Title : Improving the welfare of group housed sows fed via electronic sow feeding **NPB#12-083**

Investigator: Thomas D. Parsons, VMD, PhD

Institution: University of Pennsylvania School of Veterinary Medicine

Date Submitted: May 1, 2015

Industry Summary
Managing aggression is important to the success of gestating sows in pens. This study was designed to examine different ways of mixing sows into a large dynamic pen equipped with electronic sow feeders. Increased weight loss, lameness, and skin lesions were observed after introduction of sows to pen gestation, but these measures did not negatively impact sow productivity. Aggression was minimal immediately following introduction. Different strategies for mixing sows into the pen did not affect study outcomes. The findings highlight the ability of a well-managed pen gestation system to achieve or exceed standard levels of productivity. This results in part from the successful management of inter-animal aggression at the time of mixing. Although weight loss, lameness and skin lesions increased after sows were entered in to the pen, these changes were sufficiently small as not to have meaningful long term biological and or productivity impact. The minimum negative impact on sow productivity and health measures following introduction to this pen gestation system likely explains the lack of treatment effects as unwanted effects of aggression were prevented or minimized across all animals.

III. Keywords: Dynamic groups, Electronic sow feeding, Housing , Sow, Welfare

Scientific Abstract: This should be a scientific description limited to one page in length to describe your project and its results.

<u>Introduction</u>

Both legislative initiatives and market forces are requiring producers to transition gestating sows from individual stalls to group housing. One major challenge with group housing is managing aggression during the initial period of hierarchy formation (Giersing, 1998). Several factors have been reported to impact the degree of aggression during group formation in electronic sow feeding ESF pens, but their effects can vary (Durrell, 2002; Gonyou, 2008; Jensen, 2000; Van Putten, 1990). Here we examine how the pre-mixing of sows prior to introduction and method of subsequent introduction of animals to the established dynamic group via the ESF feeder impact animal measures indicative of aggression.

Materials and methods

The experiment used a 2 x 2 factorial arrangement with the degree of familiarity (DF) among the new sows as the first factor and the method by which new sows are introduced (MI) into the established, dynamic group as the second factor. The cohort of new sows is either familiar with each other because of pre-mixing (PMIX) or not pre-mixed and unfamiliar with each other (UMIX). UMIX sows remained in breeding stalls prior to introduction, whereas the PMIX group was fed in breeding stalls but otherwise housed as a group from weaning to introduction. The cohort of incoming sows was introduced either as a batched unit, in which all new sows were introduced into the dynamic group in the ESF pen together (BAT), or individually, in which the new sows were introduced into the dynamic group singly (IND). This created 4 treatment structures: PMIX-BAT, PMIX-IND, UMIX-BAT, and UMIX-IND. Seven replications that included 1 sow cohort of each of the 4 treatment structures (experimental unit) served as the blocks in a complete, randomized block design. Each cohort consisted of 8 weaned sows.

Results – Sows exhibited a prolonged recovery/adjustment period following weaning and then being rebred and introduced to pen gestation. Body weight decreased and lameness and lesion scores increased until mid-gestation before reversing. However treatment group had no effect on the outcome of these measures. While statistically significant, these negative changes were likely of limited biological significance. There were also no significant effects of treatment on sow behavior immediately following introduction to pen gestation. Sows spent most of their time either standing or lying down. Overt aggression was rare (3 times per hour on average) and typically carried out by only a few animals. There was also no treatment effects on productivity outcomes measured in the farrowing house. Industry standard performance was achieved with each treatment (>85% farrowing rate, >14 total born, > 12 born alive).

Discussion and Conclusions

These findings highlight the ability to achieve or exceed standard levels of productivity in a well-managed pen gestation system. This results in part from the successful management of inter-animal aggression at the time of mixing. Although weight loss, lameness and skin lesions increased after sows were entered in to the pen, these changes were sufficiently small as not to have significant long term biological and or productivity impact. The minimum negative impact on sow productivity and welfare by introduction to this pen gestation system likely explains why there were only very limited treatment effects.

