A ramp in nursery housing affects nursery pig behavior and speeds loading of market hogs

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Abstract

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Results and Discussion: In the nursery, RAMP pigs consumed less feed than FLAT pigs, while ADG during the same period was not different. RAMP pigs had fewer eating and drinking episodes and decreased aggressive interactions in the nursery compared to FLAT pigs. RAMP hogs required less time to ascend the ramp into the truck than FLAT hogs (30.52 ± 10.81 s vs. 58.87 ± 10.37 s, respectively; P = 0.04). No detrimental effects of ramped nursery housing were observed.

Implications and Applications: Adding ramps to nursery pig housing is a simple way to speed loading of market hogs, while providing benefits to efficiency and behavior in the nursery.

Keywords
conditioning, welfare, stress, growth, efficiency

Disciplines
Agriculture | Animal Sciences | Behavior and Ethology

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A ramp in nursery housing affects nursery pig behavior and speeds market hog loading

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INTRODUCTION

Transport losses include pigs that die or become injured or non-ambulatory during any stage of marketing (Ritter et al., 2009). It is estimated that transport losses affect up to 1% of all marketed pigs (Johnson et al., 2013). In the United States, over 124 million hogs were
slaughtered in 2018 (United States Department of Agriculture, 2019), so more than one million hogs may be classified as transport losses each year in the United States.

During marketing, pigs are subjected to internal and external stressors. If the stress level exceeds the body’s capacity to cope, welfare is diminished. In addition, there can be detrimental effects of marketing stress and transport losses on pork quality (Alvarez et al., 2009; Vermeulen et al., 2015). Stimuli that are novel or infrequent to the pig can be a profound stressor (Knowles and Warris, 2000; Moberg and Mench, 2000), and handling and loading specifically have been identified as stressful aspects of the marketing process for the individual pig (Faucitano, 2018, Dokmanović et al., 2014).

Typically, pigs have little or no exposure to many aspects of loading, handling and transport prior to the time of marketing, including walking up and down ramps. We hypothesized that by reducing the novelty of ramps through exposure of pigs to a ramp prior to marketing, loading during the marketing process could be made faster and more efficient. Because it is simpler and less expensive to build a ramp for smaller pigs, the ramps were placed in pens during the nursery period, thereby relying on their ability to form and remember a habit of walking up and down ramps during the approximately 5 months that passed between the end of the nursery phase and marketing. There is prior evidence of pig’s ability to recall a learned task (opening a sliding door) for 6 weeks after the task has been mastered (Viet et al., 2017). We also wanted to ensure that there were not detrimental effects of the installation of ramps in nursery pig pens. Therefore, the objectives of this study were to determine how ramp exposure (1) affects the behavior and performance of nursery pigs, and (2) affects market hog loading behavior.
MATERIALS AND METHODS

All procedures involving animals were approved by the North Dakota State University (NDSU) Institutional Animal Care and Use Committee (Protocol # A14058).

