THE USE OF SUBJECTIVE AND OBJECTIVE METHODS OF BEHAVIORAL EVALUATION IN SWINE AND DAIRY CATTLE

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Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

The objectives of the studies described in this thesis were to quantify livestock behavior and improve animal wellbeing. Subjective and objective evaluation methods can be used as an estimation parameter of animal welfare. The first study used behavioral methods to evaluate the analgesic effects of a pharmaceutical drug in lame dairy cattle. Lameness pain was evaluated by measuring weight shifting, locomotion score, and visual analog scale score. Correlation analysis of the three methods determined cohesion among subjective methods. The second study measured the behavioral effects of ramp exposure during the nursery period of swine development. Loading can be a stressful event for hogs which may cause an increased incidence of stress. Conditioning methods and environmental enrichment reduced the duration of time spent on the loading ramp and decreased production inputs. Both trials identified methods to improve animal welfare and future efforts will aid in the development of positive management strategies.

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-BLN

PREFACE

This thesis is composed of a literature review, two independent behavioral evaluation studies, and final conclusions chapter. The research trials utilized objective and subjective measures of behavioral evaluation to quantify the effects of the administered treatments. The first study illustrates the analgesic effects of a therapeutic pharmaceutical drug in lame dairy cows, while the second study examines the effects of ramp exposure on the loading behavior of market hogs. Both studies will be submitted for publication in peer-reviewed journals. The closing chapter provides final conclusions and implications.

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LIST OF ABBREVIATIONS

ADG .... average daily gain

cm .... centimeters

d .... day

FDA .... Food and Drug Administration

FLAT .... Non-ramp exposed treatment group

h .... hour

KET .... ketoprofen dosed treatment group

kg .... kilogram

m .... meter

mg .... milligram

mL .... milliliter

mm .... millimeter

NSAID .... Non-steroidal anti-inflammatory drug

RAMP .... ramp-exposed treatment group

SAL .... Sterile isotonic Saline dosed treatment group

SAS .... Statistical Analytical Software

Sec .... seconds

SHIFT .... Weight shifting value

VAS .... Visual Analog Scale

CHAPTER 1. INTRODUCTION AND LITERATURE REVIEW

Part 1: Animal Welfare and Assessment

Animal welfare can be defined as the physical and mental state of an animal. An animal's welfare status is a continuum that may be affected by numerous factors including: nutrition, environment, health status, and ability to express natural behaviors. (Mellor et al., 2009)

One of the most widely referenced assessments is the philosophy of "The Five Freedoms." Enacted by the Farm Animal Welfare Council (1993), this set of animal care principles was developed to reduce unnecessary discomfort and improve the wellbeing of production animals. The original 5 freedoms include: freedom from thirst, hunger and malnutrition; freedom from discomfort; freedom from pain, injury, and disease; freedom to express normal behavior; and freedom from fear and distress. As a majority of the freedoms cannot be assessed as easily as a nutrition screening, the use of behavioral observations can provide information regarding distress, pain, or discomfort.

Numerous methods of behavioral evaluation and their relationship to animal welfare have been validated throughout the livestock industry. These assessment methods can be classified as either subjective or objective. Subjective measurements are assessment values derived from a perception or personal judgment, while objective measurements are those calculated from empirical values which cannot be altered by user bias. Subjective assessments can generally be completed relatively quickly on the farm, and do not require the expensive equipment that is often associated with objective measurements. Common subjective methods of lameness evaluation in livestock include locomotion or gait scoring methods and visual analog scales. More objective methods of evaluation may include measures of weight shifting, pedometers, thermography, and automated gait analysis. The primary concern with subjective measures is the risk of added variability between observers due to differing experiences or training.

Regardless of subjective or objective nature, validated methods of behavioral evaluations provide valuable insight to management strategies and their impact on animal welfare.

Part 2: Lameness in Dairy Cattle

Some of the largest factors influencing animal welfare within the dairy industry are lameness conditions. In dairy cows, these conditions of the feet and legs result in pain and discomfort. Lameness pain alters the normal behavior expression of dairy cows and is associated with detrimental physiological and economic effects. The average cost of a single mild lameness-causing lesion ranged from $53 to $232 per cow per year while severe lesions are expected to cost producers $402 to $622 on the same basis. (Charfeddine et al., 2017)

Hernandez et al. 2005 found that cows with claw (hoof) lesions had a greater calving to conception interval and an increased number of inseminations per conception. Severity of the lameness condition can have an impact on performance capabilities; however cattle with even a mild lameness condition express a significant decline in reproductive function as compared to their non-lame counterparts. (Orgel et al., 2016)

Lameness alters normal behavior expression of dairy cattle. This deviation may be noted as: increased duration and frequency of lying bouts or inactive time (Thomsen et al., 2012;Ito et al., 2010; Chapinal et al., 2009), decrease in time spent consuming feed (González et al., 2008), and abnormality of gait. While two animals may be affected by similar appearing lesions, expression of the pain may not be identical. (O Callaghan et al., 2003) The variability in the expression of behaviors associated with can make identification of animals with lameness conditions difficult.

Several methods of lameness detection, both subjective and objective, have been validated. Gait or locomotion scoring methods are the most common form of lameness evaluation in production herds. These methods typically involve evaluation of six gait characteristics which include: back arch, head bob, tracking-up, joint flexion, asymmetric gait, and reluctance to bear weight (Rushen et al., 2007; Flower and Weary 2006). These criteria are considered when assigning an animal a subjective locomotion score. Animals with a locomotion score "1" are sound and show no evidence of pain, while a locomotion score "5" is the most severe degree of lameness and pain. This method is fairly simple for producers to complete onsite, but does require some training to perform consistently and accurately. Objective methods of lameness evaluation are often more sensitive than subjective methods, however they require the use of highly specialized technology such as automated gait assessment software (Chapinal et al., 2009), pedometers (O'Callaghan et al., 2003), or a 4-platform scale (Chapinal et al., 2010; Pastell and Kujala, 2007; Rushen et al., 2007).

Lame animals will distribute less weight on the affected limb and redistribute the weight to the contralateral leg (Chapinal et al., 2010; Pastell and Kujala, 2007; Rushen et al., 2007), and cows with a higher degree of lameness shift more weight between their rear limbs than those less affected.

The four platform scale on which each platform records the weight borne on a single limb has been a useful instrument when illustrating the effects of therapeutic pharmaceuticals (Chapinal et al., 2010) or other pain mitigation attempts. Rushen et al., (2007) observed that when lidocaine, a local anesthetic, was injected into the hoof bulb of lame dairy cattle, the incidence of weight shifting among limbs decreased and locomotion was mildly improved. These results would suggest that the drug offered pain relief to the affected animal, as well as agreement between the lameness detecting systems.

Another promising pharmaceutical is a nonsteroidal anti-inflammatory drug (NSAID), ketoprofen. Ketoprofen was shown to have analgesic effects in horses (Owens et al. 1995) and slight effects cattle (Chapinal et al., 2010; Flower et al., 2008; Whay et al., 2005). The studies by Flower et al., (2008) and Whay et al., (2005) evaluated the drug using gait assessment methods and found marginal effects on locomotion scores. Chapinal et al. (2010) later suggested that the gait assessment method lacks the sensitivity to identify the analgesic effects of the drug and evaluated the effects using a 4-platform scale. Results of that study determined that weight shifting behavior was lowered following ketoprofen treatment, providing evidence that the drug does provide analgesia. This suggests that measuring weight distribution is a more sensitive lameness evaluation method than gait assessment.

The objectives of the study discussed in chapter 2 of this thesis were to further investigate the analgesic effects of ketoprofen and to determine correlations between subjective and objective methods of lameness evaluation in dairy cattle.

Part 3: Swine Behavior, Movement, and Welfare

The welfare of hogs can be greatly affected by negative handling, loading, and transportation experiences (von Borell and Schaffer, 2005). Improper pre-slaughter handling elevates levels of stress which jeopardizes animal health and carcass quality (Adzitey, 2011; Lawrie, 2006). Additionally, moving from the home pen and navigating a loading ramp may be a challenging feat or some hogs. (Warriss et al., 1991)

Adaptation to stressful situations may begin with alternative housing management strategies. One emerging method of swine production is the implementation of ramp structures.