Introduction:

Group housing of gestating sows is becoming more commonplace in the swine industry today due to increased public scrutiny of conventional husbandry practices. While many alternatives to the gestation crate have been implemented, electronic sow feeding (ESF) is the only group housing solution that retains one of the major advantages of the gestation stall – individual animal nutrition. To optimize space and feeder utilization in ESF barns, sows are often housed in large pen dynamic groups. Aggressive encounters associated with the introduction of new animals into dynamic pens can lead to lameness and other injuries (Durrell et al., 2002) that threaten the welfare and productivity of these sows. Thus, one major challenge is managing aggression during the initial period of hierarchy formation (Giersing & Andersen, 1998). Levels of aggression may decrease in static groups once a social hierarchy is established (Gonyou, 2003), but in dynamic groups the ongoing introduction of new sows leads to continued aggressive interactions as sows attempt to re-establish a new social hierarchy (Anil et al., 2006; Simmins, 1993; Weng et al., 1998). Several factors have been reported to impact the degree of aggressive behavior performed during group formation in ESF pens, but their effects often vary between research studies. Increasing the percentage of new sows entering a dynamic group has been reported to both increase (O'Connell et al., 2004) and decrease (Anil et al., 2006) aggressive interactions. Likewise, the majority of fighting has been reported to occur both between new and resident animals (Moore et al., 1993) and also between new animals alone (Durrell et al., 2003; Edwards et al., 1993; Remience et al., 2008). In contrast, research studies from Europe consistently find pre-mixing sows prior to their introduction into the ESF pen beneficial by enhancing subgroup formation and reducing aggression when later introduced to the larger group (Durrell, 2003 Van Putten and Van De Burgwal, 1990). However, in the few research studies conducted in North America, the pre-mixing period has been limited to shorter time periods that yielded less positive results (Gonyou, 2008). The introduction of animals singly through the ESF station has been suggested to reduce aggression during mixing (Jensen et al., 2000), but this approach has not been scientifically tested. While the pre-mixing of sows and the introduction of individual sows through the ESF are being tried in the field in the United States, they are not widely accepted and have not been rigorously tested under conditions reflecting North American swine production (e.g. housing, genetics, feed etc). Thus the pre-mixing of sows prior to introduction to the dynamic group and introduction of animals via the ESF feeder into dynamic groups are the focus of this study.

Objectives

The long-term objective of this project is to improve the welfare of sows gestating in pens, particularly those housed in dynamic groups and fed via electronic sow feeding (ESF) stations. Several different management practices will be evaluated that are designed to mitigate the problems associated with the introduction of new sows into an existing group. This research will determine how a) the degree of familiarity of the new sows with each other and b) the method in which the new sows are introduced into the group affects the health, behavior, productivity, and welfare of the newly introduced sows.

Materials & Methods

Experimental design, treatments, animals, and housing

The experiment used a 2 x 2 factorial arrangement with a) the degree of familiarity among the new sows as the first factor and b) the method by which new sows are introduced into the established, dynamic group as the second factor. The cohort of new sows were either familiar with each other because pre-mixing (PMIX) or not pre-mixed and unfamiliar with each other (UMIX). The cohort of incoming sows were introduced either as a batched unit, in which all new sows are introduced into the dynamic group in the ESF pen together (BAT), or individually, in which the new sows were introduced into the dynamic group singly (IND). This created 4 treatment structures: PMIX-BAT, PMIX-IND, UMIX-BAT, and UMIX-IND. Seven replications that included 1 sow cohort of each of the 4 treatment structures (experimental unit) served as the blocks in a complete, randomized block design.

Each replication consisted of all 4 treatment structures. With each replication, the order of the treatment structures was randomized and a new structure began weekly. After the sows for all 4 treatment structures were introduced to the ESF pen, a 2 week break occurred in which no new experimental sows are added to the ESF pen. Following the 2 week break, the next replication commenced.

On weaning day of their previous litter (Day -8) a cohort of 8 commercially bred (PIC, Hendersonville, TN) parity 1 or greater sows were assigned to either PMIX or UMIX treatments and to either BAT or IND treatments (N = 224, equally divided among 7 replications of the 4 treatment structures). For all replications, the cohort was composed of the sows ready to be rebred after the previous weaning. Sows in the UMIX treatment were placed in gestation stalls and housed individually for 8 d, from weaning until entering the ESF pen (Day 0). Sows in the PMIX treatment were housed together to allow social interaction. The PMIX treatment pen contained 10 full-length, stalls, which were closed and only used for feeding and breeding, and a central 3.05 m x 4.9 m (10' x 16') area that provided 1.86 m^2/sow (20 ft^2). PMIX sows were housed in this way from day -8 to day 0, the same amount of time as the UMIX group was in stalls after weaning.

