Title: The influence of facility design and pre-sorting on the stress response and transportation losses of the market weight pig **– NPB #08-175.**

Investigator: Anna K. Johnson

Institution: Iowa State University

Date Submitted: 3rd May 2010

Industry Summary

Johnson et al. (2010) reported a 66 % reduction in transport losses in pigs raised in large pen configurations that were pre-sorted, however, the researchers could not determine if the transport loss reduction was from the result of pre-sorting, pen size, or a combination of both factors. Therefore, the factors of pen size and pre-sorting where separately investigated in two current trials. The objective of the first experiment was to determine the effect of pre-sorting on stress responses and transport losses in market weight pigs. Although pre-sorted pigs had lower stress responses at the time of loading, there was no difference in stress responses or transport losses between pre-sorted and not pre-sorted pigs at the harvest facility. The objective of the second experiment was to determine the grow-to-finish pen size effects on the stress responses and transport losses in the market weight pig. At loading, pigs from small pens showed lower stress responses, however; at unloading pigs from small pens had a greater incidence of skin discoloration than their large pen counterparts. There were no differences observed in the present study for any transport loss measures between pigs originating from large and small pen sizes.

Corresponding authors: Leah M. Gesing: lgesing@iastate.edu

Scientific Abstract

The objective of this study was to determine the effects of pre-sorting prior to loading and grow-to-finish pen size on stress responses and transport losses in market weight pigs. This study consisted of two separate experiments, both conducted on three commercial grow-to-finish sites in central Iowa. Each site had two rooms and both treatments from each study were represented in each room. Pre-sorting effects were determined in the first experiment and grow-to-finish pen size effects were determined in the second experiment. For the first experiment, thirty-three loads (~180 pigs/load) of market weight pigs (n=5802) were used in a complete randomized block design. The pre-sorted **(PRE)** treatment had 292 pigs/pen (0.67 m^2*pig^{-1}). Internal swing gates were used to manually pre-sort market weight pigs from pen-mates 18 h prior to marketing. The not pre-sorted **(NON)** treatment also had 292 pigs/pen (0.67 m^2*pig^{-1}) but pigs were not pre-sorted from pen mates prior to loading. For the second experiment, twenty-six loads (~174 pigs/load) of pigs (n=4522) were used in a complete randomized block design. The small pen **(SP)** treatment had 36 pigs/pen (0.59 m^2*pig^{-1}). The large pen **(LP)** treatment had 324 pigs/pen (0.59 m^2*pig^{-1}). To achieve large pens, eight consecutive swing gates were kept open. During loading, all swing gates were closed in LP pens. In both experiments, during loading pigs were moved in small groups using sort boards and electric prods if necessary, and loaded on straight deck trailers. Treatments were randomly assigned to a deck, pigs were provided with ~0.41 m^2*pig^{-1}, and transported ~1 h to a commercial harvest facility. During loading and unloading in both trials, the number of pigs displaying open mouth breathing (OMB), skin discoloration (SD) and muscle tremors (MT) were recorded. At the plant, dead and non-ambulatory pigs were recorded during unloading. Total losses were defined as the sum of dead and non-ambulatory pigs. Loading time was analyzed using mixed model procedures. Stress response and transport loss data were analyzed using Proc GLIMMIX of SAS. For experiment one (pre-sorting), dead pigs on arrival (DOA) at the harvest facility could not be run and will be presented descriptively. For experiment two, (pen size) MT at loading, injured and DOA at the harvest facility could not be run and will be presented descriptively. In experiment one, loading time differed (P < 0.01) between treatments with NON taking longer to load compared to PRE. In experiment two, loading time differed (P = 0.0047) between treatments with LP taking longer to load compared to SP. Lower (P < 0.0001) OMB and SD were observed at loading for PRE compared to NON pigs, but there were no differences between PRE and NON for MT or non-ambulatory at loading or for stress responses at unloading. The incidence of DOA was 0.07% PRE and 0% NON. No differences existed between PRE and NON for fatigued, injured, total non-ambulatory or total losses (NON=0.27 ± 0.09, PRE=0.33 ± 0.10%). SP had lower incidences of OMB (P=0.0015) and SD (P=0.01) during loading than LP. At loading MT was 0.04% SP vs. 0% LP. At the harvest facility, LP had a lower incidence of SD (P<0.0001) than SP; however, there were no (P>0.05) differences between treatments for OMB, MT, fatigued, total non-ambulatory, or total losses. The incidence of injured pigs was 0% SP vs. 0.04% LP and there were no DOA's. In conclusion, pre-sorting and small pen size appeared to have some effect on reduced stress responses on farm. However, pre-sorting pigs prior to loading and large versus small pen size did not affect stress responses or transport losses at the plant.

Key words: Pig, Transport loss, Pre-sort, Pen size

Introduction

Transportation losses of market weight pigs (dead and non-ambulatory pigs) represent multiple challenges for the entire U.S. food chain. First, improving the welfare of the finisher pig during transport and reducing the incidence of dead and non-ambulatory pigs has become an animal welfare priority (NPB, 2007). . Industry statistics reported for Dead on Arrival (defined as pigs that die on the truck) in 2004 was 0.23% of pigs marketed were lost, and incidence of Dead in Plant (defined as pigs that unload themselves but die before stunning) was reported at 0.17 % (Hill, 2004). Non-ambulatory pigs are defined as pigs unable to move or keep up with contemporaries at the and can be classified into two distinct groups; fatigued or injured. Ritter et al. (2009) calculated averages across 23 field studies (n = 6,660,569 pigs) for the fatigued (0.37 %) and injured (0.05 %) pigs, suggesting a higher ratio of fatigued to injured pigs. Second, non-ambulatory livestock are being considered for increasing rules and regulations (Down Animal Protection Act; U.S. House of Representatives Bill H.R. 661 and U.S. Senate Bill S. 394) and third, transport losses represent direct financial losses to pig producers and pork packers as dead and non-ambulatory pigs have been estimated to cost the U.S. swine industry approximately $50 to $100 million annually (Ellis et al., 2003).

