RESEARCH REPORT
ANIMAL WELFARE

Title: Optimizing on-farm management of non-infectious sow lameness during the farrowing and lactation period – NPB#14-005.

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Industry Summary:

Modern commercial sow facilities are built with durability and cleanliness in mind. Floors in these facilities are often built using slatted concrete to ensure better ease in cleaning and manure management. Unfortunately, with such flooring systems, we often see an increase in lameness and injury to the sow. Lameness is not only an animal welfare issue due to the pain associated with lameness, but it can also have significant economic impact to the producer due to poor reproductive efficiency, piglet health and sow longevity. Research is needed to identify how to mitigate the negative effects of concrete slatted floors while maintaining the ability to effectively clean these production facilities. Adding temporary and mobile substrates such as rubber mats may be one solution to minimize lameness severity and increase sow longevity and productivity. Therefore, the objective of this study was to investigate the effect of rubber mats in farrowing crates on performance and behavior of lame and non-lame commercial sows.

The study took place on a 5000 sow commercial swine farm. All sows were evaluated in group pens prior to enrollment of study by an experienced veterinarian. Sows with any evidence of disease or injury (with the exception of lameness) were ineligible for enrollment. At enrollment, sows (100-109 day of gestation) were evaluated for lameness by one trained veterinarian using a 1-3 walking and standing lameness scoring systems (1. Non-lame, 2. Lame, and 3. Severely lame; non-weight bearing on one leg).

Sows were blocked by parity and assigned to one of four treatments based on their lameness score at enrollment 1) Lame Control (LC; n=45); 2) Lame Rubber Mat (LR; n= 48); 3) Non-Lame Control (NLC; n= 61); and 4) Non-Lame Rubber Mat (NLR; n =59). The control treatment (C) consisted of a standard farrowing crate with slatted flooring in the sow and piglet area, while the rubber mat treatment (R) consisted of a farrowing crate fitted with a perforated rubber boar mat (Heavy duty rubber mat, FarmerBoy Ag, $78.08). Mats covered an area from the front of the sows shoulder to their hindquarters and remained in the farrowing crate until weaning. Once piglets were weaned and sows moved back to breeding, mats were removed from all crates, power-washed and disinfected between each use and reused the following week.

Measures collected

Lameness scores were collected weekly for each sow by a trained veterinarian utilizing the standing scoring system described previously. To evaluate the effect of lameness between the time of farrowing to the time of weaning, sows were grouped into one of four lameness categories at the end of lactation; 1. Lame-Lame (LL); sows receiving a lameness score ≥1 in gestation and at weaning (n=39); 2. Lame-Non-lame (LN; sows receiving a lameness score of ≥1 in gestation and a score of 0 at weaning (n=51); 3. Non-lame-Non-Lame (NN); sows receiving a lameness score 0 in gestation and at weaning (n=82); and, 4. Non-lame- Lame (NL); sows receiving a lameness score of 0 in gestation and a score ≥1 at weaning (n=25).

Additional measurements included sow body weight, body condition score, lesion scores, and behavior (time spent lying, standing, sitting, drinking, nursing or eating). Measurements were collected weekly until weaning. Production data was also collected and included total piglets born, number born alive, stillborns, mummies, total weaned, total cross-fostered and f piglet mortality (low viability, deformed, micro piglet, spraddle legged, starved, rupture, crushed and injured).

Results

Lameness severity was not affected by the presence of a rubber mat placed in the farrowing crate. Lameness was also not affected by sow body weight or body condition. Lesions present on the skin of the sow decreased over the time the sow was housed in the farrowing crate and the presence of the rubber mat did not increase the number of lesions. The decrease in lesions over time is likely a result of sows being

housed individually (eliminating aggressive interactions between sows) and providing time for the lesions to heal.

Lameness did not have an effect on the total piglets born, number of piglets born alive, number of stillborn, or mummified piglets per litter. No differences in average piglet weight at farrowing was found but sows entered the farrowing crate lame weaned piglets with 0.6 kg lower average weaning weight compared to other sows. Piglets housed in farrowing crates with a rubber mat had a 0.4 kg lower average weaned weight and 0.8 more piglets were laid on.

