Title: Effects of Mixed and Uniform Parity Groupings on Feeding Behaviour, Welfare and Productivity of Sows in ESF Housing – **NPB #11-067**

Investigator: F. C. Lang[1], Y. Seddon[1] and J. A. Brown[1, 2]

Institutions: [1]Prairie Swine Centre Inc., P.O. Box 21057, 2105 8th Street East, Saskatoon, SK
[2]Department of Animal Science, University of Saskatchewan

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Industry Summary

Electronic sow feeder (ESF) systems are a practical method for managing sows in group housing, as they provide an automated system for controlling individual feed intake. However, increased aggression can result, especially in the initial period following mixing, as sows compete for access to the ESF. The primary objective of this research was to compare different methods for grouping sows housed in static ESF systems, in order to assess differences in their effects on feeding behaviour, sow injury, and production. Sows were housed in groups of mixed parity (control), low parity (parities 2 & 3), medium parity (parities 3-5), and high parity (≥ parity 4). Within this framework, we compared measures of feeding behavior, sow well-being and productivity among high, medium and low parity sows in uniform versus mixed groups. Of specific interest was whether low parity (1 and 2) sows experience less aggression and injury during gestation when managed in uniform groups than in mixed groups, and what effects these treatments may have on production measures at farrowing and backfat.

The preliminary results presented here indicate that housing sows in uniform groups produced some benefits, especially for younger sows. Sows in uniform groups had reduced lameness following mixing compared to mixed groups. Increases in backfat over gestation showed that younger sows fared better in uniform groups. Young (parity 1 and 2) sows were able to increase backfat in uniform groups, as opposed to loosing it in mixed groups, suggesting that competition at the feeder was less of a challenge in the uniform group. No production differences were found between sows in uniform groups as compared to mixed groups. Managing gilts as a separate group is already a common practice, and results from this study suggest that parity 1 and 2 sows can also benefit from this

practice. Maintaining uniform groups also helped to reduce mixing injury, with injuries sustained following mixing being equal to or lower than the mixed parity groups, with only the low parity uniform group having higher injury scores. However, greater injuries in younger sows is more likely related to the social ability of these animals, and management of gilts to improve sociability may be a further management consideration that could be implemented.

Keywords: sows, ESF, grouping, parity, feeding behaviour

Scientific Abstract

Electronic sow feeder (ESF) systems are an effective method for managing sows in group housing, as they provide an automated system for controlling individual feed intake. However, low-ranking sows have been found to receive more aggression and injuries, and have poorer productivity compared to high-ranking sows. Low-ranking sows also tend to gain entry to the ESF later in the feeding cycle, and are more frequently displaced. Information on how to manage low-ranking sows is needed, and will benefit sow welfare and production.

This study compared different grouping strategies for sows in ESF systems, looking at mixed parity groups versus uniform groups of low, medium and high parity sows, to determine their effects on sow feeding behaviour, injury scores and productivity. Six replicate trials were performed with approximately 240 sows per replicate. Following confirmation of pregnancy, groups of 60 sows were formed based on parity (low, medium, high parity, and one mixed parity group as a control). Sows were weighed, body condition scored (BCS), and skin lesions and lameness were assessed. Ultrasonic backfat measures were collected on a sub-sample of 288 sows. Automated ESF records were collected for individual sows throughout gestation. Skin lesion scoring was repeated at 3 days post-mixing and 7 days after final grouping as a measure of aggression, and productivity was recorded at farrowing.

Backfat results showed that younger sows (parities 1 to 4) housed in uniform groups fared better than in mixed parity groups over the course of gestation, and were able to increase backfat depth in the uniform groups, but lost backfat when housed in a mixed parity group. This was especially true for parity 1 and 2 sows, which lost an average of 4.12 mm backfat in the mixed parity treatment. Sows of parity score 3 in the uniform medium parity treatment faired the best overall, gaining 1.99 mm of backfat over gestation. A greater risk of lameness following mixing was also found when sows were housed in mixed parity groups, and housing sows in uniform groups helped to reduce the severity of lameness that developed. There was a strong effect of the mixing pen used, suggesting that additional external factors (eg flooring or pen configuration) also contributed to differences lameness scores. Body lesion scores increased in severity following mixing in all treatments. The uniform low parity group incurred a significantly greater number of body lesions than all other treatments, and the uniform high parity group had the fewest. Body lesion data thus suggest an effect of age rather than grouping treatment, with younger sows being more aggressive at mixing. No production differences were found between sows in uniform groups as compared to mixed groups.

It is already a common practice to house gilts separately during gestation, and the results of this work show that parity 1 and 2 sows may also benefit from more uniform grouping practices. Future work to improve socialization in younger sows is recommended.

LIST OF TABLES

LIST OF FIGURES

3. Introduction

The management of sows in groups can be more complex than stall housing, and generally requires greater input from stockmen. While group-housed sows may benefit from increased freedom of movement with associated improvements in sow fitness, these systems can also result in increased aggression and decreased welfare, particularly in lower ranking animals.

Sows that have been mixed can suffer a number of negative consequences such as increased in skin lesions or leg and hoof injuries resulting from direct aggression or avoidance of high ranking animals, higher stress levels and lower weight gain during gestation (Arey and Edwards, 1998; Hayne and Gonyou, 2003; O'Connell et al., 2004; Jarvis et al., 2006; Couret et al., 2009). Electronic sow feeder (ESF) systems are a practical method for managing sows in group housing, as they provide an automated system for controlling individual feed intake. Aggression frequently occurs in group gestation systems, with most aggression occurring when sows are initially mixed and establishing their dominance hierarchy, and ongoing aggression ocurring as sows compete for access to feed and for preferred lying areas (Strawford et al., 2008). If managed correctly, ESF systems can significantly reduce this ongoing competition for feed. However, if not managed correctly, sows in ESF systems can experience prolonged daily competition for access to the feeder throughout the gestation period.