From Day -4 to -2 sows in all treatment structures were checked in crates for estrus using a boar. After the onset of estrus, each sow was artificially inseminated in the stall once a day for up to three depending on the duration of standing estrus. Sows in PMIX treatment were re-released into the pen each day after heat checking and insemination. Those sows that were not bred by day 7 were not included in the study. The total number of sows that were enrolled in the study was 212 after the exclusion of those sows not bred by day 7.

On Day 0, new sows were individually marked with livestock markers for identification and the cohort of new sows was divided in half. The total group was 6-8 sows depending on the number bred. Half of the sows were brought to the pen and entered into large pen with each sow assigned a person to do the focal follow with the video camera. After 2 hours, the second half of the group was introduced and the process repeated.

Those sows introduced as a BAT received their daily ration at 08:00 prior to the first group entering the pen at 13:00. For IND cohorts, an ESF station (Schauer Compident 7, Prambachkirchen, Austria) was temporarily re-gated so that the entrance faced the alley way. Sows were left in the alleyway and entered the ESF station from the alley way, received their daily feed allotment in the ESF station, and exited from the ESF station into the dynamic group pen. This process took approximately 10 minutes per sow and started at 13:00. The ESF pen contained 2 ESF stations and housed a total of approximately 130 gestating sows (8 new sows + 122 resident sows) at a space allowance of 1.86 m2/sow (20 ft2). Sows were fed on a feed curve dependent on their body condition score (BCS) on Day 0. After BCS assessment on day

40, adjustments were made to the sow's feed curve if needed. Following data collection on Day 108, approximately gestational day 112, the sows were moved into individual stalls in the farrowing facility. Sows that returned to estrus during the experiment were removed from the group pen for rebreeding. Data from sows removed from the study were only used in the farrowing rate calculation.

Health Measures

Body weight, BCS, lesion scores, and lameness were assessed on Days -8 for baseline data. BCS and body weight were assessed again on day -1, 7, 54 and at loading into farrowing (approximately Day 108). Lesion scores and lameness were collected on Days 3, 12, 26, 40, 54, 68, 82, and on loading into farrowing. Sows were weighed on a digital platform scale (Salter Brecknell PS1000 Livestock Scale, Fairmont, MN). Body condition was scored from 1 to 5 according to the industry standard with 1 representing an emaciated sow and 5 an obese sow (Appendix 1) (Coffey et al., 1999). Sows were scored for lameness based on ZinPro FeetFirst® Swine Locomotion Scoring System; with lameness being attributed to sows receiving a locomotion score of two or three (Appendix 2). Animals were scored for body lesions using a standardized scale measuring quality and quantity (Appendix 3).

Behavioral Measures

Aggression and Activity- Behavior was video-recorded during the introduction of new sows into the large dynamic pen with one individual following each sow and filming with a hand-held video camera (Sony Handycam SX45 Flash Memory Camcorder, New York, New York). Video data was archived on 1 terabyte portable hard drives (Western Digital, WD Elements External Hard Drive, Irvine, California) and was analyzed using software designed for observing animal behavior (ObserverXT, Noldus Information Technology, Inc., Leesburg, VA). The ethogram used for analysis included the following states: walking, standing, sitting, lying down, drinking, side pressing, and chasing. The following point behaviors were also coded: nosing sow, nosing pen, retreat, and displacement.

Feeding order- The order in which individual sows entered and ate at the ESF station was recorded daily using the electronic sow feeding station software. Due to a software issue this data is available for the last 4 replicates. Each sow was assigned a feeding rank based on the time she entered the feeder with 1 being the first sow to enter the station after feeding begins when the feeders open at 12 midnight.

Resting location- Two to three times weekly after feeding at the ESF station had concluded and most sows were resting in a sleeping area, the location of all the sows was recorded by direct observation. The ESF pen was divided into areas which were coded for identification. Resting locations were coded as either solid or slatted areas.

Production measures

The farrowing rate of the sows for each treatment structure within a replication was calculated as the number of sows bred/ the number of sows that farrowed with the study group x 100. An adjusted farrowing rate was calculated by dividing the number of sows that farrowed by the number of sows bred X 100. The total litter size and the numbers of live born, stillborn, and mummified pigs were recorded. The number of sows that were taken off the study and put in a hospital pen was recorded.

