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

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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. Further growth performance data were analyzed during different phases of the nursery stage. 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. 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 study should be carried out to investigate what factors would contribute to this data contradicting previous inferences about the relationship of teat order and feed consumption in pigs.

Introduction

It has long been inferred that dominance plays a large role in weight gain for pigs in the wean-to-finish stage of production. A more dominant pig should commandeer more access to the feed trough and be allowed to consume more, gaining weight more quickly. However, there is little literature to back up that exact relationship. The goal of this experiment is to see if this connection can be supported with evidence from birth through the end of the nursery phase of production. Starting with teat order, is it possible to see if this dominance hierarchy established just after birth is something that is maintained throughout life and if so, if it is consistently connected with an increase in feed consumption past the suckling stage.

The percentage of nursery-only sites in the US increased from 0.4% in 1995 to 8.2% in 2012. There has been an increase in all-in/all out management styles as well. All-in/all-out by room 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 animals are likely to perform so the animals' needs can be met and the producer can see the largest 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 be seeing their maximum return per pig. If they know how to feed individuals within the whole herd so that they each reach their maximum potential, more profits could be realized.

Death due to starvation was the number two cause of death during the nursery phase, with producers reporting this cause 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 like dominance or teat order, and then accommodate for individuals who would normally see 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 & 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. 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 its other conspecifics (Drits, 1998).

Total feed cost is the largest production cost per pig sold in most nurseries, and it is influenced heavily on feed efficiency (DeRouchey, Dhuyvetter, Dritz, Tokach, & Tonsor, 2014). This means that if improvements in production performance are made, feed costs can go down, but a sharp rise in feed costs over a year can set back any gains in production (Amador, Bernaus, Font, & Rocademmbosch, 2016). The goal of the nursery phase is to get pigs adjusted to the dry feed they will be consuming in the grow-finish stage of production. The faster this diet can be introduced, the less 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, Dritz, Goodband, Nelssen, & Tokach, 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 grow-finish at a more even weight in an all-in/all-out system.

Literature Review

Competition between pigs begins even before they are born. More developed pig embryos will excrete estradiol to eliminate their less developed counterparts since contact with estrogen can be fatal in early embryonic development. There is also competition for space within the uterus. Pig embryos that attach in the middle of the uterine horn often have more competition for space and end up with lower birth weights than embryos on the ends of the uterine horns (Drake, Fraser, & Weary, 2007).

Since pigs are precocial they are able to fight for their spot along the udder shortly after birth. Some pigs will fight their way to a preferred teat, sampling as many as seven teats along the way, while others hold their ground and stick to the teat they have latched on to. At birth, pigs have deciduous canine teeth that they use to fight their siblings during the process of teat selection. Since these teeth lose their function later in life due to growth, it is inferred that they are used specifically during teat selection (Drake, Fraser, & Weary, 2007).

During teat selection, pigs have a marked preference for the middle, and especially the cranial teats. In one study the cranial four sets of teats were nursed more than 60% of the time while the caudal two sets of teats were nursed less than 40% of the time (Easter, Han, Hurley, & Kim, 2000). One explanation as to the initial draw of the cranial teats is vocalization from and proximity to the sow (Cardoso, Dalla Costa, Honorato, Hötze, & Sommavilla, 2015). Another explanation is the quantity of milk obtained from the teat, odor, and the comfort of a certain nursing position (Brus, Skok, & Sˇkorjanc, 2007).

Some studies found no correlation between birth weight and teat order (Cardoso, Dalla Costa, Honorato, Hötze, & Sommavilla, 2015), (Clarke, Corson, Drury, Lean, & Litten, 2003), and another stated similar findings just adding that heavier pigs seemed to be able to drain the teat more efficiently than lighter pigs (Alberton, et al., 2014). However, other studies disagree and have found there to be a relationship between birthweight and teat order. One found heavier and or more dominant pigs often suckle from cranial mammary glands, leaving the caudal glands for smaller and more subordinate pigs (Easter, Han, Hurley, & Kim, 2000). Higher birth weight can prove to be advantageous when competing for a spot along the udder, and heavier pigs are able to drain more colostrum from the teat than lighter pigs, giving them a lower mortality rate (Drake, Fraser, & Weary, 2007). Dominance values are also often higher in pigs occupying the cranial teats after weaning, and pigs that latched to the caudal teats showed less agonistic and more submissive behaviors when regrouped after weaning (Puppe & Tuchshcherer, 2001). In some instances, certain pigs may retain attachment to their desired teat even after they have drained all of the available milk. This helps to preserve the teat order and prevent future agonistic behavior (Broom & Fraser, 2007).

