RESEARCH REPORT
ANIMAL WELFARE

Title: The use of bedding in ramp to reduce slipping and falling while loading and unloading weaned and finishing pigs – NPB #12-005

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Date Submitted: 09/18/2014

Industry Summary:

Transport is a potentially stressful event that almost all piglets/pigs go through at least once in their life considering multi-site production systems and location of packing plants. Handling stress before and after transport can affect pig welfare and losses associated with transportation. Slips and falls increase the possibility of the fallen pig being trampled, and as such pose a welfare concern for the industry. In addition to the welfare issue, slips and falls can lead to laceration, injuries and bruises in the skin, which can lead to meat quality issues due to stress. Excessive slipping and falling can also increase the loading and unloading time for the handlers.

Slips and falls during loading and unloading can be associated with the angle of the ramp that is used for loading or unloading. Also materials used on the ramp surface may improve footing according to professional judgment. However, no scientific evidence supports ramp conditions or forms of bedding that may be efficacious.

Since slips and falls while loading and unloading pigs are a measure of welfare used in audits by the American Meat Institute (AMI) and other audit companies with an accepted percentage of slips and falls being very low (1% falling); as such, attempts need to be made to meet the standards. Lower percentage of slips and falls of animals may be achieved with slight modification of the facility (lowering the ramp angle) and modifying the floor surface of the ramp (use of proper material) – but specific science-based recommendations are not available. The purpose of this study was to investigate the effects of ramp angle, bedding material, moisture of bedding material, and season to make science-based recommendations that improve welfare of weaning and finishing pigs.

1. Establishing a potential interaction between ramp angle (0, 10 or, 20 degrees), bedding materials (nothing, sand, feed, sawdust shaving or wheat straw hay) and form of bedding (dry or wet bedding; 50% moisture bedding and/or floor wet) to determine if bedding is useful in reducing or eliminating slips and falls of weaned pigs (18-23 days of age; 10-15 lb)

2. The objective of this study was to investigate the effects of three ramp angles using different bedding material at different moisture levels over 2 seasons on the welfare of weaned pigs. Weaned pigs (barrows and gilts) were removed from their home pen and walked onto a ramp with the random treatment and onto a trailer. Pigs remained on the trailer for 30 min, then were unloaded from the trailer, walked down the ramp with the same treatment and returned to their home pen. Digital camcorders were used to determine the number of slips, falls, and vocalizations and the total time of loading and unloading.

In general, with the exception of using nothing and feed, all other beddings (sand, sawdust, and hay) decreased the number of slips, falls, and vocalizations. When taking moisture into account, using feed as a bedding was not beneficial in reducing slips, falls, and vocalizations when the ramp was dry. However, if the ramp surface was wet, using feed, or any other bedding was better than using nothing at all. The numbers of slips, falls, and vocalizations increased as the slope of the ramp increased. Slips, falls, and vocalizations were higher at a 20 degree slope regardless of season and moisture. Total time to load and unload the ramp varied depending on the slope, bedding, moisture, and season.

Reducing the slope of the ramp or the use of some type of bedding when loading and unloading weaned pigs is beneficial in reducing slips, falls, and vocalizations. Not using any bedding may increase the occurrence of these, especially at a 20 degree slope. Furthermore, situational factors should be considered in combination to identify the appropriate bedding for the specific occasion.

3. Establishing a potential interaction between ramp angle (0, 10 or, 20 degrees), bedding materials (nothing, sand, feed, sawdust shaving or wheat straw hay) and form of bedding (dry or wet bedding; 50% moisture bedding and/or floor wet) to determine if bedding is useful in reducing or eliminating slips and falls of finishing pigs (250-300 lb).

The objective of this study was to investigate the effects of three ramp angles using different bedding material at different moisture levels over 2 seasons on the welfare of finishing pigs. Finishing pigs were randomly divided into groups of 10. Heart monitors were placed around the chest of 2 pigs. A total of 4 pigs (including those with heart monitors) were removed from their home pen and walked onto a ramp with the random treatment and then onto a trailer. Pigs remained on the trailer 30 min then were unloaded from the trailer, walked down the ramp with the same treatment and returned to their home pen. Digital camcorders were used to determine the number of slips, falls, and vocalizations and the total time of loading and unloading.

In contrast to weaning pigs slope, bedding, moisture, and season did not affect slips, falls, and vocalizations. However, total time to load and unload the ramp and heart rates were affected by slope, bedding, moisture, and season.

Slope played an important role in the amount of time it took to load and unload finishing pigs on the ramp. Total loading times for 0 and 10 degree slopes were similar. As the slope increased from 0 and 10 degree slopes to 20 degrees the total time it took to load and unload pigs also increased.

The season, whether summer or winter affected the amount of time it took the pigs to load and unload the ramp. The time it took to load and unload during the summer was highest for sand and hay. It took a shorter amount of time for the pigs to load and unload when feed or when nothing was placed on the ramp during the summer. During the winter months the use of sawdust, sand, and feed had the lowest loading and unloading times.

The total time it took to load and unload the pigs varied with the type of bedding, moisture, season, and slope. The longest time for loading and unloading was with a slope of 20 degrees using dry sand as a bedding in the summer. There was a reduction in the amount of time it took to load and unload the pigs using dry sand as a bedding when the slope was 0 degree or 10 degrees. Loading and unloading times did decrease for sand in the winter, regardless of moisture status or ramp angle. The shortest time to load and unload was with a 0 degree

slope using dry sawdust as a bedding in the winter. There was not an increase in total time with its use, regardless of slope.

Heart rates in finishing pigs increased as the slope increased and were observed to be higher during the summer than during the winter. Heart rates at a 0 degree slope during the summer were lower than at 10 and 20 degree slopes. There was not a difference in heart rates during the winter regardless of slope.

When bedding and season were taken into account, heart rates were lower for feed than they were for other beddings during the summer. All other beddings did not differ in their effect on heart rates during the summer. Additionally, there were not any differences in heart rates based on the bedding used during the winter.

Differences in the total time it took to load and unload finishing pigs can be attributed to slope, bedding, moisture, and season. As slope increased to 20 degrees total time increased. Suggesting the use of a lower slope is beneficial in reducing loading and unloading times. It took longer for finishing pigs to load during the summer, especially if sand or hay were used as a bedding; whereas, the use of nothing or feed helped in decreasing the total time to load and unload. During the winter, the use of sawdust, sand, and feed had lower total times to load and unload. Total times were higher when dry sand was used in the summer at a 20 degree slope. In the winter, if dry sawdust was used, it was effective in reducing total times to load and unload regardless of the ramp slope.

Heart rates increased as the slope increased, and where higher during the summer than during the winter. Heart rates did not change during the winter regardless of slope. When bedding and season were taken into account, heart rates were lower for feed then they were for other beddings during the summer. There were not any differences found in heart rated bases on bedding used during the winter. Overall, several factors should be considered in combination to identify the appropriate bedding for the specific occasion in order to address financial losses due to pre-slaughter handling and good animal welfare.

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Keywords: finishing pigs, weaned pigs, slope, ramp, slips, falls, vocalizations, animal welfare

Scientific Abstract:

1. Loading and unloading weaned pigs: effects of bedding types, ramp angle, and bedding moisture

The use of non-slip surfaces during loading and unloading of weaned pigs plays an important role in animal welfare and economics of the pork industry. Currently, the guidelines available only suggest the use of ramps below 20 degrees to load and unload pigs. Three ramp angles (0, 10 or, 20 degrees), 5 bedding materials (no bedding, sand, feed, wood shavings or wheat straw hay), 2 moistures (dry or wet bedding; > 50% moisture) over 2 seasons (> 23.9^{o}C summer, < 23.9^{o}C winter) were assessed for slips/falls/vocalizations (N = 6,000 pig observations). “Score” was calculated by the sum of slips, falls, and vocalizations. With the exception of using feed as a bedding, all beddings provided some protection against elevated slips, falls, and vocalizations (P < 0.01). Providing bedding reduced scores regardless of whether the bedding was dry or wet (P < 0.05). Scores

increased as the slope increased ($P < 0.01$). Provision of bedding, other than feed, at slopes greater than zero, decreased slips, falls and vocalizations. Minimizing slips, falls, and vocalizations when loading and unloading pigs improved animal welfare.

