

Testing the feasibility of using a conveyor belt to load weanling and nursery pigs for transportation¹

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ABSTRACT: Transportation is known to be a multifaceted stressor, with the process of loading being one of the most significant factors impacting the stress to which animals are exposed. This project was designed to determine if using a conveyor to load pigs into the top deck of a simulated straight deck trailer could lower the stress to which pigs and handlers are exposed. Pigs were assigned to either a Control group that were herded up a stationary conveyor ramp into a top deck trailer (2.5 m above the ground); or Conveyor group which were herded onto a mobile conveyor into a top deck trailer. The conveyor was 7.6 m long, 0.9 m wide and rose to 2.5 m high at a 16° slope, and moved 11.3 m/min. Two age groups were tested; Weanling pigs which were moved in groups of 20 ($n = 14$ groups/treatment) and Nursery pigs which were moved in groups of 10 ($n = 15$ groups/treatment). Behavior was recorded during loading, including slips and falls, vocalizations, assists, and time to load. Heart rate of 2 sentinel pigs/group and the handler were recorded during loading, and body temperature of the handler after loading. Pigs were held in the simulated trailer for 30 min while heart rate was recorded. After which, they were unloaded and held in

a holding pen for an additional 30 min while heart rate was recorded. There were no treatment differences for slips or falls ($P < 0.90$). Vocalizations were too few to analyze. Both Weanling (2.8 ± 0.7) and Nursery (1.6 ± 0.5) Conveyor pigs needed to be assisted onto the conveyor more than Weanling (1.2 ± 0.4) and Nursery (0.3 ± 0.1) Control pigs ($P < 0.06$). There was no difference in total loading time between the treatments for any age group ($P < 0.15$), with Weanling and Nursery pigs loading in 50 to 45 s, respectively. There were no treatment differences for heart rate variability measures ($P > 0.10$). However, loading increased heart rate of Nursery pigs (204.9 ± 5.7 bpm, $P < 0.005$), but not Weanling pigs (172.1 ± 9.0 bpm). Nursery pigs had a greater ratio of low frequency to high frequency power during loading ($P < 0.02$) compared to other phases of the procedure in both Control and Conveyor groups. Heart rate (93.9 ± 1.9 bpm) and body temperature ($31.1 \pm 0.3^\circ\text{C}$, eye temperature) of the handler was not affected by treatment ($P < 0.26$). Based on behavior and physiology, the pigs had similar experiences in both treatments. This study shows that it is feasible to use a conveyor to load pigs, but it may not be advantageous.

Key words: conveyor, ramp, stress, swine, transport

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INTRODUCTION

Approximately 199.1 million pigs are marketed yearly (NASS, 2014), illustrating the importance of proper loading and handling to ensure adequate animal welfare. In addition, pigs are transported multiple times in their life, including when they are weaned, moved from the nursery, and moved to the finisher. Therefore, pigs are exposed to at least 2 transportation events in their lifetime. Very little

research has been done on the effects of transportation of young pigs, but transportation has been established as a multi-factorial stressor for market weight animals [Schwartzkopf-Genswein et al. (2012) for review]. Loading, facility design and handling methods are highlighted as key factors that impact behavioral and physiological responses of pigs during transport. The effect of multiple stressors has resulted in reported values of 0.25% of pigs arriving to abattoirs dead and another 0.44% arriving as non-ambulatory (Ritter et al., 2009). Traditionally, sloped loading chutes are used to load and unload pigs at the farms and packing plants. In many cases, these chutes require pigs to walk up to the upper deck of a straight deck trailer on a metal, wood or concrete surface during loading. Pigs are not used to walking a long distance on a sloped ramp. These events can be stressful to the pigs both physically and psychologically (Lewis et al., 2008).

We hypothesized that an automated conveyor belt would move pigs up into a trailer with less stress to the pig and the handler. This would reduce intervention by the handlers when pigs are on the ramp, reduce slips and falls, and reduce the stress associated with loading. Reducing stress before and after transport of piglets can help ameliorate the negative impact stress can have on growth and health (Schwartzkopf-Genswein et al., 2012). Decreasing slips and falls can reduce stress, bruises, lacerations and injuries to the pigs (Grandin, 2003).