These findings suggest that the rubber mat used did not impact lameness in farrowing and lactating sows and the presence of a rubber mat resulted in greater incidence of laid on pigs. This may be most likely due to insulating properties of the rubber mat and the desire for the piglets to seek out a warmer environment within the crate. The placement of the rubber mat near the sow may be the likely reason we saw an increased in laid on pigs. Further research is needed to be able to properly assess the potential use of rubber mats as a flooring substrate to mitigate lameness in farrowing crates.

Key words: sow, lameness, rubber mat, farrowing, performance

Scientific Abstract:

The flooring commonly used in swine production facilities is designed for cleanliness and efficient manure handling. Metal or plastic flooring used in farrowing crates may increase the prevalence of lameness and lesions due the physical characteristics of the materials. The goal of this study was to investigate the effect of rubber mats in farrowing crates on lameness, behavior, reproduction, and performance during lactation. In total 213 multiparous sows were enrolled in the study after being blocked by parity and categorized as lame or non-lame. Sows were placed into farrowing crates with or without a rubber mat. Lameness, lesion scores, sow weight, and body condition measurements were obtained once weekly. Additionally, 2 hours of behavioral observations immediately after morning feeding were taken, using 15 minute interval scans (lying, standing, sitting, drinking, feeding, and nursing), over the course of 4 weeks around farrowing (1 week prior to 3 weeks post farrowing day). The rationale being that farrowing and lactating sows rarely stand except around feeding

times, thus differences in standing and feeding behavior depending on treatment and lameness status would be as most visible at this time. Piglet weights were recorded during the weeks of farrowing and weaning. Additional production and piglet mortality data were obtained post-hoc via records from the farm's computer database PigKnows®. The addition of rubber mats to farrowing crates did not affect lameness prevalence at the end of the study ($P > 0.05$) but increased the proportion of time spent lying ($P < 0.05$) compared to sows without a rubber mat. Sows that were lame throughout the study weaned piglets with lower body weights compared to non-lame sows ($P < 0.05$). Sows provided with rubber mats weaned piglets with lower body weights compared to sows housed without a rubber mat ($P < 0.05$). Sows provided with rubber mats had a higher number of crushed piglets compared to sows without a rubber mat (119 vs 62 crushed piglets/treatment; $P < 0.05$). Rubber mats did not affect the number of lesions ($P > 0.05$) but there was an overall decrease in the number lesions over time for all treatments ($P < 0.05$). In conclusion, rubber mats did not influence lameness status during lactation. Providing rubber mats in the farrowing crates increased total piglet mortality due to an increase in crushed piglets. Additional research is needed to be able to properly assess the potential use of rubber mats as a flooring substrate to mitigate lameness in farrowing crates.

Introduction:

Modern indoor intensive swine facilities are built with durability and cleanliness in mind. Breeding and farrowing floors and alleyways are often built using slatted concrete (gestation) and metal or plastic (farrowing) are commonly used in commercial swine facilities to ensure cleanliness and hygiene of the facility. Although these flooring properties may be beneficial from a management standpoint, partially slatted flooring can compromise sow welfare, potentially increasing the lameness prevalence within herds (Anil *et al*., 2007; KilBride *et al*., 2009). Floor quality plays a critical role with several factors including slat space, slat edge and surface roughness influencing lameness prevalence and severity (Anil *et al*., 2007; Heinonen *et al*., 2013). Lame sows on the farm represent a compromised population of animals that have gained considerable producer interest, not only from a welfare standpoint but from an economic standpoint due to the negative implications of lameness on reproductive status, piglet health and overall sow longevity (Grandjot, 2007).

Hence, research is needed to identify the factors that influence lameness incidence and solutions to improve sow comfort and mitigate lameness within the herd.