2. Loading and unloading finishing pigs: effects of bedding types, ramp angle, and bedding moisture

The use of non-slip surfaces during loading and unloading of finishing pigs plays an important role in animal welfare and economics of the pork industry. Currently, the guidelines available only suggest the use of ramps with a slope below 20 degrees to load and unload pigs. However, the total time it takes to load and unload animals and slips, falls, and vocalizations are a welfare concern. Three ramp angles (0, 10 or, 20 degrees), 5 bedding materials (no bedding, sand, feed, wood shavings or wheat straw hay), 2 moistures (dry or wet bedding; >50% moisture) over 2 seasons (>23.9ºC summer, <23.9ºC winter) were assessed for slips/falls/vocalizations (N = 2,400 pig observations) and analyzed with a scoring system. Heart rate and the total time it took to load and unload the ramp increases as the slope of the ramp increases ($P < 0.05$). The use of bedding during summer or winter played a role in the total time it took to load and unload the ramp ($P < 0.05$). Bedding, bedding moisture, season, and slope significantly impacted the total time to load and unload ($P < 0.05$). The current study suggests that several factors should be considered in combination to identify the appropriate bedding for the specific occasion.

Introduction:

1. Loading and unloading weaned pigs: effects of bedding types, ramp angle, and bedding moisture

The use of non-slip surfaces during loading and unloading of pigs plays an important role in animal welfare and economics of the pork industry. Losses equate to millions of dollars due to damaged/injured pigs; the incidence of transport losses is estimated to be about 1% of all pigs marketed (Ellis 2003, Ritter 2006). Steep loading ramps have also been associated with injuries and prolapses (Warriss 1994, Guise 1989). For cattle, pigs, and sheep the maximum recommended angle for adjustable ramps is 25 degrees and 20 degrees for non-adjustable ramps (Grandin 1990). Most experts would agree that anything below 20° is an acceptable ramp angle (Christensen 1994, Grandin 1982). Currently, the guidelines available only suggest the use of ramps below 20 degrees to load and unload pigs. However, these guidelines do not suggest the use of non-slip materials on the ramp floor. Minimizing slips, falls and vocalizations when loading and unloading pigs can improve animal welfare, as well as reduce financial loss from decreased meat quality and trim loss caused by poor animal welfare.

Slips and falls due to slippery surfaces are part of welfare audits and assessments when loading or unloading before or after transport. Animal welfare is an important attribute in the concept of “food quality” (Bullar 2007), and there is an increasing consumer demand for higher animal welfare standards (Valverde 2012). Producers, processors, retailers, and restaurants have added value to their products in response to the demand in animal welfare standards. However, for producers that do not integrate improved animal welfare conditions, new marketing schemes may result in a less profitable and low quality product (Valverde 2012). The objective of this study was to investigate the effects of ramp angle, bedding material, moisture of bedding material, and season on welfare of finishing pigs.

2. Loading and unloading finishing pigs: effects of bedding types, ramp angle, and bedding moisture

Loading and unloading pigs for transportation plays an important role in animal welfare and economics of the pork industry. Pork quality and yield are greatly affected by pre-slaughter handling (Tarrant 1989).Transport losses represent multimillion dollar losses for the pork industry, have become a swine well-being priority, and rules and regulations have been developed because of it (Johnson 2010). Transport losses are multifactorial and involve people, pigs, facility design, management, transportation, slaughter facility, and environmental factors (Ritter 2009b). Additionally, transport losses may be influenced by factors such as genetics, carcass muscling, health status, structural soundness, body weight, nutrition, and conditions during transport (Ritter 2005). The incidence of transport losses is estimated to be about 1% of all pigs marketed (Ellis 2003, Ritter 2006).

Steep loading ramps have also been associated with injuries and prolapses (Warriss 1994, Guise 1989). For cattle, pigs, and sheep the maximum recommended angle for adjustable ramps is 25 degrees and 20 degrees for non-adjustable ramps (Grandin 1990). Loading and unloading pigs is considered the most critical part of the transport stage. Alternatives to loading by ramps have been studied, such as the use of a lift which provides an easier mean to handle pigs and also prevents excessive coercion from workers when loading pigs (Christensen 1994). Currently, the guidelines available only suggest the use of ramps below 20 degrees to load and unload pigs. However, these guidelines do not suggest the use of non-slip materials on the ramp floor. Slipping is defined as a loss of balance without the body touching the floor, while falling is defined as a loss of balance with part of the body other than the legs in contact with the floor (Valverde 2012). Slipping and falling can represent a welfare problem because they can cause stress and injuries to animals. Pot-belly and straight trailer designs are the most commonly used in the United States to transport pigs. The internal ramps of pot-belly trailers could cause an increase in stress due to slips and falls during loading and unloading (Warriss 1991) and possibly cause transport losses because of the higher number of the internal ramps the pigs are exposed to. A good transportation system should have well designed and carefully monitored facilities for loading and unloading, holding and the veterinary care of animals (Grandin 2008). Reducing stress at loading could potentially reduce the number of dead and down pigs during transport.

Pigs may also refuse to load when it is either too cold or too bright outside, including baulking if the air is blowing in their faces (Grandin 2007). Behavioral responses when loading pigs and can indicate an animal's aversion to a situation and can be characterized by freezing, not moving forward, backing up, running away, or vocalizing (Broom 2000). Social species such as pigs will vocalize excessively when caught or hurt (Broom 2000). The reactions to unpleasant stimulation may vary from animal to animal and from species to species (Broom 2000, Grandin 1982).

Heart rate may also be used as a welfare assessment measure. Heart rate variability has been used in animal research to analyze changes in sympathovagal balance related to diseases, psychological and environmental stressors or individual characteristics such as temperament and coping strategies (Von Borrel).

The objective of this study was to investigate the effects of three ramp angles using different bedding material at different moisture levels over 2 seasons on the welfare of finishing pigs.

Objectives:

1. Loading and unloading weaned pigs: effects of bedding types, ramp angle, and bedding moisture

   The objective of this study was to investigate the effects of ramp angle, bedding material, moisture of bedding material, and season on welfare of weaning pigs.

2. Loading and unloading finishing pigs: effects of bedding types, ramp angle, and bedding moisture

The objective of this study was to investigate the effects of ramp angle, bedding material, moisture of bedding material, and season on welfare of finishing pigs.

Materials & Methods:

1. Loading and unloading weaned pigs: effects of bedding types, ramp angle, and bedding moisture

General

Pigs were PIC USA genetics using the Camborough-22 sow line and the 280 boar line. All animals were fed a diet to meet or exceed NRC nutrient requirements. Feed and water were provided ad libitum. All animal procedures were approved by the Texas Tech University Animal Care and Use Committee.

Treatments

Three ramp angles (0, 10 or, 20 degrees), 5 bedding materials nothing (N), sand (S), feed (F), wood shavings (SD) or wheat straw (H), and 2 moistures (dry or wet bedding or floor) over 2 seasons (> 23.9^{o}C summer, < 23.9^{o}C winter) were assessed for slips/falls and vocalizations on weaning barrows and gilts. The study included 1200 weaned pigs in a multifactorial design (5 bedding X 2 moistures X 3 slopes X 2 seasons = 60 treatments). Pigs were handled in units of 20 pigs per group. Five, 20-pig replications of weaned pigs were evaluated per treatment. There were a total of 6,000 pig observations (20 animals/treatment X 60 treatments X 5 replications). Since the number of required animals was high for weaned piglets, each group of 20 piglets was used to evaluate no more than 10 randomly-selected treatments out of the 60 possible treatments. Weaned pigs that were injured, lame, or apparently sick were not used on the study.