Sows in ESF systems can be managed either in static or dynamic groups. Static groups are generally preferred because of reduced aggression (Leeb et al., 2001; Durrell et al., 2002), however other studies have found no difference in aggression between static and dynamic systems, suggesting that sow well-being may be similar in dynamic groups given proper management (Strawford et al., 2008). Within ESF systems, low-ranking sows have been found to receive more aggression and injuries, and have poorer productivity compared to high-ranking sows (O'Connell et al., 2003). It has also been shown that low-ranking sows tend to gain entry to the ESF later in the daily feeding cycle, and are more frequently displaced from the entry. In static ESF groups, high-ranking sows have been found to eat earlier in the feeding cycle, and eat for longer, compared with low-ranking sows (Chapinal et al., 2008). Thus it appears that low-ranking sows are at a disadvantage in both static and dynamic ESF groups. Because the use of ESF systems is becoming more common in North America, information on how to manage low-ranking sows in these systems is needed, and will benefit sow welfare and production.

Some previous studies have looked at different criteria for forming sow groups to help reduce aggression. Durrell et al. (2002) compared static and dynamic systems, Seguin et al. (2006) looked at the inclusion of a boar in sow groups, and Strawford et al. (2008) studied several grouping factors, including static vs. dynamic, stages of gestation, and the familiarity of sows. The current study compared different grouping strategies for sows housed in ESF systems, looking at mixed parity groups and uniform parity groups of low, medium and high parity sows, to determine their effects on the feeding behaviour, injury scores and productivity of sows. The research aims to improve understanding of the management of sows in static ESF systems, with particular focus on the management of low-parity sows. If low-parity sows in mixed groups experience aggression and stress primarily as a result of competition with high parity sows, then uniform low parity groups may result in reduced aggression and stress during gestation, and possibly increased productivity. In addition to improving our understanding of the effects of different grouping strategies, the study also evaluated links between sow social status, as determined by sow weight and feeder entry order, and productivity.

4. Objectives

The primary objective of this research was to compare different methods for grouping sows housed in static ESF systems (from approximately 5 weeks gestation) to determine possible differences in effects on feeding behaviour, injury and productivity. Sows were housed in treatment groups of: a) mixed parity (control, parity range 2-7); b) low parity (parities 1, 2 & 3); c) medium parity (parities 3-7); and c) high parity (parities 4-8). Within this framework, we compared measures of feeding behavior, well-being and productivity between high, medium and low parity sows in uniform versus mixed groups. Of specific interest was the question of whether low parity (1 and 2) sows experience less aggression and injury during gestation when managed in uniform groups than in mixed groups, and what effects these treatments have on production measures at farrowing and backfat.

Using feeding behavior data automatically collected by the ESF system, a further objective was to study the effect of treatment on variation in feeding time, both within individual sows and between sows within a treatment. Based on previous research, we predicted that animals will establish a dominance hierarchy at the ESF, with dominant animals feeding earlier in the daily feeding cycle than subordinate animals. If groups rapidly adopt a stable social structure after mixing, individual variation should be reduced. Relationships were also examined between feeding order and productivity to determine whether higher social rank is associated with increased productivity, as was found by O’Connel et al. (2003).

5. Materials & Methods

5.1 Animals and Study Location

The study took place at Innovative Swine Solutions’ research facility located at High Power Pork (HPP) in Augusta, IL. HPP is a 6,000 sow farrow-to-wean facility, built in 2008. Sows in the herd are of PIC genetics, with parities ranging from 0-8, and average parity of 3.2. Gilts are housed separately at HPP, and were not used in the study. Sows in gestation are housed in 56 fully slatted pens, each containing one ESF feeder station, with 56-60 sows per pen, providing just over 18 sqft per sow. Production is weekly, with five ESF pens filled per week.

All animals used within this trial were cared for and monitored according to Innovative Swine Solutions' Standard Operating Procedures. The animal care protocol was reviewed and approved by the animal care committees of Innovative Swine Solutions and the University of Saskatchewan Animal Care Committee.

5.2 Treatments

For this study, six replicate trials were performed with approximately 240 sows per replicate, and 1,440 sows in total. Four groups of 60 sows each were formed in each replicate trial based on parity, with one group each of low (parities 1, 2 and 3), medium (parities 3 - 7) and high parity sows parity 4-8), and one mixed parity group (Control, parities 2 - 8).

Specific guidelines for group formation were as follows:

- Low parity- Parity 1, 2 & 3 sows, with minimum of 10% (6) sows in parity 2,
- Medium parity- Parity 3-7 sows, with minimum of 10% (6) sows in parity 3,
- High parity- All sows parity 4-8
- Mixed parity (Control)- Mix of parities to include minimum of 10% (6) sows from parity 2 and 10% (6) from sows ≥ parity 4.

Study replicates were preceded by a two week pilot study during which technical staff received training on study protocols and the use of data recovery systems was validated. The six study replicates were performed weekly or biweekly, depending on availability of sows needed to form the desired treatment groups.

5.3 Experimental Procedure/Data Collection

A time-line of experimental procedures for data collection is given in Figure 1.