One potential solution to mitigate sow lameness and improve comfort is by changing the flooring substrate or the facility structure. For example, straw bedding is a widely accepted substrate used to improve sow comfort and prevent hoof lesions within group systems (Kilbride *et al*., 2009). Although deep bedded straw systems would be considered an ideal solution in the treatment and prevention of sow lameness, straw is considered labor intensive, expensive, and impractical in facilities using liquid manure pit systems (Tuyttens *et al*., 2005; Pluym *et al.,* 2013). Evaluations of alternatives to straw are limited. Few studies have reported that flooring alternatives such as rubber mats may improve lameness, lesions or sow and piglet performance while housed in farrowing crates (Zurbrigg, 2006). Therefore, the objective of this study was to investigate the effect of rubber mats placed in unidirectional farrowing crate on performance and behavior of lame and non-lame commercial sows.

Objectives:

The objectives of this study are to assess the effects of rubber matting on reproductive performance, non-infectious lameness severity and recovery, feed intake, pain sensitivity and behavior of lame and non-lame sows during farrowing and lactation.

Materials & Methods

Experimental design

A total of 213 multiparous commercial sows (227.1 ± 20.8 kg, average parity 3.0, range: 1-8) were enrolled. All sows underwent a physical examination by a trained veterinarian to assess overall health status prior to selection. Any sow demonstrating clinical signs of disease (with the exception of lameness) were not eligible for enrollment At enrollment, lameness was evaluated by a trained veterinarian by assessing sow gait during locomotion and the severity of visible toe-tapping while standing. Sows were evaluated for lameness between 100-109 days of gestation while housed in group pens utilizing an adapted three point standing and walking lameness scoring system; 1. Non-lame, 2. Lame, and 3. Severely lame. However, during this study, only 2 sows were scored as severely lame, thus that category was removed from the experimental design.

Sows were blocked by parity and assigned to one of four treatments based on their lameness score at enrollment 1) Lame Control (LC; n=45); 2) Lame Rubber Mat (LR; n= 48); 3) Non-Lame Control (NLC; n= 61); and 4) Non-Lame Rubber Mat (NLR; n =59). Sows were allocated to a farrowing room with 60 crates in a rotational schedule based on expected farrowing day. All sows were randomly placed by farm staff and mixed in with the normal population of sows in the order they were brought up from gestation housing, thus an entire farrowing room was not allocated specifically for our sows due to space limitation and farm production requirements. However, treatments were balanced during sow enrollment to ensure that sows of each treatment were enrolled to the study each week.

The control treatment (C) consisted of a standard farrowing crate with slatted flooring in the sow and piglet area, while the rubber mat treatment (R) consisted of a farrowing crate fitted with a perforated rubber boar mat (Heavy duty rubber mat, width x length x thickness: 99 x 150 x 1.9 cm, perforation size: 1.4 cm, FarmerBoy Ag, Meyerstown, PA, USA; $78.08). Mats covered an area from the front of the sows shoulder to their hindquarters and remained in the farrowing crate until weaning. Once piglets were weaned and sows moved back to breeding, mats were removed from all crates, power-washed and disinfected between each use and reused the following week. Lameness scores were collected weekly for each sow by a trained veterinarian utilizing the standing scoring system described previously. To assess changes in lameness based on treatment, sows were grouped into one of four lameness categories at the end of lactation; 1. Lame-Lame (LL); sows receiving a lameness score ≥1 in gestation and at weaning (n=39); 2. Lame-Non-lame (LN; sows receiving a lameness score of ≥1 in gestation and a score of 0 at weaning (n=51); 3. Non-lame-Non-Lame (NN); sows receiving a lameness score 0 in gestation and at weaning (n=82); and, 4. Non-lame- Lame (NL); sows receiving a lameness score of 0 in gestation and a score ≥1 at weaning (n=25).

Sow measurements

Sow body weights were calculated by taking flank to flank measurements with a measuring tape while in the farrowing crate. Body Condition Scores (BCS) were calculated using a sow body condition caliper, which calculates sow body condition score based on fat accumulation around the vertebrates on a 1 to 3 scale (Knauer, 2015). All sows were visually evaluated weekly between time of enrollment and weaning for skin lesions or abrasions (Table 2). Total born, number born alive, stillborns, mummified piglets, total weaned, total

cross-fostered, piglet mortality (low viability, deformed, micro, spraddle legged, starved, rupture, crushed, and injured), and subsequent wean to estrus interval were recorded by on-farm staff and collected utilizing the PigKnows® computer software.