Teat order stability is an important factor in ensuring that all piglets are able to nurse an adequate amount. It is suggested that this suckling stability is used to cope with a decreased maternal investment and to avoid missed milk ejections due to sibling competition while nursing. Stability increases every day until the fourth day of life. One experiment observed pigs reach a stability of 98.6% for a particular region of the udder 7 days after birth, 96.8% on day 9 for a teat pair, and 95.6% on day 12 for a single teat. There was a lower stability for pigs suckling from the middle teats compared to the caudal or cranial teats. This suggests a higher level of competition in this area of the udder. Although competition was greater in this area, there was still a lower average daily gain of piglets suckling the caudal teats. Pigs that suckled in the caudal region were also found to have a lower dominance value after weaning and mixing into new groups. They exhibited more submissive and less agonistic behaviors during the transition of weaning than pigs who suckled the middle or cranial teats (Puppe & Tuchshcherer, 2001).

Pigs that nurse from the cranial teats tend to be heavier at weaning than pigs that nurse on the caudal teats due to greater milk consumption (Brus, Skok, & Sˇkorjanc, 2007). Suckling from the first four teats was found to contribute to an average of 15% greater weight gain over a 56 day lactation period (Drake, Fraser, & Weary, 2007). The main variation in weaning weight is most likely due to differences in milk production at each teat. Although middle teats have been shown to have more protein, DNA, ash, and a larger cross sectional area, cranial teats have a higher sensitivity to milk let down and higher levels of colostrum (Easter, Han, Hurley, & Kim, 2000). Higher weight gain until weaning can be attributed to greater milk intake since consumption of solid food is relatively low until the weaning period (Cardoso, Dalla Costa, Honorato, Hötze, & Sommavilla, 2015). Interestingly, when standardized by weight, there was no difference in average daily gain among pigs. When competition was eliminated all of the pigs were able to consume more equal amounts of milk. However, when the individual in the standardized groups were compared among their own litter, there was a difference in average daily gain (Alberton, et al., 2014).

Measuring feed intake in nursing pigs can be challenging, so ghrelin levels in the blood were determined to account for feed intake. Ghrelin can be used to assess appetite as it is used in the body to signal hunger and increase feed intake. When pigs are fed on a schedule there is an increase in blood-ghrelin levels before the anticipated meal, while no increases in ghrelin are observed when pigs are fed ad libitum (Sartin, Whitlock, & Daniel, 2011). One study that intravenously infused pigs with ghrelin three times a day for five days witnessed an increase in body weight, but not an increases in feed intake versus pigs infused with saline solution. The observational aspect of that study saw more pigs from the ghrelin treatment eating during observation times than the control pigs (Carroll, Keisler, Salfen, & Strauch, 2004). In studies on humans and rats, ghrelin was shown to be closely related to feed intake, with increases during starvation, hypoglycemia, cachexia, and anorexia nervosa and decreases during positive energy balance, obesity, and hyperglycemia. Overall, the main factor affecting ghrelin secretion is feeding. There will be an increase upon the anticipation of eating before a meal, and there will be a decrease upon the completion of a meal and satiety. However, the caloric and nutrient value of the meal plays just as important a role as the amount of food consumed (Kirsz & Zieba, 2011).

Ghrelin is also dose dependent and affects different age groups differently. It has a much higher intensity in juveniles than adults, and a smaller dose works more effectively in younger animals as well (Akimoto-Takano, et al., 2005).