Statistical analyses

The data were analyzed with a generalized mixed model (PROC GLIMMIX, SAS 9.4, SAS Inst. Inc., Cary, NC). The statistical model for the sow farrowing rate included the fixed effects of degree of familiarity, introduction method, and their interactions. Replication number and its interactions with familiarity and introduction method were treated as random effects. An expansion of this base model was used for all statistical analyses subsequently described. Only the fixed effects varied among the models. Sow aggression, activity, and resting location also included the fixed effect of parity category and its interactions with familiarity and introduction method. Because the numbers of sows per parity used in the trials were unbalanced, parities were divided into categories to equalize the groups' sample sizes. The categories were parities 1 and 2, parities 3 through 5, and parities 6 through 8. The total litter size; numbers stillborn, live born, and weaned; mean pig and litter weights at birth and weaning; and total and live born mortality analyses included all effects previously mentioned and also farrowing barn and its interactions with familiarity and introduction. Sow weight, BCS, lesions, and lameness used the base model plus parity category and time and their interactions as fixed effects and initial weight, BCS, etc. as covariates for the respective outcomes. In addition, outcomes that were measured on multiple days included time and its interactions as fixed effects in their models. These were analyzed as repeated measures. Data were transformed as necessary to normalize residuals and equalize their variances.

The denominator degrees of freedom were approximated using the Kenward-Roger method designed for unbalanced data. Simple effects of significant interactions were used to examine the effect of one independent variable within a level of the second independent variable. The Holm-Tukey adjustment was used to reduce experiment-wise error when multiple comparisons were made. Because the experimental questions focused on the effects of sow familiarity at mixing and the method of mixing on the outcomes, the additional factors are only presented in the results when they significantly interact with either degree of familiarity or introduction method. Statistical significance was set at $p < 0.05$ and with a trend at $0.05 \le P < 0.10$.

Results

The goal of this study was to better understand how the management of sows after weaning and up to and including introduction into group housing impacts sow productivity and welfare. Data was collected on 212 sows in 7 replicates of each of the 4 treatment groups. Findings related to health outcomes are described first and then followed by our behavioral observations.

Health Measures

Body weight

Sow weights were measured at several points from weaning until a subsequent farrowing (see Table 1). Weights declined significantly from weaning until mid-gestation. At mid-gestation there was no statistical difference from weaning. After the mid-gestation weight, weights increased significantly until farrowing. Mean difference in body weight from weaning to day 7 was -39.7 ±2.0 lbs. Mean difference in body weight from weaning to loading into farrowing was 84.2±2.7lbs.

There was no overall effect of familiarity (P=0.542) or of method of introduction (P=0.301) on body weight. There was however a familiarity by day interaction (P<0.0001). Those sows that were in the PMIX group weighed less on day -1 than those sows that were in the UMIX group (-12.2±4.4, P<0.01) presumably associated with the activity, aggression, and establishment of a social hierarchy during this time in the PMIX group.

Table 1- Differences in least square means Body Weight (lbs) by day

Comparison			Standard	
Day	Day	Estimate	Error	Adj P
-8	-1	28.67	1.62	<.0001
-8	7	39.66	2.03	<.0001
-8	54	-3.80	2.40	0.5099
-8	114	-84.22	2.68	<.0001
-1	7	10.98	1.64	<.0001
-1	54	-32.47	2.07	<.0001
-1	114	-112.90	2.45	<.0001
7	54	-43.45	1.69	<.0001
7	114	-123.88	2.12	<.0001
54	114	-80.43	1.73	<.0001

Body Condition Score (BCS)

Body condition scores also were measured at several points from weaning until a subsequent farrowing (See Table 2). BCS increased significantly from day 7 until loading into farrowing (P<0.0001).

There was no overall effect of familiarity (P=0.0628) or method of introduction (P=0.743). There was however an interaction between method of introduction and degree of familiarity (P=0.046). PMIX sows that were entered as a batch had a lower BCS than UMIX sows that were entered as a batch (0.017±0.0063, P<0.01). The reasons for this interaction are not clear.