Based on previous work pertaining to the additive stressor model in chicks (McFarlane et al., 1989a, b) and pigs (Hyun et al., 1998), Ellis and Ritter (2005) hypothesized that pre-slaughter stressors also have additive effects that impact the incidence of the non-ambulatory or dead pig at the plant. By identifying, reducing and or eliminating these sequential stressors during the marketing process, pork producers might be able to reduce pig losses. Known identified stressors are: group size (Street and Gonyou, 2008); caretaker - pig interactions (McGlone et al., 2004; Ritter, 2007; Stewart et al., 2008), pre-sorting (Chevillon, 2000; Tarrant, 1989), loading chute angle (van Putten and Elshof, 1978; Warris et al., 1991) and length (Berry et al., 2007a, b) lighting patterns (Phillips et al., (1987) and floor surface (Applegate et al., 1988).

In 2004, the National Pork Board conducted a workshop to review the current scientific literature pertaining to the well-being of the finisher pig during transportation. The scientific experts concluded that "*At the farm, major factors impacting behavioral and physiological responses of the pig during transport include genetics, slaughter weight, environmental conditions (temperature and humidity), health status, marketing strategy, time off feed,* ***pre-transport experiences****,* ***facility design****, and nature* ***of handling during loading****"* (Ritter et al., 2005). Some preliminary work by our collaborative research team compared small pens not pre-sorted the day before transportation versus large pens that were pre-sorted the day before loading and reported that utilizing large pens and pre-sorting prior to loading, reduced physical signs of stress during loading and unloading, and reduced total losses at the plant by 66 % compared to pigs from traditional finisher pens (Johnson et al., 2010). However, additional research was necessary to determine if the 66% reduction in transport losses reported by Johnson and others (2010) was due to increasing pen size (192 vs. 32) and/or due to pre-sorting market weight pigs from pen mates on the day before loading. The studies described in this proposal will allow the researchers to determine the effects of management techniques (pre-sorting) and pen design (large versus small) on transportation losses of the market weight pig.

References

Applegate, A. L., S. E. Curtis, J. L. Groppel, J. M. McFarlane and T. M. Widowski. 1988. Footing and gate of pigs on different concrete surfaces. J. Anim. Sci. 66:334-341.

Berry, N., A. Johnson, K. Stalder, T. Baas and L. Karriker. 2007a. Loading gantry versus traditional chute for the finisher pig: Effect on transportation and packing plant losses. J. Anim. Sci. 86(1): 612 (Abstr.)

Berry, N. L., A. K. Johnson, J. Hill, T. Baas, L. Karriker, and K. J. Stalder. 2007b. Loading gantry versus traditional chute for the finisher pig: Effect on welfare parameters at time of marketing. J. Anim. Sci. 86(1):612.

Chevillon, P. 2000. Pig welfare during pre-slaughter and stunning. Proceedings of l Conferência Virtual Internacional sobre Qualidade de Carne Suína, Embrapa, Brazil.

Ellis, M., and M. Ritter. 2005. Impact of animal handling and transport conditions on losses of slaughter weight swine during transport. p. 199-202 in Proceedings of the American Association of Swine Veterinarians, Toronto, Canada.

Ellis, M., F. McKeith, D. Hamilton, T. Bertol, and M. Ritter. 2003. "Analysis of the current situation: what do downers cost the industry and what can we do about it?" Pages 1-3 in Proceedings of the 4th American Meat Science Association Pork Quality Symposium, Columbia, MO.

Hyun, Y., M. Ellis, G. Riskowski, and R. W. Johnson. 1998. Growth performance of pigs subjected to multiple concurrent environmental stressors. J. Anim. Sci. 76:721-727.

Johnson, A. K., L. J. Sadler, L. M. Gesing, M. Faga, C. Feuerbach, H. Hill, R. Bailey, and M. J Ritter. 2010. Effects of facility design on the stress responses and market losses of market weight pigs during loading and unloading. Prof. Anim. Sci. 26:9-17.

McGlone, J. J., R. L. McPherson, and D. L. Anderson. 2004. Case study: moving devices for finishing pigs: Efficacy of electric prod, board, paddle, or flag. Prof. Anim. Sci. 20:518-523.

McFarlane, J. M., S. E. Curtis, R. D. Shanks, and S. G. Carmer. 1989a. Multiple concurrency stressors in chicks. 1. Effect on weight, feed intake and behavior. Poult. Sci. 68:501-509.

McFarlane, J. M., S. E. Curtis, J. Simon, and O. A. Izquierdo. 1989b. Multiple concurrent stressors in chicks. 2. Effects on hematological body composition, and pathological traits. Poult. Sci. 68: 510-521.

Phillips, P. A., B. K. Thompson, and D. Fraser. 1987. Ramp designs for young pigs. Tech Paper 87-4511. ASAE.

Ritter, M. J. 2007. Effects of animal handling and transportation factors on the welfare, stress responses, and incidences of transport losses in market weight pigs at the packing plant. PhD Diss. University of Illinois, Urbana-Champaign.

Ritter, M. J., M. Ellis, N. L. Berry, S. E. Curtis, L. Anil, E. Berg, M. Benjamin, C. Dewey, B. Driessen, P. DuBois, J.D. Hill, J.N. Marchant-Forde, P. Matzat, J. McGlone, P. Mormede, T. Moyer, K. Pfalzgraf, J. Salak-Johnson, M. Siemens, J. Sterle, C. Stull, T. Whiting, B. Wolter, S.R. Niekamp, and A.K. Johnson. 2009. REVIEW: Transport losses in market weight pigs: I. A review of definition, incidence, and economic impact. Prof. Anim. Sci. 25:404-414.

Ritter, M., M. Ellis, M. Benjamin, E. Berg, P. DuBois, J. Marchant-Forde, A. Green, P. Matzat, P. Mormede, T. Moyer, K. Pfalzgraf, M. Siemens, J. Sterle, T. Whiting, B. Wolter, and A. Johnson. 2005. The fatigued pig syndrome. J. Anim. Sci. 83(Suppl. 1):258. (Abstr.)

Stewart, G., M. Ritter, M. Culbertson, G. Mann, and R. Wofford. 2008. Effects of previous handling and feed withdrawal prior to loading on transport losses in market weight pigs. p.359 in proc. of 2008 Am. Assoc. Swine Vet. San Diego, CA.

Street, B.R. and H. W. Gonyou. 2008. Effects of housing finishing pigs in two group sizes and at two floor space allocations on production, health, behavior, and physiological variables. J. Anim. Sci. 86:982-991.

