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Pre-sorting and pen size effects on the stress responses at loading and unloading and transport losses in market weight pigs

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Introduction

Transport losses represent three challenges for the US swine industry and these are: 1) pig well-being, 2) increased rules and regulations, and 3) direct financial losses to producers and packers. Therefore, improving the well-being of pigs during transport and reducing the incidence of dead and non-ambulatory pigs is a priority for the US swine industry (NPB, 2007). Johnson et al. (2010) studied the effects of grow-finish pen size and manually pre-sorting pigs the day before loading on the stress responses at loading and unloading and transport losses in market weight pigs. The authors reported that pigs loaded from large pens (192 pigs/pen) that were pre-sorted from pen mates had 66% fewer dead and non-ambulatory pigs at the harvest facility compared to pigs loaded from small pens (32 pigs/pen) that were sorted from pen mates during loading. However, it is unclear if the reduction in transport losses was due to pen size and/or pre-sorting before marketing. Therefore, the objectives of the current two research trials were to 1) determine the effects of pre-sorting prior to loading on stress responses and transport losses at the harvest facility in the market weight pig; and 2) determine the effects of grow-finish pen size on stress responses and transport losses at the harvest facility in the market weight pig.

Materials and methods

Animals

The protocols for both studies were approved by the Iowa State University Animal Care and Use Committee. Pigs in both trials were transported to three commercial wean-to-finish facilities located in the Midwest at approximately 18 d of age and were marketed at 195 ± 16 d (Trial #1) and 199 ± 9 d (Trial #2) of age. These pigs were from a standard commercial terminal genetic line and were selected to be free of the HAL-1843 mutation, which is known to impact pre-harvest mortality and pork quality (Murray and Johnson, 1998; Fábrega et al., 2002). In trial one, thirty-three loads of mixed sexed market weight pigs ($n = 5,802$; BW = $120.3 \text{ kg} \pm 5.3 \text{ kg}$) were used. In trial two, twenty-six loads of market weight pigs ($n = 4,522$; BW = $122.0 \text{ kg} \pm 10.6 \text{ kg}$) were used.

Production sites

Sites were identical in design and had the same feed and water delivery systems. Each site was a wean-to-finish facility, divided into two, naturally ventilated rooms. Each room had fully slatted concrete floors (2.5 cm wide by 1.3 m long) and a 64 cm wide center aisle). Pens measured 7.3 m long by 2.9 m wide and were divided by steel gates and the back gates of each pen had the ability to swing freely or could be locked in a closed position (as previously described by Johnson et al., 2010). Pigs were fed a standard finishing diet that met or exceeded the pigs' nutritional requirements for this phase/weight (NRC, 1998). Pigs were provided ad libitum access using a wet dry feeder (1.4 m high \times 43.2 cm wide \times 1.5 m long; with a 12 cm deep pan). Water flow rates were 1.5 L/min, which is within the recommended guidelines for grow-to-finish pigs (NPB, 2009). Pigs were observed daily at 0800 h to ensure pig health and facility maintenance.

Treatments

In each trial, both treatments were housed within each room at each site (Figures 1 and 2). Treatment locations were alternated between the two rooms at each site allowing both treatments to be equally represented on each side of the barn. Floor space and feeder space allowances were standardized across the two treatments. Two days prior to loading, market weight pigs from both treatments were marked on the back with a red or green animal safe paint (Prima Spray-on, Prima Tech, NC, U.S.). Observers collecting data were blinded to treatments. Marking was accomplished by the primary caretaker walking through each pen and marking pigs that visually appeared to be at the target market weight window ($\sim 121 \text{ kg}$).

Trial #1

Large no pre-sort (NON). Pigs were housed in mixed gender pens of 292 ($0.65 \text{ m}^2 \cdot \text{pig}^{-1}$). Pigs that had been pre-determined to have reached the targeted market weight in NON pens were sorted from pen mates during loading. Sorting was completed by a marketing crew consisting of four experienced persons (range of 2 to 6 years of practical swine production and loading experience) shutting all the internal gates immediately prior to sorting. Market weight pigs were removed from their home pen and loaded onto

Figure 1: Schematic barn diagram for the large pen, pre-sorted (PRE) treatment and the large pen, not pre-sorted (NON) treatment used in the study determining pre-sorting effects on market weight pigs from three grow-finish facilities in a large Midwestern pork production system.