Table 2- Differences in least square means BCS by Day

Comparison Day	Day	Estimate	Standard Error	Adj P
-8	-1	-0.03	0.02	0.4705
-8	7	-0.01	0.02	0.9944
-8	54	-0.16	0.02	<.0001
-8	114	-0.24	0.03	<.0001
-1	7	0.02	0.02	0.7836
-1	54	-0.13	0.02	<.0001
-1	114	-0.21	0.02	<.0001
7	54	-0.15	0.02	<.0001
7	114	-0.23	0.02	<.0001
54	114	-0.08	0.02	0.0008

Total Lesion scores

Body lesions were observed at weaning, before entering the pen, day 3, and every two weeks until loading into farrowing. There was a significant effect of day on total lesion score (P<0.0001), which is a combined score for all body regions. Total lesion score increased significantly from the time sows entered the pen until day 12. After day 12 lesion scores decreased significantly until mid-gestation. When sows were weaned, their lesions were lower than they were at loading into farrowing (-6.7±0.47, p<.0001).

There was no overall effect of familiarity (P=0.168) or method of introduction (P=0.8243). There was however an interaction between day and degree of familiarity (P<0.0001). Those sows that were PMIX had more lesions than the UMIX sows on day -1 (10.7±0.97, P<0.0001) and day 0(6.6±0.98, P<0.0001) as expected due to the aggressive interactions that were allowed to occur in the PMIX, but not UMIX, group during this time. The UMIX sows however had more lesions than the PMIX sows on day 7 (2.9±0.987, P<0.01) and day 12 (3.0±0.99, P<0.01) likely reflecting the delayed onset of aggression in the UMIX sows and healing of lesions in the PMIX sows compared to the UMIX sows.

Lameness

Sow lameness was tracked on the same days that lesion scores were collected except on Day 3. Lameness scores increased from weaning until mid-gestation before going back down at the time of loading into farrowing. Lameness was significantly lower at weaning than on day 7 (-0.069±0.02, P<0.05) and day 54(-0.11±0.021, P<0.0001), but there was no difference between the score at weaning and the score at loading into farrowing (-0.058±0.021, P=0.167).

There was no effect of degree of familiarity on lameness scores (P= 0.783) or method of introduction on lameness scores (P= 0.5992).

Behavioral Measures

Aggression and Activity

Behavioral measure of aggression and activity (see Table 3) as well as posture (see Table 4) were recorded during the 90 minutes immediately following introduction of the sows to the pen.

Biting- There was no overall effect of familiarity (P=0.196) or method of introduction (P=0.481). There was however an interaction between degree of familiarity and method of introduction (P=0.011). Those sows that were premixed and entered as individuals showed more biting behavior than those that were put in as a batch (1.41±0.642, P<0.05).

Side Pressing - There was no overall effect of method of introduction (P=0.410) or degree of familiarity (P=0.211).

There was however an interaction between method of introduction and parity (P=0.01). For sows entered as a batch, those sows in parity category 1 (p1 and p2) side pressed less than those sows in parity category 5 (P6 and higher) (-0.018±0.0065, p<.05) suggesting that older animals once engaged in an aggressive encounter were more likely to escalate agonistic behavior..

Table 3- Number of aggressive incidents in 90 minutes

Variable	Mean	Median	Range	Lower Quartile	Upper Quartile	Standard Error
Bites	42.6	14	557	2	56	11.42
Chases	1.76	0	27	0	1	0.6
Displacements	5.35	1	48	0	7	1.21
Side Presses	5.53	2	58	1	7	1.25

Postures and Activity- There was no effect of familiarity or method of introduction on the measures of activity and posture.

Table 4- Proportion of time spent in different postures and activities

Variable	Mean	Median	Range	Lower Quartile	Upper Quartile	Standard Error
Lying down	0.32	0.3	0.76	0.13	0.52	0.03
Sitting	0.02	0.01	0.06	0	0.03	0.00
Standing	0.44	0.44	0.65	0.29	0.61	0.02
Walking	0.15	0.14	0.27	0.1	0.18	0.01

Feed Order-

There was no effect of method of introduction (P=0.134) or degree of familiarity (P=0.382) on daily feed order. There was however, an effect of day (P<.0001) on feed order as the time when a sow ate was earlier the longer she was in the pen. By day 18, the median feed rank of the treatment group had reached the midway point of the feeding order.