Tarrant, P. V. 1989. Transportation of cattle by road. Appl. Anim. Behav. Sci. 28: 153-170

U.S. House of Representatives. 2007. H. R. 661: Downed animal and food safety protection act. http://thomas.loc.gov/cgi-bin/bdquery/D?d110:1:./temp/~bdurJU:@@@L&summ2=m&|/bss/110search.html|.

Accessed Dec. 3, 2007.

U.S. Senate. 2007. S. 394: Downed animal and food safety protection act.

Van Putten, G., and W. J. Elshof. 1978. Observations on the effect of transport on the welfare and lean quality of slaughter pigs. In the Netherlands. In: Moss R. 9ed.) Transport of Animals intended for Breeding Production and Slaughter. Martinus Nijhoff, The Hague, pp 105-114.

Verstegen. 2005. Negative effects of stress immediately before slaughter on pork quality are aggravated by suboptimal transport and lairage conditions. J. Anim. Sci. 2005. 83:440–448.

Warris, P. D., E. A. Bevis, J. E. Edwards, S. N. Brown, and T. G. Knowles. 1991. Effect of the angle of slope on the ease with which pigs negotiate loading ramps. Vet. Rec. 128:419-421.

Objectives

To determine the effects of pre-sorting prior to loading and grow-to-finish pen size on the stress responses at loading and unloading and transport losses in market weight pigs.

Materials and Methods:

Animals

The protocol for both experiments was approved by the Iowa State University Animal Care and Use Committee. Pigs were transported to three commerical wean-to-finish facilities located in the Midwest. All 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; Fàbrega et al., 2002).

*Experiment One***.** Pigs were transported to the grow-to-finish site at approximately 17 d of age and were marketed at 195 ± 16 d of age. for the second trial. Thirty-three loads of mixed sexed market weight pigs (n = 5,802; BW = 120.3 kg ± 5.3 kg) were used in this study.

Experiment Two. Pigs were transported to the grow-to-finish site at approximately 18 d of age and were marketed at 199 ± 9 d of age. Twenty-six loads of mixed sex market weight pigs (n = 4,522; BW = 122.0 kg ± 10.6 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), a 64 cm wide center aisle and pens (7.3 m long by 2.9 m wide) and pigs were provided 0.65 m^2*pig^{-1} of pen floor space. Pens were divided by steel gates and the back gates of each pen had the ability to swing freely or 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 to feed and water via a wet / dry feeder (1.4 m high x 43.2 cm wide x 1.5 m long; with a 12 cm deep pan). Water flow rates were 1.5 L / min, which met the recommended guidelines for grow-to-finish pigs (NPB, 2009). Pigs were observed daily beginning at 0800 h to ensure pig health and facility maintenance.

Treatments

Experiment One. One side of the aisle was assigned to the large pen configuration that was to be pre-sorted (n = 2 pens / room), while the other side was assigned to the large pen configuration that would not be pre-sorted (n = 2 pens / room; Figure 1). 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 and feeder space (32 pigs / feeder) allowances were standardized across the two treatments. To create the large pen configuration, the back swing gate of nine consecutive pens remained open throughout the grow-to-finish period, and each large pen housed 292 mixed sex pigs. Two days prior to loading, market weight pigs from both treatments were marked on the back with a red (NON) or green (PRE) animal safe crayon (Prima Spray-on, Prima Tech, NC, U.S.). Observers collecting data were blinded to pigs receiving treatments. Marking was accomplished by the primary caretaker walking through each pen and marking pigs that visually appeared to be in the targeted market weight window (approximately 121 kg).

Large No Pre-sort (NON). Pigs that had been pre-determined to have reached the targeted market weight in NON pens (marked with a red paint stick) were sorted from pen mates during loading. Sorting was completed by a marketing crew consisting of four experienced persons (range of 2 to 6 yr of practical swine production and loading experience) shutting all the internal gates immediately prior to sorting. Pigs identified as having reached the target market weight were removed from their home pen and loaded onto 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 that had been pre-determined to have reached the targeted market weight in PRE pens (marked with a green paint stick) 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. Feed and water were provided *ad libitum* during this period. 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.

Experiment Two. One side of the aisle was arranged in the large pen configuration (n = 2 pens / room), while the other side of the aisle was arranged in the small pen configuration (n = 18 pens / room). 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 (36 pigs / feeder) 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 (SP) or green (LP) 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 (~121 kg.).

Small pen (SP). Internal swing gates remained closed throughout the grow-to-finish period to create the small pen facility design. Pigs were housed in single sex pens of 36 pigs. Pigs that had been pre-determined to have reached the target market weight (marked with a red paint stick) were sorted from pen mates during loading.

Large pen (LP). The internal swing gates of nine consecutive pens remained open throughout the grow-to-finish period to create the large pen facility design. Pigs were housed in single sex pens of 324 pigs. 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 (marked with a green paint stick) 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 (Figure 2).

Pig Handling and Loading Procedures

In both experiments loading for transport to the harvest facility took place between 1800 and 0800 h. Pigs were moved from their home pen to the loading ramp by the same four-man loading crew that pre-sorted the pigs 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 × 1.9 cm. long cleats that were spaced 20.3 cm. apart.

Transport Trailers and Transport Floor Spaces

In experiment one data collection occurred from December 23, 2008 to March 25, 2009 and in experiment two data collection occurred from July 21 to August 19, 2009. Aluminum straight-deck trailers (Wilson Trailers, Sioux City, IA) owned and operated by the production system were used for both experiments. During experiment one, air vents were partially covered and during experiment two, air vents were left open. Both procedures were in compliance with the National Pork Board's Transport Quality Assurance program™ 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. Each trailer had four upper deck compartments and five lower deck compartments (all compartments in the trailer were stocked according to the production system's current standard operating procedure of 0.41 m^2*pig^{-1}; approximately 176 pigs / load). During loading, treatments were assigned to trailer decks in an alternating pattern, and both treatments in each experiment were represented within each trailer load of pigs. Immediately after loading was complete, pigs were transported 84.8 ± 7.2 km (~1 h) to a commercial harvest facility. Drivers unloaded the trailers at the harvest facility using livestock paddles. Unloading at the harvest facility took place between 1900 and 0900 h.