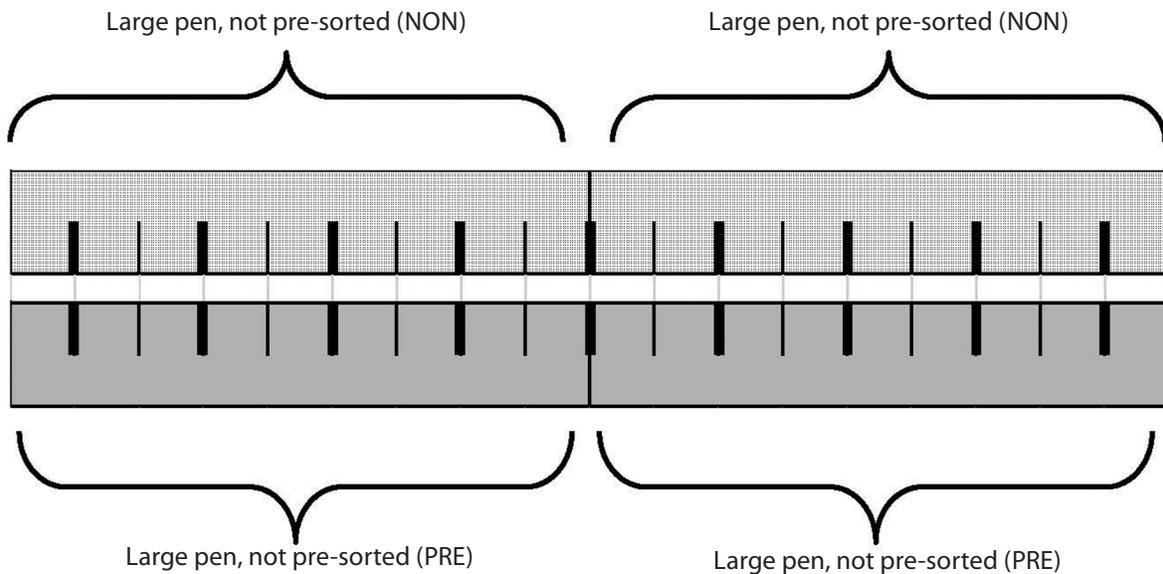
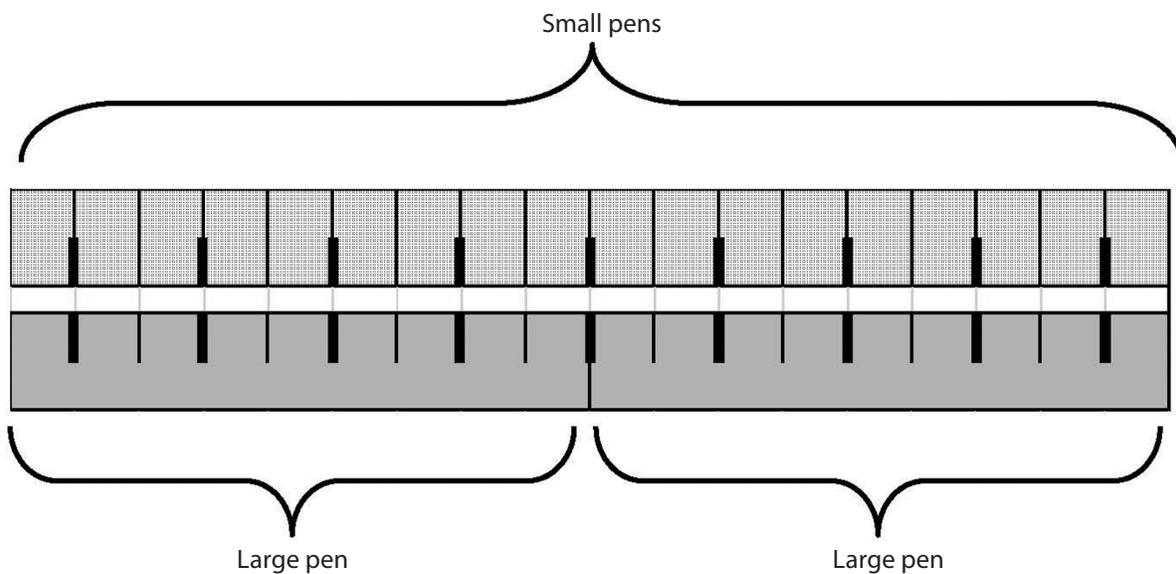