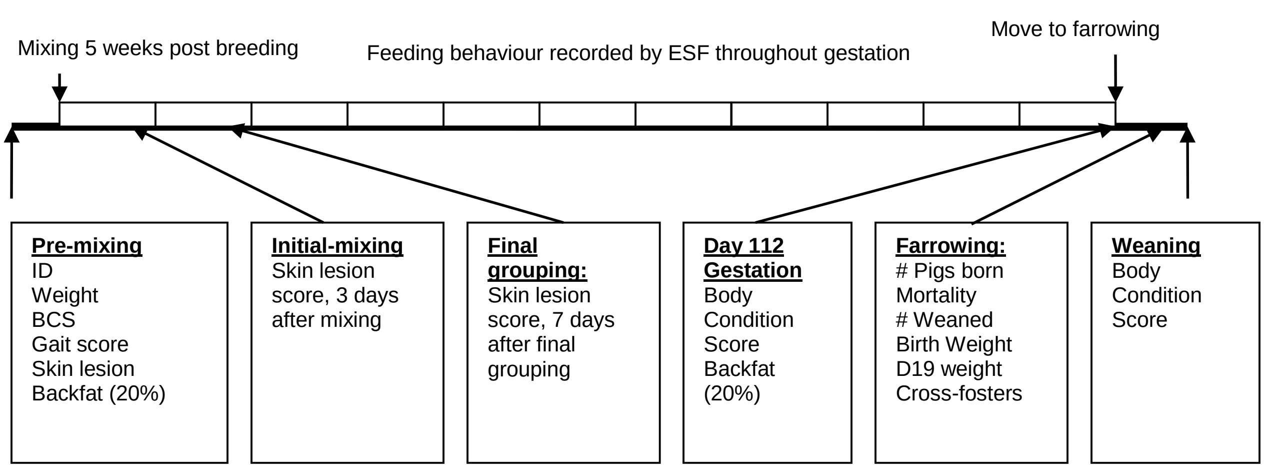

Figure 1. Timeline of experimental procedures for data collection.

Pre-mixing: Sows were mixed at 5 weeks gestation, following confirmation of pregnancy. Prior to moving into group housing, sows were weighed, body condition score (BCS) was recorded by a trained herdsperson, and skin lesions and lameness were assessed. Ultrasonic backfat measures were collected on a sub-sample of 20% of sows, this was an average of 10 sows per group, however some weekly variations occurred due to barn staff time constraints.

Initial mixing: At 5 weeks gestation, sow groups were placed into mixing pens following HPP's standard husbandry procedure. A number of measures were taken at mixing to help reduce aggression; sows received extra feed before mixing, baby powder was applied, a vasectomised boar was included in the group, and pen barriers were used to help submissive sows avoid aggression. Following entry into mixing pens, feeding behaviour data was collected automatically using the Nedap Velos ESF system. With the assistance of our partners at Nedap, software revisions were installed to allow the collection of automated records of feeding time (time of entry) and feed consumption for individual sows. Skin lesion scoring was repeated at 3 days post-mixing as a measure of aggression during group formation.

Final grouping: Within 5 to 7 days of initial mixing, sows were moved to their final gestation pens. Skin lesion scoring was repeated 7 days after final grouping. Feeding behaviour was recorded using the ESF system throughout gestation, up until the time that sows were moved to farrowing (approx. day 112).

Farrowing: At farrowing, the productivity of sows was measured, including total pigs born, number of pigs born alive, number of stillborn pigs, number of mummies, mortality to day 5 and number of piglets weaned at 22 ±2 days. A sub-sample of litter weights at birth, after cross fostering (CF), at 19 days and at weaning was collected, amounting to 27% of litters. Production data was recorded using AgriSoft production software.

5.4 Body Condition Scoring

A body condition score (BCS) was determined for each sow before being mixed at 5 weeks gestation, at day 112 of gestation, and at weaning. The BCS was determined according to a scale of 1 (very thin) to 5 (obese; see Table 1), including intermediate values of 0.25 points (Young et al., 2004).

Table 1. Body condition scoring scale

1	Poor	Hips and backbone are prominent
2	Moderate	Hips and backbone are easily felt without applying palm pressure
3	Good	Hips and backbone can only be felt with firm palm pressure

4	Very good	Hips and backbone cannot be felt
5	Fat	Hips and backbone are heavily covered

5.5 Skin Lesion Scoring

To assess levels of aggression during group formation.sows were scored for skin lesions prior to being mixed at 5 weeks gestation, at 5 days after initial mixing, and at 7 days after final grouping. Lesion scores ranged from 0 (no injury) to 3 (severe injury) and were evaluated in eleven body regions (head, ear, neck, shoulder, top of back, tail, vulva, hind leg, side, udder and front leg) on both the right and left sides of the body, Figure 2. Lesion scores accounted for fresh scratches only, and were assigned according to the descriptions given in Table 2.

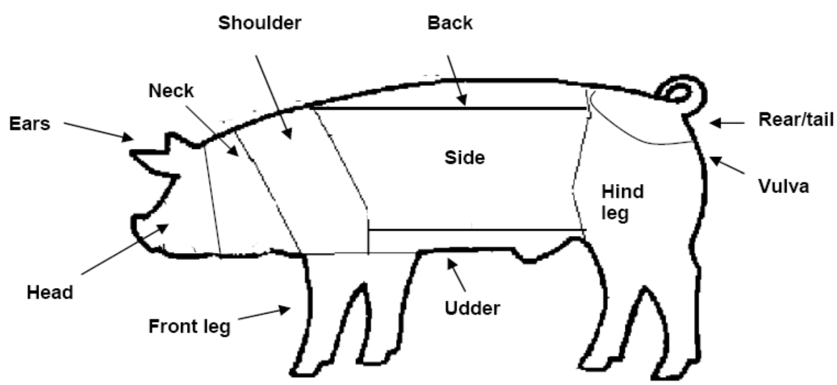

Figure 2. Skin lesion scoring regions.

Table 2. Skin lesion scoring scale.

0	No injury	skin unmarked: no evidence of injury from agonistic behaviour
1	Slight injury	< 5 superficial wounds
2	Obvious injury	5-10 superficial wounds and/or < 3 deep wounds
3	Severe injury	> 10 superficial wounds and/or > 3 deep wounds

5.6 Lameness Scoring

A lameness score (Table 3) was determined for all sows prior to mixing at 5 weeks gestation, at day 3 post mixing, and again at day 7 upon moving into the ESF gestation pen. Sows were assessed using a standardised scale from 0 to 4 (including intermediate values of 0.5 points) simplified from Main *et al.*, (2000). The score was given by visual appraisal of the sow's walking gait. Sows with lameness score of 2 or greater were removed from the study and placed in relief pens and provided care based on HPP's standard practice according to their injury. All sow removals due to lameness or other health considerations were recorded.

Table 3. Lameness scoring scale.