Phillips and Fraser (1987) built a split level housing system for grower hogs that required ascension to the top level to receive feed. They noted that the increased pen area may be beneficial for reducing pen mate manipulation.

Bulens et al., (2017) found that hogs exposed to ramps expressed less stereotypic and aggressive type behaviors resulting in a lower incidence of skin lesions. Both Bulens et al., (2017) and Phillips and Fraser (1987) utilized ramp exposure during the grow-finish stage of production and did not identify significant growth differences between exposed and non-exposed treated animals. Neither study evaluated the effects that ramp exposure may have on handling.

The effects of ramp exposure and facilitated exercise were combined by Goumon et al., (2013). Hogs were treated for two weeks to either exercise, a ramp system, both ramp and exercise, or no training. They found that heart rate and handler encouragements were lower for hogs who received exercise as compared to the other treatments. Ramp hogs balked less than their untrained counterparts but required as many handler aids. This may be explained by Grandin (1997), who hypothesized that hogs became acclimated to a ramp if it was part of their environment.

To reduce the stress of handling, several moving devices and methods have been evaluated. The use of electric prods have been proven to have detrimental effects on carcass quality (carcass bruising, blood splash standpoints.) These muscle and capillary hemorrhages or carcass bruises can be uncomfortable to the animal, and ultimately jeopardize animal welfare (Correa et al., 2010). When comparing the efficiency of an electric prod to a sorting board, the electric prod prolonged the handling time and induced more vocalizations when moving a hog through a course (Mcglone et al., 2004). The elevated frequency of vocalizations were assumed to be a negative reaction for the hog, possibly identifying handler aid averseness. However, Correa et al., (2010) found the prod to decrease handler efforts but increase the frequency of hogs slipping and overlapping. Despite this, it remains one of the most common movement aids in the industry.

Transportation methods for livestock have also come under scrutiny. Correa et al., (2013) determined that hogs found loading into a standard "pot belly" trailer more stressful and aversive than being loaded into a hydraulic lift double-decker trailer. Authors attributed the increased animal losses, poor physiological state at slaughter, and carcass differences to the multiple steep internal ramps and poor insulation of the trailers. Similar results were presented by Dalla Costa et al., (2016), who determined that hogs loaded onto trucks featuring a hydraulic deck expressed less stress –related physiological responses and were easier to load than those required to climb internal or external loading ramps.

The angle of the loading ramp can have negative effects on the animal's ability and willingness to navigate a ramp structure (Warriss et al., 1991). Angle of the ramp and ease of handling appear to be inversely related. As the ramp angle is increased, vocalization frequency and the duration of time spent on the ramps also increases (Garcia and McGlone, 2014). The use of a "flat ramp" leads to the easiest unloading compared to steeper style ramps. However ease of handling did not decrease from 16 to 26 degrees (Goumon et al., 2013). A loading ramp slope should be a maximum of 20 to 25 degrees (Marchant-Forde 2009; Warriss et al., 1991) at which, minimal effects of stress should be exhibited and movement of animals will be optimized.

The study in Chapter 3 focuses on the behavioral effects of ramp exposure on the nursery and loading behavior of market hogs.

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CHAPTER 2. THREE METHODS FOR EVALUATING THE ANALGESIC EFFECTS OF KETOPROFEN IN LAME DAIRY COWS[1]

Abstract

The objective of this study was to evaluate the effects of ketoprofen treatment on lameness pain in dairy cattle using 3 methods; visual analog scoring, locomotion scoring, and weight shifting behavior. Thirty-two lactating Holstein cows were enrolled in the study based on visual observation of abnormal locomotion. Cattle were randomly assigned to two treatment groups: KET, treated with 3 mg/kg body weight (3 mL per 100 kg) ketoprofen, or SAL, treated with saline solution at the same volume dosage. Both treatments were administered by intramuscular injection twice at a 48-hour interval. The degree of lameness before and after treatment was measured using locomotion scoring of video recordings, real time visual analog scoring, and weight-shifting behavior. Weight-shifting was calculated as the standard deviation of the weight borne on the rear limbs over 15 minutes at each data collection point; this value correlates directly with lameness pain in dairy cows. Data were collected 24h before treatment and 2 h, 6 h, 12 h, 24 h, 48 h, 60 h, and 72h after initial treatment. Mean pre-treatment locomotion scores, VAS scores, and weight shifting behaviors were not significantly different between treatment groups. Locomotion scores and VAS were marginally affected by drug treatment and further analysis determined a strong correlation between the two methods. When

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[1] The material in this chapter was co-authored by B. L. Novak, J. M. Young, J. K. Tena, and S. A. Wagner. B. L. Novak, J. M. Young, and S. A. Wagner are affiliated with the Department of Animal Sciences at North Dakota State University. J. K. Tena is affiliated with Zoetis, Inc. (Kalamazoo, MI). B. L. Novak was responsible for animal handling, data management and collection, blood draw collections, and preparation and revision of this chapter. J. M. Young was responsible for data management, statistical analysis, and proofreading. J. K. Tena provided statistical input. S. A. Wagner was responsible for the study design, data collections, study management, and revisions to the text.

compared to the SAL group, KET group cows expressed less weight-shifting between the rear limbs 12 hours after each treatment administration. These results indicate that treatment with ketoprofen alleviates pain caused by lameness, and that weight shifting may be a more sensitive measure of pain and analgesia than subjective methods of evaluating locomotion.

Key Words: analgesia, ketoprofen, lameness, pain

Introduction

Lameness is a concern for dairy producers worldwide. Recent studies in North American dairy herds have predicted values between 9.6% and 15% for the prevalence of lameness in dairy cows (Adams et al., 2016; Cook et al., 2016; King et al., 2016; Westin et al., 2016). In addition to the animal welfare implications of this painful condition, lameness is also associated with reduced milk production and diminished reproductive performance (Orgel, 2016; Relun, 2013; Huxley, 2013).

The welfare of dairy cattle can be improved by reducing or eliminating pain caused by lameness, but there are no drugs approved by the US Food and Drug Administration (FDA) for pain alleviation in cattle. The non-steroidal anti-inflammatory drug (NSAID) ketoprofen, although not approved by the US FDA for use in cattle, is approved for use as an analgesic in cattle in other countries. For example, in Canada, the drug is approved for use in cattle for the treatment of pain, fever, and inflammation associated with a variety of conditions including mastitis, arthritis, and musculoskeletal disorders (Anafen®, Merial Canada Inc, Baie-d'Urfé, QC, Canada). In horses, ketoprofen is approved by the FDA to alleviate pyrexia and the pain associated with osteoarthritis and colic (Zoetis, 2013). Despite the lack of FDA approval for such use, NSAIDs are often used to alleviate pain in cattle (Fajt et al., 2011). In dairy cows with naturally-occurring lameness, a single dose of ketoprofen has been observed to slightly decrease locomotion scores in lame dairy cows (Flower et al., 2008), and to reduce weight shifting between the rear limbs. (Chapinal et al., 2010). Weight shifting between the rear limbs has been validated as a measure of lameness pain in dairy cows (Rushen, 2007).

The objectives of this study were to investigate the analgesic effects of 2 doses of ketoprofen administered 48 hours apart in lame dairy cows using 3 methods and to determine correlations between the 3 methods. Our hypotheses were:

- Treatment with the NSAID ketoprofen will relieve pain in lame dairy cows, when pain is measured using the standard deviation of weight borne on the rear limbs over time, Visual Analog Scale (VAS) scoring and locomotion scoring.
- The administration of 2 treatments will clarify the duration of analgesia provided by the drug and provide evidence of any additive analgesic effects that might be accomplished with repeated dosing.
- Correlations will be observed between weight-shifting behavior, Visual Analog Scale (VAS) scoring and locomotion scoring.

Materials and Methods

All procedures involving animals were approved by the North Dakota State University Institutional Animal Care and Use Committee.

Cows and Management

Thirty-two grade lactating Holstein cows from a private dairy herd in western Minnesota were enrolled in the study based on abnormal locomotion indicating lameness and the absence of other health problems. Cows were housed in a free stall barn with ad libitum access to water and a ration formulated to meet the nutritional demands of lactating cows. Animals were milked twice daily in a parallel stall parlor.