Pigs and Management

Crossbred barrows and gilts from 11 litters with Chester White, Yorkshire, Duroc, and Hampshire genetics were enrolled in two cohorts of 36 animals, for a total study enrollment of 72 pigs. At 21 d of age (range 17 to 26 d), pigs were weaned and moved by trailer less than 5 km from the NDSU Swine Teaching and Research Unit to the to the NDSU Animal Nutrition and Physiology Center. Upon arrival, pigs were blocked by sex, randomly assigned into treatment groups, and placed into pens at a stocking rate of 9 pigs per pen (2 RAMP and 2 FLAT pens per cohort). Randomization was achieved by using a random number generator (random.org) to generate a sequence, then assigning pigs sequentially by ascending ear notch number to pens based on the correlating random number being odd (treatment 1) or even (treatment 2). Pigs in treatment 1, FLAT, were placed in a nursery pen measuring 4.6 x 1.8 m, while pigs in treatment 2, RAMP, were placed in a nursery pen of the same dimensions in the same room, with the addition of a ramp leading to a platform and their feed source (Figure 1). The ramp was 3.2 m long x 0.4 m wide with 0.3 m raised side barriers leading to a 0.9 x 0.5 m platform. The floor of the pen, ramp and platform was plasticized commercially available pig nursery flooring (Hog Slat, Inc., Newton Grove, NC, USA). On the ramp, additional traction was provided by coating the flooring with non-slip paint and placing 1.3 cm metal bars across the width of the ramp floor every 7.6 cm. A 91 cm wide stainless-steel nursery pig feeder of the same type installed in the flat pens was placed at the top of the ramp. When the pigs were introduced to the pen, the ramp was in a neutral flat position, lying parallel with the pen floor. The platform was then raised 15.2
cm daily until a maximum platform height of 0.9 m was achieved, resulting in a 20-degree ramp angle. Feed was provided *ad libitum* and formulated for their stage of growth. Pigs had *ad libitum* access to water from a nipple (1 per pen), located along one side of the flat portion of the pen. Room temperature was maintained at 24 °C and pigs were checked daily by facility or research personnel for signs of illness such as depression, abnormal posture, ocular discharge, lethargy, or visible failure to grow. Lights were on from 6:30 to 20:00 h each day. Pigs were removed from the nursery pens 35 days after entering, and no data were collected on d 35. Upon leaving the nursery pens, pigs were blocked by pen and randomly assigned to 1 of 2 finishing pens (n = 18 per pen), resulting in comingling of equal numbers of RAMP and FLAT pigs in each finishing pen. Pigs remained in finishing pens until they reached market weight and were comingled for the remaining study procedures.

**Performance Measures**

Orts and individual pig body weights were collected on days 0, 7, 14, 21, 28, and 34. Individual body weights were also collected when the pigs were approximately 4- and 5-mo of age. Animals were marketed upon reaching 113.4 kg or greater BW regardless of treatment assignment or pen affiliation. Pigs were weighed 1 day prior to shipping to obtain actual market BW.

**Behavioral Observations**

All pigs were continually filmed in their home pens during the nursery pen phase of the study. Video was recorded using digital cameras positioned with one camera above each pen at a height sufficient to provide a clear view of the entire floor surface of the pen. Video was captured digitally at 30 frames/s and fed into a DVR recorder using an AgCam system (Dakota Micro, Cayuga, ND). A computer screen was used to view sample DVR output daily to ensure
picture clarity and correct camera positioning. Using these recordings, behaviors were recorded by a single observer for the first 30 s of every 30 m period (on the hour and half hour), during the hours when the rooms were lit (6:30-20:00; Table 1).

There were 3 shipping dates in the first cohort and 2 shipping dates in the second cohort. Pigs that had reached market weight had a number painted dorsally (Quik Shot Spray Paint for Livestock Marking, La-Co Industries, Elk Grove Village, IL, USA) prior to being moved from their home pen to enable identification of each pig as they moved up the loading ramp onto the trailer. On the day of marketing, pigs were moved in groups of 3 to 4 pigs using sorting boards from their finishing pens a distance of approximately 10 m to a loading dock that was level with a single-deck stock trailer with a 2 m by 4.9 m floor area, onto which they were loaded (no ramp was needed and this loading was quickly and easily done). They were then transported less than 5 km to a location with a ramp typical of commercial finisher pig facility, where they were unloaded from the stock trailer and moved by farm staff using blocking boards a distance of 14.7 m to a 3.3 x 12.4 m holding pen with a textured concrete floor, positioned next to a loading ramp. Within 10 minutes of arrival at the facility, loading of the pigs into a large commercial double-decked livestock trailer using the ramp was commenced.