The objective of this study was to determine if loading piglets into a trailer with a conveyor would make the procedures less stressful and thus improve welfare. Two age groups, Weanling and Nursery pigs, were used to compare animals that differed in ease of loading.

MATERIALS AND METHODS

Procedures were approved by Purdue Animal Care and Use Committee (# 1609001473). The study was conducted at the Animal Science Research and Education Center Swine Unit at Purdue University, West Lafayette, Indiana. Weanling piglets 18 to 23 d of age and Nursery pigs 46 to 51 d of age were used. Weanling pigs were housed with their dam in standard farrowing crates with woven wire floors. Nursery pigs were housed, 8 per pen (1.52 × 1.52 m), on woven wire floors. The pigs were tested to determine if loading using a conveyor belt loader could promote self-movement of pigs, reduce stress to animals and handlers, and improve overall welfare.

Piglets were weaned at approximately 21 d of age and randomly assigned to 1 of 2 treatments. Pigs were loaded into the upper deck of a simulated straight-deck trailer using 1 of the following methods, 1) Control: Pigs were loaded using the immobile conveyor ramp, without the conveyor turned on, or 2) Conveyor: Pigs were loaded using a mobile conveyor ramp custom made for this experiment. To form a load of Weanling pigs, 20 Weanling pigs were selected by taking the entire litter of up to 2 sows and adding pigs from another sow, or leaving pigs behind from the second sow as necessary to form the group of 20. Fourteen groups of Weanling pigs were tested ($n = 14$). To form a load of Nursery pigs, 10 pigs were selected from nursery pens which contained 8 pigs per pen. One entire pen was taken plus 2 additional pigs from a neighboring pen. Fifteen groups of Nursery pigs were tested ($n = 15$). Pens contained pigs of both sexes. No effort was made to balance the loads by sex because on-farm practices would not do so either. The conveyor was 7.6 m long, 0.9 m wide and rose to 2.5 m high at a 16 degree slope, and moved 11.3 m/min (Fig. 1). It conveyed

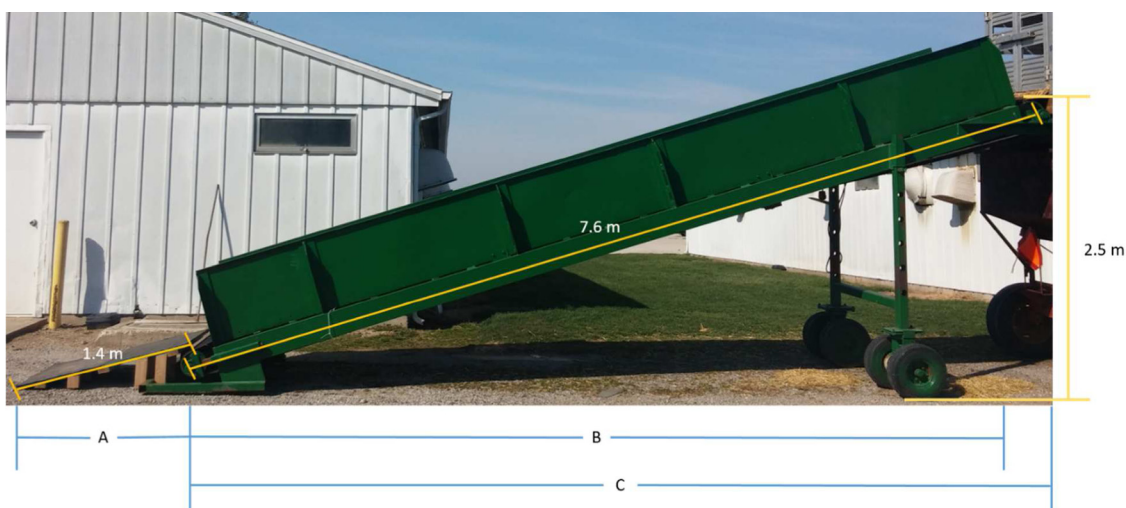


Figure 1. The ramp and conveyor used to load pigs into the simulated trailer. The time pigs spent on the ramp (A), prior to stepping onto the conveyor is denoted as “Botload” in Table 1. The time on the conveyor (B) is denoted as “TrailLat” in Table 1. And the total time to load the pigs starting from when they stepped on the conveyor (C) is denoted as “TotTime” in Table 1. The length and height are indicated in the figure.