Weight Distribution

Weight distribution among the limbs was recorded using a 4 platform scale (Pacific Industrial Scale, Richmond, BC, Canada) which records the weight borne on each limb independently approximately 11 times per second, using procedures described by Chapinal et al., (2010). Briefly, at each data collection time, each cow stood on the scale for 3 sessions lasting 5 minutes each. Between 5 minute sessions, the cow was walked off the scale from the front, then walked back on the scale from the rear. If the cow placed more than one hoof on a platform, she was repositioned and the affected data were not used in analyses. Data recorded during defecation or urination were also deleted from analyses.

After the removal of discarded data as described above, the mean and standard deviation of the mean weight borne on each limb during each 5 minute session were calculated. The means of these two values (mean and SD) were then averaged between the rear limbs and across the three 5 minute sessions to determine the weight-shifting value (SHFT).

Locomotion Scoring

After each 5 minute weighing session, cattle were walked down a straight path and video recorded from the side using a color digital camera (Canon Power Shot, Canon USA, Melville, NY, USA). The video recordings were used by a masked, trained observer to assign a locomotion score using a 5-point scale based on the one developed by Flower and Weary (2006). A score of 1 was associated with no lameness, with a score of 5 indicating cows with severe lameness. Scores were assigned in intervals of 0.5 points.

Visual Analog Scale (VAS)

Following the third session on the platform scale, cows were walked off in a straight path. An observer marked a 100mm line in a place that correlated to their perception of the animal's degree of lameness, with the left end of the line representing perfect soundness and the right end of the line representing the worst possible lameness. The distance between the left end of the line and the observer's mark, measured in millimeters, was the VAS value.

Blood Collection

Prior to treatment and at 2, 6, 12, 24, 48, 60, 72 h after initial treatment, blood was collected into 5mL vacutainers using jugular venipuncture for use in a concurrent pharmacokinetic study.

Treatment Groups

Cows were blocked by day of enrollment then randomly assigned to treatment groups using SAS. Cows assigned to the drug treatment group (KET) were treated with ketoprofen (Ketoprofen®, Zoetis Inc, Madison, NJ, USA) intramuscularly in the neck twice, at a 48-hour interval, at the dosage 3 mg/kg body weight (3 mL per 100 kg). Cows in the control group (SAL) were treated with isotonic sterile saline solution at the same volume dosage, using the same route and dosing schedule as the KET group. In both groups, each treatment was administered using a 20 g x 1.5 inch needle, with half the total volume in each side of the neck.

Study Design

***Days -4 and -5*:** Cows were acclimated to entering, exiting, and standing on the scale, in order to reduce weight shifting due to anxiety and ease the movement of cows during data collection.

***Day -1*:** Baseline weight-shifting and VAS data were collected and locomotion recordings were made.

***Day 0*:** Ketoprofen or isotonic sterile saline solution were administered as described above. Weight distribution data, locomotion videos and VAS scores were collected 2, 6, and 12 h after treatment.

***Day 1*:** Weight distribution data, locomotion videos, and VAS scores, were collected 24 h after treatment.

***Day 2*:** Weight distribution data, locomotion videos, and VAS scores were collected 48 h after treatment. Following the 48 h data collection, a second dose of ketoprofen or saline was administered, using the same dose and route described above. Twelve hours after the second treatment, weight distribution data, locomotion videos, and VAS were collected.

***Day 3*:** Weight distribution data, locomotion videos, and VAS were collected 24 hours after the second treatment.

***Day 6*:** Each cow enrolled in the study was examined by a professional hoof trimmer and observed lesions were recorded.

Statistical Analyses

The summary and analyses of data were completed using SAS Release 9.3 (SAS Institute, Cary, NC). The standard deviation of mean weight borne on the rear limbs (SHFT value) and VAS values were analyzed using a general linear mixed model with repeated measures. The model included fixed effects of treatment as well as time and treatment by time interaction. Random effects included block (day), animal within block and treatment, and error. Treatment least squares means, standard errors, 90% confidence intervals, minimums and maximums were calculated for each time point. Different covariance structures were tested and best fit on AIC and BIC was chosen. Treatment or treatment by time interactions were evaluated for significance at the $P < 0.05$ level, and treatment comparisons were completed at each time point at the 5% level of significance (2-sided).

Locomotion score data were analyzed using the Glimmix procedure in SAS. The model included fixed effects of treatment, time, and the interaction between treatment and time, covariate of the baseline measurement, and random effect of block. A repeated measures statement was used with cow as the subject and different covariance structures were tested, with the best fit being chosen based on Akaike and Bayesian information criteria.

Pearson correlations between mean weight borne on the rear limbs, locomotion scoring, and VAS were estimated using the correlation procedure in SAS.

Results

Weight Shifting Behavior

SHFT value data are shown in Figure 2.1.

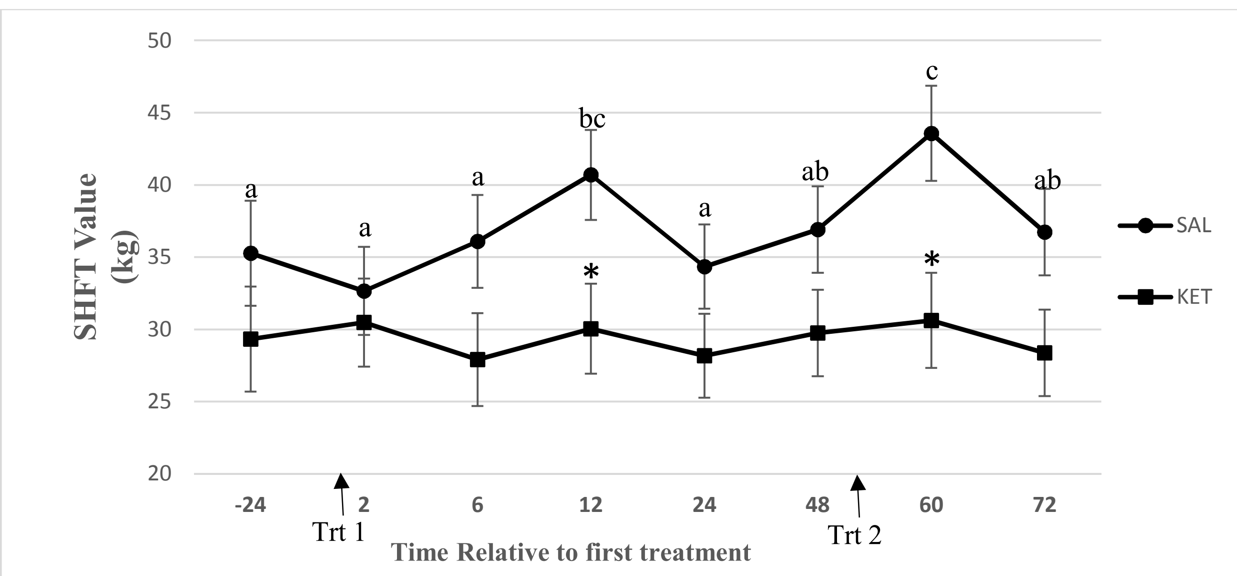

Figure 2.1. SHFT value (SD of Mean rear leg weight) over time. KET= cows treated with two identical doses of 3 mg/kg BW of ketoprofen, SAL= cows treated with 3 mL per 100 kg BW isotonic saline solution. Treatment times denoted by arrows along time axis. Significant differences between treatment group means are represented by asterisk (*) (P < 0.05). Group means over time were not different in the KET group. Time points with the same letter superscript were not different in the SAL group.

Between group comparisons.

Baseline SHFT values for SAL and KET cows were 35.3 ± 3.6 kg and 29.3 ± 3.6 kg, respectively. Differences between pre-treatment group mean values were not significant ($P = 0.21$) at baseline evaluation. Although baseline SHFT values were not statistically different, they were numerically different, so they were included as cofactors in post-treatment statistical analyses. Mean SHFT values observed 12 hours after treatment were significantly higher ($P < 0.01$) in the SAL group than the KET group (86.73 ± 3.58 and 71.25 ± 3.58, respectively). The SAL group also had a higher mean SHFT value than the KET group 12 hours after the second treatment (93.06 ± 5.10 and 72.52 ± 5.10, respectively, $P < 0.01$). All other differences between treatment groups were not significant ($P > 0.05$ for all).

Within group comparisons.

