Effect of environmental enrichment and breed line on the incidence of belly nosing in piglets weaned at 7 and 14 days-of-age

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Abstract

The effect of enrichment and breed line on belly nosing in early-weaned pigs was investigated over two studies. In a preliminary study, 291 piglets were weaned at 7 days-of-age and observed over two consecutive days (pigs ranged from 17 to 30 days-of-age at time of observation). Piglets were fed a liquid milk replacer diet for either 7 or 14 days following weaning. Pen environment was enriched by providing either an air-filled inner tube (Tube), rubber nipples in the feed trough (Nipple), or neither (Control). Pens were segregated by sex with 14–16 pigs per pen. Within pens, there were both Duroc and Yorkshire pigs. Instantaneous scan sampling by two observers was used to determine the incidence of belly nosing, belly sucking, and nosing and sucking other parts of the body. Yorkshire line pigs engaged in more belly sucking (3.97% versus 1.59%; \( P < 0.01 \)), total sucking (4.30% versus 2.21%; \( P < 0.05 \)), and belly-directed behaviour (9.2% versus 6.21%; \( P = 0.089 \)) than did Duroc line pigs. Nipple enrichment effectively reduced the level of belly sucking, overall sucking and belly-directed behaviours in the Yorkshire line pigs, while Tube enrichment reduced other nosing and oral–nasal vices directed away from the belly in the Duroc line pigs.

The second study investigated the effect of sire breed and sire within breed on the proportion of time early-weaned pigs spent belly nosing and belly sucking. Two hundred and forty-two crossbred pigs sired by Duroc (\( n = 120 \)) and Large White (\( n = 122 \)) boars were weaned at 14 days-of-age and observed at 18, 23, 28, 50, 63 and 91 days-of-age for belly nosing, belly sucking, other nosing and sucking, tail biting and other biting behaviours during the nursery and grow-finish phases of development. Continuous observations done live at 21 and 35 days-of-age were used to determine mean belly nosing and belly sucking bout durations. Pigs sired by Large White boars spent a greater proportion of time belly nosing (2.040%; \( P < 0.01 \)) and belly sucking (0.440%; \( P < 0.01 \)) compared with pigs sired by Duroc boars (1.597% and 0.308%).

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respectively). In contrast, Duroc-sired pigs spent a greater proportion of time conducting other nosing (0.356%; \(P < 0.01\)) and other sucking (2.496%; \(P < 0.001\)) behaviours compared with Large White-sired pigs (0.173% and 2.063%, respectively). Individual sire also had a significant effect on belly nosing (\(P < 0.001\)), belly sucking (\(P < 0.001\)) and other sucking (\(P < 0.01\)) behaviours post-weaning.

It was concluded that breed line differences may affect the incidence of nosing and sucking behaviours in early-weaned pigs, which may be reduced through the use of environmental enrichment tailored to the specific abnormal behaviours being performed.

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1. Introduction

Studies have repeatedly shown that belly nosing is the most common abnormal behaviours exhibited by early-weaned pigs, and as weaning age decreases, the incidence of belly nosing increases (Gonyou et al., 1998; Worobec et al., 1999). Furthermore, the effect of early weaning on behaviour persists well into the grow-finish phase of development (Gonyou et al., 1998; Worobec et al., 1999).

Similar to the naval sucking observed in calves and lambs, belly nosing resembles a principle element of normal suckling behaviour (Fraser, 1978). Specifically, belly nosing appears similar to the massage of the sow’s udder that occurs during the appetitive and post-consumatory phases of nursing behaviour (described by Fraser, 1980) prior to weaning. As a result of these apparent similarities, some researchers have hypothesized that the behaviour results from premature separation from the sow (Weary et al., 1999; Worobec et al., 1999). While the underlying motivation to perform belly nosing is not clear, the similarity of belly nosing to the udder massage phases of suckling suggests that the motivation to perform belly nosing is related to hunger. However, belly nosing does not commence until a few days after weaning, by which time the piglets are eating adequate amounts of solid feed, and nosing reaches its highest incidence 2–3 weeks later (Gonyou et al., 1998; Worobec et al., 1999). Gardner et al. (2001) also provided evidence disputing hunger as the root cause of belly nosing in the early-weaned pig. However, in calves, de Passille et al. (1997) reported that the provision of milk replacer, particularly at higher concentrations, actually increased the incidence of non-nutritive sucking behaviour.

One possible explanation for the delay in the development of belly nosing is provided by Weary et al. (1999) who suggested that belly nosing reflects a motivation to massage the udder, independent of feeding and hunger, and that the delay in its development represents a learning period. Under this hypothesis, the proximate motivation for udder massage may include the need for social contact that has been lost through the removal of the sow. Dybkjær (1992) observed that belly nosing occurred at significantly higher rates in piglets weaned with unfamiliar conspecifics in more crowded, barren environments compared with piglets weaned in littermate groups in pens enriched with straw.