Figure 2: Schematic barn diagram for the small pen (SP) facility design treatment and the large pen (LP) facility design treatment used to determine the grow-to-finish pen size effects on market weight pigs from three grow-finish facilities in a Midwestern pork production system.



the trailer. Immediately after sorting and loading was completed, all internal gates were re-opened to return to the large pen configuration.

Large pre-sort (PRE). Pigs were housed in mixed gender pens of 292 ($0.65 \text{ m}^2 \cdot \text{pig}^{-1}$). Pigs that had been pre-determined to have reached the targeted market weight in PRE pens were pre-sorted from pen mates by the same four person marketing crew as previously described. The back swing gates were used to sort market weight pigs and locked to separate sorted pigs from their pen mates 18-h

before loading. At the time of loading, pre-sorted pigs were moved onto the trailer and after all loading was completed, all internal swing gates were re-opened to return to the large pen configuration.

Trial #2

Small pen (SP). Internal swing gates remained closed throughout the grow-finish period to create the small pen facility design. Pigs were housed in single gender pens of 36 pigs ($0.59 \text{ m}^2 \cdot \text{pig}^{-1}$). Pigs that had been pre-determined

to have reached the target market weight were sorted from pen mates during loading.

Large pen (LP). The internal swing gates of nine consecutive pens remained open throughout the grow-finish period to create the large pen facility design. Pigs were housed in single gender pens of 324 pigs ($0.59 \text{ m}^2 \cdot \text{pig}^{-1}$). All eight swing gates were closed immediately prior to sorting and loading. Approximately equal pig numbers were in each newly closed small pen. Pigs that had been pre-determined to have reached the target market weight were sorted from pen mates during loading. Immediately after market weight pigs were sorted out of home pens, the back swing gates in LP were re-opened and secured against the wall to re-create the large pen facility design.

Pig handling and loading procedures

Pigs were moved from their home pen to the loading ramp by the same four-person loading crew and all the handling methods were based on the production system's standard operating procedures. Groups of four to six market weight pigs were removed from their pen, moved down the center aisle of the building and onto the transport trailer using sorting boards and if necessary electric prods. The covered loading ramp used to load pigs onto the trailer was 91 cm wide and 4.9 m long, incorporating a 14 degree angle at all sites. Each loading ramp had 4.5 cm. wide \times 1.9 cm. long cleats that were spaced 20.3 cm. apart.

Transport trailers and transport floor spaces

For Trial #1, data collection occurred from December 23, 2008 to March 25, 2009. For Trial #2, data collection occurred from July 26 to August 29, 2009. Aluminum straight-deck trailers (Wilson Trailers, Sioux City, Iowa) owned and operated by the production system were used for both trials. In each trial, air vents were in compliance with the National Pork Board's Transport Quality Assurance program(tm) recommended transport trailer set-up procedures (NPB, 2008). Fresh wood shavings were used as bedding to cover the trailer floor at ~ 2.5 cm in depth. All compartments in the trailer were stocked according to the production system's current standard operating procedure of $0.41 \text{ m}^2 \cdot \text{pig}^{-1}$; approximately 176 pigs / load). During loading, treatments were assigned to trailer decks in an alternating pattern, and both treatments were represented within each trailer load of pigs. Immediately after loading was complete, pigs were transported 84.8 ± 7.2 km (~ 1 hour) to a commercial harvest facility.