0	Normal gait, even strides
1	Abnormal gait, stiffness but no easy identification of lameness
2	Lameness detected, shortened strides, sow puts less weight on one leg
3	Sow avoids putting weight on one leg
4	Non ambulatory

5.7 Ultrasonic Backfat Measurement

Sow backfat thickness was determined for a sub-sample of 20% of sows equally distributed across parity and treatment. Backfat thickness was measured by a trained technician using an ultrasound scanner. Each animal was scanned longitudinally at the P2 location (6.5 cm off the dorsal midline at the last rib) and triplicate measurements were averaged to obtain a single backfat measurement (Young et al., 2004).

5.8 Feeding System and Data Collection

Following pregnancy confirmation at 5 weeks, sows were grouped into pens with one ESF feeder per pen (Velos Sow Feed Station, Model #9920510, Nedap Livestock Management, Groenlo, The Netherlands). Feeder settings included a feed delivery of 210 g/minute, and time out period of 1 minute. Feeding data was collected automatically from the Nedap Velos ESF system. With the assistance of our partners at Nedap, software was installed to obtain automated records of feeding time (time of entry) and feed consumption for individual sows. Daily feeder entry scores were calculated for individual sows based on their first entry, as described by Strawford et al. (2008), with Entry Score = p/(n-1), where p was the sow's numerical position in the order and n was the number of focal sows that ate that day. Based on this calculation the first sow to enter received a score of zero and the last sow received a score of one. The average daily feed intake was also determined for each sow.

5.9 Farrowing Data Collection

Piglets were tagged at birth and were processed and managed following routine HPP farm practices. Piglets in each treatment group received a different tag colour, with individual ID numbers. Cross-fostering (CF) was done only between pigs in the same treatment group. A number of productivity measures were collected for all sows at farrowing. The AgriSoft production software was used to record the total number pigs born, number of pigs born alive, number stillborn, number of mummies born, pig mortality to 5 days (number of pigs that die within 5 days of farrowing), and the number of pigs weaned at 22 ± 2 days. Technicians also obtained a sub-sample of litter weights at birth, post CF, litter weight at 19 d and litter weaning weight. This sub-sample accounted for 27% of litters. Pigs added or removed from the litter as cross-fosters, as well as pigs that died were weighed and recorded.

5.10 Statistical Analysis

To aid in the analysis, sow parity was classified into 3 categories, grouping sows of similar parity. Parity score was assigned as follows: PS 1: Parities 1 & 2; PS 2: Parities 3 & 4; PS 3: Parities 5 – 8. The total lesion score for each side of the sow's body was calculated, and the average of the two totals calculated for analysis. Delta values were calculated for sow backfat and injury scores, allowing the change in these measures between observations to be analysed. A mixed model analysis in SAS (Proc Mixed) was used to compare the injury scores and productivity of sows of similar parities (low, medium or high) in uniform versus mixed groups. The model included treatment (uniform or mixed) and parity score (1-3) nested within treatment as main effects, and replicate as the random effect, with individual sow as the experimental unit. For the analysis of lameness and injury scores, the effect of mixing pen nested within treatment was also included as a main effect.

Detailed feeding behaviour was analysed on a subsample of focal sows, chosen at random (50% or 30 sows per pen: 720 in total). Due to the volume of feeder data, focal days were also selected to give a representative examination of feeding behaviour. Focal days were days 2 and 5 of weeks 1 and 2 (early gestation), weeks 5 and 6 (mid gestation) and weeks 9 and 10 (late gestation). The ESF Nedap time stamp files were sorted and the relevant information regarding the focal sows on focal days was extracted. Erroneous data were removed where there had been an obvious misinterpretation of data from the ESF station. For example, time entries > 2hr were deleted as it was deemed unlikely that one sow would be in the ESF station for such a long period of time. The focal sow feeding data were then used to calculate average daily feeding duration per sow and ESF average daily entry order. ESF feeder entry order was calculated using the equation suggested by Strawford et al. (2008). Feeders were reset at midnight each day. Within each day, the first sow to enter an ESF station received a score of zero and the last sow received a score of one. Each sow was received an average feeding entry order for each period (early, mid, late, gestation). The mean (and standard deviation) of feeder entry scores was calculated for each individual sow. Within each treatment, the mean feeder entry order scores were correlated with measures of production. A mixed model (reml) analysis was also used to compare the average daily feeding duration and average daily ESF entry scores in uniform versus mixed parity groups, through the three time periods (early, mid or late gestation). This model also included treatment (uniform or mixed) and parity score nested within treatment as main effects, with replicate as a random effect. To examine relationships between ESF entry order with sow weight and parity, a Pearson's correlation analysis was performed.

From the preliminary analysis of production parameters, backfat appeared to be a more sensitive indicator of treatment effects than other measures (e.g. body condition score). Of the 20% of sows that were backfat sampled only 79 had complete measurements of back fat both going into pen and before farrowing, allowing a calculation of change in backfat over gestation. The change in backfat value from entering the gestation pen at 5 weeks until 15 weeks gestation was analysed using a mixed model analysis (Proc Mixed), with both average daily feeding time, and ESF entry score as covariates.

6. Results

6.1 Feeding behaviour

Daily feeding duration: The average daily feeding duration for each treatment during the three periods studied (early – weeks 1 and 2; mid – weeks 5 and 6; and late - weeks 9 and 10 following mixing) is shown in Figure 3.