Among members of the same litter and between litters, there is considerable variation in the incidence of belly nosing as well as in the amount of time it takes for the behaviour to commence following weaning (Fraser, 1978; Li and Gonyou, 2002). Li and Gonyou (2002) studied the temporal association of belly nosing with other behaviours in an attempt to identify the proximate cause of the behaviour. The authors found that the social environment can have a profound effect on the incidence of belly nosing, possibly explaining some of the variation in belly nosing observed between litters. Welfare concerns regarding the incidence of belly nosing in early-weaned pigs have
reflected the environmental contribution to the development of the aberrant behaviour while the genetic component has not been researched beyond preliminary findings (Bench, 2005).

The objectives of the first study were to determine the influence of breed line and environmental enrichment, simulating components of the sow’s udder, on the incidence of belly nosing and its associated behaviours in pigs early-weaned at 7 days-of-age, and to further examine the effect of duration of milk replacer diet and gender on these behaviours. The objective of the second study was to compare the incidence of belly nosing (and its associated behaviours), teat order consistency, and nursing behaviour between three sires within two common breed lines of pigs: one of Duroc and one of Large White origin. Specifically, it is hypothesized that both breed line and environmental enrichment influence belly nosing in the early-weaned pig.

2. Materials and methods—study 1

2.1. Animals, housing and diets

A preliminary study was conducted in a nursery room at BioSearch in St. Andrew, Manitoba on October 30th and 31st of 1999. The room was ventilated using a negative pressure system and heated to 32–34 °C with a natural gas heater. Fans and heaters for the room were controlled by thermostat in order to maintain a comfortable thermal environment for the pigs. All pens were made of durable plastic penning and tribar flooring. Lighting was provided on a 12-h cycle, turned on at 07:00 and turned off at 19:00 h.

2.2. Experimental design and treatments

The incidence of belly nosing and belly sucking, as well as other nosing and sucking behaviours were observed in 291 piglets, weaned at 7 days-of-age, sorted according to gender (males: \( n = 9 \), females: \( n = 10 \)), and housed in 24 pens. Five pens had to be removed from the study due to health. Each pen of 14–16 pigs contained pigs of both Yorkshire and Duroc lines. The numbers of Yorkshire and Duroc piglets per pen were approximately equal. At the time of observation, pigs ranged from 17 to 30 days-of-age (10–23 days following weaning) across all 24 pens. Prior to the study, piglets had been kept with their mother in a single sow farrowing crate, without environmental enrichment.

Upon weaning, pen environment was modified by providing either an air-filled black rubber inner-tube (Tube; \( n = 6 \)), eight rubber baby bottle nipples anchored vertically in the feed trough (Nipple; \( n = 6 \); based on work by Rau, 2002), or neither (Control; \( n = 7 \)). Enrichment was placed in the center of each pen. Piglets in each enrichment treatment group received commercial liquid milk replacer for either 7 ( \( n = 9 \) ) or 14 ( \( n = 10 \) ) days following weaning, and were then switched to a standard pelleted diet for early-weaned piglets. Piglets receiving Nipple enrichment, continued to have nipples anchored vertically in the pellet feeder, once on solid feed. Thus, the study included 12 treatment combinations (each with an \( n = 1 \) or 2), with all treatment combinations distributed evenly across the wide age range at the time of observations.

2.3. Observation techniques

Instantaneous scan sampling by two observers, at 5-min intervals, was used to determine the mean percentage of time piglets spent belly nosing and belly sucking, as well as other nosing and sucking for 8-h (from 08:00 to 16:00 h; i.e. 192 scans per observation day) for two consecutive days. Prior to the scan sampling, both observers determined the definitions of belly nosing and belly sucking, as well as other nosing and sucking through a series of practice sessions conducted at the Prairie Swine Centre, Inc., Saskatoon, SK in order to avoid observer bias during the 2-day experimental observations. The observers recorded the number of piglets in each breed engaged in each of the mutually exclusive behaviours within each pen. The breed of the recipients was not recorded.
2.4. Statistical analysis

A Kolmogorov–Smirnov test was conducted using the Univariate procedure of SAS (SAS Institute Inc., 2000) to test for normality of the data. All data were found to be normally distributed.

The effects of breed line (Yorkshire or Duroc), gender (barrow or gilt), duration of liquid milk replacer supplementation (7 days versus 14 days), and type of environmental enrichment (Tube, Nipple or Control) were tested using the General Linear Model (GLM) procedure of SAS with duration of liquid milk replacer, environmental enrichment and gender in the main plot, and breed line as the sub-plot. For all analyses, the experimental unit for the main plot was the pen. A Bonferroni means separation test was also performed. Belly nosing, belly sucking and other nosing and sucking were expressed as the total percentage of time spent performing the behaviour. The total percentage of time spent nosing was defined as the sum time spent belly nosing and other nosing. Total percentage of time spent sucking was defined as the sum time spent belly sucking and other sucking. Total percentage of time spent engaged in behaviour directed at the belly was defined as total percentage of time spent belly nosing and belly sucking, while total percentage of time spent engaged in behaviour directed at regions other than the belly was defined as the total percentage of time spent conducting other nosing and sucking.