Resting Location

There was no effect of method of introduction (P=0.594) or familiarity (P=0.092) on the percent of time sows were observed sleeping on slatted or solid laying areas.

Production Measures

Farrowing rate

There was no effect of treatment on farrowing rate which was defined as the number of sows to remain in the pen and reach the farrowing room with the study group (See Table 5). The adjusted farrowing rate is defined as the number of sows that started in the group and then farrowed even if they did not stay in the pen and on the study. There was an effect of method of introduction on the proportion of animals to enter a hospital pen (P=0.05) with more sows entered as a batch sorted into a hospital pen.

Table 5- Farrowing rate by treatment

Treatment	Total sows	All Farrow	Farrow in group	Hospital	PCN	Recycle	Abort	Cull	Death	Euth	Farrow Rate	Adj FR
PMIX	107	99	96	4	1	3	1	1	1	0	89.7%	92.5%
UMIX	105	93	90	4	7	3	0	0	0	1	85.7%	88.6%
IND	105	96	96	0	5	1	1	1	1	0	91.4%	91.4%
BATCH	107	96	90	8	3	5	0	0	0	1	84.1%	89.7%

Litter Size

There was no effect of method of introduction on the total born (P=0.364), or live born (P=0.339), nor was there an effect of familiarity on total born (P=0.809), or live born (P=0.780).

Table 6- Total born and live born by treatment

	Total born	SE	Live born	SE
PMIX	14.82	0.45	12.60	0.55
UMIX	15.00	0.57	12.85	0.68
IND	15.29	0.46	13.12	0.52
BATCH	14.54	0.62	12.32	0.67

IX. Discussion: Explain your research results and include a summary of the results that is of immediate or future benefit to pork producers.

The detailed measurements in this study highlight the prolonged period of recovery and adjustment the sow faces following weaning, being rebred, and then entering into pen gestation. The health data shows that sows lose weight until mid-gestation and show increasing lameness until mid-gestation. Lesions peak at day 12 in the pen and then decline. BCS increases throughout gestation. However, on average the change in body weight, lameness and lesions scores during this period, while statistically significant, seemed to have limited long term impact on the sows. Subsequent production levels from these sows were comparable to industry standards and thus re-enforces the minimal impact of this adjustment period to the sow's productivity. These scientific findings are consistent with an expectation that sows in a well-managed pen gestation system can have transient increases in scratches and lameness in the period immediately following introduction to the pen, but these measures equilibrate throughout gestation without negatively impacting productivity.

Perhaps not surprisingly then the treatments had very little impact on our measures as negative outcomes across all treatments were limited. What was detected was more a function of sow physiology rather than treatment effect (weight loss following weaning, time course for skin lesions to heal, increase in BCS over gestation). Method of introduction showed no impact on the health measures.

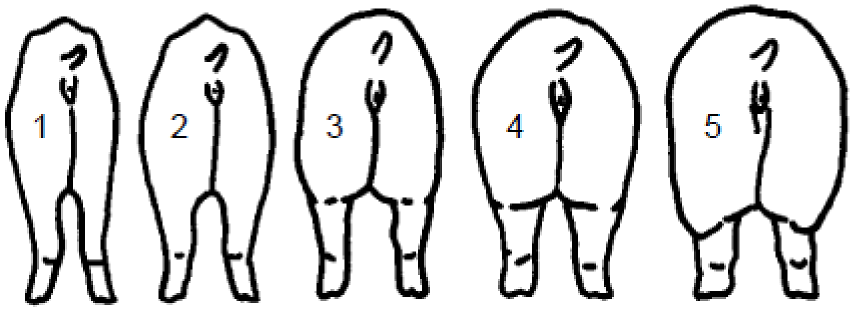
Degree of familiarity showed little impact on the health measures except to indicate that the premixed sows had more lesions before they entered the pen compared to unmixed sows, but fewer lesions after entering the pen. This suggests that there was less fighting amongst the premixed sows after entering the pen as social order and associated aggression was resolved prior to entering the pen in the premixed group. The behavior of the sows in their first two hours after entering the pen shows that they spent over 40% of the time standing and over one third of the time lying down. On average, the sows engaged in almost 6 aggressive encounters as measured by side pressing or once every 20 minutes. The response of individual animals was highly variable given the standard deviation of 9.24 side presses suggesting that a small number of sows engaged in the majority of the aggression. Neither method of introduction, nor degree of familiarity, impacted the amount of fighting nor any other behaviors measured. Overall, it is striking how little time sows spend engaged in aggressive activities during the first 2 hours in the pen. The location where sows chose to lie down, resting location, was not affected by the method of introduction or the degree of familiarity. The order in which sows ate, feed order, was also unaffected by treatment but was impacted by day. Immediately following introduction, sows tended to eat later in the day, but by 18 days in the pen, the animals were equilibrated into the group.