Pigs were moved out of the holding pen as a single pig, a pair, or a trio, based on how many pigs moved out most easily each time the farm staff returned to the holding pen. All pigs were moved out of the pen and up the ramp by the same handler, a member of the research team with extensive experience moving swine who was masked to treatments. The handler worked without any handling tools. The ramp width entrance was 2.9 m, tapering to 0.8 m within 7.3 m; it then remained consistent in width for the rest of the ramp length of 12 m. Digital video recordings were collected on all pigs traversing the ramp using digital cameras (Canon
PowerShot, Canon USA, Huntington, NY). The digital recordings were reviewed by a single member of the research team to record refusals and handler encouragements as well as the total time needed to move up the ramp for each pig (Table 1).

**Statistical Analyses**

Data were analyzed using the mixed procedure of SAS (SAS v. 9.4, SAS Institute, Inc., Cary, NC). For growth traits, fixed effects included cohort, sex, and treatment, and random effects were litter nested within cohort, and finishing pen nested within cohort (except for Nursery ADG, which finishing pen would not have affected). For market weight, age at market was included as a covariate. For feed intake, fixed effects included cohort and treatment and random effects included pen, nested within cohort, and week, nested within cohort for weekly feed intake. Fitting week as a random effect accounts for the repeated measures for a pen across weeks without over parameterizing the model by using a repeated statement, since there were so few total observations. For nursery behavior, fixed effects included cohort, treatment (FLAT vs. RAMP), day (D0 to D34), and the interaction between treatment and day. A repeated measures statement was fit with pen as the subject. Different covariance structures were tested and the best fit based on AIC was chosen. For loading, fixed effects included sex (barrow and gilt), treatment (FLAT vs RAMP) and shipping date, and random effects were group up the ramp nested within shipping date, and litter. Interactions between fixed effects were tested and removed from the model if $P > 0.10$. Means for treatment groups were estimated using the LS MEANS statement and compared for significance at the $P < 0.05$ level.
Pig Removal from Study

Ten pigs (5 per treatment group) were removed from the study during the finishing phase due to incidences of abdominal hernias, structural soundness issues, or mortality.

Performance measures

Mean BW at the end of the nursery period was not different between FLAT and RAMP pigs (22.1 ± 0.9 kg vs, 21.4 ± 0.9; P = 0.24). Mean BW at 4-mo was not different at 76.1 ± 1.4 kg for FLAT pigs and 76.1 ± 1.4 kg for RAMP pigs (P = 0.98), nor was mean 5 mo BW different (106.4 ± 1.5 vs. 104.7 ± 1.5 kg, respectively; P = 0.28). Average finishing pig market weights were 123.2 ± 1.3 kg and 123.7 ± 1.3 kg for FLAT and RAMP pigs, respectively (P = 0.67).

Weekly feed intake was greater among FLAT pigs than RAMP pigs during the nursery period (41.1 ± 6.2 kg and 38.1 ± 6.2 kg, respectively; P = 0.02). During the entire nursery period, FLAT pigs consumed a total of 205.3 ± 3.1 kg of feed while RAMP pigs consumed 190.4 ± 3.1 kg of feed (P = 0.02).

No difference between mean ADG in FLAT and RAMP treatments was observed during the nursery or growing phases. Nursery ADG was 0.39 ± 0.01 kg and 0.38 ± 0.01 kg for FLAT and RAMP pigs, respectively (P = 0.15). Early ADG (between leaving the nursery and 4-mo of age) was 0.89 ± 0.01 kg and 0.90 ± 0.01 kg for FLAT and RAMP pigs, respectively (P = 0.56). Mid-ADG (between 4 and 5-mo of age) was 0.99 ± 0.04 kg and 0.98 ± 0.04 kg for FLAT and RAMP hogs, respectively (P = 0.75). Late ADG (between 5-mo of age and market) was 0.84 ± 0.04 kg and 0.88 ± 0.04 kg for FLAT and RAMP hogs, respectively (P = 0.44). Finishing ADG (between leaving the nursery and market) was 0.92 ± 0.02 kg for both FLAT and RAMP hogs (P = 0.96).
Pig Behavior in the Nursery