Since both active and total ghrelin values were evaluated in the selected pigs, understanding the relationship between the two is also important. A study done on human cancer patients experiencing cachexia observed an increase both active ghrelin and an increase in the active to total ghrelin ratio. These higher levels correlated positively with weight loss, but not anorexia over a 6 month period (Cunningham, et al., 2005). Another human study looked at how active and total ghrelin levels differed in children who were experiencing poor weight gain. After fasting, total ghrelin levels seemed unaffected, but active ghrelin levels were elevated more so than in children without poor weight gain, suggesting a possible resistance to active ghrelin (Chan, et al., 2010). Total ghrelin is made of acyl or active ghrelin and des-acyl ghrelin. While the role of des-acyl ghrelin is not yet fully understood, it is believed to be both an antagonist to active ghrelin, and carry out independent functions. Obese mice were found to have elevated acyl to des-acyl ghrelin levels, indicating a higher level of active ghrelin within the total ghrelin. Mice were also observed decreasing feed intake when des-acyl ghrelin levels were elevated (Delhanty, Neggers, & van der Lely, 2012). Des-acyl ghrelin was found to not effect food intake after a starvation period, however, it directly antagonized the appetite stimulating effects of peripherally administered acyl ghrelin (Cabral, et al., 2016). Since total ghrelin is composed of active and des-acyl ghrelin, a higher active to total ghrelin ratio would indicate a less satisfied animal.

After weaning, weight seems to be one of the major contributing factors to growth rate in pigs. So, pigs that gain more while nursing are more likely to be heavier at the end of the finishing process. Similar weight at birth seems to be the strongest contributing factor in having a low variation in weight and growth rate throughout the growth phase. One study found that pigs grouped in similar weight classes had a reduction in weight variation at 15 and 20 weeks compared to pigs grouped in mixed weight classes. The same study also examined average daily gain and feed intake. Both were consistently higher in medium and heavy weight pigs than in light weight pigs. The higher feed intake accounts for the higher average daily gain, which is consistent with heavier pigs continuing to be heavier throughout the growth phase (Ball, et al., 2011).

The size of the groups pigs are placed into can also affect their growth. Smaller groups of pigs seem to gain more during the first eight weeks after weaning than larger groups. When put into groups of 25, 50, and 100 pigs, the group of 25 contained heavier pigs at the end of the eight week period. The pigs in groups of 50 and 100 had lower average daily gain and a smaller feed to gain ratio, even though their average daily feed intake was similar to the group of 25 pigs. After the first eight weeks the different groups all had similar average daily gains. At the end of the growth period the pigs in the group of 25 were heavier than the larger groups because of their greater average daily gain during the first eight weeks of the study (Augspurger, et al.).

Diet is also a very important consideration. Obviously having the same feed type and amount for each pig is important, even though providing the same amount of feed per pig does not guarantee that each pig consumes the same amount of feed. Pigs fed with feed containing higher energy content are going to gain more weight than pigs fed on low energy feeds. Growth rate before weaning does not have an effect on growth rate after weaning. Growth rate is highly dependent on weight and diet however, and pigs heavier at weaning are going to grow faster as well as pigs fed with a higher energy content feed. Pigs heavier at weaning were heavier at 56 days of age than light pigs and reached a desired slaughter weight 8.6 days faster than light pigs fed similar diets (Ellis & Wolter, 2001).

The transition of being weaned can be very stressful on a young pig. They have to learn to eat solid food and are without the comfort and safety of their mother for the first time. This can have an impact on their behavior and feed intake. Pigs that suckled on the cranial teat were observed to spend more time lying and less time eating and vocalizing than pigs that suckled from teats further along the udder. While weight gain in piglets that suckle from the anterior teat was greater before weaning, it was not from the first to fifth day after weaning. This behavior and deceased feed intake did decrease over time and it is believed to be a coping mechanism to deal with being in a new environment away from the mother (Cardoso, Dalla Costa, Honorato, Hötze, & Sommavilla, 2015).

The transition from nursing to eating solid feed can be quite an adjustment for young pigs. Feeding behavior can easily be learned from observing other animals, and preferences in feed can be made solely off of what a conspecific is seen consuming. It's been found that young pigs often copy the feeding behavior of a relative with the expectation of obtaining a similar reward. When first weaned, piglets have to face a new environment, the stress of being mixed with unfamiliar pigs, and a drastic change in feed. This often causes pigs to exhibit anorexia using their first few days after being weaned, which can be a major problem in production systems. In one study, pigs that watched a pen-mate consume a flavored feed ate more of that flavored feed than the non-flavored feed they were used to consuming. When the same situation occurred with an unfamiliar pig, there was no observed difference in preference of flavored feed over the non-flavored feed. This means how soon a pig adapts to eating solely solid feed and their preference in feed can be dramatically altered by observing the behavior of their fellow pen mates (Figueroa, Manteca, Pérez, & Solà-Oriol, 2013).