The bedding material was either dry (greater than 80% dry matter with a target of 90% dry matter) or wet (less than 80% dry matter with a target of 50% dry matter). Seasons were determined by outside air temperature. Temperatures were categorized as summer (> 23.9°C to < 37.8°C) or winter (> -6.7°C to < 23.9^{o}C). Air temperature was used as a covariate within season in the statistical model, as well as air temperature effects. Temperature, humidity and wind speed outside the building were recorded every 5 minutes using a Kestrel® 4500 (Nielsen-Kellerman, Boothwyn, PA).When bedding was used on the ramp, it covered all the floor surface of the ramp. When wood shavings and straw were used as bedding material, its depth was 9.5 mm which is equivalent to using 1 bale (22.7 kg) of wood shavings in a 1.3 m X 2.5 m ramp. Similarly, when feed (non-pelleted, ground mixture of corn and soybean meal) and sand were used, 6.5 mm depth of bedding was used to cover the entire ramp floor surface. Twenty weaned pigs were loaded at a time and all the measures were recorded using digital Sony® camcorders DCR-SR85 (Sony, San Diego, CA). A camcorder was fitted at the back of the trailer facing towards the exit door of the barn to record slips, falls and vocalizations. Only 2 trained personnel were involved in moving the pigs and observing the video.

Loading and unloading onto the ramp and trailer

Barrows and gilts were weaned at 21 ± 3 d and put into groups of 20 pigs (4.5- 6.8 kg) per pen on wire floored pens (2.4 m X 1.2m). One week after weaning, 1 pen of 20 pigs was removed from their home pen and walked a distance of 37.5 to 46.7 m inside the building with a 1.2 m wide aisle and walked onto a ramp with the random treatment and onto a trailer. When pigs were reluctant to move, a high pitch whistling sound was made, or sorting board was used. Pigs walked on the ramp for a length of 4.6 m and then into the trailer. Pigs were moved the same distance irrespectively of ramp angle to get inside the trailer. Trailer pens were 2.1 X 2.4 m dimension. The ramp had a metallic chute, with a total length of 3.6 m and adjustable height. The chute was solid on the sides to 0.9 m high, then partially open above 0.9 m above the solid side. The ramp had cleats 0.3 m

apart to prevent slips and falls. Pigs remained on the trailer for 30 min then were unloaded from the trailer, down the ramp with the same treatment and returned to their home pen.

Behavioral recordings

Digital camcorders were placed so that the first and last steps on and off the ramp were recorded in order to determine the total time to load/unload. The time of loading/unloading was determined by the first pig's step onto the ramp and ended when the last pig stepped off the ramp onto the trailer (loading) or onto the aisle (unloading). The loading and unloading times were added to determine the total time. Video was analyzed for slips, falls, and vocalizations.

The sum of slips, falls, and vocalizations were recorded as a score in part because the data set for any one measure contained many zero values. Treatments were then given a score based on the observations. As the slips, falls, and vocalizations increased, the score increased. Lower scores meant a lower number of slips, falls, and vocalizations which was considered better than high scores. Slips were defined as when one foot missed a step but the pig caught itself; falling was considered an imbalance of the pig's body with some part of the body physically touching the floor; vocalizations were any squeals produced by the pigs other than grunts.

Statistical Analysis

The study used a Complete Randomized Design with 5 repetitions per treatment examining a total of 60 treatments. A general linear model was used and the data were analyzed using analysis of variance procedures in SAS. The statistical model included the effects of bedding, slope, wet/dry, season, all possible interactions, and temperature as a covariate. When wind was used as a covariate it was not significant. All data were tested for homogenous variances and normal distributions. The experimental unit was a group of 20 pigs. All data were analyzed using SAS 9.3 General Linear Models procedure (SAS, 2010 SAS Inst., Inc., Cary, NC).

2. Loading and unloading finishing pigs: effects of bedding types, ramp angle, and bedding moisture

General

Pigs were PIC USA genetics using the Camborough-22 sow line and the 280 boar line and weighed between 70 kg and 120 kg. All animals were fed a diet to meet or exceed NRC nutrient requirements. Feed and water were provided ad libitum. All animal procedures were approved by the Texas Tech University Animal Care and Use Committee.

Treatments

Three ramp angles (0, 10 or, 20 degrees), 5 bedding materials nothing (N), sand (S), feed (F), wood shavings (SD) or wheat straw (H), and 2 moistures (dry or wet bedding or floor) over 2 seasons (> 23.9^{o}C summer, < 23.9^{o}C winter) were assessed for slips/falls and vocalizations on finishing barrows and gilts. The study included 240 finishing pigs in a multifactorial design (5 bedding X 2 moistures X 3 slopes X 2 seasons = 60 treatments). Pigs were handled in units of 4 pigs per group. Five, 4-pig replications of pigs were evaluated per treatment. There were a total of 1200 pig observations (4 animals/treatment X 60 treatments X 5 replications). Since the number of required animals was high for finishing pigs, each group of 4 pigs was used to evaluate no more than 10 randomly-selected treatments out of the 60 possible treatments. Pigs that were injured, lame, or apparently sick were not used on the study.

The bedding material was either dry (greater than 80% dry matter with a target of 90% dry matter) or wet (less than 80% dry matter with a target of 50% dry matter). Seasons were determined by outside air

temperature. Temperatures were categorized into summer (> 23.9°C to < 37.8°C) and winter (> -6.7°C to < 23.9°C). Actual air temperature was used as a covariate within season in the statistical model, as well as air temperature effects. Temperature, humidity and wind speed outside the building were recorded every 5 minutes using a Kestrel® 4500 (Nielsen-Kellerman, Boothwyn, PA).When bedding was used on the ramp, it covered all the floor surface of the ramp. When wood shavings and straw were used as bedding material, its depth was 9.5 mm which is equivalent to using 1 bale of wood shavings in a 1.3 m X 2.5 m ramp. Similarly, when feed (a non-pelleted combination of corn and soybean meal) and sand were used, 6.5 mm depth of bedding was used to cover the entire ramp floor surface.

Heart rate monitor recordings

Heart rate monitors (Polar® RS800CX) were randomly placed around 2 of the finishing pigs' chests to collect heart rate information during loading and unloading. The heart rate monitors were started during loading once the pigs reached the door, but prior to loading the ramp. The heart rate monitors were kept on the pigs, and restarted when they were ready to be unloaded. The heart monitors were started once the gate to the trailer was open and they had access to the ramp. All the behavioral measures were recorded using digital Sony® camcorders DCR-SR85 (Sony, San Diego, CA). A wide angle camera was fitted at the back of the trailer facing towards the exit door of the barn to record slips, falls and vocalizations. Only 2 trained personnel were involved in moving the pigs and observing the video.

Loading and unloading onto the ramp and trailer

Pigs were put into groups of 10 in wire floored pens (2.1 m x 3.7 m). Heart monitors were placed around the chest of 2 pigs. A total of 4 pigs (including those with heart monitors) were removed from their home pen and walked a distance of 37.5 to 46.7 m inside the building with a 1.2 m wide aisle and walked onto a ramp with the random treatment and onto a trailer. When pigs were reluctant to move, a high pitch whistling sound was made, or a sorting board was used. Pigs walked on the ramp for a length 4.6 m and then into the trailer. Pigs were moved the same distance irrespectively of ramp angle to get inside the trailer. Trailer pens were 2.1 X 2.4 m dimension. The ramp had a metallic chute, with a total length of 3.6 m and adjustable height. The chute was solid on the sides to 0.9 m high, then partially open above 0.9 m above the solid side. The ramp had cleats 0.3 m apart to prevent slips and falls. Pigs remained on the trailer 30 min then were unloaded from the trailer, down the ramp with the same treatment and returned to their home pen. Digital camcorders (Sony) were placed so that the first and last steps on and off the ramp were recorded in order to determine the total time to load/unload. The time of loading/unloading was determined by the first pig's step onto the ramp and ended when the last pig stepped off the ramp onto the trailer (loading) or onto the aisle (unloading). The loading and unloading times were added to determine the total time. Video was downloaded and analyzed for slips, falls, and vocalizations.

Behavioral recordings

The sum of slips, falls, and vocalizations were recorded as a score in part because the data set for any one measure contained many zero values. Treatments were then given a score based on the observations. As the slips, falls, and vocalizations increased, the score increased. Lower scores meant a lower number of slips, falls, and vocalizations which was considered better than high scores. Slips were defined as when one foot missed a step but the pig caught itself; falling was considered an imbalance of the pig's body with some part of the body physically touching the floor; vocalizations were any squeals produced by the pigs other than grunts.