Figure 2. This figure displays the chevron pattern of flooring that comprised the belt of the conveyor. The rise of the texture was approximately 3.2 mm.

pigs up to an aluminum small livestock transporter, 2.3 m long \times 1.1 m wide \times 1.1 m high, bedded with straw. The surface of the conveyor was slightly textured with a chevron pattern approximately 3.2 mm in height (Fig. 2).

This study was conducted in 4 and 3 replications for Weanling and Nursery pigs respectively during the months of November through March. Temperature averaged 7.8°C and ranged from 0.7°C to 22.3°C. Piglets were only used once to ensure that the piglets were equally novel to the handling and loading experience.

Step-wise Procedure

Two randomly selected pigs in a group were fitted with heart rate monitors (Polar V800, Polar Electro Inc., North New Hyde Park, NY) around their chest to record heart rate variability. Random pigs were selected by picking a male and female of average to above average weight, excluding smaller pigs. Pigs then remained in their home pen for 30 min to acclimate and collect baseline heart rate data. The handler (S. A. Enneking) wore the same type of heart rate monitor to collect their own heart rate data during handling. Pigs were herded in a group of 20 (Weanling piglets) or 10 (Nursery pigs) through a distance of 39.9 m with an average alley width of 1.3 m and loaded into the upper deck of a simulated straight-decked trailer (Fig. 3). The handler used a plastic board and shaker paddle to move the pigs. When pigs were loaded, a second handler stood at the top of the conveyor (out of sight, on the outside) to assist piglets moving forward when they reached the trailer. Pigs remained in the trailer for 30 min and then were unloaded down the non-moving conveyor (Fig. 4) and returned to a holding pen for 30 min, and heart rate continued to be recorded. Pigs were video recorded during loading to record slips, falls and vocalizations at the top and bottom of the conveyor



Figure 3. The figure on the left is the alley used to herd pigs to the conveyor. Black cloth was laid down to make continuous flooring from the barn to the conveyor. The figure on the right depicts pigs being conveyed on the mobile conveyor (treatment Conveyor) up into the simulated trailer. The pigs with black belts around their chest are sentinel pigs used to assess heart rate. Note that pigs are investigating the conveyor and also that they appear to hesitate at the top before entering the transporter.



Figure 4. Pigs are being unloaded from the simulated trailer onto a small ramp that connects the conveyor to the ground.

(Sony, HDR-CX240 Handycam, Sony Corp. of Amer., New York City, NY; and Canon Vixia HFR700 camcorder, Canon USA Inc. Melville, NY)

The following measures were recorded:

Slips and Falls: The number of times pigs slipped (foot misses a step) or fell (imbalance of pig's body with its body touching floor) as defined by Grandin (2003).

Vocalizations: Any squeals by pigs, other than grunts.

Number of Assists: The number of times the handler needed to push or lift a pig onto the conveyor, recorded from the time the pigs entered the ramp and until they were on the conveyor. The ramp was a 1.4 m textured board that was used to elevate the pigs to the height of the conveyor, approximately 0.3 m (Fig. 1).

Time to Load: Total time to load and unload the group of pigs. Time started when the first pig of the group put its first step onto the ramp and the time ended when the last pig put its head and shoulders into the simulated trailer.

Pig and Handler Heart Rate: Heart rate was recorded using heart rate monitors wrapped around the pigs' and handler's rib cage. Heart rate data files were downloaded using Polar Flow (Polar Electro Inc.; Lake Success, NY). Total time and R-R time (time between successive R peaks in the QRS complex of the heart rate) were copied from the original files into Excel (Microsoft; Redmond, WA). Percent change was calculated for each R-R time with more than 20% change signaling an error. Two hundred and fifty-six beats with no more than 5% error were isolated from each phase. The errors were corrected according to Marchant-Forde et al. (2004). These data were analyzed using heart rate variability software (Kubios

HRV, University of Eastern Finland; Kuopio, Finland). Frequency ranges were defined as Low frequency from 0.0 to 0.09 Hz, and high frequency from 0.09 to 2 Hz (Poletto et al., 2011). The remove trend components was set to first order and interpolation rate was set to 4 Hz. The fast fourier transform spectrum window width was set to 128 s with a 50% window overlap.