In the KET group, differences in weight shifting behavior were not significant among any days ($P > 0.05$ for all between-day comparisons). In the SAL group, weight shifting was significantly greater than baseline at 12 hours after the first treatment ($P = 0.03$) and 12 hours after the second treatment ($P < 0.01$).

Locomotion Scores

Locomotion score data are shown in Figure 2.2.

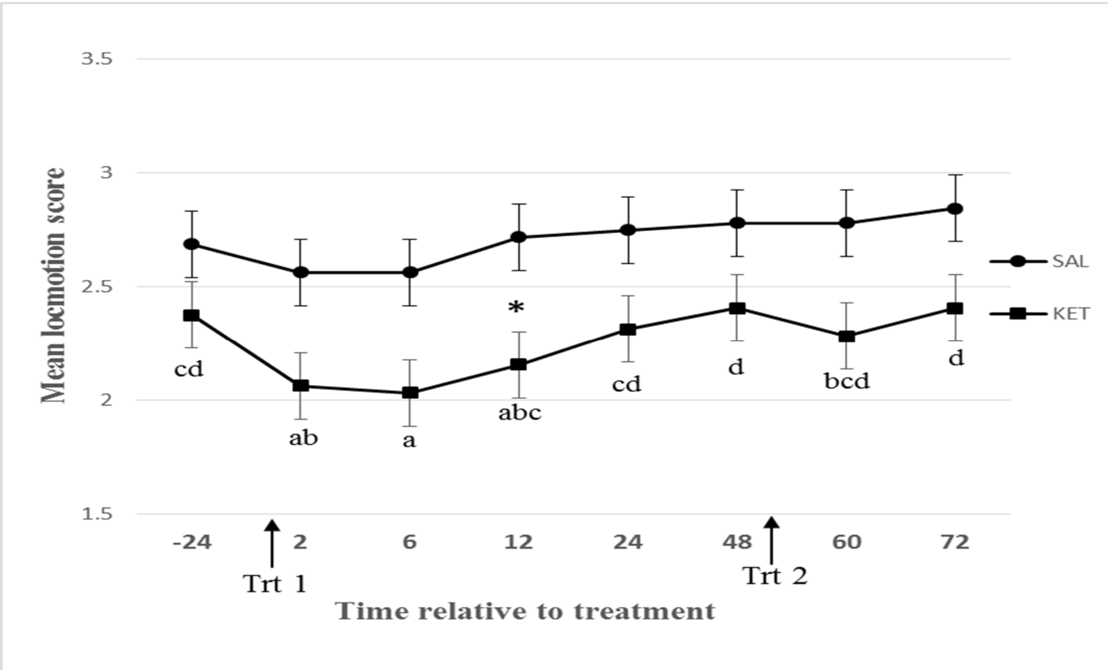

Figure 2.2. Mean locomotion score ± SE over time relative to treatment. KET= cows treated with two identical doses of 3 mg/kg BW of ketoprofen, SAL= cows treated with 3 mL per 100 kg BW isotonic saline solution. Relative treatment times denoted by arrows along time axis. Significant differences between treatment group means are represented by asterisk (*) ($P < 0.05$). Group means over time were not different in the SAL group. Time points with the same letter superscript were not different in the KET group.

Between group comparisons.

Mean baseline locomotion scores for SAL and KET were 2.7 ± 0.1 and 2.4 ± 0.1, respectively; these values were not different ($P = 0.13$). Similarly to SHFT, mean baseline locomotion scores were factored as covariates in subsequent analyses. Differences in mean locomotion scores between SAL and KET groups were not significant at 2, 6, 24, 48, 60, and 72 h after first treatment. The SAL group mean locomotion score was significantly higher than the KET group mean 12 hours after the first treatment ($P = 0.04$)

Within group comparisons.

Mean locomotion scores of the SAL treated cows were not statistically different when comparing each time point to is baseline value ($P > 0.05$). Mean locomotion scores of the KET group were significantly lower than baseline at 2 h and 6 h following the initial treatment ($P < 0.01$ for both comparisons).

Visual Analog Scale (VAS)

Visual Analog Scale data are shown in Figure 2.3.

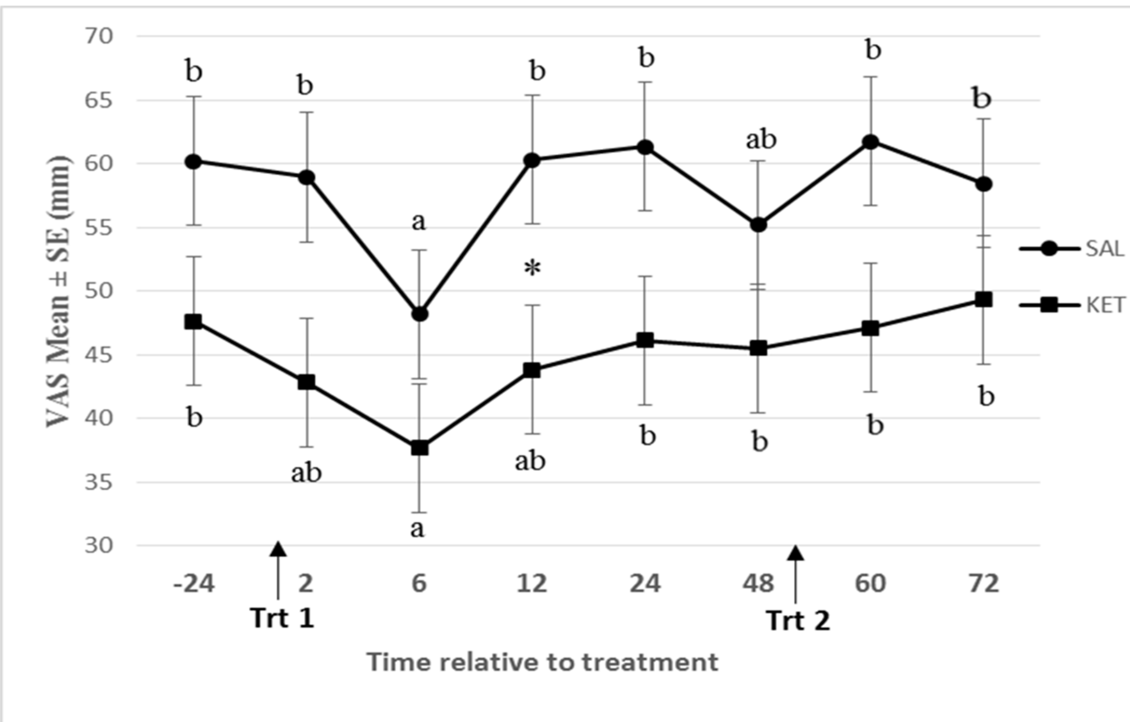

Figure 2.3. Mean ± SE VAS per treatment across time. VAS defined as distance (mm) measured from left terminus to observer mark related to animals' degree of lameness. KET= cows treated with two identical doses of 3 mg/kg BW of ketoprofen, SAL= cows treated with 3 mL per 100 kg BW isotonic saline solution. Relative treatment times denoted by arrows along time axis. Significant differences between treatment group means are represented by asterisk (*) ($P < 0.05$). Within-group comparisons are denoted by alphabetical superscripts and subscripts; time points with the same letter superscript were not different.

Between group comparisons.

Mean baseline VAS scores were not significantly different between SAL and KET groups, with values of 60.2 ± 5.1 and 47.6 ± 5.1, respectively ($P = 0.09$). Baseline values were included as cofactors in post-treatment analyses. A significant difference between group mean VAS scores was identified 12 h after the first treatment, when SAL cows had higher VAS scores than KET cows ($P= 0.04$). All other differences between mean VAS scores were not significant ($P > 0.05$).

Within group comparisons.

In the SAL and KET groups, 6 h VAS scores were significantly lower than their corresponding baseline evaluation, ($P = 0.01$) and ($P < 0.01$), respectively. In both groups, all other treatment group means were not significantly different from baseline evaluation ($P > 0.05$).

Correlations

VAS scores and locomotion scores had a strong positive correlation with the Pearson correlation coefficient $r = 0.80$ ($P < 0.0001$) as shown as figure 2.4. SHFT and VAS scores were positively correlated with $r = 0.15$ ($P = 0.02$), Figure 2.5. Similarly, the correlation between SHFT and locomotion score was $r = 0.15$ ($P = 0.02$), as shown in Figure 2.6.