Behavioral Measurements

Sow observations were conducted by a team of five observers that were trained and evaluated utilizing a live 15 minute instantaneous scan method. Training results indicated all observers achieved a strong inter-observer agreement (Correlation coefficient level; $r \geq 0.90$; $P < 0.05$).

On farm observations occurred in a 120 minute period on the same day each week and were measured in four defined stages post enrollment. Gestation (G) encompassed entry to the farrowing crate and prior to parturition. Farrowing (F) encompassed the observation in the week of parturition. Week one post farrowing (F1) encompassed the week after the F observation. Weaning (W) encompassed the week a sow was weaned. Observations were initiated at 10:30 a.m., immediately following the timed feed delivery within the production unit. The behavior ethogram is described in Table 3.

Piglet measurements

Individual piglet body weights were recorded using a digital scale between days 1-7 of age (farrowing weight) and 14-23 days of age (weaning weight). Individual piglet weights were summed and averaged to obtain litter weights.

Results:

Sow Measurements

Of the 213 enrolled sows, 1 sow died and 15 sows were either culled or euthanized during the study. Their data were subsequently removed leaving 197 sows in the final analysis. Of those removed, six were lame and ten were non-lame on enrollment. Sow body weights in gestation and weaning were not impacted by either lameness status or treatments ($P > 0.05$). No difference in body condition score was observed between lameness categories nor between treatments ($P > 0.05$). All sows, regardless of treatment group had a greater number of lesions while in gestation when compared to measurements at weaning (G: 27.74 ± 4.30; W: 7.56 ± 1.17, average lesions per sow ± S.E, $P < 0.05$). No overall differences in the total number of lesions and abrasions between treatments or lameness status were found ($P > 0.05$). Out of 197 sows that completed the

study 133 exhibited a normal return to estrus 4 to 6 days post weaning and 48 were not serviced post weaning. At the time of farrowing there were no observed effects of sow lameness at enrollment on total born, number born alive, stillborn, or mummified piglets per litter ($P > 0.05$, Table 1). Furthermore, there was no difference ($P > 0.05$) in the number of piglets weaned per sow when comparing between treatments nor when assessing lameness categories (data not shown).

Table 1. Least squared means ± SE of sow reproductive performance factors[1] influenced by lameness status at enrollment and rubber mat treatment.

	LC[2]	LR	NLC	NLR
Sow Weight	219.9 ± 3.8[a]	213.0 ± 3.4[ab]	207.9 ± 3.3[b]	216.8 ± 3.7[ab]
Sow BCS[2]	1.9 ± 0.1[a]	1.9 ± 0.1[a]	1.9 ± 0.1[a]	1.9 ± 0.1[a]
Total Born	13.8 ± 0.6[a]	15.3 ± 0.6[a]	13.4 ± 0.5[a]	14.8 ± 0.5[a]
Born Alive	13.6 ± 0.5[ab]	14.4 ± 0.5[a]	12.7 ± 0.5[b]	13.8 ± 0.5[ab]
Mummies	0.3 ± 0.1[a]	0.4 ± 0.1[a]	0.2 ± 0.1[a]	0.3 ± 0.1[a]
Stillbirths	0.5 ± 0.2[a]	0.5 ± 0.1[a]	0.7 ± 0.1[a]	0.7 ± 0.1[a]
Piglet Weight	5.8 ± 0.2[a]	5.4 ± 0.1[a]	5.8 ± 0.1[a]	5.6 ± 0.2[a]

[1] Sow weight and BCS measured prior to farrowing (G), all other measurements taken the week for farrowing (F)
[2] LC=Lame Control, LR= Lame Rubber Mat, NLC=Non-Lame Control, and NLR=Non-Lame Rubber Mat
[3] Body Condition Scores (BCS) are reported on a 1-3 scale
[a-b] Differences in superscripts indicates a p-value < 0.05 between groups

Behavioral measurements

No differences in sow behavior were found between lameness categories ($P > 0.05$). Sows provided with a rubber mat tended to stand more ($P = 0.07$) and spent much less time lying ($P = 0.02$) compared to those sows in the control treatment. However, stage (G, F, F1, W) impacted the amount of time sows spent lying, standing, sitting, and eating ($P < 0.001$), and drinking ($P < 0.05$; Table 2).