Statistical Analysis

The study used a Complete Randomized Design with 5 repetitions per treatment for a total of 60 treatments. A general linear model was used and the data were analyzed using analysis of variance procedures in SAS. The

statistical model included the effects of bedding, slope, wet/dry, season, heart rate, all possible interactions, and temperature and wind as a covariate. All data were tested for homogenous variances and normal distributions. The experimental unit was a group of 4 pigs. All data were analyzed using SAS 9.3 General Linear Models procedure (SAS, 2010 SAS Inst., Inc., Cary, NC).

Results:

1. Loading and unloading weaned pigs: effects of bedding types, ramp angle, and bedding moisture

Bedding types (nothing, feed, sand, sawdust, and hay) were used on a ramp to determine which was more effective in preventing slips, falls, and vocalizations at different angles (0, 10, 20), moisture levels (wet or dry) and seasons (summer or winter). Presented in Table 1 are *P* values for each measure over each variable in the model. The score combines each of the measures. Because so many observations were zero (ex. no slips, falls or vocalizations at zero degree slope), the score may be the most robust measure. A combined view of score and total time (TTime) to load and unload gives the best overall view of the results. Main effects will be summarized first followed by interactions.

3.1 Bedding Effect

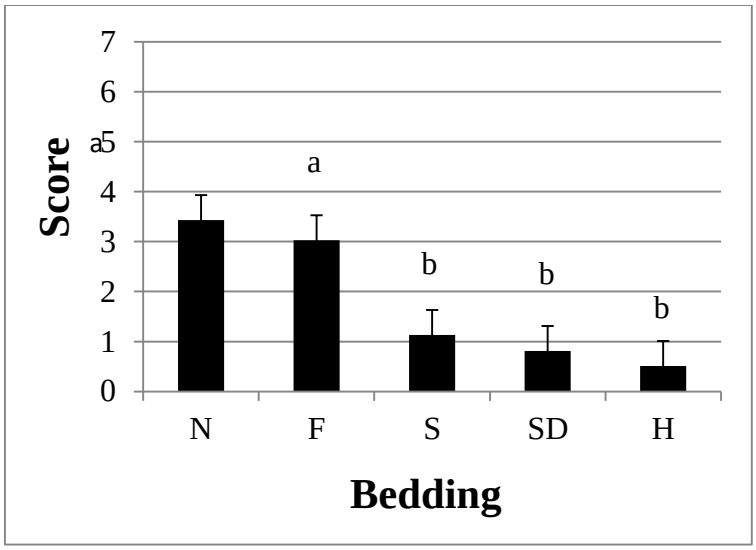
With the exception of using feed as bedding, all bedding materials provided some protection against slips, falls, and vocalizations ($P < 0.01$) compared to no bedding (Table 1). Score levels were lower for bedding that provided the most protection (Fig. 1).

Table 1. Least Squares means accompanied by pooled standard error for slips, falls, vocalizations, time (sec), and total score for loading (U) and unloading (D) for different bedding materials.

MEASURE	NOTHING	FEED	SAND	SAW DUST	HAY	SE	P VALUE
SLIP (U)	1.4^{a}	0.7^{b}	0.2^{bc}	0.4^{bc}	0.1^{c}	0.2	0.0023*
FALL (U)	0.4^{a}	0.4^{ab}	0.2^{bc}	0.1^{c}	0.1^{c}	0.1	0.0023*
VOCAL (U)	0.8	1.1	0	0.2	0.0	0.4	0.5268
TIME, S (U)	91.3	92.1	82.2	87	65.2	9.6	0.1260
SLIP (D)	0.5^{a}	0.6^{a}	0.4^{a}	0.1^{b}	0.1^{b}	0.1	0.0001*
FALL (D)	0.2	0.2	0.2	0	0.2	0.1	0.1372
VOCAL (D)	0.1	0.1	0.1	0	0	0.1	0.2110
TIME, S (D)	34.6^{a}	34.4^{a}	19.3^{b}	29.2^{ac}	25^{bc}	3.2	0.0010*
TTIME, S	126	126	101	116	90.1	11.2	0.0780
SCORE	3.4^{a}	$3.^{a}$	1.1^{b}	0.8^{b}	0.5^{b}	0.5	0.0086*

$^{a\text{-}c}$ within the Score row, means without a common superscript differ ($P < 0.05$)

Figure 1. Least square means ± 0.53 for score of slips, falls, and vocalizations for the different types of beddings ($P < 0.01$). Bedding was rated based on a score system which was calculated by the sum of slips, falls, and vocalizations. N = 60 observations/bedding types.

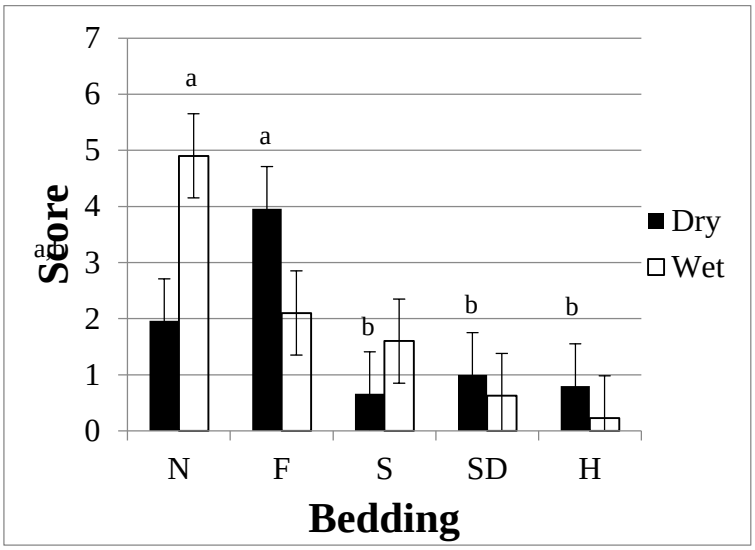


Superscripts are different at $P < 0.05$. Beddings abbreviated by N = nothing, F = feed, S = sand, SD = sawdust, H = hay. N = 60 observations/bedding types.

3.2 Moisture Effects

The interaction between moisture and bedding type was significant at ($P < 0.05$). The scores for dry ramp within bedding were similar, with the exception of feed (Fig. 2). Scores for nothing were not different than the other beddings, including feed ($P > 0.05$), but dry feed scores differed from other beddings ($P < 0.05$). The most evident protection on a dry surface was provided respectively by sand, hay, and sawdust. The lowest score on a dry surface was with sand (0.6 ± 0.75; $P > 0.05$). On a wet surface the use of hay, sawdust, sand, and feed reduced scores significantly compared to nothing. The lowest score with a wet surface was with hay (0.8 ± 0.75; $P > 0.05$). In the current study, using feed as a bedding was not beneficial in reducing slips, falls, and vocalizations when the ramp was dry. However, if the ramp surface was wet, using feed, or any other bedding was better than not using anything at all.

Figure 2. Least Square Means ± 0.33 for scores with the use of wet or dry bedding ($P < 0.05$). Bedding was rated based on a score system which was calculated by the sum of slips, falls, and vocalizations. N = 30 observations/bedding moisture.

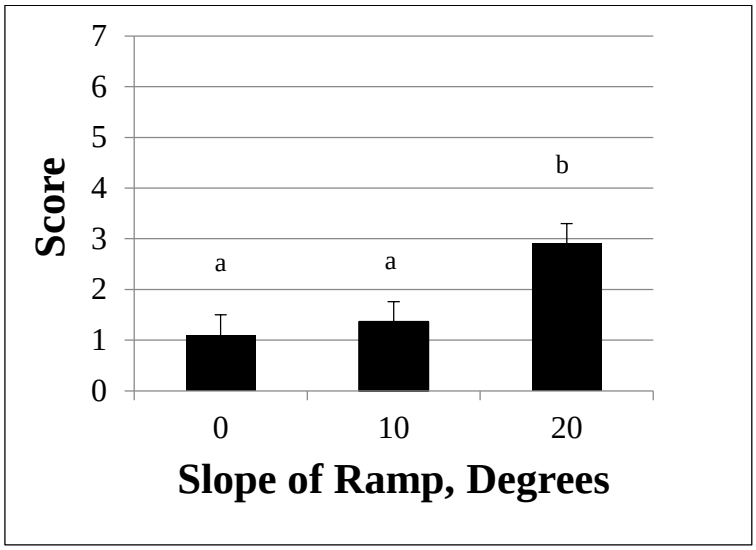


Superscripts are different at $P < 0.05$ with in moisture types. Beddings abbreviated by N = nothing, F = feed, S = sand, SD = sawdust, H = hay. Black bars represent dry bedding and open bars represent wet bedding.