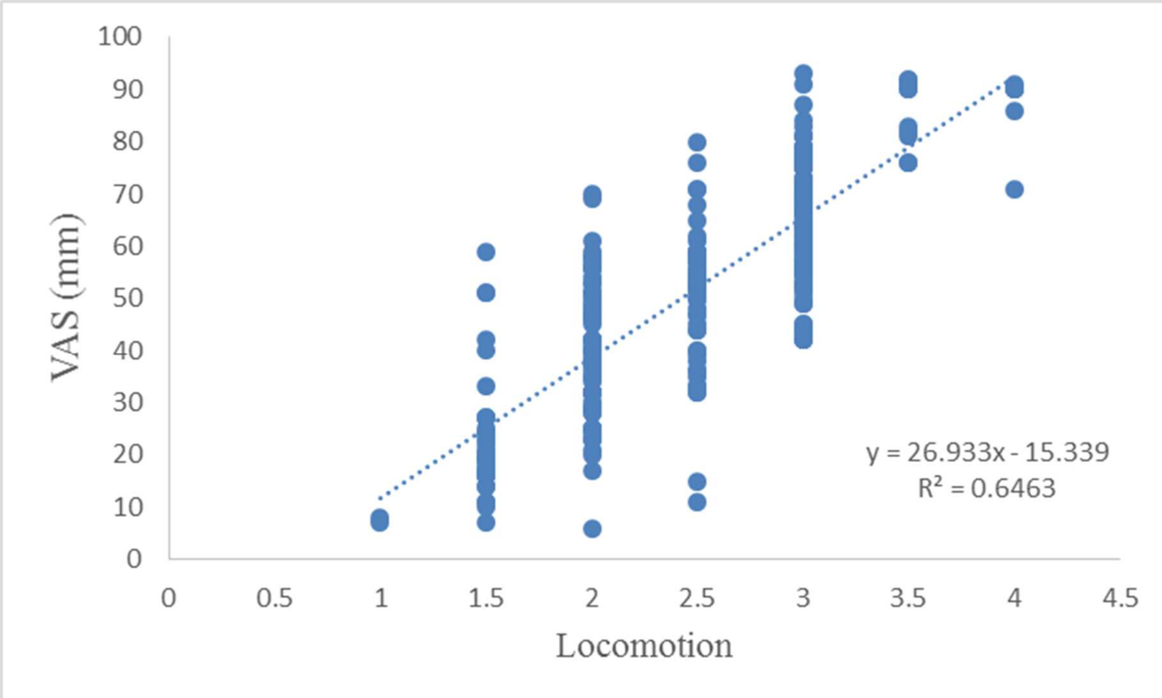

Figure 2.4. Correlation between VAS (mm) and locomotion scores for all cows. Pearson Correlation coefficient r = 0.80 ($P < 0.0001$).

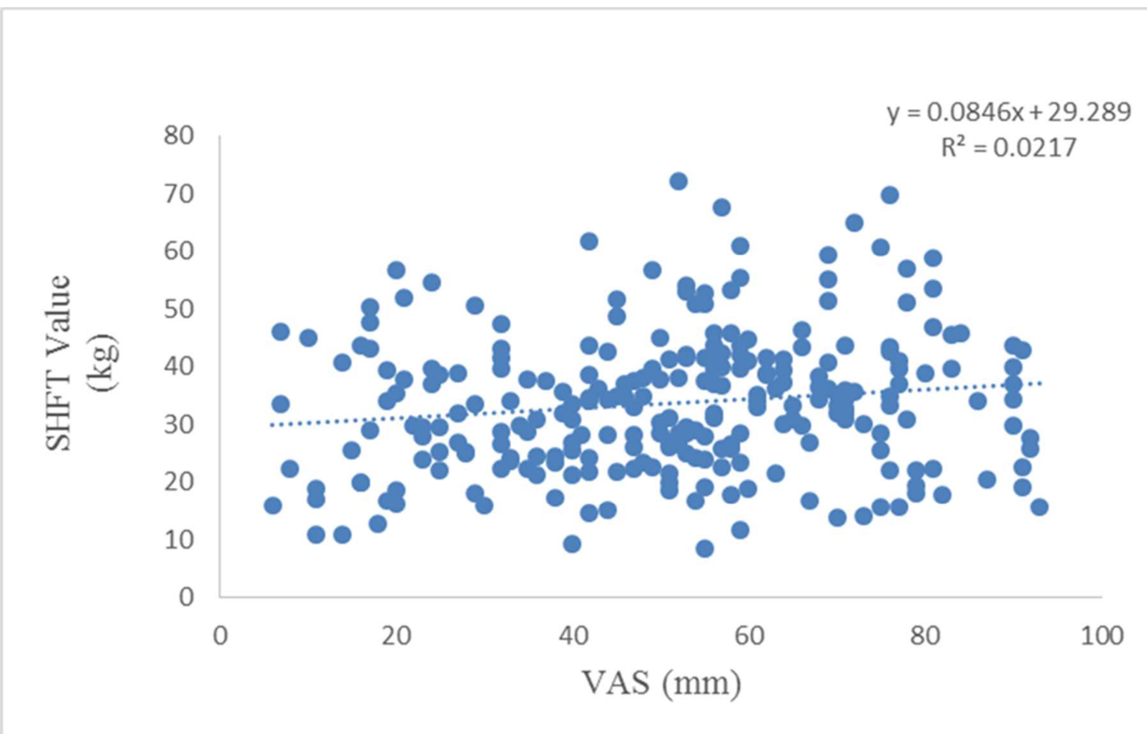

Figure 2.5. Correlation between SHFT value (SD of Mean rear leg weight) and VAS score (mm) for all cows. Pearson Correlation Coefficient r = 0.15 ($P = 0.02$).

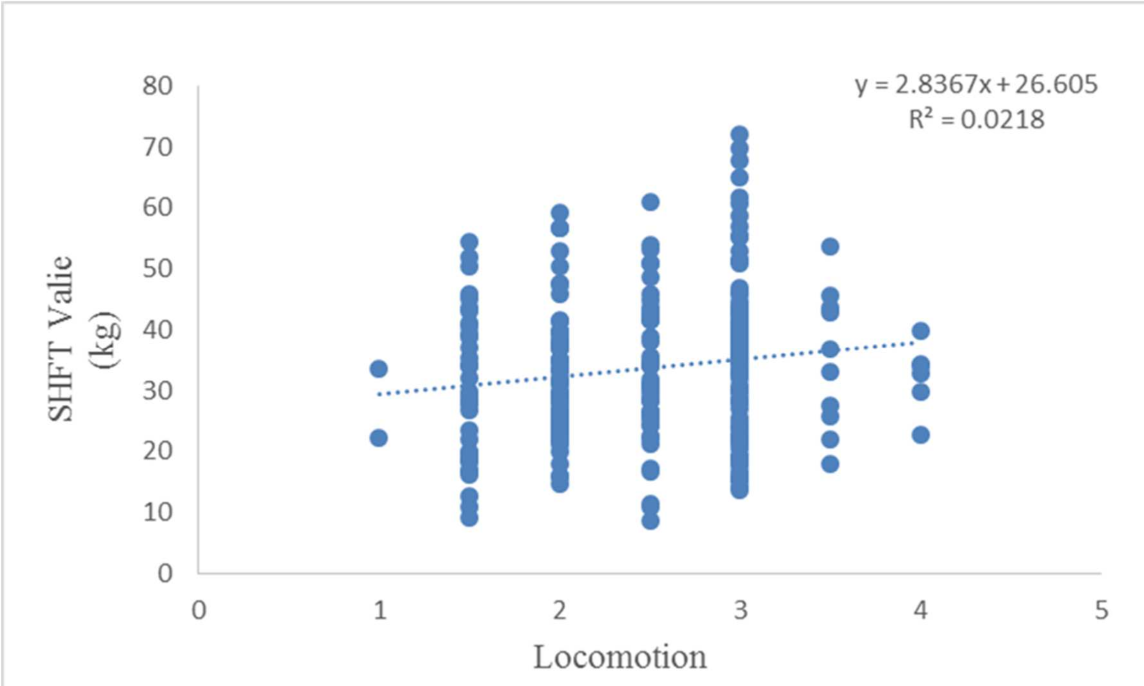

Figure 2.6. Correlation of SHFT value (SD of Mean rear leg weight) and locomotion scores for all cows. Pearson Correlation Coefficient r = 0.15 (P = 0.02).