Productivity was not statistically significantly different for any of the treatments but farrowing rate and total born were numerically lowest for those sows entered as an unmixed batch. Significantly more animals entering as a batch ended up in a hospital pen indicating the possibility of increased injuries from this approach.

The goal of this study was to develop scientific information on the best methods of mixing sows. There is some indication that entering sows through the feeder may be beneficial for improving production. The data also shows a prolonged period of adjustment to the pen that lasts well into the first week in the pen. It is important for producers to recognize this window and provide increased monitoring to sows during this timeframe.

Acknowledgements – I want to thank Dr. Meghann K. Pierdon for her management of this project that included study implementation, data collection, management and analysis as well as Dr. Laurie A. Mack for her contributions to study design and statistical analysis of the data.

Appendix 1. Body Condition Score. Adapted from Pork Quality Assurance Plus Manual.



Score	Condition	Detect of ribs, backbone, "H" bones, and pin bones
1	emaciated	obvious
2	thin	easily detected with palm pressure
3	ideal	barely felt with firm palm pressure
4	fat	none
5	overly fat	none

Appendix 2. Feet First Swine Locomotion Scoring System

Locomotion Score	**Description**
1	Sow moves relatively easy, but visible signs of lameness or abnormal gate are apparent in at least one leg.
2	Lameness is involved in one or more limbs. The sow exhibits compensatory behaviors such as dipping her head or arching her back.
3	There is a real reluctance to walk and bear weight on one or more legs. It is difficult to move her from place to place on the farm.

Appendix 3. Operational definitions of lesion scoring.

Category	Score	Description
Quality	A	Thin (<2 mm wide) and shallow; epidermis may be broken with mild surface inflammation;
	B	Moderately deep cuts (2-4 mm wide); epidermal and dermal layers may be broken with moderate inflammation;
	C	Occurrence of a wide (>4 mm) or deep cuts; dermal layers broken with severe inflammation
Quantity	1	≤ 5 cuts
	2	6 to 10 cuts
	3	11 to 20 cuts
	4	21 to 30 cuts
	5	> 31 cuts

References

Anil, L., S. S. Anil, J. Deen, S. K. Baidoo, and R. D. Walker. 2006. Effect of group size and structure on the welfare and performance of pregnant sows in pens with electronic sow feeders. Can. J. Vet. Res. 70:128-136.

Arey, D. S., and S. A. Edwards. 1998. Factors influencing aggression between sows after mixing and the consequences for welfare and production. Livest. Prod. Sci. 56:61-70.

Coffey, R. D., G. R. Parker, and K. M. Laurent. 1999. Assessing sow body condition. ASC-158. Cooperative Extension Service, University of Kentucky, Lexington, KY.

Chapinal, N., J. L. Ruiz-de-la-Torre, A. Cerisuelo, M. D. Baucells, J. Gasa, and X. Manteca. 2008. Feeder use patterns in group-housed pregnant sows fed with an unprotected electronic sow feeder (Fitmix). J. Appl. Anim. Welf. Sci. 11:319-336.

Chapinal, N., J. L. Ruiz-De-La-Torre, A. Cerisuelo, J. Gasa, M. D. Baucells, and X. Manteca. 2010. Aggressive behavior in two different group-housing systems for pregnant sows. J. Appl. Anim. Welf. Sci. 13:137-153.

Durrell, J. L., V. E. Beattie, I. A. Sneddon, and D. Kilpatrick. 2003. Pre-mixing as a technique for facilitating subgroup formation and reducing sow aggression in large dynamic groups. Appl. Anim. Behav. Sci. 84:89-99.

Durrell, J. L., I. A. Sneddon, V. E. Beattie, and D. J. Kilpatrick. 2002. Sow behaviour and welfare in voluntary cubicle pens (small static groups) and split-yard systems (large dynamic groups). Anim. Sci. 75:67-74.