3. Materials and methods—study 2

3.1. Animals, housing and diets

The study was conducted at the Prairie Swine Centre Inc., Saskatoon, Sask., between May 2001 and March 2002. Twenty-four litters were observed with an average of 10–11 piglets per litter. A total of 242 piglets from the 24 litters (two batches of 12 litters) were the focus of behavioural observations from birth to 13 weeks-of-age. All animals were fed nutritionally balanced diets ad libitum and kept in a climate appropriate for the age and weight of the pigs throughout the study.

3.2. Experimental design and treatments

All piglets used in the study were born to PIC-Camborough 15 strain sows (25% Duroc, 25% Large White, 50% Landrace) with 120 of the piglets sired by three purebred Duroc boars (PIC line 280) and 122 piglets sired by three purebred Large White (PIC line 3) boars. Three boars of each genetic strain were bred to 48 sows over the course of the study. Fresh semen from each sire was obtained from Carlo Genetics (Ste. Anne, Manitoba), tested for transmittable diseases, shipped via air to the Prairie Swine Centre, and stored at 15–17 °C until use. To minimize age spread of piglets, five millilitres of PG600® (Intervet, Millsboro, Delaware) was administered intramuscularly 4 days prior to the first breeding of each sow in order to synchronize estrus. Each sow was bred to the same boar on two consecutive days corresponding with behavioural estrus. Duroc boars #1 and 2 were half-siblings; all other sires were unrelated to one another. Of the 48 litters born, the 24 most viable litters (four from each sire) with more than 12 piglets per litter were selected for the study. This ensured a minimum number of 240 animals for the duration of the study, including the expected loss of a small percentage of animals due to mortality and morbidity.

Two to three days prior to farrowing, sows were washed and moved into tubular steel farrowing crates (2.0 m × 0.8 m). Farrowing pen floors were plastic-coated expanded metal (Tenderfoot®, Tandem Products Ltd., Blooming Prairie, MN). Sows were housed in one of four rooms. Each farrowing room had a capacity of up to seven sows and their litters. To further
control for the age spread of piglets, two millilitters Planate™ (Schering-Plough Animal Health) was administered intramuscularly to sows the day before expected farrowing in order to ensure that all sows farrowed within a 12-h window.

Within 24–36 h of birth, piglets were crossfostered between litters within sire (Price et al., 1994). Five piglets from each litter were randomly selected and kept on their own sow, while 5–6 piglets in each litter were crossfostered from another sow. The average size of the resultant litters was 10–11 pigs per litter. Thereafter, 'litter' referred to piglets nursed by the same sow. Crossfostering was used as a means of controlling for maternal effects on piglet behaviour and performance. No milk replacer supplementation or creep feed was provided at any point during the pre-weaning phase.

At 14 days-of-age, all piglets were weaned and moved as intact litters into the nursery. Two identical nursery rooms of six pens, each (1.5 m × 1.5 m) equipped with Tenderfoot® flooring and durable plastic side paneling were used. Each nursery pen was equipped with a trough feeder large enough for four piglets to eat simultaneously. Two nipple drinkers were provided at the rear of each pen. Piglets remained in the nursery for 6 weeks, at which time they were again moved as intact litters to four identical grow-finish rooms. Within each grow-finish room, six litters were housed in pens (3.6 m × 4.8 m) with fully slated concrete flooring and solid plastic side paneling. Within each grow-finish pen, two single-spaced dry feeders were placed in the right and left front corners. Two nipple drinkers were located along the rear wall of the pen.

3.3. Observation techniques

For all observations, piglets were individually identified through back markings (nursery phase) and ear tags (grow-finish phase) and observed within each pen. During the pre-weaning phase, teat order, nursing bout length and nursing cycle length for each litter were recorded. Teat order was determined through live continuous observations done in two 2-h blocks at 4 and 12 days-of-age. Nursing bout and cycle lengths were obtained through continuous observations made via 24-h videotaping at 7–8 days-of-age. A nursing bout was defined (in minutes) as the start of more than half the pigs in a litter suckling from the sow’s teats until more than half the litter had stopped suckling. A nursing cycle was defined as the time (in minutes) from the beginning of one nursing bout to the start of the next nursing bout.

During the nursery phase of development, both instantaneous scan sampling and continuous observations were used. Instantaneous scan sampling, at 5-min intervals, was used to determine the mean percentage of time spent belly nosing, belly sucking, other nosing, and other sucking for 8-h (i.e. 96 scans/observation day) at 18, 23, 28 and 50 days-of-age (4, 9, 14, and 36 days following weaning). Continuous observations were also conducted at 21 and 35 days-of-age (7 and 21 days following weaning), for 4-h each observation day, to determine the mean time (in seconds) spent per belly nosing and belly sucking bout as well as the total time spent belly nosing and belly sucking. Bout length was defined as the length of time (in seconds) between the start of nosing or sucking the belly of a penmate until the behaviour ceased to continue for more than 5 s (Li and Gonyou, 2002). Total time spent belly nosing and belly sucking was calculated as the sum of all bouts.