Pigs assigned to the FLAT treatment had more eating events per day than RAMP pigs (44.0 ± 1.4 eating events/d vs. 37.0 ± 1.4 eating events/d; \( P = 0.001 \)) (Figure 2). This difference was driven by a cohort by treatment interaction (\( P = 0.05 \)); in cohort 1, FLAT pigs had more eating events/d than RAMP pigs (52.6 ± 1.9 vs. 41.7 ± 1.9 events, respectively; \( P = 0.0003 \)). There were not differences in eating events for cohort 2 (35.4 ± 1.9 for FLAT vs. 32.2 ± 1.9 for RAMP; \( P = 0.26 \)).

Drinking behavior (Figure 3) differed with FLAT pigs having 10.7 ± 0.7 events/d and RAMP pigs having 7.9 ± 0.7 events (\( P = 0.005 \)). There was a cohort by treatment interaction for drinking events per day: FLAT and RAMP pigs had 11.1 ± 0.6 and 7.9 ± 0.6 events/d respectively in Cohort 1 (\( P = 0.02 \)), while they had 10.3 ± 0.7 and 7.8 ± 0.7 (\( P = 0.07 \)) events/d respectively in Cohort 2.

The mean number of fighting bouts/d differed with FLAT pigs having 1.61 ± 0.11 bouts/d and RAMP pigs having 1.22 ± 0.11 bouts/d (\( P = 0.01 \)) (Figure 4). This difference was driven a cohort by treatment interaction (\( P = 0.04 \)). In cohort 1, FLAT pigs had 2.14 ± 0.16 fighting bouts/d and RAMP pigs had 1.42 ± 0.16 bouts/d (\( P = 0.001 \)). For cohort 2, there was not a difference (1.08 ± 0.16 vs. 1.02 ± 0.16 fighting bouts/d, respectively; \( P = 0.79 \)).

Loading Behavior in Market-Weight Pigs

FLAT pigs ascended the ramp in 58.9 ± 10.4 s while RAMP pigs completed the same distance in 30.5 ± 10.8 s (\( P = 0.04 \)). No differences were found between FLAT and RAMP pigs for the number of refusals (3.60 ± 0.59 FLAT vs. 3.10 ± 0.60 RAMP; \( P = 0.40 \)) or encouragements (3.53 ± 0.87 FLAT vs. 3.97 ± 0.83 RAMP; \( P = 0.67 \)).
**Discussion**

How pigs load onto the trailer for market affects animal well-being and meat quality. For example, rough handling of pigs when loading has been found to increase stress and decrease meat quality (Dokmanović et al., 2014). Rabaste et al. (2007) found that pigs subjected to rough handling (including prod use) were more likely to turn around, slip, and climb on each other and decreased meat quality resulted, with an increased prevalence of exudative meat. In addition to facilitating a decrease in the use of the electric prod and other types of rough handling, pigs that load and unload more quickly and easily will also spend less time in the confined trailer where there is a greater risk of injury, stress, and higher ambient temperatures (Fitzgerald et al., 2009). Correa et al. (2010) concluded that “…additional research is necessary to identify methods that improve the loading efficiencies…without adversely affecting animal welfare parameters”. Our primary objective was to examine the effects of ramped nursery housing on the loading behavior of market hogs. Additional objectives were to examine the effects of ramped nursery housing on behavior, growth, and efficiency during the nursery period and on overall growth.