Edwards, S. A., F. Brouns, and A. H. Stewart. 1993. Influence of feeding system on the welfare and production of group housed sows. Pages 166–172 in Livestock Environment IV. E. Collins and C. Boon, eds. American Society of Agricultural Engineers, St. Joseph, MI.

Giersing, M., and A. Andersson. 1998. How does former acquaintance affect aggressive behaviour in repeatedly mixed male and female pigs? Appl. Anim. Behav. Sci. 59:297-306

Gonyou, H. W. 2003. Group housing: Alternative systems, alternative management. Adv Pork Prod 14:101-107.

Gonyou, H. W. 2008. Comparison of management factors affecting aggression in group housed sows. NPB# 05-067. Pork Checkoff, DesMoines, IA.

Jensen, P. 1980. An ethogram of social interaction patterns in group-housed sows. Appl. Anim. Ethol. 6:341-350.

Jensen, P. 1982. An analysis of agonistic interaction patterns in group-housed dry sows-Aggression regulation through an "avoidance order". Appl. Anim. Ethol. 9:47-61.

Jensen, K. H., L. S. Sørensen, D. Bertelsen, A. R. Pedersen, E. Jørgensen, N. P. Nielsen, and K. S. Vestergaard. 2000. Management factors affecting activity and aggression in dynamic group housing systems with electronic sow feeding: a field trial. Anim. Sci. 71:535-545.

Marchant-Forde, J. N. 2009. Welfare of dry sows. Pages 95-139 in The Welfare of Pigs. J. N. Marchant-Forde, ed. Animal Welfare. Springer, New York, NY.

Mendl, M., A. J. Zanella, and D. M. Broom. 1992. Physiological and reproductive correlates of behavioural strategies in female domestic pigs. Anim. Behav. 44:1107-1121.

Moore, A. S., H. W. Gonyou, and A. W. Ghent. 1993. Integration of newly introduced and resident sows following grouping. Appl. Anim. Behav. Sci. 38:257-267.

O'Connell, N. E., V. E. Beattie, and B. W. Moss. 2003. Influence of social status on the welfare of sows in static and dynamic groups. Anim. Welf. 12:239-249.

O'Connell, N. E., V. E. Beattie, and B. W. Moss. 2004. Influence of replacement rate on the welfare of sows introduced to a large dynamic group. Appl. Anim. Behav. Sci. 85:43-56.

Olsson, A.-C., M. Andersson, J. Botermans, D. Rantzer, and J. Svendsen. 2011. Animal interaction and response to electronic sow feeding (ESF) in 3 different herds and effects of function settings to increase capacity. Livest. Sci. 137:268-272.

Pork Checkoff. 2010. Site Assessment Guide. Des Moines, IA Accessed May 16, 2012. http://www.pork.org/filelibrary/PQAPlus/SiteStatus/PQAPlusAssessmentGuide2010.pdf.

Remience, V., J. Wavreille, B. Canart, M.-C. Meunier-Salaun, A. Prunier, N. Bartiaux-Thill, B. Nicks, and M. Vandenheede. 2008. Effects of space allowance on the welfare of dry sows kept in dynamic groups and fed with an electronic sow feeder. Appl. Anim. Behav. Sci. 112:284-296.

Simmins, P. H. 1993. Reproductive performance of sows entering stable and dynamic groups after mating. Anim Prod 57:293-298.

Turner, S. P., M. J. Farnworth, I. M. S. White, S. Brotherstone, M. Mendl, P. Knap, P. Penny, and A. B. Lawrence. 2006. The accumulation of skin lesions and their use as a predictor of individual aggressiveness in pigs. Appl. Anim. Behav. Sci. 96:245-259.

Van Putten, G., and J. Van de Burgwal. 1990. Vulva biting in group-housed sows: preliminary report. Appl. Anim. Behav. Sci. 26:181-186.

Weng, R. C., S. A. Edwards, and P. R. English. 1998. Behaviour, social interactions and lesion scores of group-housed sows in relation to floor space allowance. Appl. Anim. Behav. Sci. 59:307-316.

ZinPro. Feet First Swine Locomotion Scoring System. Accessed May 17, 2012. http://www.zinpro.com/lameness/swine/locomotion-scoring.