Handler Body Temperature: Handler body temperature was recorded after loading using infrared thermography (T440, FLIR Systems Inc., Wilsonville, OR). On images from the camera, an area around the eye and neck were marked and the maximum temperature of each was recorded (Fig. 5).

Data Analysis

Data were recorded by 1 individual for each specific data type and analyzed to compare slips, falls, vocalizations, handling assists, time to load, heart rate variability of pigs, heart rate of handler, and body temperature of handler. Analysis of variance using mixed models (treatment as a fixed effect and day, outside temperature, and baseline values as random effect) was used to analyze all data. Data that were not normal were transformed, and if normality could not be achieved data were analyzed using the Wilcoxon-Mann-Whitney test. Group was considered the experimental unit. Significance was set at $P < 0.05$, and considered a tendency at $P > 0.05 < 0.10$.

RESULTS

Results are presented as the means \pm standard error for each group of pigs.

Slips and Falls: There were no treatment differences ($P < 0.90$) for slips or falls for Weanling or Nursery pigs, with pigs from both treatments having very few of either. Weanling pigs had 1.6 ± 0.8 and 1.7 ± 0.9 slips during loading for the Control and Conveyor treatment, respectively. While Nursery pigs had 1.8 ± 0.5 and 1.7 ± 0.4 slips for the Control and Conveyor treatments, respectively. Weanling pigs had 0.4 ± 0.2 and 0.8 ± 0.7 falls during loading for the Control and Conveyor treatment, respectively. While Nursery pigs had 0.9 ± 0.4 and 0.7 ± 0.3 falls for the Control and Conveyor treatments, respectively.

Vocalizations: The number of times piglets squealed during loading was also recorded. Due to the very low number, however, they were not analyzed statistically. Regardless of age category (Weanling or Nursery) Control pigs squealed 1.4 ± 0.6 times and Conveyor pigs squealed 1.1 ± 0.5 times during loading.

Number of Assists: Weanling Conveyor pigs tended to be assisted (pushed or placed) onto the conveyor more ($P < 0.06$) than Weanling Control pigs, 2.8



Figure 5. This thermal image is of the handler immediately after loading group 19, Nursery pigs. Body temperature of the handler was measured by drawing squares on the image around the eye and neck and recording the maximum temperature in each area. The scale on the right shows the range of temperature in the photo. The box on the top left provides the maximum, minimum and average temperatures.

Table 1. Behavior of pigs during the process of loading¹

Weanling pigs			
Variable ²	Control ³	Conveyor ³	<i>P</i> =
Time (s) from the first pig stepping on the ramp to the first pig stepping onto the conveyor.	11.4 ± 1.82	22.6 ± 3.29	0.007
Time (s) from the first pig approaching the conveyor to the first pig stepping onto the conveyor.	1.9 ± 0.52	8.6 ± 2.72	0.01
BotLoad (s) is the total loading time at the bottom of the conveyor, from the first pig stepping on the ramp to the last pig stepping onto the conveyor.	31.8 ± 2.42	46.4 ± 4.66	0.02
Assists (#) is the number of times the handler had to push or lift a pig onto the conveyor.	1.2 ± 0.42	2.8 ± 0.68	0.06
Time (s) from the first pig stepping onto the conveyor to the first pig arriving at the trailer.	22.33 ± 2.34	21.25 ± 1.77	0.83
TrailLat (s) the time from the first pig stepping on the conveyor to the first pig stepping into the trailer.	27.22 ± 3.41	26.0 ± 1.86	0.91
TotTime (s) the total time from the first pig stepping onto the conveyor to the last pig stepping into the trailer.	57.17 ± 5.06	46.64 ± 4.39	0.14
Nursery pigs			
Variable ²	Control ³	Conveyor ³	<i>P</i> =
Time (s) from the first pig stepping on the ramp to the first pig stepping onto the conveyor.	12.0 ± 2.70	17.64 ± 1.98	0.07
Time (s) from the first pig approaching the conveyor to the first pig stepping onto the conveyor.	1.61 ± 0.29	6.78 ± 2.04	0.006
BotLoad (s) is the total loading time at the bottom of the conveyor, from the first pig stepping on the ramp to the last pig stepping onto the conveyor.	31.08 ± 5.28	46.75 ± 9.47	0.15
Assists (#) is the number of times the handler had to push or lift a pig onto the conveyor.	0.33 ± 0.14	1.64 ± 0.45	0.03
Time (s) from the first pig stepping onto the conveyor to the first pig arriving at the trailer.	20.3 ± 2.55	14.8 ± 1.43	0.03
TrailLat (s) the time from the first pig stepping on the conveyor to the first pig stepping into the trailer.	28.9 ± 5.17	19.78 ± 2.77	0.06
TotTime (s) the total time from the first pig stepping onto the conveyor to the last pig stepping into the trailer.	49.69 ± 6.15	40.07 ± 3.69	0.15