Loading time by treatment

Loading time by treatment was defined as the time interval when the first pig stepped onto the trailer to the time when the last trailer compartment gate was closed. All swing gates in NON and LP were closed immediately prior to loading, therefore this was not included in loading time.

Stress responses and losses during loading and unloading

Physical signs of stress were recorded by 3 trained during loading (1 at the farm site) and unloading (2 at the plant). During loading and unloading the following measures were recorded: 1) open-mouth breathing frequency (defined as the pigs upper and lower jaw being held open, the top lip could be pulled back exposing gum and/or teeth and pigs were seen to be panting [inhalation and exhalation of the flanks was pronounced]), 2) skin discoloration (defined as a blotchy red appearance that was typically visible on any body part of the pig), and 3) muscle tremors (defined as muscular contractions that were typically observed on the flanks / limbs of the pig). At loading farm non-ambulatory (defined as pigs at the time of loading that were unable to move or maintain the same walking speed as the other pigs within the group; Anderson et al., 2002) was also recorded. Harvest facility employees identified dead pigs on arrival (DOA) and non-ambulatory pigs. Trained Iowa State University personnel at the harvest facility classified non-ambulatory pigs into two categories: fatigued and injured. Fatigued pigs were defined as non-ambulatory or slow moving pigs that displayed physical signs of stress (open-mouth breathing, skin discoloration, and / or muscle tremors). Injured pigs were defined as pigs with a compromised ability to move due to an injury or structural unsoundness. Total losses at the plant were defined as the sum of dead and total non-ambulatory (summation of fatigued and injured) pigs at the harvest facility.

Statistical analysis

The effects of 1) pre-sorting before marketing and 2) grow-finish pen size; on the stress responses during loading and unloading and transport losses at the plant were compared in a randomized complete block design, where the trailer load of pigs was the blocking factor and the trailer deck was the experimental unit. All data were evaluated for normal distribution prior to analysis using PROC Univariate of SAS (SAS Inst. Inc., Cary, NC). Data used to evaluate the physical signs of stress during loading and unloading (open mouth breathing, skin discoloration and muscle tremors) and transport losses (non-ambulatory pigs) failed to meet the assumption of normally distributed data. These data were analyzed by using PROC GLIMMIX of SAS (SAS Inst. Inc., Cary, North Carolina). The model included the fixed effect of treatment and the random effects of date nested within site and the trailer load of pigs, which was nested within date and site. The number of pigs transported was used as a linear covariate. A Poisson distribution was noted and used in the evaluation using the GLIMMIX procedures. Further, the I-Link option was used to transform the mean and standard error values back to the original units of mea-

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sure. For trial #1, at unloading, dead pigs on arrival could not be run due to low occurrences and will be presented descriptively. For trial #2, at loading, the incidence of muscle tremors and farm non-ambulatory would not run due to low occurrences, and at unloading, dead pigs on arrival and injured pigs could not be completed in SAS and will also be presented descriptively. Loading time data were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC). The model included the fixed effect of treatment and the random effects of date nested within site and the trailer load of pigs, which was nested within date and site. Number of pigs transported within a deck was used as a linear covariate. A P -value of ≤ 0.05 was considered to be significant.

Results and discussion

Length of time to load a trailer deck

Trial #1: Loading times differed ($P < 0.001$) between treatments with NON pigs (21.7 min/deck) taking longer to load compared to PRE pigs (17.4 min/deck).

Trial #2: Loading time differed ($P = 0.0047$) between housing facility design systems with the LP pigs taking longer to load (21.1 min/deck) compared to the SP pigs (18.9 min/deck).

Stress responses and losses during loading and unloading

Trial #1: During loading, PRE pigs had fewer incidences of open mouth breathing ($P < 0.0001$) and skin discoloration ($P < 0.0001$) compared to NON pigs, demonstrating that allowing PRE pigs resting time after being sorted was beneficial. However, the muscle tremors and non-ambulatory incidences at loading and open mouth breathing, skin discoloration, and muscle tremors incidences at unloading were low in general and were not ($P > 0.05$) different between treatments (Table 1). There were no ($P > 0.05$) differences between PRE and NON pigs for the incidence of fatigued, injured, total non-ambulatory, and total losses at the harvest facility (Table 2). During the marketing process only two pigs were classified as DOA in the PRE treatment, while there were no DOAs for the NON treatment at the harvest facility. It is important to note that the total transport losses observed in this study were 0.33% (PRE) and 0.27% (NON).