The average amount of time that pigs spend at the feeder grows until it reaches a natural plateau. In one study the average time spent eating started at 24 minutes per day and increased until the plateau was reached 30 to 42 days later with time spent feeding at an average of 76.7 minutes per day. As pigs were removed and sent to slaughter, the remaining pigs began to spend more time eating. This suggests that the heavier pigs had a monopoly over the feeding area, possibly due to social rank. Barrows are more likely to spend longer periods eating and reached their plateau later than gilts did. Heavier pigs were also more likely to spend more time feeding with an average of 79.1 minutes per day than lighter weight pigs with an average of 63.6 minutes per day (Brown-Brandl, Eigenberg, & Rohrer, 2013).

In an automatic feeding system where there was limited space per pig, a slightly different outcome was observed. This system had more dominant animals making fewer trips to the feeder throughout the day than less dominant animals. However, though they made fewer trips, at each trip the higher ranking pig would spend more time eating and have a higher feed intake than a lower ranking pig would have in one of its trips to the feeder (Hoy, Schamun, & Weirich, 2012). Dominant pigs will spend significantly longer at a feeding trough than their subordinate conspecifics. With this extra time spent at the feed trough dominant pigs gained more weight over the growth period and had a higher average daily gain than subordinate pigs. This again suggests that more dominant pigs have control over feed intake and are able to consume more feed and grow more rapidly than their subordinate pen mates (Schönfelder, 2005).

Materials and Methods

Observational Study

All sows used farrowed on November 10, 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 were selected between two pre-existing dietary treatment groups (one control group and one group supplemented with fish, porcine, and microbial peptides at an inclusion rate of .5%). Three litters were chose from sows from the supplemented diet, and four litters were chosen from the sows on the control diet. Each selected sow had at least 8 piglets by the end of parturition. Piglets were observed during birth and marked with a non-toxic, permanent marker individually 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 hours 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 six pigs from six litters were selected. One of the litters with a sow from the control diet lost one pig, and her litter no longer contained enough piglets for the study. That left three litters from the treatment diet, and three litters from the control diet. The six pigs from each litter were chosen based on their position along the udder. Two pigs were chosen from the cranial portion of the udder, two from the middle portion, and two from the caudal portion. When all 36 piglets were identified, 33 were selected for blood sampling. In the three litters where only five 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 EDTA and aprotinin before being placed on ice until centrifuged (2,000 × *g*, 20 minutes, 4° C). Plasma was then transferred to 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

Pigs were weaned at 21 days of age. Along with a blood sample, a weaning weight was also recorded at this time. At weaning, pigs were moved to off-site housing and placed in nursery pens that were 1.6 m x 1.2 m and had a capacity of 7 pigs. There were two 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 six weeks of the nursery period. Nursery was divided into three phases that each lasted two weeks. Phase one 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. Feed consumption was measured on a per pen basis since each pig in the same pen nursed on the same area of the udder of the same sow. 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 two diet for two weeks, and a phase three diet for two weeks where the process was repeated. 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 weighed at the transition of every phase change and at the end of the nursery period. Once the nursery period was over, the pigs moved on through the usual stages of production before being marketed through normal market channels.

Plasma Analysis

Active ghrelin was assessed from the acidified plasma samples using a commercial RIA kit (GHRA-88HK; Active Ghrelin; EMD Millipore, Billerica, MA, USA). 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, B.A., Lents, W.T., & Rohrer, 2015). Sensitivity for this assay is 7.8 pg/mL when a 100 µL sample is used.

Total ghrelin was assessed from the acidified plasma samples using a commercial RIA kit (GHRA-89HK; Total Ghrelin; EMD Millipore, Billerica, MA, USA). This kit has also been successfully utilized in the same study as the active ghrelin (Brown-Brandl, B.A., Lents, W.T., & Rohrer, 2015). Sensitivity for this assay is 93 pg/mL when a 100 µL sample is used.

Statistical Analysis

Data were analyzed as a randomized complete design with sow/litter as the blocking factor (random effect), and piglet as the experimental unit. The ANOVA 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

Performance Data

No effect of teat order was found on average daily gain (**ADG**) overall (*P* = 0.909) or throughout nursery (*P* = 0.870) (Table 1). In nursery phase 1 (**N1**) there was a linear relationship (*P* = 0.1063) between teat order and ADG (Figure 1). Pigs in the cranial teat position had the lowest ADG at 116 g/day, and pigs in the caudal teat position had the greatest ADG at 168 g/day. The middle teat position had an ADG of 149 g/day.