¹Fourteen groups of Weanling pigs, 20 pigs per group, were loaded; while 15 groups of Nursery pigs, 10 pigs per group, were loaded.

²The time it took pigs to move between different facets of loading was recorded as defined under Variable.

³Control pigs were herded onto the immobile conveyor ramp, while Conveyor pigs were herded onto the mobile conveyor ramp.

± 0.7 and 1.2 ± 0.4 respectively (Table 1). Similarly, Nursery Conveyor pigs also needed to be assisted onto the conveyor more ($P < 0.03$) than Nursery Control pigs, 1.6 ± 0.5 and 0.3 ± 0.1, respectively.

Time to Load: Overall, it took Conveyor pigs several seconds longer to step onto the conveyor than it did the Control pigs. From the time the first Weanling pig approached the conveyor and stepped onto the con-

veyor was 11.4 ± 1.8 s for Control pigs and 22.6 ± 3.3 s for Conveyor pigs ($P < 0.007$, Table 1). Similarly, from the time the first Nursery pig approached the conveyor and stepped onto the conveyor was 12.0 ± 2.7 s for Control pigs and 17.6 ± 2.0 s for Conveyor pigs ($P < 0.07$, Table 1). This longer time for the first Conveyor pig to get onto the conveyor is reflected in the longer time for the entire group to be loaded onto the conveyor. From the time the group approached the conveyor it took Weanling Control pigs 31.8 ± 2.4 s for the group to be on the conveyor and 46.4 ± 4.7 s for the group of Conveyor pigs to be loaded onto the conveyor ($P < 0.02$, Table 1). Nursery pigs behaved similarly but there were no treatment differences ($P < 0.15$) for the entire group to move onto the conveyor (Table 1).

The time from the first pig stepping onto the conveyor to the first pig entering the trailer was not different for Weanling pigs in either treatment (Table 1), averaging approximately 26.5 s to move up the conveyor. In contrast, Nursery Conveyor pigs tended to move from stepping on the conveyor to stepping into the trailer more quickly ($P < 0.06$), taking 19.8 ± 2.8 s,

compared to Nursery Control pigs that took 28.9 ± 5.1 s (Table 1). So the conveyor is helping to load the pigs more quickly once they step onto it. Although we have found differences at particular stages of loading, there was no treatment difference ($P < 0.15$) in the total time it took for pigs to step onto the conveyor and be completely loaded into the trailer, with all Weanling pigs being loaded in approximately 50 s, and Nursery pigs in approximately 45 s (Table 1).

Pig and Handler Heart Rate: No treatment differences were found for any measures of heart rate variability ($P > 0.10$, Table 2) for either Weanling or Nursery pigs. There was an effect of 'phase' for some variables for Nursery pigs, but not for Weanling pigs. Phase was defined as data collected at 1) baseline in the home pen, 2) during loading, 3) in the trailer, or 4) in the holding pen after unloading (Table 2). Mean R-R, defined as the time between the R peaks of a QRS complex in the heart beat, was greater for Nursery pigs during loading when compared to being in the trailer or holding pen ($P < 0.10$, Table 2); but no differences were detected for Weanling pigs. The standard deviation of normal R-R