3.3 Slope Effect

Scores increased with increasing slopes (Fig. 3). A ramp with a 20 degree slope caused a higher score ($P < 0.05$) than either 0 or 10 degree slopes. Scores increase by double from 0 to a 10 degree slope and almost by triple from 0 to a 20 degree slope. Therefore, the linear increase in scores suggest it is more effective to use a lower slope to decrease scores, but if decreasing the slope is not a possibility the use of bedding is beneficial.

Figure 3. Least Squares means for scores at different ramp slopes ($P < 0.01$). Scores were calculated based on the sum of slips, falls, and vocalizations. N = 300 observation of 20 pigs each.

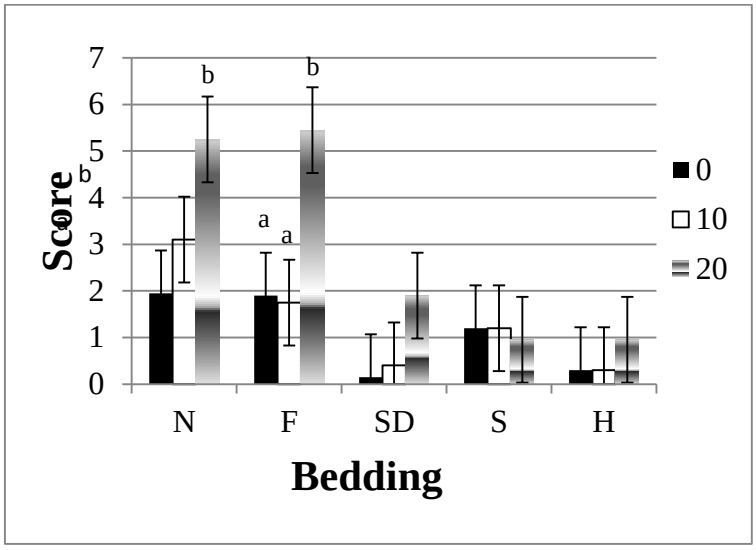


Superscripts are different at $P < 0.05$.

3.3 Interactions

The bedding by slope effect was significant ($P = 0.01$; Fig. 4). Not using any bedding or using feed had higher scores than other beddings at both 20 and 10 degree slopes. At a 0 degree slope the score for all beddings decreased significantly compared to 20 degree slope, except for sand which showed to have a relatively stable score regardless of the slope. The score for no bedding and feed increased in a linear fashion as slope increased. All other beddings decreased scores in comparison to no bedding and feed. Both sand and hay had the same effect on 20 degree slope scores.

Figure 4. Least Squares means ± 0.92 for scores at different ramp slopes with the use of different beddings ($P < 0.01$). Bedding was rated based on a score system which was calculated by the sum of slips, falls, and vocalizations.



Superscripts within bedding are different at $P < 0.05$.

There was a significant 3-way interaction for moisture level, season, and slope for score ($P < 0.05$). Scores for 20 degree slopes were higher than the other slopes among season and moisture levels (Table 2).

Table 2. Least Squares means ± 0.82 for score in response to the 3-way interaction for Moisture (D = Dry, W = Wet), season, and slope ($P < 0.05$). N = 60 treatments.

Moisture	Season	Slope	Score
D	Summer	0	0.8
D	Summer	10	1.4
D	Summer	20	1.6
D	Winter	0	0.8[a]
D	Winter	10	0.6[a]
D	Winter	20	4.7[b]
W	Summer	0	0.9[a]
W	Summer	10	1.4[a]
W	Summer	20	3.0[b]
W	Winter	0	1.7
W	Winter	10	1.9
W	Winter	20	2.2

Superscripts within each moisture, season, slope, and score differ at ($P < 0.05$).

The 20 degree slope for a dry surface during winter and a wet surface during summer had the highest scores when compared to other beddings, moisture levels, and seasons. The longest total times for loading and unloading was found when no bedding was used at a 20 degree slope during summer on a wet surface (Table 3), and the fastest time was when hay was used at a 10 degree slope during winter on a wet surface (Table 4). Additionally, an additive effect was seen with certain beddings. If the ramp was at a 20 degree slope and had no bedding on it and the surface was wet, scores increased, and the time it took to load also increased. During the course of the study, it was observed that certain beddings were effective in decreasing scores but also increased total times, possibly due to the pigs being distracted by the bedding. This behavior was observed mostly with wet sawdust, which distracted the pigs and caused them to spend more time playing and eating the bedding than going up the ramp. The amount of time spent loading and unloading is important in the swine industry since loading pigs is considered a critical part of the transport stage. Therefore, the current study shows that several factors should be considered in combination to identify the appropriate bedding for the specific occasion.

Table 3. Least Squares means ± 39.09 for total time (sec) during the summer in response to the four-way interaction of bedding, moisture level (W/D), season, and slope.

Bedding	Moisture level[1]	Season	Slope, °	Total Time, sec	Score
Nothing	D	Summer	0	112.2	0.6
Nothing	D	Summer	10	113.2	1.2
Nothing	D	Summer	20	78.2	1.4
Nothing	W	Summer	0	75.2[a]	1.4
Nothing	W	Summer	10	133.6[a]	4.4
Nothing	W	Summer	20	257.2[b]	11.2
Feed	D	Summer	0	191.2[a]	2.8
Feed	D	Summer	10	83.0[b]	4.8
Feed	D	Summer	20	121.6[a,b]	4.0
Feed	W	Summer	0	122.2	1.4
Feed	W	Summer	10	101.0	1.0
Feed	W	Summer	20	99.0	2.4
Sand	D	Summer	0	137.4	0.4
Sand	D	Summer	10	82.2	1.0
Sand	D	Summer	20	143.0	0.8
Sand	W	Summer	0	101.4	1.4
Sand	W	Summer	10	105.6	0.6
Sand	W	Summer	20	60.8	1.4
Sawdust	D	Summer	0	96.2	0.0
Sawdust	D	Summer	10	121.4	0.0
Sawdust	D	Summer	20	119.0	0.2
Sawdust	W	Summer	0	99.4	0.2
Sawdust	W	Summer	10	164.8	1.2
Sawdust	W	Summer	20	109.0	0.0
Hay	D	Summer	0	104.6	0.4
Hay	D	Summer	10	116.6	0.2
Hay	D	Summer	20	73.8	1.6
Hay	W	Summer	0	138	0.4
Hay	W	Summer	10	110.8	0.2
Hay	W	Summer	20	79.4	0.2

Superscripts are different at $P < 0.05$ within a bedding, moisture level, and season. [1] Moisture levels: dry (D); wet (W)

Table 4. Least Squares means ± 39.09 for total time (sec) during the winter in response to the four-way interaction of bedding, moisture level (W/D), season, and slope.