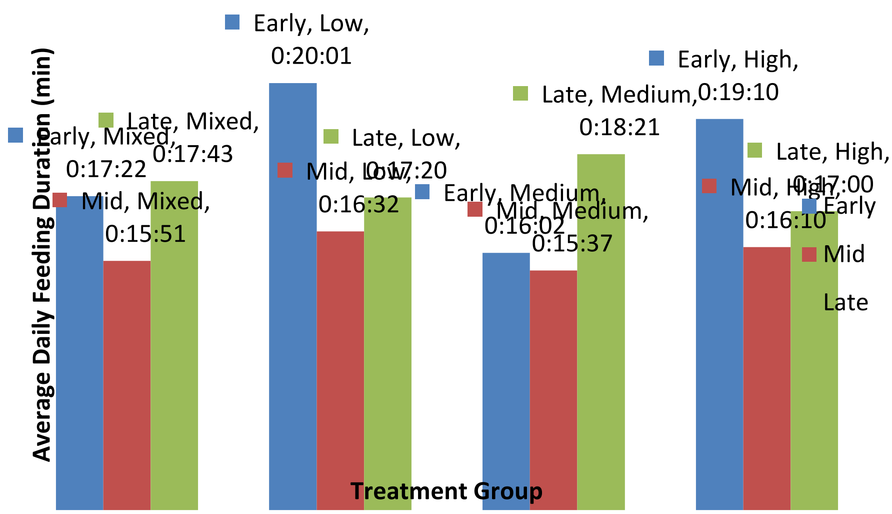

Figure 3. Average daily feeding duration (mins per sow) of mixed parity and uniform low, medium and high parity groups in early, mid, and late gestation periods.

Table 4 shows the same daily feeding data in more detail. Throughout all of the treatments and periods, the average meal length varied between 15 and 20 minutes. The longest feeding duration was found in the first period (first 2 weeks after mixing) with an average time of 20:01 for sows in the low parity treatment group. The longer feeder visits by low parity groups on entry into the ESF system may be due to the novelty of the feeder for younger sows. There was no significant difference in average feeding duration between treatments (F=0.88, DF=3, P=0.45), however, there was a significant difference between periods within treatments (Table 5) and interactions between treatments and periods (F=0.88, DF=3, P < 0.001) all involving the first period of the low treatment with another combination. As described in the methods section above, feeder visits > 2hrs were deleted from the data set, and several sows were recorded as having spent in excess of 20hrs in the feeding station over a 24hr period.

This was an unexpected finding and may highlight errors with either the RFID tags or the data recorder itself. Advice has been sought from Nedap and HPP as to what could have caused this problem.

Table 4. Mean, minimum, maximum and standard deviation of daily feeding duration (minutes per sow) over three periods of gestation (early, mid, late).

Treatment	**Time Period***	**Mean**	**Min**	**Max**	**S.D**
Control	Early	0:17.22	0:02:14	1:24:09	0:09:20
	Mid	0:15:51	0:01:52	1:05:14	0:07:29
	Late	0:17:43	0:00:21	1:05:33	0:07:51
Low	Early	0:20:01	0:06:42	1:50:13	0:13:42
	Mid	0:16:32	0:04:19	1:07:42	0:08:08
	Late	0:17:20	0:00:07	0:57:36	0:09:00
Medium	Early	0:16:02	0:00:17	0:57:50	0:07:29
	Mid	0:15:37	0:01:28	0:35:15	0:05:40
	Late	0:18:21	0:00:07	0:46:28	0:08:01
High	Early	0:19:10	0:00:09	1:13:07	0:11:47
	Mid	0:16:10	0:01:17	0:56:24	0:06:38
	Late	0:17:00	0:00:21	0:38:47	0:06:59

**Period: Early = weeks 1 and 2; Mid = weeks 5 and 6; Late = weeks 9 and 10 following mixing.*

Table 5. Least squares means for daily feeding duration compared across gestation periods for mixed parity and uniform low, medium and high parity groups.

**Period: Early = weeks 1 and 2; Mid = weeks 5 and 6; Late = weeks 9 and 10 following mixing.*

Treatment	Period 1 (Early)	Period* Period 2 (Mid)	Period 3 (Late)	Pooled SEM	*P*-value**
Mixed	0:17:22	0:15:51	0:17:43	0:08:13	NS
Low	0:20:01*a*	0:16:32*b*	0:17:20*b*	0:10:17	<0.01
Medium	0:16:02	0:15:37	0:18:21	0:07:03	NS
High	0:19:10	0:16:10	0:17:00	0:08:28	NS

***Within a row, where superscripts differ, P<0.05*

Feeder entry order: In order to determine if feeder entry order was related to dominance within the group, Pearson's correlations were performed between average entry order and body weight (on entering the study) and parity as indicators of dominance. While both correlations produced P-values <0.01, the correlation coefficients were extremely low (body weight x entry order: R=0.13; parity x entry order: R=0.07), displaying a significant, but very weak positive relationship. Due to the variation in parity (and sow size) across treatments, further analysis will be done to explore these correlations within treatment groups.

6.2 Feeding behaviour as a predictor of production

The change in backfat over gestation was not affected by the average entry score (F=0.12, *P*= 0.949), or by the average daily feeding duration (F=0.13, *P*= 0.722). For the backfat values of sows going into farrowing there was a significant effect of average entry score (F=7.49, *P*= 0.007), however, no effect of treatment was found. There was also a significant effect of average daily feeding duration on backfat (F=4.19, *P*= 0.042), but again no treatment effect was found.

A Spearman's Rank Correlation was performed to investigate the relationship between backfat depth before entering farrowing and the average daily feeding duration throughout gestation. A significant positive correlation was found, showing that sows with longer feeding times had greater backfat levels. However, similar to the earlier correlations the R-value was very low (R=0.15; P <0.05). Correlation of the average ESF entry score and backfat depths before going into farrowing also gave a significant result (R=-0.14; P<0.05), indicating that sows which fed earlier in the daily feeding cycle had greater backfat.

6.1 Effect of grouping on sow production performance

Between treatments, differences were found in the number of stillborn piglets, mortality to 5 days and number of piglets weaned. These results are presented in Table 6.

Table 6. Least squares means of production variables per litter for each treatment group, showing differences among treatments.

	Treatment*					
Variable	Mixed	Low	Medium	High	SEM	*P*
Stillborn	0.63a	0.40b	0.55ab	0.81a	0.14	<0.005
Piglet mortality	1.19a	1.14a	1.51ab	1.83b	0.15	<0.001
Full value weaned	9.92a	10.22a	10.00ab	9.37b	0.19	<0.005

**Within a row, where superscripts differ, P<0.05.*

Sows in the medium and high groups did not differ in their productivity. However, compared to the mixed and uniform low groups, sows in the uniform high treatment weaned significantly fewer full value piglets and had higher piglet mortality, with the uniform medium treatment falling in between. Between treatments, there were no differences in the total number of piglets born, the total number born alive, or mummified piglets born (data not shown).