Length of Time to Pre sort the Market Weight Pig (Experiment one)

Equal numbers of pigs from each treatment were removed from their home pen and marketed over three time points. These different marketing groups are typically referred to as "cuts." Length of time to pre-sort market weight pigs during these cuts from each site were recorded by one person using a stopwatch. The total number of pigs that were sorted from each pen / cut / site was also recorded. First cut was defined as the first group of pigs that had reached their targeted market weight from one particular site (approximately 23% of pigs, 177 d of age; marketed over 1 d). Intermediate cuts were defined as the second and third groups of pigs that had reached their targeted market weight from a particular site (approximately 30% of pigs, 195 d of age; over 2 d), and final cuts were defined as the remaining pigs that reached their targeted market weight from each site (approximately 47% of pigs, 204 d of age; over 1 d). Length of time (sec) to pre-sort these pigs by cut will be reported descriptively. The following calculation was completed to determine the time to pre-sort;

Time to pre-sort a market weight pig = Total time (sec) to pre-sort a pen ÷ Total number of pigs in a pen.

Event Times and Environmental Conditions Inside the Trailer

For both experiments, the timing of all events (loading, waiting period at the farm before transport, transport, waiting period at the harvest facility before unloading, unloading and total time from loading to unloading) were recorded. Loading was defined as the time interval from when the first pig was removed from the barn pen to the time in which the last trailer compartment gate was closed. Waiting period at the farm was defined as the time from when the last trailer compartment gate was closed to the time the trailer left the farm.

Transport was defined as the time interval from when the trailer left the farm to the time in which the trailer arrived at the harvest facility. Waiting period at the harvest facility before unloading was defined as the time interval from when the truck arrived at the plant to the time in which the driver started unloading the trailer. Unloading was defined as the time interval from when the driver started unloading the trailer to the time in which the last pig exited the trailer. For each of these events, the mean, standard deviation, and range (minimum [MIN] and maximum [MAX] times) in min were calculated. 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 the time to complete this was not included in loading time.

Each trailer was equipped with two electronic data loggers for temperature and relative humidity (HOBO; Hobo Pro series, Janesville, WI). The data loggers were affixed inside the trailers, one on the upper deck and one on the bottom deck in the compartment closest to the truck. Both data loggers were located on the right hand side of the trailer when viewing the trailer from the rear (1 m from the trailer floor level, 31 cm from the front of the trailer). Ambient temperature (^{o}C) and relative humidity (RH, %) were recorded in 1-min intervals for all events (loading at the farm to unloading at the harvest facility). Environmental parameters were calculated to determine the mean, standard deviation, and range (minimum [MIN] and maximum [MAX]) for temperatures and RH by event for this trial.

Stress Responses and Losses During Loading and Unloading

Physical signs of stress were recorded by 3 trained observers (defined as a person that had previous experience viewing and scoring stress responses of market weight pigs) during loading (1 at the farm site) and unloading (2 at the plant) for both experiments. 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 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 pre-sorting before loading and grow-to-finish pen size on the stress responses during loading and unloading and transport losses at the plant were compared in two separate experiments, each using a randomized complete block design. The trailer load of pigs was the blocking factor and the trailer deck was the experimental unit in both trials. 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, 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. 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 measure. For experiment one, at unloading dead pigs on arrival was so low that statistical analysis was not warranted and a summary of this data is presented. For experiment two, at loading, the incidence of muscle tremors and farm non-ambulatory was so low that statistical analysis was not warranted and a summary of this data are presented descriptively. Also for experiment two, at unloading, dead pigs on arrival and injured pigs was so low that statistical analysis was not warranted and a summary of this data are presented descriptively. Loading time data from both experiments 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

Event Times

Experiment one. Mean times for loading, waiting at the farm before transport and transport were 42, 7, and 61 min, respectively. Mean waiting time at the harvest facility before unloading was 22 min but varied across loads (3 to 98 min). Mean unloading time was 25 min, which included time needed to remove DOA's from the trailer (Table 1).

Experiment two. Mean times for loading, waiting at the farm before transport and transport were 38, 6, and 59 min, respectively. Mean waiting time at the harvest facility before unloading was 15 min but varied over loads (4 to 64 min). Unloading times averaged 18 min (range from 8 to 41 min, Table 2).

Environmental Conditions Inside the Trailer

Experiment one. Temperatures inside the trailer increased when the trailer was not moving (i.e. during waiting period at the farm before transport and waiting period at the harvest facility before unloading). During transportation, temperature inside the trailer dropped by approximately 2 ^{o}C (Table 3). Overall relative humidity in the trailer was 72.0%. Relative humidity was lowest at loading (68.2%) and greatest when the trailer was waiting to be unloaded at the harvest facility (74.7%). Relative humidity rose by approximately 5% after the trailer was loaded at the farm and waiting to begin transport (Table 3).

Experiment two. Temperature inside the trailer was highest waiting at the farm after loading and prior to transport (23.8 ^{o}C) and lowest at unloading at the packing plant (21.9 ^{o}C). Once the transport process began, the temperature began to drop throughout transport (22.6 ^{o}C; Table 4). Relative humidity inside the trailer increased when the trailer was not moving (i.e. during waiting period at the farm before transport and waiting period at the packing plant before unloading). Overall relative humidity in the trailer was 77.5 %. Relative humidity was lowest during transport (76.2 %) and greatest while waiting at the farm after loading and prior to transport (78.5 %, Table 4).

Length of Time to Pre-sort (Experiment one)

On average, the time required to pre-sort pigs from first, intermediate and final barn cuts / site was 24, 15, and 5 sec / pig, respectively. When adjusting these times to a truckload basis of 176 pigs, first barn cuts took 4200 sec (70 min) to pre-sort, intermediate barn cuts, 2640 sec (44 min), and final barn cuts 900 sec (15 min).

Time to Load a Trailer Deck

Experiment one. Loading time 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).

Experiment two. Loading time differed ($P = 0.0047$) between housing facility design systems with the LP pigs taking longer to load a trailer deck (21.1 ± 2.3 min) compared to the SP pigs (18.9 ± 2.3 min).

Stress Responses at Loading and Unloading

Experiment one. PRE pigs had fewer incidences of open mouth breathing ($P < 0.0001$) and skin discoloration ($P < 0.0001$) compared to NON pigs. 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 5).