Table 2. Measures of heart rate variability during 4 phases of the experiment¹

HRV parameters	Weanling pigs								P =	
	Control ²				Conveyor ²					
	Baseline pen	Loading	Trailer	Holding pen	Baseline pen	Loading	Trailer	Holding pen	Phase	Trt
Mean R-R ³ (ms ⁴)	340.6 ± 12.8	400.1 ± 9.5	372.1 ± 16.5	367.0 ± 17.2	351.7 ± 14.9	377.5 ± 10.9	369.9 ± 15.4	364.5 ± 18.3	0.98	0.49
SDNN ⁵ (ms)	14.7 ± 1.6	12.2 ± 1.7	11.3 ± 1.1	10.31 ± 0.8	13.1 ± 1.3	9.1 ± 1.1	11.1 ± 1.5	10.0 ± 0.9	0.21	0.68
Mean HR ⁶ (bpm ⁷)	181.5 ± 6.4	150.8 ± 3.4	168.5 ± 8.4	171.5 ± 8.7	177.5 ± 7.3	153.8 ± 7.0	165.2 ± 8.6	172.7 ± 9.2	0.84	0.76
Std HR ⁸ (bpm)	8.0 ± 0.9	4.5 ± 0.6	4.9 ± 0.5	5.0 ± 0.5	6.8 ± 0.7	3.8 ± 0.4	5.4 ± 1.1	4.9 ± 0.7	0.62	0.18
RMSSD ⁹ (ms)	7.5 ± 0.9	3.9 ± 0.6	4.5 ± 0.3	4.2 ± 0.4	6.6 ± 0.5	4.8 ± 0.8	4.7 ± 0.7	5.1 ± 0.7	0.95	0.16
LF/HF ¹⁰	6.9 ± 2.8	20.7 ± 14.4	4.9 ± 1.2	8.4 ± 2.3	2.9 ± 1.1	10.6 ± 4.3	3.1 ± 0.3	4.6 ± 1.2	0.87	0.13

HRV parameters	Nursery pigs								P =	
	Control ²				Conveyor ²					
	Baseline pen	Loading	Trailer	Holding pen	Baseline pen	Loading	Trailer	Holding pen	Phase	Trt
Mean R-R ³ (ms ⁴)	323.00 ± 14.1	333.2 ^a ± 17.4	295.4 ^b ± 9.0	298.6 ^b ± 11.0	310.1 ± 9.1	344.6 ^a ± 16.2	301.8 ^b ± 10.3	301.0 ^b ± 12.0	0.01	0.26
SDNN ⁵ (ms)	13.9 ± 1.2	13.0 ^a ± 2.2	11.3 ^b ± 1.0	11.5 ^b ± 0.8	14.00 ± 1.3	14.12 ^a ± 2.1	12.9 ^b ± 1.2	11.1 ^b ± 1.1	0.02	0.80
Mean HR ⁶ (bpm ⁷)	193.3 ± 6.5	187.2 ^a ± 9.7	206.7 ^b ± 4.8	205.8 ^b ± 5.3	197.5 ± 4.7	180.0 ^a ± 8.61	202.5 ^b ± 5.5	204.0 ^b ± 6.1	0.01	0.25
Std HR ⁸ (bpm)	8.3 ± 0.7	7.2 ± 1.3	7.9 ± 0.6	8.1 ± 0.6	8.9 ± 0.8	7.8 ± 1.4	8.8 ± 0.8	7.7 ± 0.7	0.94	0.92
RMSSD ⁹ (ms)	6.6 ± 0.6	5.3 ± 0.8	5.9 ± 0.6	6.6 ± 0.7	7.1 ± 0.6	6.0 ± 0.8	6.5 ± 0.5	6.2 ± 0.9	0.46	0.71
LF/HF ¹⁰	3.42 ± 0.84	6.71 ^a ± 1.9	2.58 ^b ± 0.6	2.49 ^b ± 0.57	2.8 ± 0.4	4.3 ^a ± 1.4	1.8 ^b ± 0.3	2.3 ^b ± 0.4	0.02	0.14

^{a,b}Means within the same row with different superscripts differ ($P < 0.01$).