Hoof lesions

Observed hoof lesions are presented in Table 2.1. The most commonly observed lesions were solar lesions, including thin soles, toe ulcers, white line disease, and sole hemorrhage.

Table 2.1. Observed hoof lesions (number of cows affected within each condition) by treatment group

	SAL	KET
Sole lesion, 1 rear	6	3
Sole lesion both rear	1	3
Sole Lesion, 2 rear and 2 front	1	0
Sole lesion, 1 rear and Injury	1	1
Digital dermatitis, both rear	0	2
Old lesion with atypical hoof growth, 1 rear	2	1
Old lesion with atypical hoof growth, 2 rear	1	0
No lesions observed	1	0
No lesion data recorded	3	6

Discussion

Weight shifting between the rear limbs has been validated as an objective, quantitative method for measuring foot discomfort (Neveux et al., 2006), for detecting differences between lame and non-lame dairy cows (Pastell and Kujala, 2007; Rushen et al., 2007) and for evaluating the analgesic effects of a single dose of ketoprofen in lame dairy cows (Chapinal et al., 2010). In this study , in addition to evaluating the analgesic effects of ketoprofen after repeated dosing in lame dairy cows, we also performed the first analysis of correlation between 3 methods of evaluating lameness: weight shifting behavior, locomotion scoring (a non-continuous variable) and Visual Analog Scale scoring (a continuous variable) .

Weight shifting behavior, measured as the SHFT value, is a sensitive measure of analgesia after NSAID therapy. When compared to untreated controls, the ketoprofen-treated cows in this study were observed to have significantly less weight shifting behavior 12 hours after each treatment. Weight shifting behavior did not change significantly over the duration of the study in the KET group; differences between groups appeared to be primarily due to increased weight shifting in the SAL group. On the days that the cows were treated, they spent increased time standing due to the demands of study procedures, which included data collection while walking and standing on the scale multiple times per day on treatment days. Standing and increased activity is known to increase the severity of lameness pain in dairy cows (Shearer et al., 2013). Additional time spent standing due to data collection likely resulted in higher degrees of lameness in SAL cows but not KET cows on the days of drug treatment. Ketoprofen provided analgesia to lame dairy cows, protecting them from increased lameness pain due to increased time spent standing during the study. A different pattern was observed in an earlier study in which cows had weight-shifting behavior collected less frequently (Chapinal et al., 2010). In that study, in which cows had weight shifting data collected only once daily, the ketoprofen-treated group had decreased weight shifting compared to untreated cows and compared to baseline values, while weight shifting in untreated cows was unchanged over the study period. The comparison of the outcomes of these 2 studies supports the hypothesis that the pattern of within-group weight shifting over time in this study is attributable to the increased amount of time the cows spent standing during the study.

Unlike weight shifting behavior, locomotion scoring and visual analog scoring of lameness are subjective methods of lameness evaluation and identification. In this study, a significant difference between locomotion scores in the SAL and KET groups was identified 12 hours after first treatment, but not after the second treatment. Within both groups, all mean locomotion scores across time remained within a narrow range of less than 0.4/5 points. In the

KET group, the difference between the group mean baseline score and the mean score 12 h after treatment (the only time when treatment group differences in locomotion score were significant) was less than 0.25 point. The slight improvement in locomotion scores after ketoprofen treatment is in accordance with earlier research by Flower et al., (2008) and O'Callaghan (2002).

Similarly to locomotion scoring, significant differences in VAS scores were observed between KET and SAL cows 12 hours after the first treatment, but not after the second treatment. In both the SAL and KET group, mean VAS scores were lower than baseline 6 h after treatment. The 6 h data collection occurred shortly after the cows were milked; as this difference was observed in both groups, the most likely explanation for the difference between baseline and 6 h VAS scores may be altered locomotion following emptying of the udder. Locomotion scores were numerically lower than baseline at 6h, but unlike VAS scores, the difference was not significant.

In contrast to SHFT value between-group comparisons, between-group differences in both subjective measures of locomotion did not appear to be primarily due to increased evidence of lameness pain in the saline-treated control cows. Treatment differences between VAS score and locomotion score values were observed 12 h after the first treatment using both methods, and with both methods, 12 h groups means were numerically similar to baseline in the SAL group and numerically lower than baseline in the KET group. Subjective evaluation of locomotion appears to capture differences in lameness pain differently than the objective measure of weight-shifting behavior. One component of locomotion behavior that is not a component of standing behavior is forward movement. A possible explanation for the differences in trends over time for weight-shifting measures versus observations of locomotion is walking speed. In 2010, Chapinal et al. reported that forward speed at the walk was inversely correlated with locomotion scores in dairy cows (Chapinal et al., 2010b). It is possible that the KET cows in this study stepped off the scale and walked forward more quickly than the SAL treated cows did, due to the presence of less lameness pain, and that this difference caused the differing patterns of within-group differences observed between weight-shifting and locomotion-based measures.

One objective of this study was to investigate the effect of multiple doses of ketoprofen. In Canada, where the drug is approved for the relief of pain in cows, the recommended dosing interval is once daily. When Chapinal et al., (2010a) administered 2 doses of ketoprofen at a 24 hour interval, weight shifting was found to be decreased in treated cows, compared to controls, 2 h after each treatment. In this study, the interval between doses was stretched to 48 hours, and weight shifting data were collected more often- at 2, 6, 12, 24 and 48 h after the first treatment, and at 12 h and 24 h after the second treatment. The current study is the first to use weight shifting behavior as a measure of the analgesic efficacy of ketoprofen in lame dairy cows more than 2 h after treatment. Unlike the previous study, in this study, differences in weight shifting behavior were not observed 2 h after the first drug treatment. Similarly to the previous study, treatment differences were no longer present 24 h after treatment. Treatment group size was slightly larger in this study. Cows in the earlier study were more lame than those in the current study when measured using locomotion scoring; it is possible that this had some effect on the time elapsed until treatment effects were detected. In the current study, treatment effects were not observed until 12 h after the first treatment.

All methods of evaluation reflected an analgesic effect of ketoprofen 12 h after the first treatment, but only the SHFT value reflected a significant analgesic effect 12 h after the second treatment. This difference between method outcomes may have to do with the forward-motion component of locomotion. In an earlier study in which cows had their locomotion evaluated repeatedly over a period of 29 days, walking speed slowed throughout the study period (Chapinal et al, 2010a). Cows are likely to relax and move more slowly as they become more acclimated to personnel and to a study procedure (walking) that is not intrinsically unpleasant for them. It is possible that decreased walking speed over time may have influenced evaluation of locomotion as the study progressed, and that this influence may have confounded both methods of locomotion evaluation enough to erase treatment effects. It is also possible that the second dose of ketoprofen did not have the same degree of analgesic effect as the first dose. Little has been published about the development of tolerance (diminished response after repeated dosing) to NSAIDs, the drug class that includes ketoprofen. A study of daily administration of the NSAIDs analgene, ketorolac, and xefocam to rats over a 5 d period did describe the development of tolerance to their analgesic effects (Tsiklauri et al, 2010). If the cows in the current study developed some tolerance to ketoprofen after repeated administration, the results suggest that weight shifting is a more sensitive measure of analgesia than either method involving the subjective assessment of locomotion.