Bedding	Moisture level[1]	Season	Slope, °	Total Time, sec	Score
Nothing	D	Winter	0	82.4[a]	2.0
Nothing	D	Winter	10	112.8[a]	0.8
Nothing	D	Winter	20	223.4[b]	5.8
Nothing	W	Winter	0	105.8	3.8
Nothing	W	Winter	10	136.6	6.0
Nothing	W	Winter	20	81.6	2.6
Feed	D	Winter	0	73.2	1.4
Feed	D	Winter	10	103.8	0.0
Feed	D	Winter	20	170.6	10.8
Feed	W	Winter	0	251[a]	2.0
Feed	W	Winter	10	131.8[b]	1.2
Feed	W	Winter	20	70.8[b]	4.6
Sand	D	Winter	0	124.2	0.2
Sand	D	Winter	10	97.8	1.2
Sand	D	Winter	20	85.2	0.4
Sand	W	Winter	0	116.8	2.8
Sand	W	Winter	10	83.8	2.2
Sand	W	Winter	20	80.4	1.2
Sawdust	D	Winter	0	91.6[a]	0.2
Sawdust	D	Winter	10	67.0[a]	0.4
Sawdust	D	Winter	20	217.6[b]	5.2
Sawdust	W	Winter	0	110.2[ab]	0.2
Sawdust	W	Winter	10	188.0[a]	0.0
Sawdust	W	Winter	20	73.8[b]	2.2
Hay	D	Winter	0	114.8	0.4
Hay	D	Winter	10	75.4	0.6
Hay	D	Winter	20	65.2	1.6
Hay	W	Winter	0	90.8	0.0
Hay	W	Winter	10	46.8	0.2
Hay	W	Winter	20	65.4	0.4

Superscripts are different at $P < 0.05$ within a bedding, moisture level, and season. [1] Moisture levels: dry (D); wet (W)

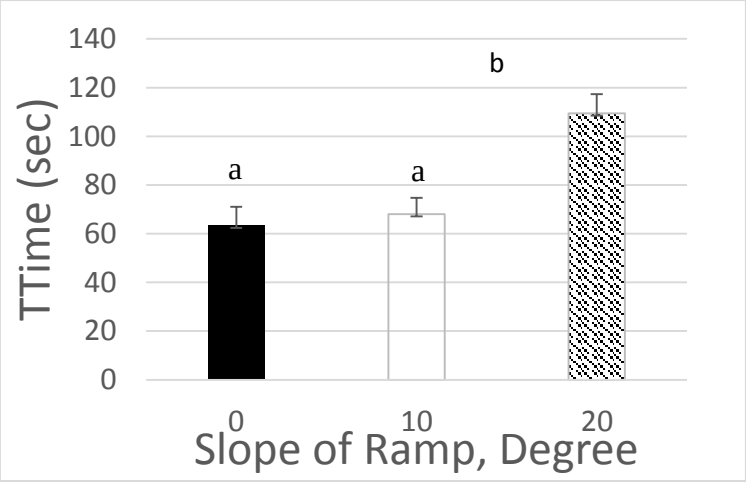
2. Loading and unloading finishing pigs: effects of bedding types, ramp angle, and bedding moisture

Bedding types (nothing, feed, sand, sawdust, and hay) were used on a ramp to determine which was more effective in preventing slips, falls, and vocalizations at different angles (0, 10, 20), moisture levels (wet or dry) and seasons (summer or winter). The score combines each of the measures. Because so many observations were zero (ex. There were no slips, falls or vocalizations at zero degree slope), the score may be the most robust measure. A combined view of score and total time (TTime) to load and unload gives the best overall view of the results. Main effects will be summarized first followed by interactions

3.1 Total Time: Slope Effect

Slope played an important role in the amount of time it took to load and unload finishing pigs on the ramp. As the slope increased the time it took to load and unload increased (Fig. 1).

Figure 1. Least Squares means for total time it took to load and unload pigs on a ramp with slopes of 0, 10, 20 ($P < 0.01$). N = 100 observation of 4 pigs each.



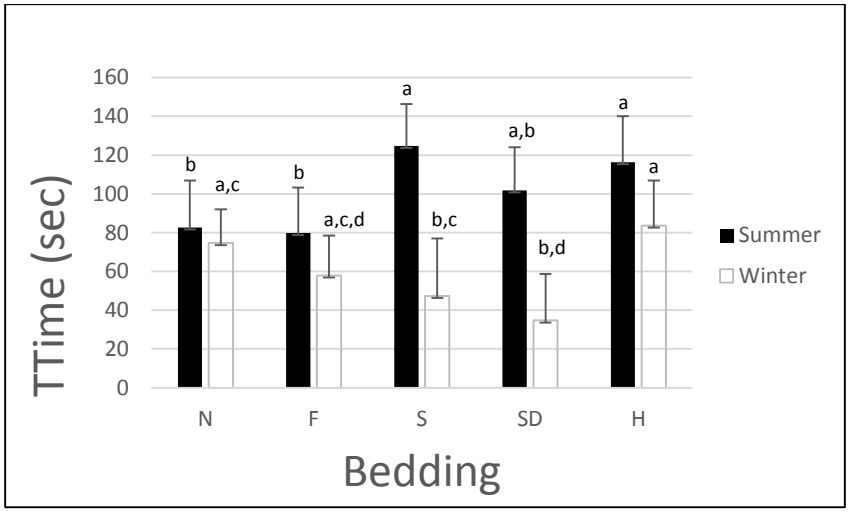
Superscripts are different at $P < 0.05$.

3.2 Total Time: Interaction for Bedding by Season

The season, whether summer or winter affected the amount of time it took the pigs to load and unload the ramp. There was a significant interaction for season by bedding ($P < 0.05$). The time it took to load/unload during the summer was highest for sand, and hay, respectively 125 ± 21.7 sec and 116 ± 23.7 sec (Figure 2). It took a shorter amount of time for the pigs to load when feed or when nothing was placed on the ramp, respectively 80 ± 23.4 sec and 83 ± 24.3 sec. Feed was used as a bedding because it is sometimes used by people trying to load pigs at the farm when other bedding is not available. According to this study the use of feed is an effective method to reduce loading and unloading times in the summer, but not using any bedding on the ramp is also acceptable in reducing the total time it takes to load and unload finishing pigs. During the winter months the use of sawdust sand, and feed had the lowest loading and unloading times, respectively, 35 ± 24.1 sec, 47 ± 29.6 sec, and 58 ±20.1 sec. Differences in the total time it took to load with different beddings may have been due to

preferences in the smell and consistency of the beddings. For example, feed placed on the ramp was the same type of feed the pigs were fed on a daily basis and the smell may not have been novel to them, hence not attracting them to stay longer smelling and investigating it. The other beddings were novel and this may be the reason some total times increased with their use.

Figure 2. Least Squares means for total time for bedding x season interaction ($P < 0.05$). N = 30 observations. Bedding abbreviations N = nothing, F = feed, S = sand, SD = sawdust, H = hay.



Superscripts for total time within season are different at $P < 0.05$.

3.3 Total Time: Interaction for Bedding, Moisture, Season, and Slope

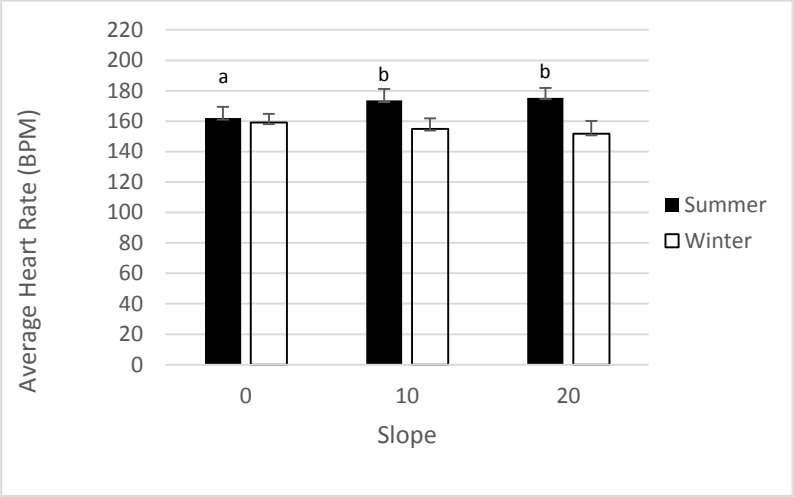
The total time it took to load and unload the pigs varied with the type of bedding, moisture, season, and slope. The longest time for loading and unloading was with a slope of 20 degree using dry sand as a bedding in the summer with a total time of 302.8 ± 34.7 sec (Table 1). There was a significant reduction ($P > 0.05$) in the amount of time it took to load and unload the pigs using dry sand as a bedding when the slope was 0 degree or 10 degree (respectively 58 ± 33 sec and 86 ± 36.2 sec). Loading and unloading times did decrease for sand in the winter, regardless of moisture status or ramp angle (Table 2). The shortest time to load and unload was with a 0 degree slope using dry sawdust as a bedding in the winter (25 ± 33.6 sec). There was no significant increases in total time with its use, regardless of slope (25 ± 49.1 with 10 sec degree slope and 50 ± 34.5 sec with a 20 degree slope).. Furthermore, it was efficient in decreasing loading times even if used when wet during the winter at all slopes, just like the use of dry sawdust. However, if used in the summer loading and unloading times increased with its use, with the shortest amount of time for loading and unloading being 65 ± 37 sec and 180 ± 32.9 sec at its longest amount of time. The use dry hay irrespective of the season increased total times significantly from a 0 degree slope to a 20 degree slope. Therefore, dry hay would not be a recommendable bedding to decrease loading times in the summer.