Experiment two. 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 6). 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 6).

Transport losses

Experiment one. There were no pig mortalities from the time that market weight pigs were identified (marked using colored paint) until the pigs were removed from their pens during loading for either treatment. 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 7). 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).

Experiment two. There were no pig mortalities from the time that market weight pigs were identified (marked using colored paint), until the pigs were removed from their pens during loading. 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 (Figure 3). There were no injured pigs from SP and two from LP and no dead on arrivals from either housing facility design treatment.

Discussion

Time to load a trailer deck

Experiment one. Previous work conducted by Chevillon, (1998, 2000) reported that allowing pigs a 2 h resting period prior to transport reduced loading times. In agreement with Chevillon (1998, 2000) loading times differed between treatments with NON pigs taking longer to load compared to PRE pigs. It should be noted that NON pigs at the time of loading had all the swing gates closed to change the large pen configuration to small pen configurations. If these back swing gates had not been closed, it could be hypothesized that loading times for NON pigs would be greater than those reported in this study.

Experiment two. Loading time differed between housing facility design systems with the LP pigs taking longer to load a trailer deck compared to the SP pigs. Unpublished results collected from a previous trial using the same three sites that compared a large pen system design with no pre-sorting reported similar mean times to load a trailer deck (21.7 min; Gesing et al., 2010). However; Johnson et al. (2010) conducted a similar trial at these sites that compared a small pen, not pre-sorted treatment and reported a mean loading time of 22.2 min; over 3 min longer than the current trial. A possible reason for the decrease in loading times between Johnson et al. (2010) and the current study could be the implementation and review of training for all personnel involved in the marketing process that took place in the intermittent time period. Further research would be needed to determine why the difference existed in loading times between SP and LP in the current study, and whether this difference occurred in movement from the home pen to the alley, movement from the alley to the trailer or it was a combination of both.

Stress responses during loading and unloading

Experiment one. Chevillon (1998; 2000) demonstrated that the use of resting pens may have important implications for minimizing stress and improving pig well-being and may be an effective management strategy to reduce transport losses under commercial conditions. In this study during loading, PRE pigs had fewer incidences of open mouth breathing and skin discoloration compared to NON pigs, demonstrating that allowing PRE pigs resting time after being sorted was beneficial.

Experiment two. 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. According to the trial protocol, all back swing gates in the LP housing facility design were closed immediately prior to loading. To accomplish this, the loading crew entered the large pen and proceeded to close all eight swing gates in the pen. Furthermore, the crew moved approximately equal numbers of pigs into each newly formed small pen. This whole process suggests a greater amount of handling was placed upon LP pigs at loading compared to SP pigs, and in turn may explain the higher open mouth breathing and skin discoloration incidences that were observed in LP pigs at loading.

One possible reason for SP pigs displaying higher skin discoloration incidences at unloading may have been due to these pigs being mixed with a higher ratio of unfamiliar pigs on the trailer. Bradshaw et al. (1996) compared pigs mixed and not mixed during transport to a harvest facility. Mixed pigs had 3 times higher activity levels (descriptively presented) and higher salivary cortisol levels ($P < 0.01$) in the middle of the journey, suggesting a higher stress response in these pigs. Another possibility may be that SP pigs were taking longer to recover from the exertion of the marketing process than LP pigs.

Transport losses

Experiment one. The total transport losses observed in this experiment were 0.33% (PRE) and 0.27% (NON). While the total losses seen for PRE are similar (0.30%) to values reported by Johnson et al. (2010) for large pens that pre-sorted prior to loading, the total losses in this study for both treatments were only about one-third as high as total losses (0.89%) from the small pen, not pre-sorted treatment from the same Johnson et al. (2010) study. Additionally, when comparing the total loss percentages from the present study to losses on a national level, the estimated national average for total losses from a summary of 23 commercial field trials is 0.69% (Ritter et al., 2009), or about twice as high as total losses recorded from the present study.

Previous work by Chevillon (1998; 2000) reported that pre-sorting reduced transport losses; therefore if a producer has higher than average transport losses for their grow-to-finish site, they may wish to consider pre-sorting. However, a cost / benefit calculation is recommended to determine if profits would be made. Variables within the calculation could include: number of persons needed to pre-sort, wage per person, time to load, and incidence of transport losses at the harvest facility.

Experiment two. Johnson et al. (2010) compared two treatments: small pens containing 32 pigs / pen that were not pre-sorted and large pens containing 192 pigs / pen that were pre-sorted prior to loading. These authors reported a 66 % reduction in total transport losses from pigs housed in a large pen facility design that were pre-sorted. However; this group was unable to ascertain if the reduction in transport losses was due to the large pen size or pre-sorting. Furthermore, the incidence of total losses from small pens was 0.89 % (Johnson et al., 2010). In the present study, the incidence of total transport losses from pigs housed in the small pen facility design was considerably lower (0.34%). Gesing et al. (2010) studied the effects of pre-sorting prior to loading on transport losses in pigs from two large pen configurations (~292 pigs / pen; one treatment pre-sorted; one treatment not pre-sorted). The incidence of total transport losses in the not pre-sorted pigs was similar (0.27 %) to total losses from pigs in the large pen facility design from the current study. In addition, total transport losses from the large pen, pre-sorted group from Gesing et al. (2010) were similar (0.33 %) to incidences of total transport losses from both housing facility designs in the current study. Total transport losses observed in the current trial were approximately one-half the percentage of total transport losses recorded in a summary of 23 commercial field trials (Ritter et al., 2009). One reason for why these sites had inherently low overall transport losses may be a result of the continual on farm training and experience received from the marketing crew, truck drivers, and plant personnel who performed all loading and handling of pigs at the time of marketing. All members of the marketing crew had extensive experience with handling pigs and were PQA™ Plus trained (NPB, 2007). Similarly, truckers and plant personnel were TQA Plus™ trained (NPB, 2008).

Therefore, in conclusion, overall transport losses from both treatment groups in both trials were approximately one half of the estimated national average reported from a summary of 23 commercial field trials (0.69 %; Ritter et al., 2009). The relatively very low overall transport losses experienced amongst all treatments in the present study makes it is questionable whether using intervention strategies such as pre-sorting prior to loading and large pen size is beneficial on production sites that are already experiencing low transport losses compared to the national average.