In this study, the pigs exposed to a ramp during the nursery period did not differ from flat-housed pigs in their rate of growth. This finding is consistent with previous work reporting that ramp exposure did not have a negative impact on growth (Bulens et al., 2017; Phillips and Fraser, 1987). Phillips and Fraser (1987) did find an initial negative effect of ramp implementation on feed consumption, based on lower 7-d weights of ramp-exposed pigs when compared to flat-housed pigs. In the current study, this effect was avoided by increasing the ramp angle incrementally over the first week in the nursery pen, gradually acclimating the pigs to the ramp system. In the current study, ramp-housed nursery pigs had reduced feed consumption and reduced eating event frequency compared to flat-housed pigs. RAMP pigs also exhibited
decreased drinking behaviors compared to FLAT pigs. Because pigs are prandial drinkers, eating and drinking are correlated, with one study showing that 75% of daily water intake is closely associated with eating bouts (Bigelow and Houpt, 1988). It is possible that the decreased number of episodes of eating and drinking by RAMP pigs may be related to the increased distance those pigs had to travel to eat and drink, because the feed was at the top of the ramp and the waterer was in the flat portion of the pen.

There is little published work regarding the effects of ramped housing on behavior in pigs. Bulens et al. (2017) examined the use of a two-level pen to decrease stocking density in growing and finishing pigs from 30 kg to 110 kg and found that pigs manipulated pen mates less and were observed to have fewer lesions on their ears, tails, and bodies. Similarly, we found that pigs housed in a pen with a ramp and small platform in it had fewer aggressive interactions than did pigs in flat pens; this may be because the addition of the ramp and platform added environmental enrichment. The decrease in aggressive interactions in the ramp-housed pigs was probably not due to greater pen floor area, because only a small portion of the space under the ramp was usable by the pigs, especially later in the nursery phase. There was an interaction between cohort and treatment for the number of eating bouts, drinking bouts, and aggressive interactions in the nursery; for all of these behaviors overall between-group differences were a result of differences observed in Cohort 1; treatment effects were not observed in Cohort 2 for these behaviors. Although the Cohorts were in the nursery at different times of year (Cohort 1 mostly in July and Cohort 2 mostly in February), the seasonal difference is unlikely to explain the observation, because the nursery was in a facility built for research in which the temperature, ventilation characteristics, and daylight hours were kept constant for both groups. Both cohorts also came out of a farrowing unit that is kept warm and has the same lighted hours year-round.
The difference in behaviors might be explained by genetics. Litters were split between treatments so that the genetic makeup of the treatments within a cohort was the same, but the genetic makeup of the two cohorts was not the same. In Cohort 1, the pigs came from sows that were Chester White x Yorkshire crosses and the boar semen from a commercial vendor was advertised as a “Crossbred x Duroc”. In Cohort 2, the pigs came mostly from Yorkshire sows (4 Yorkshire, one Chester White x Yorkshire cross), and the boar was a Hampshire x Duroc cross. It is possible that some innate characteristics of the pigs influenced their activity levels in the nursery and their response to the ramped housing.

The study reported here is the first to examine the effect of ramped housing in the nursery period on loading behavior at market weight. The effect we found is not only meaningful statistically, it is also has practical implications; pigs housed in conventional nursery pens took nearly twice as long to ascend the loading ramp at marketing compared to pigs from nursery pens with ramps. Constructing the ramp system for nursery housing is likely to be less expensive than constructing a similar system for larger hogs, and more pigs can be exposed to ramps using fewer modified pens, as nursery pens typically have more pigs per pen than do growing and finishing pens. There is evidence that pigs can learn tasks rapidly by classical and operant conditioning methods (Gieling et al., 2011; Baldwin and Stevens, 1973; Chaput et al., 1973), and that conditioning methods can alter the long-term memory of pigs if they receive a positive reinforcement to a response during the nursery period (de Jong et al., 2000). Additionally, pigs are highly motivated to perform a task if they receive an immediate positive reinforcement (Elmore et al., 2012). In the current study, immediate reinforcement of ramp-climbing behavior by nursery pigs was provided by positioning the feeding area at the top of the ramp.
Although exposure to the ramp system in the nursery period increased the speed of traversing the loading ramp at marketing, it did not affect the refusal or encouragement frequencies. The reduction in loading time among ramp-housed pigs is likely due to conditioning and positive reinforcement. Skinner (1969) determined a strong association can be formed between a task and reward in livestock species. It is possible that exposed hogs associated the ramp with receiving feed, which made them more motivated to navigate the loading ramp.