3.4 Heart Rate: Interaction for Bedding by Season

Heart rates in finishing pigs increased as the slope increased and were observed to be higher during the summer than during the winter ($P < 0.05$). Heart rates at a 0 degree slope during the summer were significantly lower than at 10 and 20 degree slopes ($P < 0.05$) (Figure 3). There was not a difference in heart rates during the winter

regardless of slope. The increase in heart rates during the summer may also be attributed to heat stress and not solely just the bedding and slope of the ramp.

Figure 3. Least Squares means for average heart rate at different slopes during summer or winter season ($P < 0.05$).

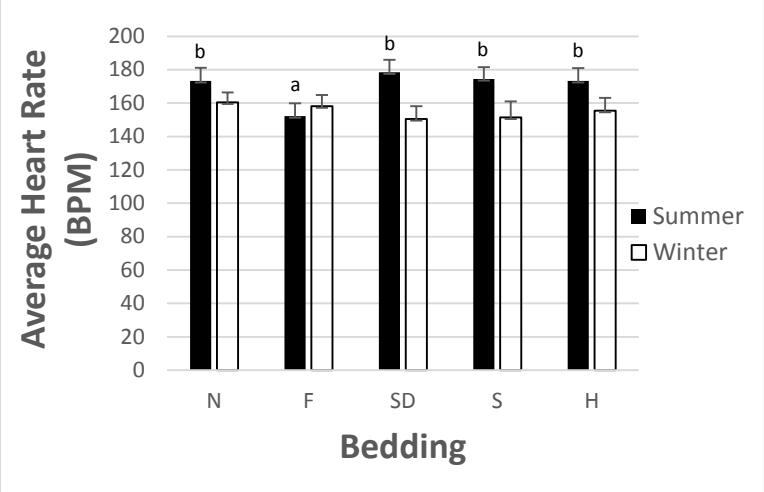


Superscripts are different at $P < 0.05$ within season.

3.5 Heart Rate: Interaction for Bedding by Season

The use of bedding on the ramp was significant based on the season ($P < 0.01$). Heart rates were lower for feed than they were for other beddings during the summer (Figure 4). All other beddings did not differ in their effect on heart rates during the summer. Additionally, there were not any differences in heart rates based on the bedding used during the winter.

Figure 4. Least Squares means for average heart rate for different beddings during summer or winter season ($P < 0.01$). Bedding abbreviations N = nothing, F = feed, S = sand, SD = sawdust, H = hay.

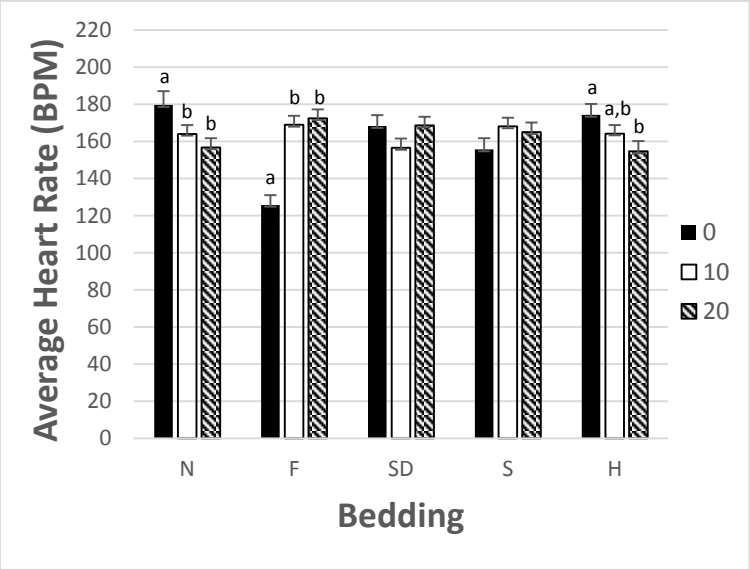


Average heart rate within season. Superscripts are different at $P < 0.05$ within bedding. Black bars represent summer and open bars represent winter.

3.6 Heart Rate: Interaction for Bedding by Slope

The use of bedding at different slopes either significantly reduced heart rates or increased them ($P < 0.01$). Using nothing at a 0 degree slopes had higher heart rates than at 10 and 20 degree slopes, therefore heart rates decreases as the slope increased (Figure 5). This can possibly be attributed to the speed at which the finishing pigs went up the ramp. At a 0 degree slope, finishing pigs tended to run up the ramp when there was no bedding. When the slope increased they slowed down their pace of loading. The use of hay as a bedding had similar results as using nothing. Heart rates were higher at a 0 degree slope and they decreased as the slope increased. When feed was used on the ramp heart rates increased as the slope increased. Heart rates were significantly higher at 10 and 20 degree slopes.

Figure 5. Least Squares means for average heart rate for different beddings 0, 10, and 20 degree slopes ($P < 0.01$). Beddings abbreviated by N = nothing, F = feed, S = sand, SD = sawdust, H = hay.



Superscripts are different at $P < 0.05$ within bedding.

3.7 Heart Rate: Interaction for Bedding, Season, and Slope

The use of bedding during either summer or winter at 0, 10, and 20 degree slopes had a significant effect on heart rate ($P < 0.05$). Using nothing on the ramp during the summer season at a 0 degree slope had a higher heart rate than at a 20 degree slope (Table 3). The use of hay during the summer season had similar results as using nothing. Heart rates were higher at a 0 degree slope than with a 20 degree slope. The use of feed during the summer had a linear increase in heart rate, which is more typical of what should happen when pigs are loading and unloading the ramp. Heart rates during the summer were more elevated than they were during the winter.

Table 3. Least Squares means for heart rate (BPM) during loading and unloading in response to the three-way interaction of bedding, season, and slope ($P < 0.05$).

Bedding	Season	Slope, º	Avg HR (BPM)	SE
Nothing	Summer	0	184[a]	11.78
Nothing	Summer	10	172[ab]	9.09
Nothing	Summer	20	164[b]	8.35
Nothing	Winter	0	175	9.16
Nothing	Winter	10	157	7.32
Nothing	Winter	20	150	10.91
Feed	Summer	0	103[a]	9.36
Feed	Summer	10	174[b]	9.87
Feed	Summer	20	180[b]	9.04
Feed	Winter	0	147	10.71
Feed	Winter	10	162	8.46
Feed	Winter	20	165	7.27
Sand	Summer	0	169	8.92
Sand	Summer	10	176	9.30
Sand	Summer	20	178	9.21
Sand	Winter	0	143	12.68
Sand	Winter	10	160	9.32
Sand	Winter	20	152	11.87
Sawdust	Summer	0	178	11.11
Sawdust	Summer	10	175	8.96
Sawdust	Summer	20	183	8.20
Sawdust	Winter	0	159	7.45
Sawdust	Winter	10	138	11.80
Sawdust	Winter	20	154	9.58
Hay	Summer	0	176	8.88
Hay	Summer	10	172	10.26
Hay	Summer	20	172	9.17
Hay	Winter	0	172[a]	7.54
Hay	Winter	10	157[a]	9.99
Hay	Winter	20	137[b]	13.52

Superscripts are different at $P < 0.05$ within bedding.