Table 1. Descriptive statistics from a study evaluating pre-sorting effects on the stress responses and transport losses in market weight pigs. Event times during the marketing process in the Midwest from December 2008 to March 2009[1].

			Range	
Event time, min	**Mean**	**SD[2]**	**MIN[3]**	**MAX[4]**
Loading[5]	42	9	28	68
Waiting period at the farm before transport[6]	7	3	3	13
Transport[7]	61	4	51	71
Waiting period at the harvest facility before unloading[8]	22	23	3	98
Unloading[9]	25	13	11	53
Total time from loading to unloading[10]	157	31	100	225
Number of trailer loads within a day	3.3	1.3	2	6

[1]Based on 33 trailer loads of market weight pigs (defined as a pig that has reached a target weight of ~120-125 kg).
[2]SD abbreviation for standard deviation.
[3]MIN abbreviation for minimum.
[4]MAX abbreviation for maximum.
[5]Loading was defined as the time interval from when the first pig stepped on the truck to the time in which the last trailer compartment gate was closed.
[6]Waiting period at the farm was defined as the time from when the last trailer compartment gate was closed to the time the trailer left the farm.
[7]Transport was defined as the time interval from when the trailer left the farm to the time in which the trailer arrived at the harvest facility.
[8]Waiting period at the harvest facility before unloading was defined as the time interval from when the truck arrived at the plant to the time in which the driver started unloading the trailer.
[9]Unloading was defined as the time interval from when the driver started unloading the trailer to the time in which the last pig exited the trailer.
[10]Total time from loading to unloading defined as the summation of the previously described categories for events.

Table 2. Descriptive statistics from a study evaluating pen size effects on the stress responses and transport losses in market weight pigs. Event times during the marketing process in the Midwest from July to August 2009[1].

			Range	
Event time, min	**Mean**	**SD[2]**	**MIN[3]**	**MAX[3]**
Loading[5]	38	13	23	66
Waiting period at the farm before transport[6]	6	2	3	11
Transport[7]	59	5	45	67
Waiting period at the harvest facility before unloading[8]	15	17	4	64
Unloading[9]	18	10	8	41
Total time from loading to unloading[10]	136	23	110	205
Number of trailer loads within a day	3.7	2.1	1	7

[1]Based on 26 trailer loads of market weight pigs (defined as a pig that has reached a target weight of ~120-125 kg).
[2]SD abbreviation for standard deviation.
[3]MIN abbreviation for minimum.
[4]MAX abbreviation for maximum.
[5]Loading was defined as the time interval from when the first pig was removed from the barn pen to the time in which the last trailer compartment gate was closed.
[6]Waiting period at the farm was defined as the time from when the last trailer compartment gate was closed to the time the trailer left the farm.
[7]Transport was defined as the time interval from when the trailer left the farm to the time in which the trailer arrived at the harvest facility.
[8]Waiting period at the harvest facility before unloading was defined as the time interval from when the truck arrived at the plant to the time in which the driver started unloading the trailer.
[9]Unloading was defined as the time interval from when the driver started unloading the trailer to the time in which the last pig exited the trailer.
[10]Total time from loading to unloading defined as the summation of the previously described categories for events.

Table 3. Descriptive statistics from a study evaluating pre-sorting effects on the stress responses and transport losses in market weight pigs. Internal trailer temperature and relative humidity during the marketing process in the Midwest from December 2008 to March 2009.[1]

			Range	
Temperature in the trailer by event, °C	**Mean**	**SD[2]**	**MIN[3]**	**MAX[4]**
Loading[5]	2.0	2.5	-10.9	10.8
Waiting period at the farm before transport[6]	6.1	4.3	-4.9	15.8
Transport[7]	4.3	4.5	-9.3	11.8
Waiting period at the harvest facility before unloading[8]	5.5	4.0	-5.9	12.9
Unloading	4.0	4.7	-7.3	12.1
Load average: temperature	4.4	4.0	-7.7	12.7
Relative Humidity in the trailer by event, %				
Loading	68.2	10.4	48.4	88.2
Waiting at the farm before transport	73.3	9.1	49.7	88.6
Transport	74.0	8.2	56.8	90.4
Waiting at the harvest facility before unloading	74.7	10.1	51.2	93.7
Unloading[9]	69.9	11.1	53.7	92.8
Load average: relative humidity	72.0	9.78	52.0	90.7

[1]Based on 27 trailer loads of market weight pigs (defined as a pig that has reached a target weight of ~120-125 kg); 6 trailer loads had to be removed from the data set because of a HOBO on one of the decks malfunctioning.
[2]SD abbreviation for standard deviation.
[3]MIN abbreviation for minimum.
[4]MAX abbreviation for maximum.
[5]Loading was defined as the time interval from when the first pig was removed from the barn pen to the time in which the last trailer compartment gate was closed.
[6]Waiting period at the farm was defined as the time from when the last trailer compartment gate was closed to the time the trailer left the farm.
[7]Transport was defined as the time interval from when the trailer left the farm to the time in which the trailer arrived at the harvest facility.
[8]Waiting period at the harvest facility before unloading was defined as the time interval from when the truck arrived at the plant to the time in which the driver started unloading the trailer.
[9]Unloading was defined as the time interval from when the driver started unloading the trailer to the time in which the last pig exited the trailer.

Table 4. Descriptive statistics from a study evaluating pen size effects on the stress responses and transport losses for market weight pigs. Internal trailer temperature and relative humidity during the marketing process in the Midwest from July- August 2009.[1]

			Range	
Temperature in the trailer by event, °C	**Mean**	**SD[2]**	**MIN[3]**	**MAX[4]**
Loading[5]	22.3	3.2	17.8	36
Waiting period at the farm before transport [6]	23.8	3.7	18.7	31.0
Transport[7]	22.6	2.2	16.0	26.6
Waiting period at the harvest facility before unloading[8]	22.4	2.0	18.6	27.1
Unloading[9]	21.9	2.1	17.6	27.9
Load average: temperature	22.6	2.6	17.7	29.7
Relative Humidity in the trailer by event, %				
Loading	78.4	13.1	31.5	96.7
Waiting at the farm before transport	78.5	12.3	31.2	96.1
Transport	76.2	9.7	37.0	86.3
Waiting at the harvest facility before unloading	76.5	10.9	33.9	91.8
Unloading	78.0	7.7	43.2	89.2
Load average: relative humidity	77.5	10.1	35.4	92.0