Trial #2: The SP pigs had fewer incidences of open mouth breathing ($P = 0.0015$) and skin discoloration ($P = 0.01$) at loading than LP pigs (Table 3). Due to the low incidence of muscle tremors statistical analyses were not appropriate and are presented in only a descriptive form. Two pigs were classified as exhibiting muscle tremors in the SP facility design and no pigs exhibited muscle tremors in the LP facility design at loading. There were no non-

ambulatory pigs from either facility design at the time of loading. At unloading skin discoloration was higher ($P < 0.0001$) for SP pigs but no differences ($P > 0.05$) were observed between facility designs for open mouth breathing or muscle tremors (Table 3). At loading there was a higher incidence of open mouth breathing and skin discoloration observed for pigs in LP, while at unloading a higher incidence of skin discoloration was observed in SP. There were no differences ($P < 0.05$) between SP and LP pigs for the incidence of fatigued (0.30 ± 0.39 vs. 0.21 ± 0.44), total non-ambulatory (0.34 ± 0.37 vs. 0.31 ± 0.38), and total losses at the harvest facility (0.34 ± 0.37 vs. 0.31 ± 0.38 ; Figure 3). There were no injured pigs from SP and two from LP and no dead on arrivals from either housing facility design treatment.

Conclusion

Ritter et al. (2009) summarized 23 commercial field trials that obtained transport loss data and found that the estimated national average for total transport losses was 0.69%. Overall, total transport loss percentages obtained in both trials were only each about one-half of this reported national average. It should be noted that intervention strategies such as pre-sorting prior to loading and large grow-finish pen size may not be useful in reducing transport losses on sites that are already experiencing very low overall transport loss incidences, such as the sites in this study. Therefore; further research is necessary to determine whether these implementation strategies are useful on grow-finish sites that are experiencing transport loss percentages at or above the estimated national average.

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Table 1: Stress response least square means (SE) at loading and unloading from pre-sorted versus not pre-sorted market weight pigs.

Measure, %	Treatment		P-value
	NON ¹	PRE ²	
Number of trailer decks ³	33	33	
Number of pigs	2920	2882	
Stress responses at loading			
Open mouth breathing ⁴	12.3 ± 1.7	6.1 ± 0.9	< 0.0001
Skin discoloration ⁵	15.3 ± 3.7	8.1 ± 2.0	< 0.0001
Muscle tremors ⁶	0.2 ± 1.0	0.1 ± 0.1	0.23
Farm non-ambulatory ⁷	0.0 ± 0.0	0.1 ± 0.0	0.53
Stress responses at unloading			
Open mouth breathing	0.3 ± 0.1	0.3 ± 0.1	0.69
Skin discoloration	0.1 ± 0.1	0.1 ± 0.1	0.45
Muscle tremors	0.3 ± 0.1	0.3 ± 0.1	0.96

¹ Large pens, not presorted (NON) had 292 mixed sexed pigs per pen, housed at 0.65 m²*pig⁻¹. Pigs were sorted immediately prior to loading.

² Large pen, pre-sorted (PRE) had 292 mixed sexed pigs per pen, housed at 0.65 m²*pig⁻¹ Pigs were pre-sorted 18 h before market.

³ Trailer deck was the experimental unit for facility design treatments.

⁴ Open mouth breathing is defined as the pig's upper and lower jaw being held open, the top lip could be pulled back exposing gum and / or teeth and pigs were seen to be panting.

⁵ Skin discoloration is defined as a blotchy red appearance that was typically visible on any body part of the pig.