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CHAPTER 3. EFFECTS OF RAMP EXPOSURE DURING THE NURSERY PERIOD ON LOADING BEHAVIOR IN SWINE[1]

Abstract

Stress induced by handling, loading, and transportation events are key facilitators in the reduction of swine welfare and well-being. Exposure to bouts of stress causes decreases in carcass quality and increased risk of injury, and mortality. The objectives of this study were to determine if exposure to a ramp during the nursery period would decrease the time required for market hogs to ascend the loading ramp, and to identify any growth performance traits altered by a split level pen. Seventy-two crossbred hogs were enrolled at weaning, blocked by sex and litter, and randomly assigned to one of two treatment groups: FLAT or RAMP. FLAT hogs were raised in a conventional style pen, while RAMP hogs were exposed to a split level pen design which required climbing a ramp to receive feed. Video recordings, body weights, and orts were collected weekly while in nursey (day 0-34). Ethograms were developed from recordings and behavioral observations included: consuming behaviors, and aggressive type behaviors. When mean body weight reached 23 kg, hogs were blocked by sex and treatment and randomly assignment to finish pens. Four and five month body weights were collected. At time of market, treatment-blind identification was assigned to each hog and they were evaluated on duration on ramp, number of refusals, and handler encouragements. RAMP hogs required significantly less

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[1] The material in this chapter was co-authored by B. L. Novak, J. M. Young, D. J. Newman, and S. A. Wagner. All authors were affiliated with the Department of Animal Sciences at North Dakota State University at the time of the study. B. L. Novak was responsible for animal selection and enrollment, handling and weighing of study animals, data collection coordination, data management, ethogram development, and preparation and revision of this chapter. J. M. Young is credited with statistical analyses, animal weighing, loading day handling, and proofreading. D. J. Newman provided study design input. S. A. Wagner assisted with data collections, statistical input, study design development, and proofreading.

time to complete the loading ramp than FLAT, 30.52 ± 10.81 sec and 58.87 ± 10.37 sec, respectively ($P = 0.04$). RAMP hogs consumed significantly less feed than FLAT hogs during the nursery period 190.37 ± 3.11 and 205.25 ± 3.11 ($P = 0.02$), respectively. Ramp exposure did not significantly affect other growth or behavioral measurements. Results of this study suggest ramp exposure reduces stress associated with handling and loading of market hogs, while also reducing feed inputs during the nursery stage of development.

Key Words: stress, loading, ramp, conditioning

Introduction

Handling and loading processes are known to be stressful for many livestock species. Market hogs exposed to high levels of stress are at greater risk of injury, fatigue, reductions of carcass quality, and mortality (Adzitey, 2011; Bench et al., 2008; Lawrie, 2006). Livestock are able to adapt to environmental or handling stressors following repeated exposure (Sadler et al., 2015; Wickham et al., 2012; Bovin et al., 1998); however, throughout a production life cycle, market hogs may only be exposed to moving or transportation twice during their lifetime (Voslarova et al., 2017).

Pigs are willing animals and learn tasks rapidly by classical and operant conditioning methods (Gieling et al., 2011; Baldwin and Stevens, 1973; Chaput et al., 1973). Conditioning methods can alter the long-term memory of hogs if they receive a positive reinforcement to a response during the nursery period (de Jong et al., 2000). Pigs are likelier to be motivated to perform a task if they receive an immediate positive reinforcement (Elmore et al., 2012).

Efforts to improve the handling of swine have directed attention to split level housing systems. Research has shown that ramp exposure during the production cycle does not have negative impact on growth traits (Bulens et al., 2017; Gourmon et al., 2013; Phillips and Fraser, 1987), decreases aggressive behaviors (Bulens et al., 2017), and reduces the number of balks on a loading ramp (Goumon et al., 2013).

The angle of the loading ramp affects the behavior of a hog (Warriss et al., 1991) As the slope of the ramp increases, so does the frequency of balks and handler encouragements (Garcia and McGlone, 2014; Goumon et al., 2013). Swine appear to favor a ramp that is more flat (Goumon et al., 2013), and the suggested loading ramp slope should be set to a maximum of 20 to 25 degrees (Marchant-Forde, 2009; Warriss et al., 1991).

By exposing and acclimating nursery hogs to a ramp system, it is possible to create a positive association between ramp structures and feed, facilitating movement of market hogs up the loading ramp. Measurements of handling efficiency include the number of balks, duration of time on the ramp, and the number of handler encouragements. The objectives of this study were to determine the effects of ramp exposure during the nursery period on loading behavior of market hogs. Our hypotheses were:

- Nursery pigs exposed to the ramp feeder would be more willing to maneuver a loading ramp exhibiting less refusals and handler encouragements.
- Exposure to ramps would not have negative effect on production as measured by body weight and average daily gain.

Materials and Methods

All procedures involving animals were approved by the North Dakota State University Institutional Animal Care and Use Committee.

Hogs and Management

Seventy-two crossbred hogs of similar genetics were divided and used over two experimental periods. Males and females were selected in pairs from each litter to achieve an enrollment cohort of 36 animals.

At 21 days of age, Day 0 of study, hogs were weaned and moved to the NDSU Animal Nutrition and Physiology Center. Upon arrival, animals were blocked by sex and randomly sorted into one of two treatment groups, then further assigned to a treatment pens.

Hogs were allowed ad libitum access to feed and water and were housed on slatted floor pens.

Treatments

Hogs in treatment group 1, FLAT, were raised under normal nursery housing conditions while hogs in treatment 2, RAMP, were raised with a ramp system which required hogs to navigate an angled ramp to obtain feed. Groups of nine hogs were housed in four identical pens measuring 4.6 x 1.8 meters. The ramp platform was approximately 0.91 x 0.46 meters, while the ramp itself was 3.2 x 0.41 meters with 0.30 meter raised side barriers. The ramp was started in a neutral flat position and raised 15.24 cm per day, until a maximum height of 0.91 meters was achieved. This allowed for a maximum angle of 20 degrees. Photographs of RAMP and FLAT pens are identified as Figure 3.1.

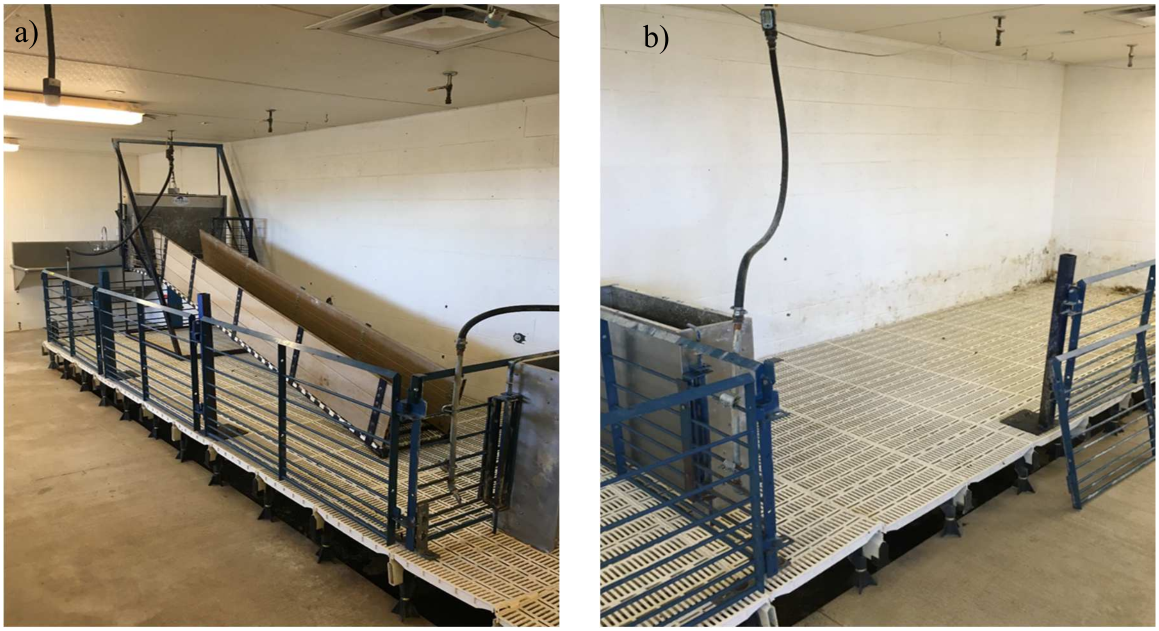

Figure 3.1. RAMP (a) and FLAT (b) pen configurations.

Body Weights and Orts

Orts and body weights were collected during the nursery period on days 0, 7, 14, 21, 28, 34. Hogs remained in the nursery pens until approximately 23 kg body weights were achieved.

Video Recording and Ethogram Development

Video recordings of each pen were started on day 0 and continued through day 34. Ethogram observations were completed by a single observer at intervals of thirty-seconds, every thirty minutes, starting at 0630 and ending at 2000. Observations included eating, drinking, and fighting behaviors. Statistical analysis was completed using the frequency of observed behaviors at each data collection time. Behavioral observation explanations detailed in Table 3.1.