Table 2. Least square means and ± SE for percentage of time for sow[1] behavior over four stages; Gestation (G), Farrowing (F), Post Farrowing (F1), and Weaning (W), and by treatment in the farrowing crate.

	Stage				Treatment		P-Value	
Behavior	Gestation(G)	Farrowing(F)	Post Farrowing(F1)	Weaning(W)	Control(C)	Rubber Mat(R)	Stage	Treatment
Lying	78.9±1.6[a]	71.1±1.6[b]	62.4±1.6[c]	62.4±1.6[d]	66.7±1.2	62.7±1.2	<0.001	0.02
Standing	4.3±0.6[a]	3.0±0.6[a]	3.8±0.6[a]	6.9±0.78[b]	3.9±0.5	5.1±0.5	<0.001	0.07
Sitting	3.9±0.8[a]	4.1±0.8[a]	6.4±0.7[b]	11.1±0.8[c]	6.0±0.6	6.8±0.6	<0.001	NS
Nursing	N/A	15.2±0.9[a]	13.8±0.9[ab]	12.6±1.0[b]	9.8±0.7	10.9±0.7	NS	NS
Eating	8.8±1.0[a]	6.6±1.0[a]	11.4±1.0[b]	15.1±1.0[c]	9.9±0.8	11.0±0.7	<0.001	NS
Drinking	1.5±0.3[ab]	1.6±0.3[ab]	0.9±0.3[a]	2.3±0.4[b]	1.4±0.3	1.8±0.7	<0.05	NS

[1] 197 multiparous commercial sows (227.1± 20.8 kg, average parity 3.0)
[a-d] Indicates a p-value of <0.05 between stages.

Piglet Measurements

No differences in average piglet farrowing weights were found across treatments and lameness categories at enrollment (P > 0.05). However, sow lameness affected average piglet weaning weight with piglets weaned from LL sows weighing less when compared to piglets from sows in the LN and NN lameness categories (5.20±0.18 vs. 5.86±0.15 and 5.80±0.12 kg, ±SE; LL vs. LN, and NN respectively, P < 0.01). However, there were no weight differences when comparing LL vs. NL sows (5.20±0.18 vs. 5.38±0.22 kg, ±SE P > 0.05). Additionally, piglets housed on a rubber mat regardless of sow lameness status demonstrated decreased weights at weaning (5.38±0.12 vs. 5.75±0.12 kg, ± SE, R and C, respectively, P < 0.05).

More piglets dies due to overlying by sows housed on a rubber mat (1.29±0.14 vs 0.62±0.14 piglets SE, P < 0.05) across all lameness categories which in turn resulted in an increase in the total number of pigs dying (2.19±0.20 vs 1.40±0.20, SE, P < 0.01). There were no effects (P > 0.05) of lameness or the presence of rubber mats on the other identified causes of piglet mortality (Table 3). Piglet mortality per sow was greater when a rubber mat was present (2.19±0.20 vs. 1.39±0.20 piglets ± SE, P < 0.05), and the total number of pigs weaned per sow was not effected (P > 0.05). There were no effects of lameness category or treatment on the number of pigs added or removed during cross-fostering (P > 0.05). Piglet losses within lameness category and treatment are summarized in Table 3.

Table 3. Piglet mortalities[1] per lameness category and rubber mat treatment.

	Lameness Category				Treatment	
Cause of mortality	LL[2]	LN	NN	NL	Control (C)	Rubber Mat (R)
Low Viability	11	5	8	0	13	11
Deformed	3	5	1	1	2	8
Micro (Runt)	11	14	23	12	28	32
Spraddle Legged	2	2	0	1	0	5
Starved	3	12	5	2	6	16
Rupture	14	10	2	0	11	15
Crushed	40	50	71	20	62	119
Injured	0	4	7	2	9	4
Total	84	102	117	38	131	210

[1]All data obtained for Pigknows®
[2] LL = Lame-Lame, LN = Lame-Non Lame, NN = Non Lame-Non Lame, NL = Non Lame-Lame prior to farrowing and during the week of weaning, respectively.