Significant interactions were found between parity score and treatment for total piglets born, piglet mortality and piglets weaned (Table 7). However, when considering the interactions among treatments within parity score (which is of greatest interest to this study), there were few differences. Primarily, these interactions reflected differences in productivity that can be expected between sows of different parities, rather than as a direct result of the treatments. For example, sows of parity score 2 in the uniform high treatment had higher total born, but lost more piglets during lactation and consequently weaned fewer piglets, and is likely due to the fact that parity score 2 sows in the uniform high treatment were all in parity 4, whereas parity score 2 sows in other treatments were a mixture of parities 3 and 4.

Table 7. Least squares means for significant sow production variables, showing interactions among treatments within parity score. Within a parity score, where superscripts differ, $P < 0.05$.

	Parity score 1*		Parity score 2*				Parity score 3*				
Variable	Mixed	Low	Mixed	Low	Medium	High	Mixed	Medium	High	Pooled SEM	*P***
Total Born	12.96a	13.47a	14.19ab	13.66a	14.02a	15.51b	13.42a	13.39a	13.36a	0.50	<0.05
Born Alive	12.98	12.57	12.63	12.96	12.84	13.08	12.31	12.78	12.13	0.25	<0.01
Stillborn	0.41	0.52	0.54	0.29	0.54	0.57	0.95	0.56	1.06	0.17	<0.01
Mummified	0.29	0.60	0.52	0.44	0.31	0.04	0.45	0.32	0.50	0.16	NS
Piglet mortality	0.81a	1.18a	1.24a	1.11a	1.11a	1.93b	1.53a	1.92a	1.73a	0.19	<0.05
Number of pigs weaned	10.27a	10.06a	10.01ab	10.37a	10.25a	9.44b	9.47a	9.74a	9.30a	0.24	<0.05

** Parity scores: 1= parities 1 &2; 2= parities 3 & 4; 3= parities 5-8 .*

***P values for overall parity score x treatment interaction.*

Analysis of the change in backfat between entering the gestation pen (at five weeks gestation) to 15 weeks gestation showed significant interactions between treatment and parity score (Table 8).

In general this data suggests that younger sows (parity score 1 and 2) housed in uniform groups fared better than in mixed parity groups over the course of gestation, and were able to increase backfat depth in the uniform groups, but lost backfat when housed in a mixed parity group. This was especially true for sows of parity score 1, which lost an average of 4.12 mm backfat in the mixed parity treatment. Sows of parity score 3 in the uniform medium parity treatment faired the best overall, gaining 1.99 mm of backfat over gestation.

Table 8. Changes in sow backfat (mm) between entering the gestation pen (5 weeks gestation) to 15 weeks gestation, showing interactions among treatments within parity score, (n = 262).

Parity Score		
1	2	3
Treatment	Treatment	Treatment

Mixed	Low	Mixed	Low	Medium	High	Mixed	Medium	High	Pooled SEM	P
-4.12[a]	0.22[bc]	-0.45[bc]	0.99[c]	0.87[c]	0.50[bc]	0.17[bc]	1.99[bc]	-0.64[b]	1.29	<0.05

Within a parity score, where superscripts differ, P<0.05

6.2 Effect of group type (mixed vs uniform) on sow welfare

6.2.1 Sow lameness

Comparing the change in sow gait scores between the different observation periods, (pre-mixing to days 3 and 7 after mixing), the mixed parity group had a significantly greater increase in average lameness score from the pre-mixing assessment to day 3 after mixing, and also in the period from premixing to the seven days after mixing, than did in the three uniform parity groups (Table 9). This indicates that there was a greater risk of lameness following mixing when sows were housed in mixed parity groups, and that housing sows in uniform groups helped to reduce the severity of lameness which developed as a result of mixing.

Table 9. Changes in average lameness score following mixing in mixed and uniform parity treatment groups.

Observation period	Treatment*				Pooled SEM	*P*
	Mixed (control)	Low	Medium	High		
Pre-mixing to D3 after mixing	0.228a	0.068b	-0.015bc	-0.09c	0.05	<0.01
D3 to D7 after mixing	-0.115	-0.011	0.086	0.046	0.09	0.09
Pre-mixing to D7 after mixing	0.173a	0.039b	0.001b	0.055b	0.06	0.05

*Significant differences between treatment groups were superscripts differ. Negative values represent a reduction in lameness severity, positive values represent an increase in lameness severity.

For all analysis of lameness, there was a strong effect of the mixing pen used, suggesting that there may be additional external factors (eg flooring or pen configuration) contributing to why some groups of sows experienced more lameness than others.

6.2.2 Sow lesion scores

The total average body lesion score increased in severity from premixing to rescoring at five days after mixing in all treatments. From premixing to day 5 after mixing the uniform high parity group had significantly lower change in lesion scores than all other treatments, and the uniform low parity group had the greatest change, being significantly higher than the mixed and uniform high groups (Table 10). This suggests that younger sows were more aggressive at mixing, whereas older sows displayed less aggression. Total average lesion scores decreased from five days after mixing to the final measure at seven days after entry to the gestation pen, with the mixed, and uniform low and medium parity group treatments showing significantly greater reductions in lesion score severity than the uniform high treatment.

Table 10. Changes in total average lesion score at different observation periods following mixing in mixed and uniform parity treatment groups.

Observation period	Treatment*				Pooled SEM	*P*
	Mixed (control)	Low	Medium	High		
Premixing to D5 after mixing (in mixing pens)	5.84[b]	6.90[a]	6.52[ab]	3.83[c]	0.55	<0.001
D5 after mixing to D7 after movement to gestation pen	-3.98[a]	-4.08[a]	-4.37[a]	-0.47[b]	0.59	<0.001

*Where superscripts differ within a row, P<0.005.