During the grow-finish phase of development, instantaneous scan sampling, at 5-min intervals, was used to determine the mean percentage of time spent belly nosing, belly sucking, other nosing, other sucking, tail biting, and other biting for 8-h (i.e. 96 scans per observation day)
at 63 and 91 days-of-age (7 and 11 weeks following weaning). Continuous observations were not utilized during the grow-finish phase.

3.4. Calculation of teat order consistency

Teat order consistency was calculated using piglet teat preference data acquired through live continuous observations conducted during the pre-weaning phase of the study. Teat preference per piglet in a litter was determined in two 2-h time blocks at both 4 and 12 days-of-age. As a result of these observations, all piglets were assigned a preferred teat within their litter, based on which teat pair and side (right or left) of the sow they spent nursing the most during the observation periods. Teat consistency score calculations were based on earlier work by Hemsworth et al. (1976), and were formulated (per pig per litter) as:

$$\text{Teat Consistency Score} = \frac{\text{Number of observations at the preferred teat}}{\text{Total number of nursing observations}}$$

Teat order consistency was calculated as the mean teat consistency score for each litter.

3.5. Statistical analysis

A Kolmogorov–Smirnov test was conducted using the Univariate procedure of SAS to test for normality of the behaviour data. Behaviour data for belly sucking, other nosing, other sucking, and other biting were square root transformed and tail biting behaviour data were transformed using square root plus one, prior to statistical analysis. For clarity purposes, data provided in tables has not been transformed.

Teat consistency scores, nursing bout length, and nursing cycle duration during the pre-weaning phase, belly nosing, belly sucking, other nosing, and other sucking behaviours during the nursery phase, and belly nosing, belly sucking, other nosing, other sucking, tail biting, and other biting behaviours during the grow-finish phase were all compared using the pen as the experimental unit as a split-plot over time model provided within the GLM analyses for repeated measures in SAS, with sire breed (Duroc PIC line 3 and Large White PIC line 280) and sire within breed (e.g.: DB1 versus DB2 versus DB3) in the main plot and age in the sub-plot. Age was defined as days-of-age. Subsequently, the effect of crossfostering piglets at 24 h-of-age was analyzed as a split-split-plot over time model provided with the GLM analyses for repeated measures in SAS, with sire breed and sire within breed in the main plot, age in the sub-plot and crossfostering in the sub-sub plot. Durations of behaviours were expressed as the mean percentage of time spent performing the behaviour. Total time spent performing belly nosing and belly sucking behaviour at 21 and 35 days-of-age was also compared. A Bonferroni means separation test was performed using sire breed, sire within breed and age.

4. Results—study 1

4.1. Effect of gender and milk replacer

Gender and duration of liquid milk replacer (7 days versus 14 days) did not have any significant effect on any of the behaviours observed. Likewise, no significant interaction was found between these two parameters.
4.2. Effect of breed line

Breed line was found to have a significant effect on a number of the behaviours observed (Table 1). Specifically, while breed line did not significantly affect belly nosing ($P > 0.10$) or total nosing ($P > 0.10$) behaviours, it was found to significantly affect other nosing ($P < 0.01$) with Duroc piglets observed performing nosing behaviour 3.64% of the time compared with 1.83% in Yorkshire pigs. Duroc pigs also had a higher incidence of other sucking behaviour compared with Yorkshires ($P < 0.05$) and exhibited higher overall levels of total other behaviours in contrast to Yorkshire pigs ($P < 0.001$). Yorkshires tended to exhibit more total belly-directed behaviours ($P = 0.089$) and engaged in significantly higher levels of total sucking ($P < 0.05$) behaviours than Durocs. Yorkshire pigs also spent more time engaged in belly sucking behaviour than Durocs ($P < 0.01$).

4.3. Effect of environmental enrichment

Environmental enrichment devices (Nipple versus Tube) used to simulate components of the sow’s udder environment were also found to have a significant effect on a number of the behaviours observed (Table 2). Providing some type of environmental enrichment did not significantly reduce the incidence of belly nosing, other sucking, or total nosing behaviours. Piglets not provided with any enrichment (Control) had the highest incidence of belly sucking, other nosing, total sucking, total belly, and total other behaviours compared with