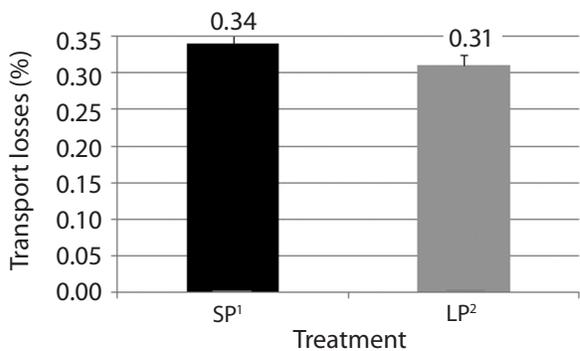
⁶ Muscle tremors are defined as contractions that were typically observed on the flanks / limbs of the pig.

⁷ Farm non-ambulatory is defined as pigs at the time of loading that were unable to move or maintain the same walking speed as the rest of the group.

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Figure 3: Total transport losses by housing facility design. Market weight pigs from both housing facility designs were sorted from pen-mates at the time of loading.



¹ SP facility design consisted of 36 pigs / pen (0.59 m²* pig⁻¹).

² LP facility design consisted of 324 pigs / pen (0.59 m²* pig⁻¹).

Table 2: Transport losses least square means (SE) at the harvest facility for the market weight pig when pre-sorted and not pre-sorted prior to marketing.

Measure, %	Treatment		P-value
	NON ¹	PRE ²	
Number of trailer decks ³	33	33	
Number of pigs	2920	2882	
Fatigued ⁴	0.1 ± 0.1	0.1 ± 0.1	0.94
Injured ⁵	0.1 ± 0.1	0.1 ± 0.1	0.88
Total non-ambulatory ⁶	0.3 ± 0.1	0.3 ± 0.1	0.88
Total losses ⁷	0.3 ± 0.1	0.3 ± 0.1	0.68

- ¹ Large pens, not pre-sorted (NON) had 292 pigs/ pen housed at 0.65 m²*pig⁻¹. Pigs were sorted immediately prior to loading.
- ² Large pens, pre-sorted (PRE) had 292 pigs / pen housed at 0.65 m²*pig⁻¹. Pigs were pre-sorted 18 h prior to market.
- ³ Trailer deck was the experimental unit for facility design treatments.
- ⁴ Fatigued pigs were defined as non-ambulatory or slow moving pigs that displayed physical signs of stress (open-mouth breathing, skin discoloration, and/or muscle tremors).
- ⁵ Injured pigs were defined as pigs with a compromised ability to move due to an injury or structural unsoundness.
- ⁶ Total non-ambulatory pigs were defined as pigs unable to move or keep the same walking speed as the rest of the group (Anderson et al., 2002).
- ⁷ Total losses at the plant were defined as the sum of dead and non-ambulatory (fatigued and injured) at the harvest facility.

Table 3: Stress response least square means (SE) at loading and unloading from small (n = 26 loads) versus large (n = 26 loads) pen size market weight pigs.

Measure, %	Treatment		P-value
	SP ¹	LP ²	
Number of trailer decks ³	26	26	
Number of pigs	2260	2262	
Loading			
Open mouth breathing ⁴	18.2 ± 0.1	22.9 ± 0.1	0.0015
Skin discoloration ⁵	22.7 ± 0.1	26.4 ± 0.1	0.01
Unloading			
Open mouth breathing	4.2 ± 0.3	3.3 ± 0.7	0.13
Skin discoloration	5.8 ± 0.5	3.0 ± 0.5	< 0.0001
Muscle tremors ⁶	0.3 ± 0.5	0.3 ± .05	0.74

- ¹ Small pens (SP) had 34 single sexed pigs per pen, housed at 0.59 m²*pig⁻¹.
- ² Large pens (LP) had 324 single sexed pigs per pen, housed at 0.59 m²*pig⁻¹.
- ³ Trailer deck was the experimental unit for facility design treatments.
- ⁴ Open mouth breathing is defined as the pigs upper and lower jaw being held open, the top lip could be pulled back exposing gum and/or teeth and pigs were seen to be panting [inhalation and exhalation of the flanks were pronounced.
- ⁵ Skin discoloration is defined as a blotchy red appearance that was typically visible on any body part of the pig.
- ⁶ Muscle tremors is defined as contractions that were typically observed on the flanks / limbs of the pig.