Discussion:

Sow productivity

Prevalence of lameness influences feed intake as the sow's physiological and immunological response to pain often results in increased inactivity and anorexia (Pluym *et al*., 2013). Reduced feed intake of the sow, especially during lactation, can result in several negative consequences to the sow and her litter including severe weight loss, poor lactation (Revel *et al*., 1998) and delayed return to estrus (Thaker and Bilkei, 2004). However in the present study, neither lameness status nor the presence or absence of a rubber mat in the farrowing crate influenced sow body condition, bodyweight, or subsequent wean to estrus interval. The results from this study suggest that either lameness does not have as strong of an impact on sow performance and productivity as demonstrated by previous research (Grandjot, 2007; Anil *et al.*, 2008; Heinonen *et al*., 2013) or that lameness status evaluated in this study was not severe enough to counteract the strong nutritional

program and selection criteria of these sows utilized on the site. As noted, a three point lameness scoring system was utilized to enroll sows. Of the 213 enrolled sows, only 2 sows fit the criteria of a lameness score 2 (i.e. non-weight bearing on one or more leg). With a lack of a population of severely lame sows, the trial compared non-lame sows to mild or moderately lame sows with lameness indicators that ranged anywhere from slight toe-tapping while standing to abnormal deviations in gait. The lack of variation among the sample population, can be attributed to the limited scale of measurement used, as well as the subjectivity of evaluating lameness through visual observation alone It is well acknowledged in the field that evaluation of gait abnormalities to assess lameness in swine are difficult to perform due to the nature of pig locomotion (e.g. little vertical head movement; shortened, rapid locomotion) and external factors influencing pig movement including uneven or slippery surfaces, limited area to move, and the influence of pen mates or presence of a person (Velarde, 2007). Therefore, our attempt to identify the impact of lameness on sow productivity via body weight, condition and reproductive success may have been thwarted by the unknown lameness etiology of the population, difficulty in assessing lameness through visual observation alone, and the lack of variation of lameness among those sows identified.

The lack of a severely lame population of sows enrolled on this study may have also resulted in the lack of clear differences among lame and non-lame sows when evaluated behaviorally. Prior work has found that lame sows demonstrate deviations in behavior including decreased time spent standing (Pairis-Garcia *et al.*, 2015) and eating (Fitzgerald *et al*., 2012; Gregoire *et al*., 2013) and more time spent lying (Pairis-Garcia *et al.*, 2015). Previous research has also demonstrated that the presence of rubber mats influences sow behavior with increased standing frequency in sows provided with rubber mats compared to slatted concrete in group gestation (Elmore *et al*., 2010). Although our study is in agreement with Elmore *et al.* (2010) and demonstrated that sows with rubber mats tended to stand more and lie less than sows in control crates, the results from our study were in disagreement with previously conducted research (Fitzgerald *et al*., 2012; Gregoire *et al*., 2013, Pairis-Garcia *et al.*, 2015) which demonstrated no impact of lameness status on standing, lying or eating behaviors during the farrowing and lactation period. This may most likely be due to the lack of severely lame sows represented in the data set but may also be influenced by other factors including *ad libitum* access to feed and temperature. In addition to the lack of severely lame sows, the low number of behavioral observations

per sow highly limited the interpretation and conclusion regarding behavioral differences between weeks and treatments.

As sows were provided *ad libitum* access to feed throughout the day, evaluating sow behavior only during the 2 hours post-morning feed drop may not have captured a true representation of feeding behavior and general sow activity in the farrowing rooms as motivation to eat and stand during this time period may have been limited as a result of sows knowing they have access to feed throughout the day. In addition, temperature may have also played a significant role on sow behavior. Tuyttens (2005), concluded that rubber mats provided insulation in cooler temperatures and that sows avoided lying on rubber mats in the summer. However, in our study, sows did not have the option to move away from the mat but rather only to sit or stand if the mat would have been too warm which could have induced more sitting or standing behavior. However, as with the other behaviors, the chosen time slot after feeding may have influenced their motivation to stand around that time, which could have counteracted any effect of increased temperature of the lying area during warmer days. Even though temperatures within the farrowing rooms were targeted accordingly to the farm SOP for farrowing rooms, they were greatly influenced by outdoor air temperatures which ranged from 1.1-32.2ºC throughout this trial. Utilizing THI as a covariate in the model took into account this variation, changes in temperature within the day and between farrowing rooms was not taken into account and may have influenced patterns in sow behavior.

