest time transitioning into the nursery phase. Accommodating the needs of pigs based on the time it takes them to adjust to a new environment seems to be a viable option in feeding pigs. Because the cranial pigs take more time to adjust, they struggle with ADG while eating the same amount of feed, so allowing them access to more feed could remedy their poor gains.

Conclusions

Overall, there was no difference in the growth performance or plasma ghrelin levels of pigs from the cranial, middle, or caudal portion of the udder, even though previous studies suggested otherwise. One explanation for this could be the changing genetics of pigs used in modern production systems. Many of the studies done in this area were conducted several decades ago, and the genetics of the pigs used in those studies have been altered to meet the needs of the current production systems. With years of artificial selection, it is possible that modern pigs are able to produce more uniform litters and a more uniform distribution of milk throughout the udder. This would explain the lack of difference in growth performance and plasma ghrelin levels, although further study would be needed for a more definite conclusion.

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