The ramp was also a source of environmental enrichment. Stolba and Wood-Gush (1980) determined that environmental enrichment increases exploratory behavior and reduces stress and fear in growing hogs. Goumon et al. (2013) examined the effect of two weeks’ exposure of pigs near finishing weight to a short ramp in their pen with a plastic toy at the top and found no improvement in movement ease during a subsequent simulated loading event; compared to this study, the exposure to ramps by Goumon et al. was shorter in duration and closer to the time of marketing, and they placed a toy at the top of the ramp while we placed feeders on the platform at the top of the ramp. The effects of positive association, acclimation to ramp climbing, and interest in exploration are likely contributors to the reduced loading time observed in ramp-housed pigs in this study.

In summary, adding a ramp and platform to nursery pig housing is associated with increased loading speed at market weight, reduced frequency of fighting behaviors in the nursery period, and had no detrimental effect on growth. Both increased loading speed of market pigs and decreased aggression between nursery pigs may be contribute to improved animal welfare.

APPLICATIONS

The objective of this study was to measure the effects of ramped nursery housing on outcomes in nursery pigs and market hogs. Hogs from ramped nursery pigs loaded with nearly
twice the speed of control hogs, without requiring additional encouragement. No detrimental effects of ramped housing were observed; growth rate was the same between treatments and ramp housed pigs were less aggressive in the nursery period. Adding ramps to nursery housing is a simple and relatively inexpensive adaptation with the potential to improve the welfare of pigs during the nursery phase and at marketing.

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LITERATURE CITED


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Effect of previous ramp exposure and regular handling on heart rate, ease of handling and


The effects of handling and group size on welfare of pigs in lairage and their influence on stomach weight, carcass microbial contamination and meat


United States Department of Agriculture. 2019. Livestock Slaughter 2018 Summary. Published April 2019


Table 1. Behavioral ethogram to evaluate pigs when raised in a regular flat pen (FLAT) or a pen with a ramp in it (RAMP) over 34 days in the nursery and at the time of marketing.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nursery pen, frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Eating</td>
<td>Pig at feeder actively consuming feed or masticating.</td>
</tr>
<tr>
<td>Drinking</td>
<td>Pig at mouth piece actively consuming water.</td>
</tr>
<tr>
<td>Fighting</td>
<td>Animal engaged in aggressive physical contact with another animal (threat, head knock, thrust, biting attempt, or biting) * .</td>
</tr>
<tr>
<td><strong>Loading</strong></td>
<td></td>
</tr>
<tr>
<td>Total Time (Sec)</td>
<td>Time elapsed while ascending the ramp, measured from the shoulder entering the incline of the ramp to shoulder crossing the determined finish point (entrance to the truck).</td>
</tr>
<tr>
<td>Refusal, frequency</td>
<td>Stop of forward motion after shoulder crossed ramp start line</td>
</tr>
<tr>
<td>Encouragement, frequency</td>
<td>Vocal or physical cue by handler to direct animal to reestablish forward movement, defined as any verbal encouragement or physical contact with a stopped pig.</td>
</tr>
</tbody>
</table>

Figure 1. RAMP (a) and FLAT (b) pen configurations.
Figure 2. Mean ± SE FLAT (●) and RAMP (■) observed eating behavior frequency across time. Differences between treatment group means are indicated with an asterisk (*) (P < 0.05).
Figure 3. Mean ± SE FLAT (●) and RAMP (■) observed drinking behavior frequency across time. Differences between treatment group means are indicated with an asterisk (*) (P < 0.05).
Figure 4. Mean ± SE FLAT (■■■) and RAMP (■■■) observed fighting behavior frequency across time. Differences between treatment group means are indicated with an asterisk (*) (P < 0.05).