¹Two sentinel pigs from each load group were used. In total, 14 Wean pigs groups were tested using 28 sentinel pigs for heart rate monitoring ($n = 14$). Fifteen Nursery pig groups were tested using 30 sentinel pigs for heart rate monitoring ($n = 15$). Heart rate was recorded when the pigs were in their home pen (Baseline Pen), during Loading, when they were held in the Trailer for 30 min, and after unloading when they were held in a Holding Pen.

²Control pigs were herded onto the immobile conveyor ramp, while Conveyor pigs were herded onto the mobile conveyor ramp.

³Mean R-R is defined as the time between the R peaks of a QRS complex in the heart beats.

⁴ms = milliseconds.

⁵SDNN = standard deviation of normal R-R intervals.

⁶Mean HR = mean heart rate during a specific phase of the process.

⁷bpm = beats per min.

⁸Std HR = standard deviation of the heart rate.

⁹RMSSD = root square mean of successive differences.

¹⁰LF/HF = ratio of low frequency and high frequency power of the spectral analysis.

intervals (SDNN) followed a similar pattern as expected ($P < 0.02$, Table 2). The mean heart rate also differed by phase for Nursery pigs with rates being higher in the trailer and holding pen when compared to loading ($P < 0.01$). And finally, the ratio of low frequency to high frequency power differed by phase for Nursery pigs ($P < 0.02$), characterized by more low frequency power during loading when compared to that during the time on the trailer and in the holding pen (Table 2).

The heart rate of the handler immediately after loading the Weanling pigs was not different between treatments ($P < 0.75$), averaging 93.8 ± 1.9 beats/min when loading the Control pigs and 93.9 ± 1.9 beats/min when loading the Conveyor pigs. The same was found to be true when loading the Nursery pigs, with heart rate at 95.0 ± 2.0 beats/min when loading the Control pigs and 91.5 ± 2.1 beats/min when loading the Conveyor pigs.

Handler Body Temperature: There were no treatment differences when comparing eye and neck temperature of the handler ($P < 0.68$). However, there was a pig age effect ($P < 0.0006$, Fig. 6) characterized by the handler having a higher body temperature when loading Weanling pigs as compared to Nursery pigs.

DISCUSSION

The results from this study indicate that it is feasible to load pigs using a conveyor. In terms of decreasing the amount of stress to which pigs are exposed, however, there appears to be little advantage in doing so, based on behavioral and physiological data collected in this experiment. Although pigs hesitated for a few more seconds when approaching the moving conveyor. The conveyor worked to move pigs more quickly up to the trailer. Thus, the total time to load between Conveyor pigs and Control pigs was the same.

This study was designed to determine if using a conveyor to automatically move pigs up into a trailer could decrease the stress they experience. Previous studies have investigated ramp angles, ramp materials (Goumon et al., 2013, Garcia and McGlone, 2015), and cleats (Phillips et al., 1989). These methods might be able to reduce stress to some extent but do not completely eliminate stress to the animals and handlers. Using lower angle ramps to load pigs to the upper deck of trailers would require very long ramps. However, Goumon et al. (2013) have suggested that longer ramps might be more psychologically challenging to the pigs by increasing difficulty in handling and reluctance to move. Using slip resistant materials can decrease slipping, however they lose their helpfulness when ramps exceed 20 degrees (Garcia et al., 2014). Thus we sought a novel method of using a conveyor.

Heart rate, vocalizations and slips and falls have been used as non-invasive measures and indicators of stress

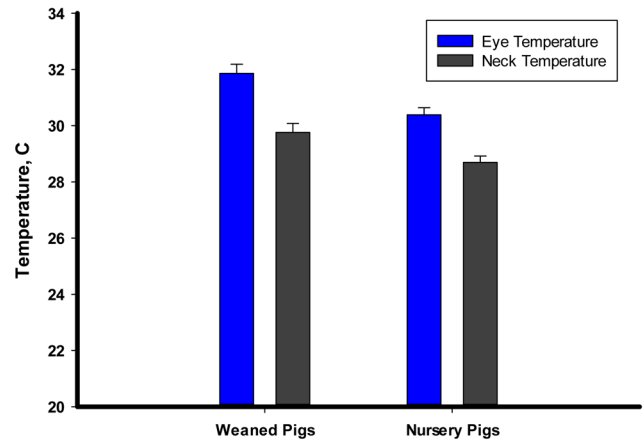


Figure 6. Eye and neck temperature of the handler immediately after loading Weanling and Nursery pigs. Body temperature was greater after handling Weanling pigs as compared to Nursery pigs ($P < 0.0006$).