No effect of teat order on feed consumption was found (Table 1). There was no difference (P = 0.668) in the average daily feed intake (**ADFI**) of pigs from each teat type for the overall nursery period. The only phase during the nursery period where a difference (*P* = 0.089) in ADFI was observed was during nursery phase 2 (**N2**). A linear relationship (*P* = 0.0472) between teat order and feed intake was observed (Figure 2). Pigs in the cranial teat position had the greatest ADFI at 737 g/day, and pigs in the caudal teat position had the lowest ADFI at 606 g/day. The middle teat position had an ADFI of 725 g/day. No other stage in nursery had a difference in feed intake.

Feed efficiency was measured as a gain to feed ratio (**G:F**) (Table 1). In regards to teat order, no effect (*P* = 0.332) was found in the overall nursery period. A relationship between G:F and teat position was observed in N1 (*P* = 0.024). A strong linear relationship (*P* = 0.0143) was also observed during N1 (Figure 3). Pigs in the cranial teat position had the lowest G:F at 0.428, and pigs in the caudal teat position had the greatest G:F at 0.648. The middle teat position had a G:F of 0.634.

No difference in body weight was observed at birth (*P* = 0.905), weaning (*P* = 0.949), or any nursery stage (N1, N2, and N3; *P* = 0.873, 0.647, and 0.941, respectively [Table 1 and Figure 4]).

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 is consistent with previous observations (Cardoso, Dalla Costa, Honorato, Hötze, & Sommavilla, 2015). The pigs that nursed on the caudal portion of the udder are perhaps more independent since the contact they had with their dam was less direct. This would make the transition of weaning easier on the piglets. Since ADFI did not differ during this phase, but the gain to feed ratio linearly favored caudal piglets, the data 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 largest ADFI in nursery phase 2 suggests that those piglets had time to adjust to their new environment and were able to catch up to the 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.

The variances in just certain stages of the nursery period emphasizes the importance of producers understanding their animals and how well they are able to make transitions between different stages of production. Weights never varied significantly among the pigs from birth to nursery, so feeding pigs based on standardized weight classes may not be the most efficient approach. It seems that the most dominant, cranial pigs tend to have a more difficult time adjusting after weaning than middle and caudal pigs. Previous studies have suggested feeding by weight class and giving larger pigs less feed so that smaller pigs could catch up (DeRouchey, Dhuyvetter, Dritz, Tokach, & Tonsor, 2014). With no difference in weight across the udder, cranial pigs that happen to be heavier might suffer in a set up like this. They would be having a more difficult time adjusting, and they would be offered less food, which could hurt further growth. If nursery producers penned their pigs by teat region, needs could be better met by allowing less independent pigs to have access to more food once they adjust to their new environment so they have the opportunity to catch up in ADG.

Plasma Data

To better fit a normal distribution, plasma data is presented using log-transformed means (Table 2). *P*-values were calculated based on treatment, day, and treatment × day for active ghrelin (**AG**), total ghrelin (**TG**), and the active to total ghrelin ratio (**A:T)**. No difference was observed among treatment groups for AG (P = 0.18), TG (P = 0.63), or A:T (P = 0.68). There were also no treatment by day interactions for AG (P = 0.79). TG (P = 0.65), or A:T (P = 0.58). The only difference observed was when comparing values by day for AG (P = 0.04, [Figure 5]) and TG (P = <0.01, [Figure 6]). No difference was observed for A:T (P = 0.12) when comparing by day.

Since 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 data 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 studies that maintained that cranial piglets consume the most milk and continue to consume the most feed in later stages of production.

A difference in both AG and TG was seen over the different days, specifically on day 21. This was the day that the piglets were weaned. Blood samples were collected after 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 appetite stimulation. This would be consistent with observed decreases in feed intake after weaning (Cardoso, Dalla Costa, Honorato, Hötze, & Sommavilla, 2015).

Conclusion

Both the growth performance and plasma data 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.

The pigs in this study did not differ in weight among teat position in any stage of production, including at birth. So, birth weight must not be the sole factor that determines dominance and access to a preferred teat position. With no difference in weight at weaning, or ghrelin concentrations at seven days or at weaning, the piglets must have been consuming comparable amounts of milk while nursing. 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 study 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.