Discussion:

1. Loading and unloading weaned pigs: effects of bedding types, ramp angle, and bedding moisture

The use of some type of bedding when loading and unloading pigs on a ramp is beneficial in reducing slips, falls, and vocalizations; whereas, not using any bedding may increase the occurrence of these. The welfare assessment during audits of pigs including, slips, falls, fear, thermoregulation behaviors, sickness, and dead animals are measured during unloading off the truck [9].To our knowledge, the type of bedding to be used on ramps to reduce slips, falls, and vocalizations during loading and unloading has not been evaluated. In most occurrences, if bedding is used at all, the choice of material is based on what is cheapest or what may be at hand.

In the current study, with the exception of using nothing and feed as a bedding, sand, sawdust, and hay decreased the number of slips, falls, and vocalizations. When taking moisture into account, using feed as a bedding was not beneficial in reducing slips, falls, and vocalizations when the ramp was dry. However, if the ramp surface was wet, using feed, or any other bedding was better than not using anything at all. The numbers of slips, falls, and vocalizations increased as the slope of the ramp increased. If nothing was used or feed was used as a bedding, there was an increase in slips falls and vocalizations compared to sand, sawdust, and hay. Total time to load and unload the ramp varied depending on the slope, bedding, moisture, and season.

Slope of the ramp is another factor to take into consideration. As the slope of the ramp increased the scores increased. Thus, the score was highest at the 20 degree slope. The scores increased almost by double from 10 degree to 20 degree slope and almost by triple from 0 to a 20 degree slope. Therefore, the linear increase in scores suggests it is more effective to use a lower slope to decrease scores and if decreasing the slope is not a possibility the use of bedding is beneficial. Furthermore, several factors should be considered in combination to identify the appropriate bedding for the specific occasion.

Both cattle and pigs remember bad experiences and when handled roughly they are harder to handle in the future (Grandin 1993, 1994). Pigs are socially investigative (investigate con-specifics) or non-socially investigative (investigate the environment) (Coutellier 2007) either the smell or the consistency of the bedding in the current study may have caused the pigs to increase exploring; this slower traffic up the ramp may reduce slips, falls, and vocalizations while increased total time. Even if bedding decreased scores, the increased time to load could potentially create additional problems. Some of the delays in loading or unloading may not directly be caused by bedding. Other than investigative behaviors, an animal's aversion to a situation can increase loading and unloading times. Aversion to a situation may be characterized by freezing, not moving forward, backing up, running away, or vocalizing (Broom 1996). It has also been suggested that pigs refuse to load when it is either too cold or too bright outside (Grandin 2007). Therefore, several factors should be considered in combination to identify the appropriate bedding for the specific occasion.

Further studies are needed to find more effective non-slip footing surfaces. Cleats spaced to the length of the pigs stride can prevent leg injuries (Mayes 1978). However, when cleats are too close together the animal will step on top of the cleats instead of between them, not providing traction (Grandin 2008). If the cleats are spaced too far apart then they can also cause slipping and possibly damage piglet dew claws (Grandin 2008). This is because most ramps are made for finishing pigs or cattle and, therefore are not appropriate for weaned pigs. Stair step ramps on concrete have also been reported to be effective non-slip footing surfaces (Grandin 1997, Grandin 1998), but concrete reinforcing rods can also make good cleats on steel ramps and provide a good non-

slip surface as long as cleats are adequately spaced (Grandin 2008). The use of rubber tire mats also may merit further research. Rubber tire mats are economical and can be an effective non-slip surface. Providing non slip surfaces is of the essence in order to stay compliant with animal welfare perspectives and to avoid monetary losses. Furthermore, there is a growing consensus toward the implementation of higher animal welfare standards. Vehicles used to haul animals, scales, and stunning areas should also consist of non-slip flooring (Grandin 2006).

Scientific data on material type, moisture of bedding, and ramp angles based on pigs' size will allow pork producers to improve animal welfare quality, while also addressing financial cost of pre-slaughter handling.

2. Loading and unloading finishing pigs: effects of bedding types, ramp angle, and bedding moisture

The use of some type of bedding when loading and unloading finishing pigs on a ramp is beneficial in reducing the total time it takes for the animals to load and unload. Reducing loading times can reduce transportation stress and may prevent excessive coercion from workers. The amount of time spent loading and unloading is important in the swine industry since loading pigs is considered the most critical part of the transport stage. The delay in loading and unloading due to unmanageable pigs may be frustrating to the handler, and even small amounts of threatening behaviors by humans can produce a chronic stress response in pigs (Barnett 1986). Aggressive handling, including the use of electric prods, produce a major metabolic response that results in an increase in body temperature, decreased blood pH, and a high incidence of fatigued pigs (Ellis 200). It is important to train employees on how to handle animals, using methods that are less stressful, and possibly even conduct weekly audits with a numerical scoring systems to ensure that high welfare standards are maintained (Grandin 2008).

To our knowledge, the type of bedding to be used on ramps to reduce slips, falls, and vocalizations in finishing pigs during loading and unloading has not been evaluated. In the current study the use of bedding did not significantly affect scores, but did affect loading and unloading times as well as heart rate.

It seems that having a bedding pigs are familiar with in the summer reduces or prevents investigative behavior, and hence, may decrease loading and unloading time. Additionally, decreasing the slope is the best option to reduce loading and unloading time, but if it is not a possibility the use of bedding is beneficial, depending on the season. As the slope of the ramp increased the total times also increased. Thus, total time to load and unload was highest at the 20 degree slope. Total time to load and unload finishing pigs was very similar between 0 and 10 degree slopes but it increased almost by double from 0 and 10 to a 20 degree slope. Therefore, the linear increase suggests it is more effective to use a lower slope in order to decease the total time it takes to load and unload finishing pigs. Decreasing the slope is the best option to reduce loading and unloading time but if it is not a possibility the use of bedding is beneficial, depending on the season.

There was a significant difference in the effect bedding and season had on the total time it took to load and unload the pigs. During the winter months the use of sand and sawdust was very effective in reducing the amount of time it took to load and unload the pigs. However, during the summer months not using any bedding or using feed as a bedding reduced the amount of time it took for the finishing pigs to load and unload the ramp.

In the current study, heart rates also increased as the slope increased, and where higher during the summer than during the winter. Heart rates did not change during the winter regardless of slope. When bedding and season

were taken into account, heart rates were lower for feed then they were for other beddings during the summer. There were not any differences found in heart rated based on bedding used during the winter.

Pigs are socially investigative (investigate con-specifics) or non-socially investigative (investigate the environment) (Coutellier 2007). Either the smell or the consistency of the bedding in the current study seemed to cause the pigs to increase non-socially investigative behaviors. Additionally, in commercial settings where pigs are typically loaded and unloaded quickly, slow loading and unloading times caused by increased exploration could potentially create additional problems. Some of the delays in loading or unloading may not directly be caused by bedding. Causes for delays in loading and unloading can include aversion to shadows, noise, either too cold or too bright outside (Grandin 2007, VanPutten 1982), current injuries the animals may have that prevent them from loading rapidly, novelty of objects they are not accustomed to seeing, interaction with humans, and other undermined causations. Hence, aversive situations can increase loading and unloading times because they are characterized by freezing, not moving forward, backing up, running away, or vocalizing (Broom 1996). Good methods to decrease stress and loading times may also include having pens positioned next to the loading area, not mixing unfamiliar pigs, regular handling of pigs when they are young (Broom 1996, Hemsworth 1987), and moving them in small groups, rather than in big groups or individually when they are being loaded (VanPutten 1982).

Heart rate is an important measure commonly used to evaluate animal welfare during stimulated handling and transportation (Perremans 1998). Heart rate is used as a sign of autonomic response to stress and welfare of animals during exposure to stressors (Fraser 1990) and may also be related to body weight (Perremans 1998). Pigs may perceive environmental aspects as aversive, and it has been suggested that noise may also be a disturbing factor that may increase heart rate (Geverink 1998).

Slip-resistance of floors merit further study. Furthermore, slip-resistance of floors should be studied in combination with characteristics of flooring such as abrasion, surface profile, and hardness, to avoid injuries to pigs (McKee 1995). It is also important to understand that pigs can adapt to fouled floor conditions by reducing their walking speed and stride length, but it is not sufficient to ensure walking safety (Von Wachenfelt 2009).

Overall, several factors should be considered in combination to identify the appropriate bedding for the specific occasion in order to address financial losses due to pre-slaughter handling and good animal welfare.

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