levels in pigs. Heart rates of pigs in this study were similar to other studies which invoked stress in young pigs (White et al., 1995; Webster and Jones, 1998; Rault et al., 2015). Garcia and McGlone (2015) found that heart rate of pigs (70 to 120 kg BW) being loaded was greater when the ramp slope was 10 or 20° compared to 0°, in the summer, but not different in the winter. Similarly, Garcia and McGlone (2015) found an increase in cumulative slips, falls, and vocalizations (combined to form a score because the incidence of each was so infrequent) for weanling pigs when the slope of the ramp increased and no bedding was provided. Previous studies have used vocalizations to assess animal welfare and stress levels when pigs were given electric shocks (Düpján et al., 2008) or castrated (Sutherland et al., 2010). Schrader and Todt (1998) have associated vocalizations with increased concentrations of adrenaline. Animal welfare audits and guidelines, including the one by Grandin (2003) used by the American Meat Institute, allow very low rates of vocalizations and slips or falls during loading, unloading, and handling of animals to pass the audit.

Slips and falls were minimal in this study and this measure of loading stress is likely more applicable for market weight animals. Garcia and McGlone (2015) also measured slips, falls, and vocalizations in weaned pigs and found such a low occurrence that they had to sum them into a score to even reach a sum of 2 to 3. Similarly, vocalizations characterized as squeals, are a useful measure of handling distress for market weight pigs, but do not appear to be useful in weanling and nursery pigs. This suggests that young pigs are able to be loaded with less force compared to what seems to be used in market weight animals. The number of assists was recorded as a measure of how many pigs balked at stepping onto the conveyor. More Conveyor pigs needed to be assisted onto the conveyor, thus increasing the work required to load the pigs. Pigs typically hesitate from moving from

one surface to another, based on texture, lighting, and color. We suspect that the fact that the conveyor was moving increased this hesitation by several seconds; however, once the pigs were on the moving conveyor they easily walked up and down the conveyor, as well as investigated the conveyor, indicative of a low stress situation. Upon all pigs having stepped onto the conveyor, the mobile conveyor moved the pigs into the trailer more quickly making loading time identical.

Heart rate and heart rate variability were calculated for pigs as a measure of distress. Greater heart rate and less heart rate variability are indicative of distress (Poletto et al., 2011). No treatment differences were found for Weanling pigs. In contrast, heart rate and heart rate variability did differ for Nursery pigs by phase of loading but not by treatment. Nursery pigs exhibited a decrease in R-R intervals when they were in the trailer and the holding pen. This is indicative of a higher heart rate being controlled by both sympathetic and parasympathetic stimulation; and likely due to the fact that they were in a novel environment and mixed with unfamiliar pigs. Nursery pigs showed a significant increase in low frequency power during the loading phase. This is indicative of an increase in sympathetic activity (see review, von Borell et al., 2007), meaning that they were more distressed, during loading as compared to all other phases of the procedure. Loading is known to be stressful, but it is interesting that Weanling pigs did not show the same response. Evaluation of the data does show a similar arithmetic response, but this was not statistically significant. This may be due to the relative under development of the autonomic nervous system at this age in weanling pigs. Or, it could be related to the inability of such young animals to comprehend their situation.

The heart rate and body temperature of the handler were recorded as measures of exertion from the work of loading. Neither measure differed between treatments, indicating that the handler had to work to a similar effort for both Conveyor and Control pigs. This is likely due to the fact that even if Conveyor pigs were being automatically conveyed up to the trailer, the handler was still walking up the conveyor to ensure they entered the trailer. The body temperature of the handler did indicate that it takes more work to load weanling pigs than it does to load nursery pigs. Based on observations in this study, this is simply due to weanling pigs not being as mobile and thus needing to be pushed along the alley. In contrast, nursery pigs easily walked down alley spaces and moved freely away from the handler.

In conclusion, the use of a conveyor to load pigs into the top deck of a straight deck livestock trailer works very well. However, it does not appear to significantly decrease the stress of loading for the pig, or the work required by the handler.

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