Weaning and the first two phases of nursery seem to be the most stressful for the pig. Decreased levels of ghrelin at weaning could explain observed anorexia among pigs during the first few days after weaning. Further study could be done to see if stress has an impact on ghrelin levels in pigs, and if stressful events other than weaning caused an observed decrease in plasma ghrelin concentration.

Since there has been a trend towards all-in/all-out systems recently, having a consistent herd at the end of a production stage is essential for the viability of an operation. Having producers understand the importance of the transition to solid food and the transition among phases during nursery can help them to have a more uniform group of pigs when they move on to the grow-finish stage of production. Pigs that nursed on the cranial portion of the udder appear to have the hardest time transitioning in 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. 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.

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 has 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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Table 1. Growth Performance Data

	Cranial	Middle	Caudal	SE	Pr>F	Linear	Quadratic
Average Daily Gain, grams/day							
Birth to Weaning	258	258	247	27.70	0.956	0.8011	0.8775
Nursery Phase 1	116	149	168	21.24	0.251	0.1063	0.7732
Nursery Phase 2	481	536	458	32.04	0.246	0.6252	0.1128
Nursery Phase 3	770	725	771	27.76	0.429	0.9721	0.201
Nursery	457	473	465	21.95	0.870	0.7870	0.6568
Overall	394	405	396	19.15	0.909	0.9232	0.6755
Average Daily Feed Intake, grams/day							
Nursery Phase 1	258	236	249	22.01	0.790	0.7901	0.5341
Nursery Phase 2	737	725	606	42.74	0.089	0.0472	0.3242
Nursery Phase 3	1077	1129	1128	65.88	0.821	0.5934	0.7531
Nursery	693	698	658	33.30	0.668	0.4769	0.5929
Gain to Feed							
Nursery Phase 1	0.428	0.634	0.648	0.0563	0.024	0.0143	0.1838
Nursery Phase 2	0.661	0.744	0.771	0.0538	0.344	0.1666	0.677
Nursery Phase 3	0.720	0.650	0.691	0.0272	0.222	0.4593	0.1174
Nursery	0.661	0.682	0.707	0.0210	0.332	0.1441	0.9518
Weight, kilograms							
Birth	1.44	1.39	1.45	0.108	0.905	0.9573	0.662
Weaning	6.40	6.28	6.15	0.539	0.949	0.7513	0.9896
Nursery Phase 1	7.91	8.23	8.33	0.598	0.873	0.623	0.8821
Nursery Phase 2	15.1	16.3	15.2	0.952	0.647	0.95	0.3598
Nursery Phase 3	25.1	25.7	25.2	1.21	0.941	0.9514	0.7351

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

Ghrelin values pg/mL (Log-transformed Means)

	Treatment[1]				*P*- value		
Item	1	2	3	SEM[2]	Treatment	Day	Treatment × day
Active pg/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, pg/mL							
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

[a-b]Columns without common letter superscripts differ, Main effect of day, $P < 0.05$.
[1]Treatment 1 = ,
[2]Pooled standard error of the mean for the interaction.

Figure 1. Average daily gain of pigs during phase one of the nursery stage of production.