Comparing injury score levels between the sows of the same parity score across treatments (Table 11), we found that sows of parity score 2 (i.e sows of parity 3 or 4) in the uniform high treatment had the lowest injury scores following mixing, while sows in the uniform low treatment had the highest scores, with sows in the mixed and medium groups showing no difference. A similar relationship was found across treatments in sows of parity score 3. No difference in injury scores was found between mixed and uniform treatments in sows of parity score 1 (parities 1 - 2). These results support the conclusion that younger sows displayed more aggression than older sows, similar to the main treatment effect described above.

Table 11. Changes in total average lesion score at different observation periods, showing interactions across treatments within parity score.

Observation period*	Parity Score**									Pooled SEM	P
	1		2				3				
	Mixed	Low	Mixed	Low	Medium	High	Mixed	Medium	High		
Premixing to D5 after mixing	6.23a	6.57a	6.19a	7.23b	6.52a	4.50c	5.09a	6.52a	3.16b	0.60	<0.01
D5 after mixing to D7	-4.14	-3.75	-4.37	-4.41	-3.90	-0.78	-3.43	-4.84	-0.15	0.65	0.09

** Observation periods: Premixing to day 5 after mixing: sows were housed in a mixing pen. Day 5 after mixing to day 7 after movement to the final gestation pen.*

*** Within parity score, where superscripts differ, P<0.05.*

6.3 Further analysis of results

The results presented in this report are a preliminary analysis. A more thorough analysis of feeding behavior during gestation is ongoing. Further raw data will be extracted from the ESF time stamp files, such as time of first entry for each focal sow on each focal day, and number of visits made to the feeding station throughout the day to determine the level of recycling. We will also determine if feeder visits varies with treatment or parity, or if this changes over time in gestation.

Correlations of feeder entry order with sow size and parity will be repeated within treatment groups. Correlations between backfat depth and average feeder entry order and avg feeder time will also be repeated within treatments to determine if sows entering earlier in the feed cycle have greater backfat levels. Relationships will also be tested between feeding behaviour and lesion and lameness scores.

In addition, the number of sows that were removed from the different treatments during the course of gestation due to low BCS, injury and lameness will be compared among treatments. The authors will continue to develop this data analysis in preparation for presentation at 2014 conferences, and for preparation of a manuscript for submission to a peer reviewed journal.

7. Discussion

As a preface to this discussion, it should be noted that data collection for this study was preceded by a PRRS outbreak in the herd. This resulted in delays in the data collection and reduced production levels in sows, and should be taken into consideration when evaluating the performance data presented in this report. However, all treatments were tested in parallel, and efforts were made to ensure that any effects due to PRRS exposure would be evenly distributed among the treatments.

The longest average feeding duration was performed by the low parity treatment group during the first 2 weeks after mixing in the gestation pen, with these sows spending approximately 20 minutes per day feeding. The longer feeding times in younger sows may be the result of their lack of familiarity with the system as compared to older sows. Longer feeding times in young sows could also be an effect of age, as previous studies have shown that feeding time decreases with age in grower pigs (H. Gonyou and Y. Li, pers. comm.) Looking at the range of feeding durations observed, all treatments showed extremes, with some feeding durations lasting only seconds and, others lasting close up to one hour. These extremes in feeding duration suggest that the ESF system may not running to the best of its ability. The short feeder times may indicate that some sows are not able to eat their complete ration each day, and the longer durations may indicate recycling within the system (repeated feeder visits). Further analysis of the feeder data will examine these possibilities.

In this study, both body weight and parity were correlated with feeder entry order score, however the r values obtained were extremely low. This is likely due to the fact that the correlation did not take into account the distribution of parities across treatment. Further analysis is needed to explore these relationships, as previous studies, such as Strawford et al (2008) have found a significant effect of parity on the feeder entry order in mixed parity groups, with young sows eating significantly later in the feeding cycle than old or intermediate sows. Significant correlations were also found between backfat levels and average feeding duration and ESF entry scores. Again, the r values were extremely low, and the analysis will be repeated within treatments.

Production differences:

The production differences observed between treatments (number of full value piglets weaned, number of stillborn piglets and piglet mortality), are a likely result of effects of parity on production, rather than the effect of the treatment itself. The same is believed for the many interactions seen in the production data, between the treatments and within the parity differences. Overall, the better performance, in terms of largest number of total pigs born, born alive and weaned, was achieved with the medium parity sows (3-4), in both the uniform and mixed parity groups. It is commonly known that sows are most productive between parities 3 to 6 (Hypor, 2009), and hence sows in this range would be expected to be performing at their best (in all treatments). The treatments were not significant enough to greatly influence production. This is also likely as every sow that remained in the ESF system for full gestation, and thus was included in the production analysis, are sows that were able to successfully maintain BCS, and were not severely lame or injured etc, as these would have been removed from the pen for treatment or culling. Thus, they were also likely to maintain a successful pregnancy. Therefore, it is questionable as to whether it would be expected to see production differences in such sows as a result of the ESF. Further analysis that is ongoing to examine differences in the number of sows that were removed from the different treatments during the course of gestation due to low BCS, injury and lameness. If the number of removals is high, this could highlight areas of parity grouping management that may not work well in ESF systems. This may also highlight problem areas for the management of ESF systems.