Evaluation of lesions to the integument was conducted primarily to assess physical roughness of the mat and negative consequences of mat use by the sow. No differences were found between lesion scores in lame or non-lame sows and all lesion scores, regardless of treatment, decreased over the study. As the sow was not required to compete for resources in the farrowing crate as she would have in a group gestation pen, this time allowed for skin lesions originating in gestation to heal over the course of farrowing and lactation. These results are in agreement with Bos *et al.* (2016) that reported that flooring type, rubber or concrete, had no effect on the incidence or severity of skin lesion throughout the entire reproductive cycle.

It should be noted of the 213 sows enrolled, three sows developed severe lesions on the front shoulder which required treatment. These lesions did not fit the criteria of a shoulder sore (defined as a lesion resulting from pressure compressing the blood vessels supplying the skin and tissues covering the shoulder blade;

National Pork Board, 2015) but appeared to be a superficial skin abrasion caudal to the shoulder blade. Of the three cases, the sows were older and larger in size and the lesion appeared at the location where the rubber mat ended. A possible explanation for this injury was due to the slight decline of the sow at this point where the rubber mat ended and plastic floor began. As these sows were relatively large in nature, weight associated with this deviation in floor surface may have contributed to the observed lesions. This would coincide with results from Schubbert *et al.* (2014) which found total contact area to increase as sow weight increased.

Sow lameness will not only have a negative impact on the welfare of the sow but can have severe consequences to the health and viability of her litter. In this present study, lameness status at enrollment did not have an effect on the number of stillborn or mummified piglets indicating that lameness did not influence reproduction rates established early in gestation at the time of conception nor in late gestation in relation to piglet losses near and at term, concurring with research findings reported by Anil *et al.* (2008). However, sows that remained lame for the duration of lactation weaned lighter pigs which may result in longer term economic consequences to the producer as lighter weaned pigs require more days on feed and a greater total amount of feed throughout the growing and finishing phases (Mahan and Lepine, 1991). Pigs weaned from crates with rubber mats were also lighter in the present study. Decreased air flow caused by the mat may have negatively influenced piglet health, and therefore weight gain (Drummond *et al*., 1980). Within the rubber mat treatment, some manure piling behind the sow was observed, which has been shown to increase piglet morbidity (Svendsen *et al*., 1984).

An unexpected outcome of placing rubber mats in the farrowing crate resulted in increased overall piglet mortality as driven by an increase in the number of piglets crushed by the sow. This finding is in contrast of previous studies where rubber or neoprene mats reduced the number of pigs crushed in farrowing crates (Gu *et al*., 2010) but in agreement with a recent study evaluating rubber mat use in pen systems (Andersen and Morland, 2016). Crushing of piglets has been identified as the most common reported cause of pre-weaning mortality on commercial swine farms (Weary *et al.*, 1996). The majority of piglets crushed are laid on in the first 48 hours post farrowing as an attempt to place themselves closer to the sow to manage cold stress and hunger (Weary *et al*., 1996). In the present study, piglets housed in farrowing crates with rubber mats demonstrated increased mortality associated with crushing. As black rubber mats have greater insulating

ability than the plastic floors, and thus hold heat more efficiently (Christison and Farmer, 1982), a potential reason for this increase in total crushed pigs may be due to the piglet seeking a warmer environment and placing themselves in close proximity to the sow by utilizing the rubber mat. Presence of a rubber mat may have also encouraged natural rooting behavior among piglets who are highly motivated to manipulate substrates (Stolba and Wood-Gush, 1989). As the PigKnows® program did not break down piglet mortality information by age, it is unclear if the incidence of piglets crushed occurred within the first 48 hours (indicative of seeking the rubber mat for warmth) or later on (indicative of potential piglet interest in manipulating the substrate). Future research evaluating piglet behavior and interaction with the rubber mat is needed to better understand the factors influencing piglet mortality.