<table>
<thead>
<tr>
<th>Breeding line</th>
<th>Yorkshire</th>
<th>Duroc</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belly nosing</td>
<td>5.25 ± 0.81</td>
<td>4.62 ± 0.54</td>
<td>$&gt;0.10$</td>
</tr>
<tr>
<td>Belly sucking</td>
<td>3.97 ± 0.60</td>
<td>1.59 ± 0.40</td>
<td>$&lt;0.01$</td>
</tr>
<tr>
<td>Other nosing</td>
<td>1.83 ± 0.31</td>
<td>3.64 ± 0.21</td>
<td>$&lt;0.01$</td>
</tr>
<tr>
<td>Other sucking</td>
<td>0.33 ± 0.11</td>
<td>0.626 ± 0.071</td>
<td>$&lt;0.05$</td>
</tr>
<tr>
<td>Total nosing</td>
<td>7.1 ± 1.0</td>
<td>8.26 ± 0.67</td>
<td>$&gt;0.10$</td>
</tr>
<tr>
<td>Total sucking</td>
<td>4.30 ± 0.60</td>
<td>2.21 ± 0.40</td>
<td>$&lt;0.05$</td>
</tr>
<tr>
<td>Total belly</td>
<td>9.2 ± 1.3</td>
<td>6.21 ± 0.90</td>
<td>0.089</td>
</tr>
<tr>
<td>Total other</td>
<td>2.16 ± 0.29</td>
<td>4.27 ± 0.20</td>
<td>$&lt;0.001$</td>
</tr>
</tbody>
</table>

Includes Bonferroni means separation results (means with different letters along same row are not significantly different).

<table>
<thead>
<tr>
<th>Enrichment</th>
<th>Nipples</th>
<th>Tube</th>
<th>Control</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belly nosing</td>
<td>3.49 ± 0.89</td>
<td>5.71 ± 0.98</td>
<td>5.59 ± 0.67</td>
<td>$&gt;0.10$</td>
</tr>
<tr>
<td>Belly sucking</td>
<td>1.10 ± 0.66 b</td>
<td>3.12 ± 0.73 a,b</td>
<td>4.12 ± 0.50 a</td>
<td>$&lt;0.05$</td>
</tr>
<tr>
<td>Other nosing</td>
<td>3.02 ± 0.35 a</td>
<td>2.00 ± 0.38 b</td>
<td>3.18 ± 0.26 a</td>
<td>$&lt;0.05$</td>
</tr>
<tr>
<td>Other sucking</td>
<td>0.47 ± 0.12</td>
<td>0.34 ± 0.13</td>
<td>0.63 ± 0.88</td>
<td>$&gt;0.10$</td>
</tr>
<tr>
<td>Total nosing</td>
<td>6.5 ± 1.1</td>
<td>7.7 ± 1.2</td>
<td>8.78 ± 0.84</td>
<td>$&gt;0.10$</td>
</tr>
<tr>
<td>Total sucking</td>
<td>1.57 ± 0.66 b</td>
<td>3.46 ± 0.73 a,b</td>
<td>4.75 ± 0.50 b</td>
<td>$&lt;0.01$</td>
</tr>
<tr>
<td>Total belly</td>
<td>4.6 ± 1.5 b</td>
<td>8.8 ± 1.6 a</td>
<td>9.7 ± 1.1 a</td>
<td>0.072</td>
</tr>
<tr>
<td>Total other</td>
<td>3.49 ± 0.32 a</td>
<td>2.34 ± 0.35 b</td>
<td>3.81 ± 0.24 a</td>
<td>$&lt;0.05$</td>
</tr>
</tbody>
</table>
pens which received either the Nipple or Tube enrichments. Providing Tube enrichment significantly reduced the incidence of other nosing \((P < 0.05)\) and total other behaviours \((P < 0.05)\) compared with Nipple enrichment. However, Nipple enrichment had a significant effect on reducing the incidence of belly sucking \((P < 0.05)\) and total sucking \((P < 0.01)\) behaviours compared with Tube enrichment. Providing Nipple enrichment also tended to reduce the incidence of total belly-directed \((P = 0.072)\) behaviours compared with Tube enrichment.

4.4. Breed line and environmental enrichment interactions

Significant breed line by environmental enrichment treatment interactions were observed for several variables. While Yorkshire pigs were found to exhibit a higher incidence of belly sucking (6.5%) behaviour compared with Duroc pigs (1.7%) under Control conditions, providing Yorkshire pigs with Nipple enrichment significantly reduced the incidence of the behaviour (1.0%; \(P < 0.05\)) compared with Tube enrichment (4.4%; Fig. 1a) in the Yorkshire line. Similarly, Yorkshire pigs were also found to engage in more total sucking (7.0%; Fig. 1b) and belly-directed behaviours (13.7%; Fig. 1c) compared with Duroc pigs (2.5% and 5.8%, respectively) under Control conditions. Providing Nipple enrichment was effective in

![Interaction between breed line and pen enrichment on the mean percentage of time (±S.E.) spent performing nosing and sucking behaviours directed at the belly and other regions of penmates. (a) Belly sucking behaviour; (b) total sucking behaviour; (c) total belly behaviour; (d) other nosing behaviour; (e) total other behaviour; (f) total nosing behaviour.](image)
reducing the incidence of total sucking to 1.3% ($P < 0.05$) and total belly to 3.6% ($P = 0.054$) in Yorkshire pigs, levels similar to those observed in the Duroc pigs (1.8% and 5.6%, respectively).