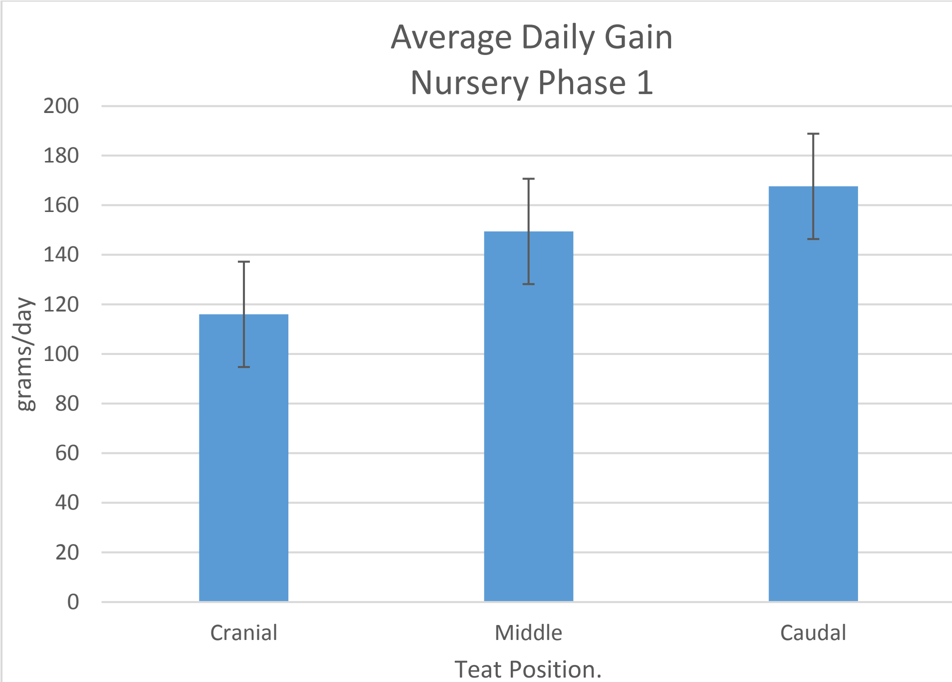

Figure 2. Average daily feed intake of pigs during phase two of the nursery stage of production.

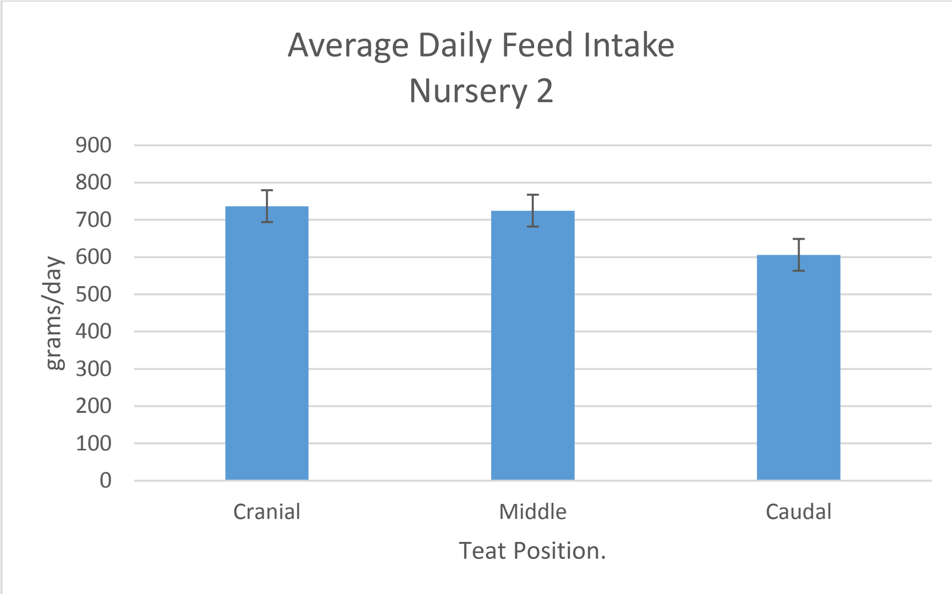

Figure 3. Gain to feed ratio during phase one of the nursery stage of production.

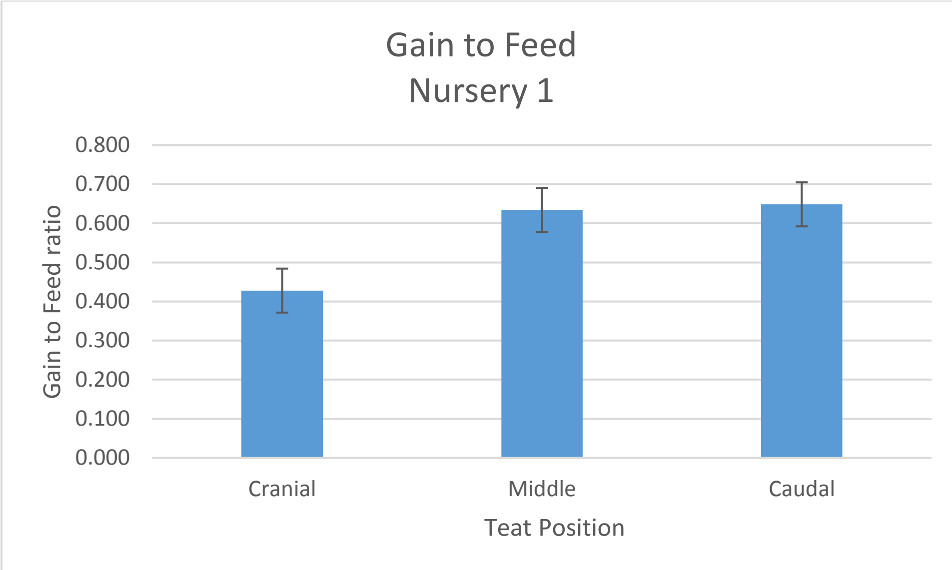

Figure 4. Body weight of pigs at the end of phase three of the nursery stage of production.