[1]Based on 25 trailer loads of market weight pigs (defined as a pig that has reached a target weight of ~120-125 kg); 1 trailer load had to be dropped because a HOBO on one of the decks malfunctioned.
[2]SD abbreviation for standard deviation.
[3]MIN abbreviation for minimum.
[4]MAX abbreviation for maximum.
[5]Loading was defined as the time interval from when the first pig was removed from the barn pen to the time in which the last trailer compartment gate was closed.
[6]Waiting period at the farm was defined as the time from when the last trailer compartment gate was closed to the time the trailer left the farm.
[7]Transport was defined as the time interval from when the trailer left the farm to the time in which the trailer arrived at the harvest facility.
[8]Waiting period at the harvest facility before unloading was defined as the time interval from when the truck arrived at the plant to the time in which the driver started unloading the trailer.
[9]Unloading was defined as the time interval from when the driver started unloading the trailer to the time in which the last pig exited the trailer.

Table 5. Stress response least square means (SE) at loading and unloading from pre-sorted versus not pre-sorted market weight pigs.

	Treatment		
Measure, %	**NON[1]**	**PRE[2]**	***P*-value**
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 m^2*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 m^2*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.

Table 6. 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.

	Treatment		
Measure, %	**SP[1]**	**LP[2]**	***P*-value**
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 m^2*pig^{-1}.
[2]Large pens (LP) had 324 single sexed pigs per pen, housed at 0.59 m^2*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.

Table 7. 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.

	Treatment		
Measure, %	**NON[1]**	**PRE[2]**	***P*-value**
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 m^2*pig^{-1}. Pigs were sorted immediately prior to loading.

[2]Large pens, pre-sorted (PRE) had 292 pigs / pen housed at 0.65 m^2*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.

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.

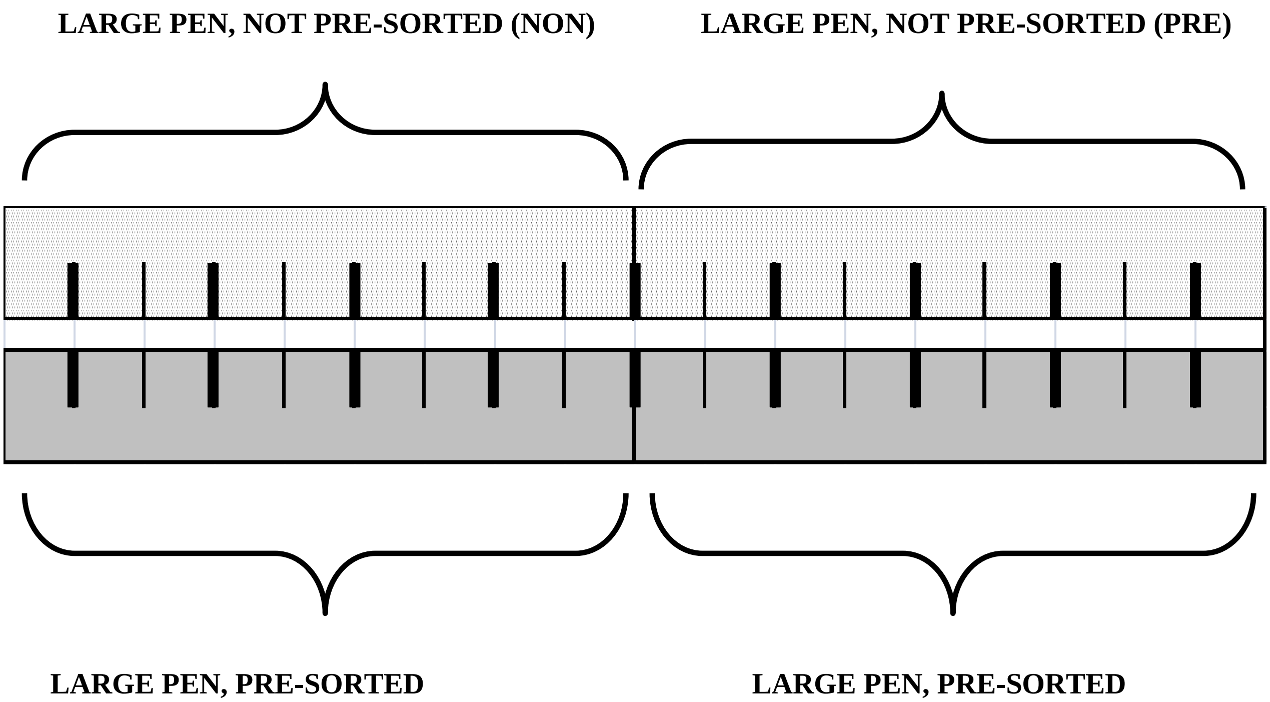


Figure 2. Schematic barn diagram for the small pen **(SP)** facility design treatment and the large pen **(LP)** facility design treatment used to determine the grow-to-finish pen size effects on market weight pigs from three grow-finish facilities in a Midwestern pork production system.