In contrast, for other nosing (Fig. 1d) and total other behaviours (Fig. 1e), in which Durocs (3.5% and 4.3%, respectively) and Yorkshires (2.8% and 3.3%, respectively) did not differ under Control conditions, providing either Tube or Nipple enrichment tended to be effective in reducing the incidence of these behaviours in Yorkshire pigs. However, Yorkshire line pigs given Tube enrichment tended to spend less time performing other nosing (0.5%; $P = 0.099$) and total other (0.7%; $P = 0.071$) behaviours, compared with Yorkshires provided with Nipple enrichment (2.1% and 2.5%, respectively).

However, for total nosing behaviour (Fig. 1f), in which Durocs and Yorkshires did not differ under Control conditions (7.6% and 10.0%, respectively), providing either Tube or Nipple enrichment tended to be effective in reducing the incidence of generalized nosing behaviour in Yorkshire pigs. Providing Nipple enrichment had the greatest effect of reducing overall nosing behaviour (4.7%; $P = 0.097$) compared with Tube enrichment (6.5%).

4.5. Other interactions

Aside from interactions between breed line and environmental enrichment, interactions between gender and environmental enrichment as well as duration of liquid milk replacer supplementation and breed line were found. The interaction between gender and environmental enrichment was found to have a significant effect on other sucking behaviour (Fig. 2; $P < 0.05$). Specifically, males were found to exhibit a higher incidence of other sucking behaviour in both the Control (0.3%) and Tube (0.6%) enrichments compared with females (0.1% and 0.1%, respectively). However, the incidence of other sucking behaviour was almost equally as high in both genders when provided with Nipple enrichment (male = 0.4%; female = 0.5%). Similarly, the interaction between duration of liquid milk replacer supplementation and breed line also tended to have an effect on other sucking behaviour (Fig. 3). In this case, both Duroc and Yorkshire pigs exhibited equally high levels of other sucking behaviour when milk replacer was provided for seven days following weaning (0.6% for both breed lines). However, providing milk
replacer for an additional seven days significantly reduced the incidence of other sucking behaviour in Yorkshire pigs (0.1%) compared with Duroc pigs (0.7%; \( P = 0.064 \)). No other significant interactions were found.

5. Results—study 2

5.1. Nursing behaviour and teat order consistency

During the pre-weaning phase of development, the total number of nursing bouts and nursing cycles, along with the mean time spent per nursing bout and per nursing cycle were found not to differ significantly when breed lines or sires within lines were compared. Likewise, teat consistency scores were not significantly different.

5.2. Belly nosing and belly sucking bout and cycle lengths

Mean total time spent belly nosing per litter did not significantly differ by age. However, a significant age by breed of sire interaction was found (Table 3). Duroc-sired pigs spent the least amount of time per litter involved in belly nosing at 21 days-of-age (1107 s/4 h), while the highest incidence of the behaviour occurred in Large White-sired pigs at the same age (2777 s/4 h). In contrast, the relationship was reversed at 35 days-of-age when the mean time spent belly nosing per Duroc-sired litter increased to 2072 s/4 h and dropped in Large White-sired litters to 1791 s/4 h (\( P < 0.05 \)). Table 4 shows the effect of sire within breed line on mean time spent belly nosing per litter.

5.3. Observed aberrant behaviours

All nosing and sucking behaviours observed, both directed at the belly as well as directed to other regions of the body, were significantly affected by sire breed (Table 5). However, incidence of tail biting and other biting behaviours did not differ significantly between sire breed lines. Pigs sired by Large White boars exhibited a greater proportion of their mean daily
time budget per litter in belly nosing (2.04%) and belly sucking (0.440%) behaviour compared with Duroc-sired pigs (1.597% and 0.308%; \( P < 0.01 \) and 0.01, respectively; Table 5). However, Duroc-sired pigs were observed spending a greater proportion of their time performing generalized nosing (other nosing = 0.356%) and sucking (other sucking = 2.496%) behaviours compared with Large White-sired pigs (\( P < 0.01 \) and 0.001, respectively; Table 5).

Fig. 4a and b provide a more detailed account of the breakdown of mean percentage of time spent per litter performing belly nosing and its related vices by both breed line and age. Significant breed of sire and age interactions were found for belly nosing (\( P < 0.01 \)) and other sucking (\( P < 0.05 \)) behaviours. It should be noted that breeds of sire did not significantly differ in weaning weight.