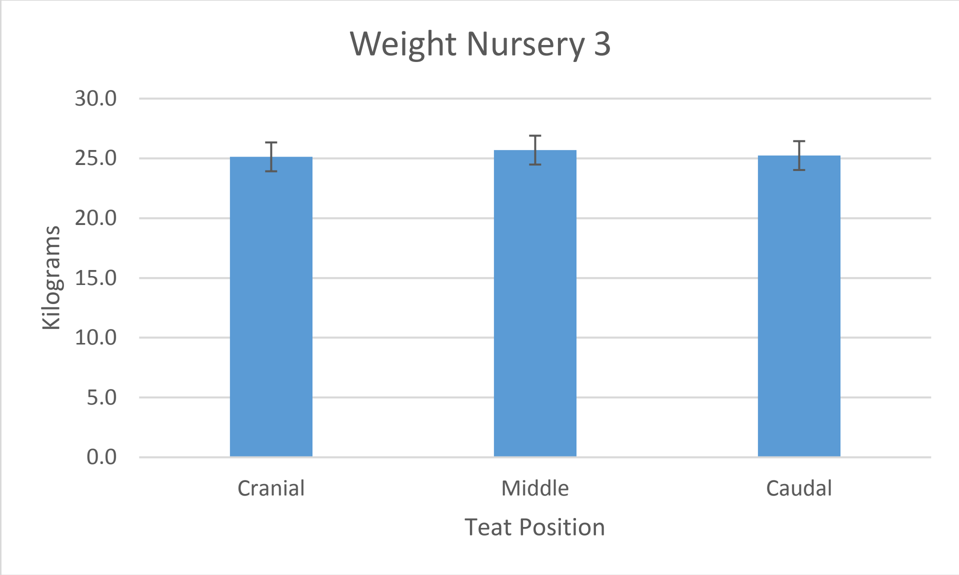

Figure 5. Active ghrelin concentrations in pigs on D7, D21, and D62.

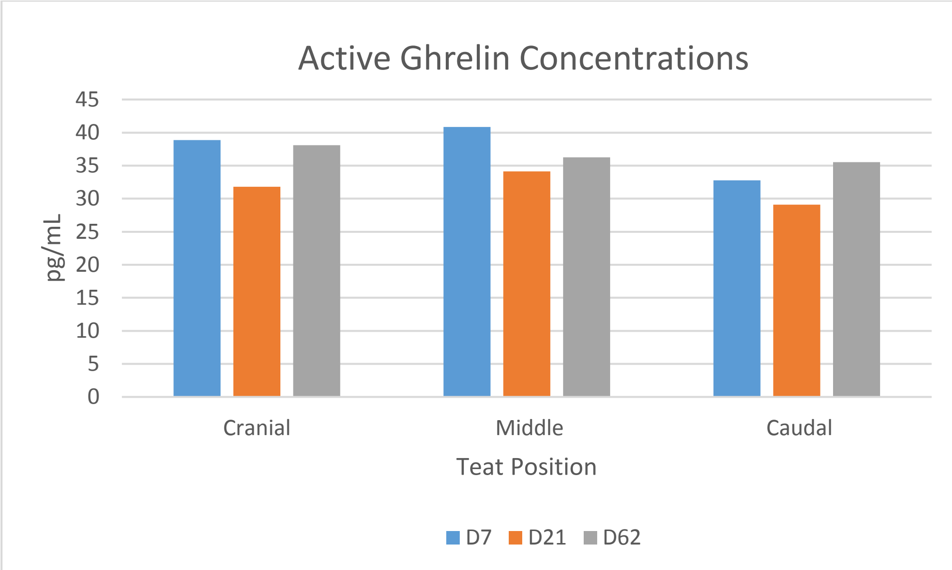

Figure 6. Total ghrelin concentrations in pigs on D7, D21, and D62.