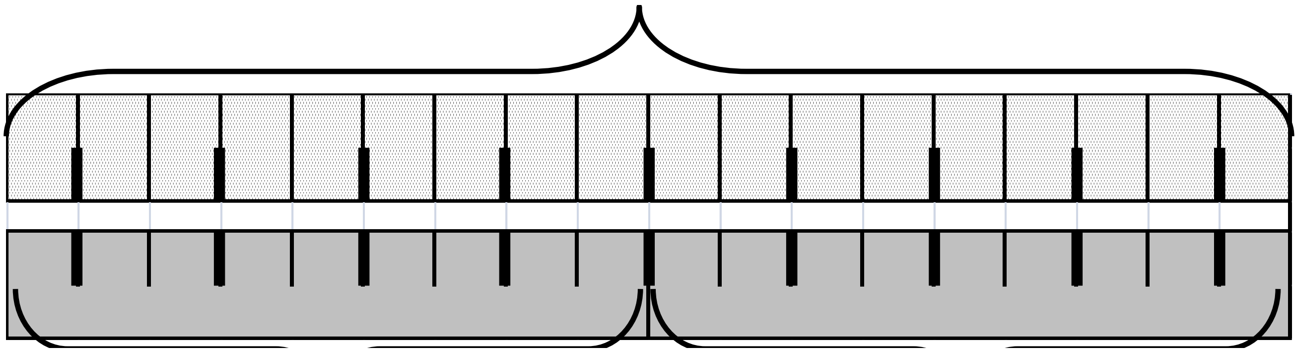
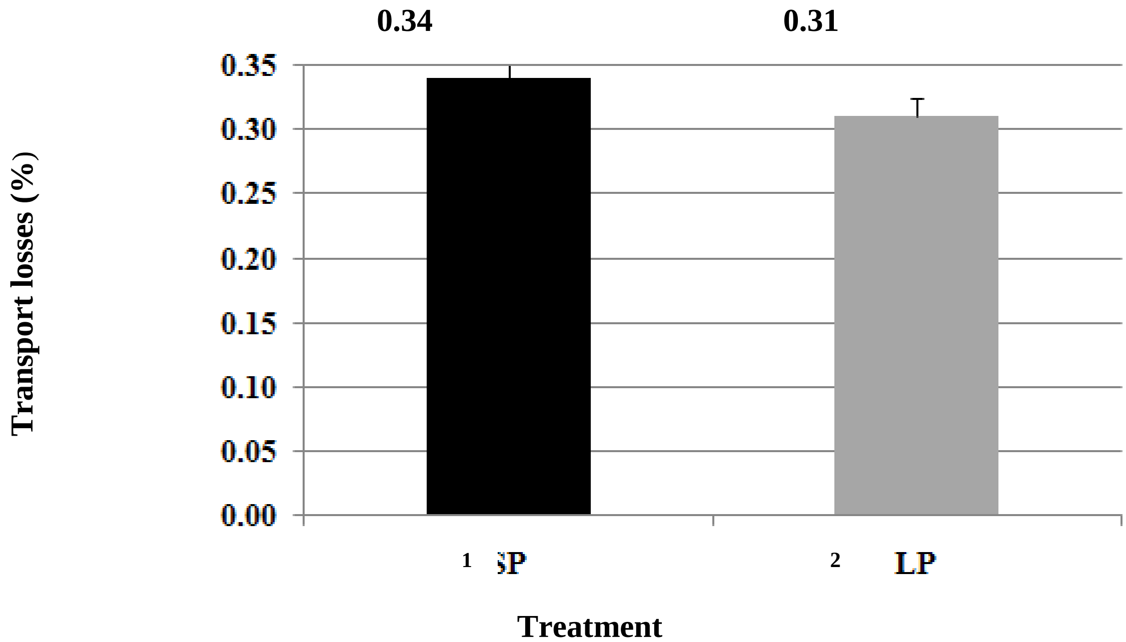


Figure 3. Total transport losses by housing facility design. Market weight pigs from both housing facility designs were sorted from pen-mates at the time of loading.



[1]SP facility design consisted of 36 pigs / pen (0.59 m^2*pig^{-1}).
[2]LP facility design consisted of 324 pigs / pen (0.59 m^2*pig^{-1}).

Publications, presentation or abstracts from this project:

Professional Meetings:

Gesing, L. M., A. K. Johnson, K. J. Stalder, J. T. Selsby, H. Hill, C. Feurbach, M. Faga, A. Whiley, and M. J. Ritter. 2010. Effects of pre-sorting prior to loading on the stress responses at loading and unloading and transport losses in market weight pigs. Presented at 2010 Midwest ASAS Mtgs. Des Moines, IA.

Media:

Gesing, L. M., A. K. Johnson, K. J. Stalder, J. T. Selsby, H. Hill, C. Feurbach, M. Faga, A. Whiley, and M. J. Ritter. 2010. Pre-sorting market hogs may not pay off. National Hog Farmer Annual Swine Research Review. http://nationalhogfarmer.com/behavior-welfare/1215-presorting-markets-not-payingoff/.

Master's Thesis:

Gesing, L. M. 2010. Pre-sorting and pen size effects on the stress responses at loading and unloading and transport losses in market weight pigs. Iowa State University, May, 2010.

Peer reviewed papers:

Gesing, L. M., A. K. Johnson, K. J. Stalder, J. T. Selsby, H. Hill, C. Feurbach, M. Faga, A. Whiley, and M. J. Ritter. 2010. Effects of pre-sorting on stress responses at loading and unloading and the impact on transport losses from market weight pigs. Submitted to the Professional Animal Scientist, April, 2010.

Animal Industry Reports:

Gesing, L., A. Johnson, J. Selsby, K. Stalder, M. Faga, C. Feurbach, H. Hill, R. Bailey, and M. Ritter. 2009. Effects of pre-sorting prior to loading on the stress response of market weight pigs during loading and unloading. Animal Industry Report. R2551.

Coming in 2010:

Meetings:

Gesing, L., A. Johnson, J. Selsby, K. Stalder, M. Faga, A. Whiley, S. Abrams, H. Hill, R. Bailey, and M. Ritter. 2010. Effects of pen size on stress response of market weight pigs at loading and unloading. Submitted, accepted and to be presented at 2010 Joint Annual ASAS Mtgs. Denver, CO.

Media:

Gesing, L., A. Johnson, J. Selsby, K. Stalder, M. Faga, A. Whiley, S. Abrams, H. Hill, R. Bailey, and M. Ritter. Effects of pen size on stress responses at loading and unloading and transport losses in market weight pigs. To be submitted to National Hog Farmer Swine Research Review: Transportation/Marketing. October, 2010 for consideration.

Peer reviewed papers:

Gesing, L., A. Johnson, J. Selsby, K. Stalder, M. Faga, A. Whiley, S. Abrams, H. Hill, R. Bailey, and M. Ritter. Effects of pen size on stress responses at loading and unloading and transport losses in market weight pigs. To be submitted to Professional Animal Scientist, July, 2010.

Animal Industry Reports:

Gesing, L., A. Johnson, J. Selsby, K. Stalder, M. Faga, A. Whiley, S. Abrams, H. Hill, R. Bailey, and M. Ritter. Effects of pen size on stress responses at loading and unloading and transport losses in market weight pigs. To be submitted as an Animal Industry Report, October, 2010