Sire within breed line was found to have a significant affect on the incidence of belly nosing (\( P < 0.001 \)), belly sucking (\( P < 0.001 \)), and other sucking (\( P < 0.01 \)) behaviours in the post-weaning environment (Table 6). While offspring from Duroc boars consistently spent more than 2.0% of their daily time budget performing other sucking behaviour compared with offspring of Large White boars, only piglets from one Large White line boar were found to outperform the others in both belly nosing (Large White boar #3) and belly sucking (Large White boar #1) behaviour. Significant boar and age interactions were also found in belly nosing (\( P < 0.01 \)), belly sucking (\( P < 0.001 \)), and other sucking (\( P < 0.01 \)) behaviours in addition to other biting behaviour (\( P < 0.01 \)).
5.4. Crossfostering

Crossfostering piglets at 24–36 h-of-age was not found to have any statistically significant effect on any of the observed behaviours, during either the pre- or post-weaning phases of the study.

6. Discussion

The results of the preliminary study found that duration of milk replacer was not found to be a significant contributor to the development of nosing and sucking behaviours in the early-weaned
pig. These findings agree with Gardner et al. (2001) who concluded that belly nosing was not hunger motivated. Gender was also found not to have a significant influence on the development of oral–nasal aberrant behaviours in the early-weaned pig.

In general, piglets of the Yorkshire line spent more time performing sucking and belly-directed behaviours, including belly sucking, than did Duroc pigs. In contrast, Duroc pigs exhibited higher levels of nosing and sucking behaviours directed away from the belly of penmates. These findings are similar to those of the second study which indicated that belly nosing, and some of its associated behaviours, particularly those involving nosing and sucking, are influenced by breed line and sire within a breed to a degree. Specifically, Large White-sired pigs were found to exhibit more nosing and sucking behaviours directed toward the belly region of penmates (belly nosing and belly sucking behaviours), while Duroc-sired pigs performed more generalized behaviours (nosing and sucking behaviours directed towards regions other than the belly of penmates, such as other nosing and other sucking behaviours). While the immediate reasons for the significant difference in abnormal behaviours observed in these two breed lines are not apparent, it may be due in part to genetic selection. The Yorkshire breed, similar to the Large White, is popular for use as a maternal line in commercial herds due to its prolificacy and excellent maternal instincts (Briggs, 1983). In contrast, the Duroc breed was selected for its heavy carcass production and makes particularly good sires, although Duroc males have been known to be aggressive (Briggs and Briggs, 1980). The difference in the proportion of time spent performing abnormal behaviours between the two breeds may be the result of either genetic selection for maternal versus carcass characteristics, in which the aberrant behaviours or tolerance to them may have been inadvertently selected along with the desired production characteristics, or due to genetic drift.

In addition to breed of sire, sire within breed line (study 2) also had a significant effect on the percentage of time pigs spent performing belly nosing, belly sucking, other nosing, other sucking, tail biting and other biting per litter.

### Table 6

<table>
<thead>
<tr>
<th>Sire breed</th>
<th>Duroc</th>
<th>Large White</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boar 1 (% time)</td>
<td>Boar 2 (% time)</td>
</tr>
<tr>
<td>Belly nosing</td>
<td>1.83 b</td>
<td>1.52 b</td>
</tr>
<tr>
<td>Belly sucking</td>
<td>0.338 b</td>
<td>0.199 c</td>
</tr>
<tr>
<td>Other nosing</td>
<td>0.363 0.448 0.207</td>
<td></td>
</tr>
<tr>
<td>Other sucking</td>
<td>2.60 a</td>
<td>2.50 a</td>
</tr>
<tr>
<td>Tail biting</td>
<td>0.372</td>
<td>0.372</td>
</tr>
<tr>
<td>Other biting</td>
<td>1.075</td>
<td>1.124</td>
</tr>
</tbody>
</table>

Letters represent means separation of six boars used in the study (means with different letter along same row are not significantly different). Statistical analysis performed on transformed data, while data in table reflects non-transformed values.

*P*-value reflects boar (sire breed) with 4 degrees of freedom. Effect of sire breed has not been removed.

Variables include a significant sire breed effect.
from breeds or sires with a low incidence of aberrant behaviours, such as belly nosing, may be a useful means of helping to reduce such behaviours in an early weaning management system. However, further large-scale investigations into the effect of breed line and sire on abnormal behaviours in pigs are needed, particularly those that extend over multiple generations.

Tail biting and generalized biting (other biting) were not significantly affected by the two breed lines used in the second study or by sire, thereby indicating that these behaviours, which are more closely associated with the grow-finish phase of development, may be largely due to environmental factors. However, given the limited number of breed lines and sires in the study, further investigations are warranted. In piglets, chewing on penmates, including the tails of penmates has been suggested as being derived from suckling behaviour (Newberry and Swanson, 2001), which has been re-directed (Mason et al., 2003). Furthermore, many environmental factors have been found to contribute to the development of tail biting behaviour, including overcrowding (Gonyou, 2001), the presence of blood (Fraser, 1987a,b) and diet (Ewbank, 1973; Denton, 1984; McIntyre and Edwards, 2002). It has also been found that generalized nosing and sucking behaviours are a better predictor for tail biting in the grow-finish period than the incidence of belly nosing (Bench, 2005). Therefore, while genetics may affect the incidence of belly nosing and belly sucking behaviours, tail biting behaviour seems to have more to do with the environment than either breed line or sire.