Backfat levels:

Within the mixed parity treatment, high parity sows were the only sows able to increase back fat depth over the course of gestation, while sows of medium and low parity (parity scores 1 and 2) housed in mixed groups lost backfat over the course of gestation. In the mixed parity treatment, parity 1 and 2 sows (parity score 1) fared the worst, losing 4.12 mm of backfat on average, while in the uniform treatment these sows showed an average gain of 0.22 mm, indicating a clear benefit of the uniform treatment for young sows. Although parity 3 and 4 sows (parity score 2) did not fare significantly better in uniform groups, these sows did show positive gains when in uniform groups, but lost backfat in the mixed treatment. This suggests that in the mixed group, high parity sows were faring better, possibly by dominating access to the ESF system, and reducing the ability of younger parity sows to feed at regular intervals, or preferred times of day. In ESF systems, larger, more dominant sows have been found to get priority use of the ESF, eating earlier in the feeding cycle than younger sows (Strawford et al. 2008). In mixed groups, the older, dominant sows will have increased success at getting their daily feed allowance, and may also gain access to feed of lower ranking sows. Kranendonk et al. (2007) found that high social ranking sows fed in an ESF gained more weight over gestation than lower ranking sows, and sow backfat thickness has been found to correlate to sow body weight (Rossi et al. 2008). Exploring feeder entry order of the focal sows and relating to backfat may help to explore and explain this further.

Overall, housing younger sows in groups of uniform parity appeared to help them to maintain condition by evening out competition at the feeder. Among the uniform treatment groups, only the high parity sows in the uniform high parity group lost backfat over gestation, suggesting that some of the older sows were not able to compete as well, and suffered more from competition in a uniform group of high parity sows.

<u>Lameness:</u> Housing sows in mixed parity groups also appears to lead to increased lameness following mixing. Sows in mixed parity groups showed a significantly a greater increase in lameness scores between premixing to day 3 after mixing than any of the uniform treatment groups. This suggests that uniform groups fought less, and are thus at less risk of injury and lameness following mixing. However, this was not supported by lesion scores (discussed below) and several other studies have found the opposite; that groups of uniform parity pigs will typically fight more, with less intensive fighting occurring in groups of pigs varying in size (Moore et al. 1994, Rushen 1987). There was also a significant effect of mixing pen on sow lameness, and this is an area that would be worthwhile investigating further to determine whether the environment pigs were mixed in (e.g. flooring or pen layout) could be having an effect on the lameness, more than the treatments themselves.

<u>Sow lesion scores:</u> The lesion score data suggest that the greatest amount of mixing aggression occurred in the initial days following mixing. Injury scores from D5 post mixing in the mixing pen to D7 in the final gestation pen were reduced in all groups, indicating that time in the mixing pen had resulted in stable groups, with minimal aggression after movement to the gestation pen.

Unlike the lameness results, the use of uniform parity groups did not result in reduced injury scores following mixing in this study. Instead, levels of aggression appeared to be related to sow age, with the uniform low parity group having the highest level of injury scores. Medium and mixed parity groups had intermediate lesion scores, and high parity having the lowest level of injuries at D5 post mixing. Previous studies have found that housing sows in uniform groups resulted in more intense fighting (Moore et al. 1994, Rushen, 1987), primarily as uniform groups even out the competition between individuals, and thus it could be expected higher injury scores would ensue. The high parity treatment group having lower lesion scores than other groups post treatment may suggest that the older sows become better adapted to mixing over time, and are possibly more familiar with pen mates, and thus fought less. In comparison to injury scores between uniform parity groups housed in ESF, Strawford et al. (2008) also found the low parity sows had the highest injury score post mixing. However, based on behavioural analysis, Strawford et al. (2008) found that in uniform parity groups, sows of a higher parity had more aggressive interactions than did sows of an intermediate and low parity groups, suggesting that the type of aggressive interaction may change between older and younger parity sows, with older sows performing aggression, yet receiving fewer injuries. Pitts et al. (2000) suggest that the type of aggression may alter in larger pigs due to the relative space in the pen, larger pigs having less space to manoeuvre and escape from attacks. Similarly, pigs with improved social abilities (e.g. previous mixing experience) have been found to reach a stable hierarchy quicker (D' Eath, 2005).

<u>ESF feeder data</u>: ESF feeders provide automated data on the feeding behaviour of sows, and as such have great potential as a research tool for studying the behaviour of gestating sows. A number of manufacturers produce these systems, and each system varies in how it registers the sow at feeding, and what reports and data are available to export. The Nedap Velos feeder uses one RFID tag reader located near the feed bowl. In many cases, multiple feeding records were recorded for one sow, giving the impression that the sow had made multiple visits to the feeder. However, on closer examination it was found that, if the sow remained in the stall but moved her head away from the feeder, multiple data lines were created even though the sow had made only one 'visit' to the feeder. For this reason it is recommended that researchers perform an initial analysis of feeding behaviour (from live observations or video recording), and correlate this with feeder data before conducting more lengthy analysis. This will help to validate subsequent analysis of the feeder data, and add strength to any conclusions made. There were also a variety of data problems which were impossible to interpret, even with the assistance of technical staff at Nedap. This resulted in a lengthy manual data cleaning process in order to produce files which were suitable for analysis.

Further studies on ESF feeding behaviour, for example: the relation between feeder settings and feeding time per sow, comparisons of feeder time in different ESF systems, or further research on social dynamics in group housing, is recommended. In future, ESFs may also be combined with a broad range of sensors, eg infrared detectors, or force plate scales, providing information on sow health.

Conclusions and Take-home message

The preliminary results from this study suggest that housing sows in uniform groups in ESF systems may be a positive strategy for the management of group housed sows. In this study housing sows in uniform groups helped to reduce the severity of lameness developing as a result of mixing. The increases in backfat over gestation, particularly in young sows in uniform groups, also suggest that the well-being of younger sows may be better in uniform groups over the course of gestation. Young (parity 1 and 2) sows in uniform groups were able to increase backfat, as opposed to loosing it in mixed groups, suggesting that competition at the feeder may not be as great a challenge in uniform groupings. The practice of managing gilts separately is already a common practice, and the results of this study indicate that parity 1 and 2 sows may also benefit from this practice. The productivity of sows in uniform groups was equivalent to that of mixed groups. Maintaining uniform groups may help reduce mixing injury, with injuries sustained following mixing being equal to or lower than the mixed parity groups, with only the low parity uniform group having higher injury scores. This appears to be related to the social ability of younger pigs, rather than grouping, and thus management practices that improve sociability of gilts (e.g. group housing with repeated mixing before breeding) may be a further area of research to be examined.

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