Many studies have supported the provision of environmental enrichment to pigs as a means of reducing and/or eliminating aberrant behaviours, including tail biting in the grow-finish phase of development. The results of the preliminary study support such findings. The results revealed that providing environmental enrichments, which simulate the nipples and smooth surface of the sow’s mammary area, were effective in reducing the incidence of oral–nasal behavioural vices associated with belly nosing. These results agree with similar findings by Widowski et al. (2005) which found that devices that accommodate the sucking and massage needs of piglets can reduce behaviours directed toward penmates. The results of the present study found that providing nipples, anchored vertically in milk replacer troughs and dry feeders, was effective in reducing sucking and belly-directed behaviours, including belly sucking, while providing air-filled inner tubes was effective in reducing more generally focused behaviours, such as nosing behaviour directed away from the belly of penmates. While the pigs may have been motivated to seek manipulative objects, these findings may also support the hypothesis of Weary et al. (1999) that the underlying motivation to perform belly nosing in the early-weaned pig is to seek comfort. In this case, if piglets seek comfort from the belly region specifically, the presence of nipples may be the determining factor in whether that need is met. Likewise, if piglets seek comfort in general, then the provision of an inner tube may meet this need better than providing nipples, since it allows the piglets to pile up with one another in the center of the tube. As such, those pigs that seek comfort in general may be more socially motivated than piglets that seek comfort from the belly region specifically.

The most interesting finding of the preliminary study involves the interaction between breed line and environmental enrichment. Both breed lines differed little under Control conditions when it came to other nosing, total nosing, and total other behaviours. However, Yorkshire pigs were much more responsive to the provision of either Nipple or Tube enrichment than the Duroc pigs when it came to these specific behaviours. In contrast, Yorkshires exhibited higher levels of belly sucking, total belly and total sucking behaviours compared with Duroc pigs under Control conditions, but were again found to be very responsive to enrichment. In comparison with Yorkshire pigs, Duroc pigs consistently demonstrated lower levels of these same behaviours, despite the enrichment treatment. As such, it appears that breed line not only affects the types and
incidence of aberrant oral–nasal behaviours performed, but also how responsive animals are to the provision of environmental enrichment. Furthermore, the types of environmental enrichments that work in one breed line may not necessarily work in another breed line. The findings also suggest that not all abnormal behaviours observed in early-weaned piglets respond to Nipple and Tube enrichment.

Of particular interest is how tailored an environmental enrichment treatment needs to be to reduce a specific aberrant behaviour. In this study, the Nipple treatment was found to reduce the incidence of abnormal behaviours that involved sucking behaviour and were belly-directed. This makes sense, since the sow’s teats are located at her belly and stimulate sucking behaviour. In contrast, the Tube treatment was found to reduce the incidence of behaviours directed away from the belly. In this case, such types of generalized behaviours may be effectively reduced through the provision of a large surface that provides some sort of resistance suitable for redirected nosing behaviour or huddling in groups. Again, this would make sense, given that piglets are commonly observed sleeping next to the sow’s udder, particularly after a nursing bout, as well as next to one another, thigmotactically.

In addition to breed by environmental enrichment interactions, two other interactions in the first study were also found. Both interactions were found to be significant for generalized sucking behaviour only. The first interaction occurred between gender and type of environmental enrichment. Females of both breeds demonstrated lower levels of other sucking behaviour than did males. However, when provided with Nipple enrichment, the incidence of other sucking behaviour significantly increased among females. This leads to the question of whether some types of enrichment actually encourage the development of abnormal behaviours in some populations. In this case, does providing Nipple enrichment to females stimulate sucking behaviour? Another interesting observation was made regarding the interaction between the duration of liquid milk replacer and breed line. Both the Yorkshire and Duroc lines exhibited similar levels of other sucking behaviour when given liquid milk replacer for 1 week following weaning. However, when given milk replacer for an additional week, Yorkshire piglets showed a greater reduction in the incidence of the behaviour than piglets of the Duroc line. One possible explanation for this may be that piglets within the Duroc breed have a higher genetic predisposition to exhibit other sucking behaviour than piglets in the Yorkshire breed, and this predisposition cannot be easily overcome through the provision of milk replacer alone. Interestingly, providing Duroc pigs with Tube enrichment was also ineffective at reducing the incidence of other sucking behaviour.

7. Implications

These findings suggest that breed line and sire differences may affect the incidence of nosing and sucking behaviours in early-weaned pigs, which may be reduced through the use of environmental enrichment tailored to the specific aberrant behaviours being performed.

Compared with nosing and sucking behaviours in the early-weaned pig, tail biting and generalized biting associated with the grow-finish phase of development were not significantly affected by either sire breed or sire within breed, which may suggest that biting behaviour is more the result of environmental factors.

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