Table 3.1. Description of criteria for behaviors used to evaluate hogs in nursery

Behavior	Description
Eating	Animal is standing at feeder actively consuming feed or masticating.
Drinking	Animal is standing at mouth piece actively consuming water.
Fighting	Animal engages in physical contact with another animal.

Finishing Treatments

Animals were blocked by pen and randomly assigned to one of two finish pens and reared to market weight. Individual body weights were collected at 4 months and 5 months of age. Animals were marketed upon reaching 113.4 kg or greater body weight regardless of treatment assignment or pen affiliation.

Hogs were weighed one day prior to shipping to obtain actual market body weights and assign shipping numbers. If a hog was market ready, a number was painted onto their topline for treatment-blind identification when reviewing loading videos.

Loading and Loading Observations

An experienced treatment-masked handler moved hogs up the length of the loading ramp, (12 meters), in groups of 1-3. Video recording of the loading process was completed using digital cameras. Number of refusals or balks, number of handler encouragements, and duration to move up ramp. Descriptions of evaluation parameters detailed in Table 3.2. Loading videos were reviewed by the same individual observer.

Table 3.2. Description of evaluation measurements collected at loading

Parameter	Description
Total Time (Seconds)	The duration of time to ascend the ramp, measured as the shoulder crossing the established start point to crossing the determined finish point.
Refusal	Stop of forward motion after crossing start line of ramp
Encouragement	Vocal or physical cue by handler to direct animal to reestablish forward movement

Animals were collected in a holding pen at the base of the ramp. The opening of the ramp was 2.9 m and tapered down to 0.76 m, which was the consistent width of the ramp. Animals were observed for a distance of 12 m, which began once they passed the funneled entrance.

Statistical Analyses

Data were analyzed using the mixed procedure of SAS (SAS v. 9.4, SAS Institute, Inc., Cary, NC). For loading data, fixed effects included were sex, treatment, and shipping date and random effects were group nested within shipping date and litter nested within rep. For growth traits, fixed effects included were rep, sex, and treatment and random effects were litter nested within rep and finishing pen nested within rep (except for Nursery ADG). For market weight, age at market was included as a covariate. Interactions between fixed effects were tested and removed from the model if $P < 0.10$. Means for treatment groups were estimated using the LS MEANS statement and compared for significance at the $P < 0.05$ level.

Results

Removal from Study

Ten hogs (5 from each treatment group) were unable to complete the study and were removed due to incidences of abdominal hernias, structural soundness issues, or mortality.

Body Weights

Nursery.

Mean body weight during nursery period was not significantly different between RAMP and FLAT hogs at any of the weekly collection points. ($P > 0.05$)

Four months of age.

Mean body weight at 4 months of age was not significantly different. Mean FLAT hog weight at 4 months of age was 76.11 ± 1.39 kg and mean RAMP hog weight was 76.09 ± 1.40 kg ($P = 0.10$).

Five months of age.

Mean 5 month body weight of FLAT and RAMP hogs were not statistically different ($P = 0.28$), 106.44 ± 1.47 kg and 104.76 ± 1.51 kg, respectively.

Market weight.

Average finish market shipping weights were 123.64 ± 1.26 kg and 123.75 ± 1.27 kg for FLAT and RAMP, respectively ($P = 0.67$).

Feed Intake

Weekly feed intake.

Weekly feed intake was significantly different between treatment groups during treatment exposure in nursery. Mean weekly feed consumption for the whole FLAT group combined was

41.05 ± 6.20 kg, while all RAMP hogs combined consumed an average of 38.07 ± 6.20 kg (P = 0.02).

Total nursery feed intake.

The difference of weekly feed intake for FLAT and RAMP subsequently allowed for a significant difference in total feed intake during the nursery stage. FLAT hogs consumed a total of 205.25 ± 3.11 kg while RAMP treated hogs consumed 190.37 ± 3.11 kg (P = 0.02).

Average Daily Gain (ADG)

Significant differences between mean ADG in FLAT and RAMP treatments were not observed during nursery, 4 month, 5 month, and market ages.

Nursery Behavior

Eating.

A significant treatment effect on eating behavior was observed between FLAT and RAMP hogs on days 8 and 26 of the nursery stage. Eating behaviors observed on day 8 of nursery for FLAT (66.07 ± 5.51 events per day) and RAMP (44.67 ± 5.51 events per day), (P < 0.01), and Day 26 FLAT (52.28 ± 5.51 events per day) and RAMP (34.27 ±5.51 events per day), (P = 0.02). Other daily treatment comparisons were non-significant (P > 0.05). Eating behavior frequency shown in figure 3.2.

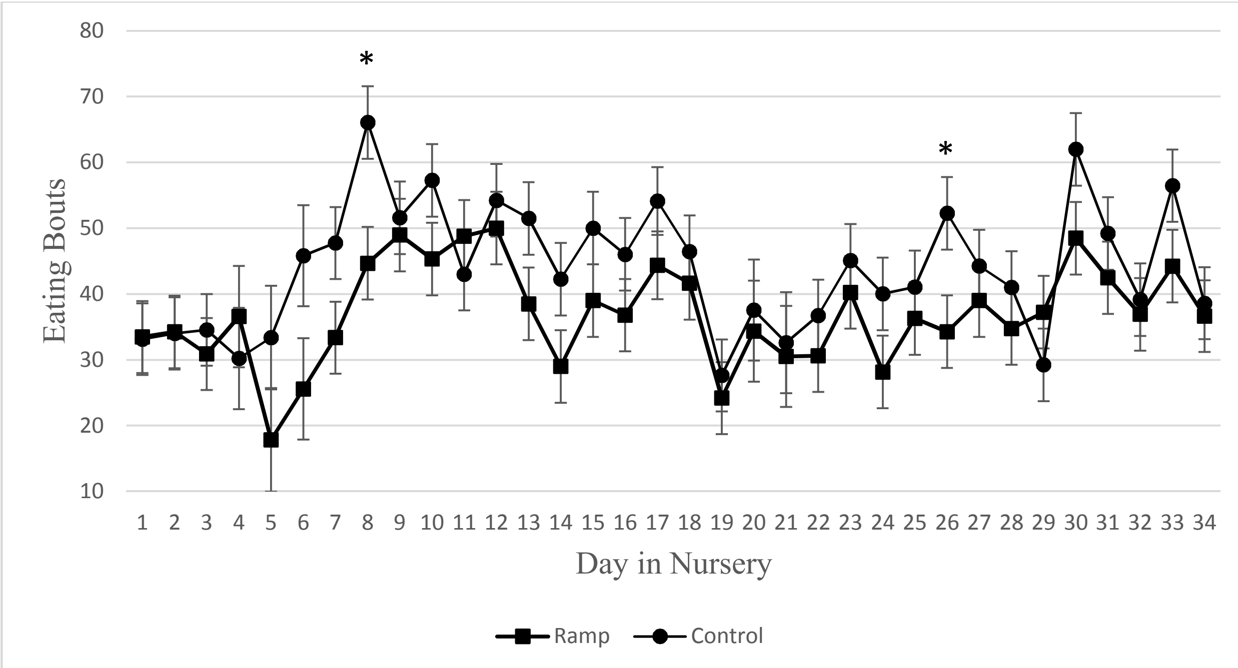

Figure 3.2. Mean ± SE FLAT and RAMP observed eating behavior frequency across time. Observed behaviors were counted when animal was standing in close proximity to the feeder or was visibly consuming feed. Significant differences between treatment group means are represented by asterisk (*) ($P < 0.05$).

Drinking.

Differences of drinking behavior in FLAT and RAMP hogs were significantly different on days 1 ($P = 0.01$), 15 ($P = 0.02$), 26 ($P = 0.05$), and 30 ($P = 0.02$). Observed drinking behavior frequency for FLAT and RAMP treatments on day 1 (29.85 ± 2.36 events per day) and (21.28 ± 2.36 events per day), ($P = 0.01$); day 15 (13.75 ± 2.40 events per day) and (5.52 ± 2.40 events per day), ($P = 0.02$); day 26 (13.78 ± 2.40 events per day) and (7.01 ± 2.40 events per day), ($P = 0.05$); and day 30 (16.96 ± 2.40 events per day) and (9.20 ± 2.40 events per day), ($P = 0.02$). Drinking behavior frequency shown in figure 3.3.

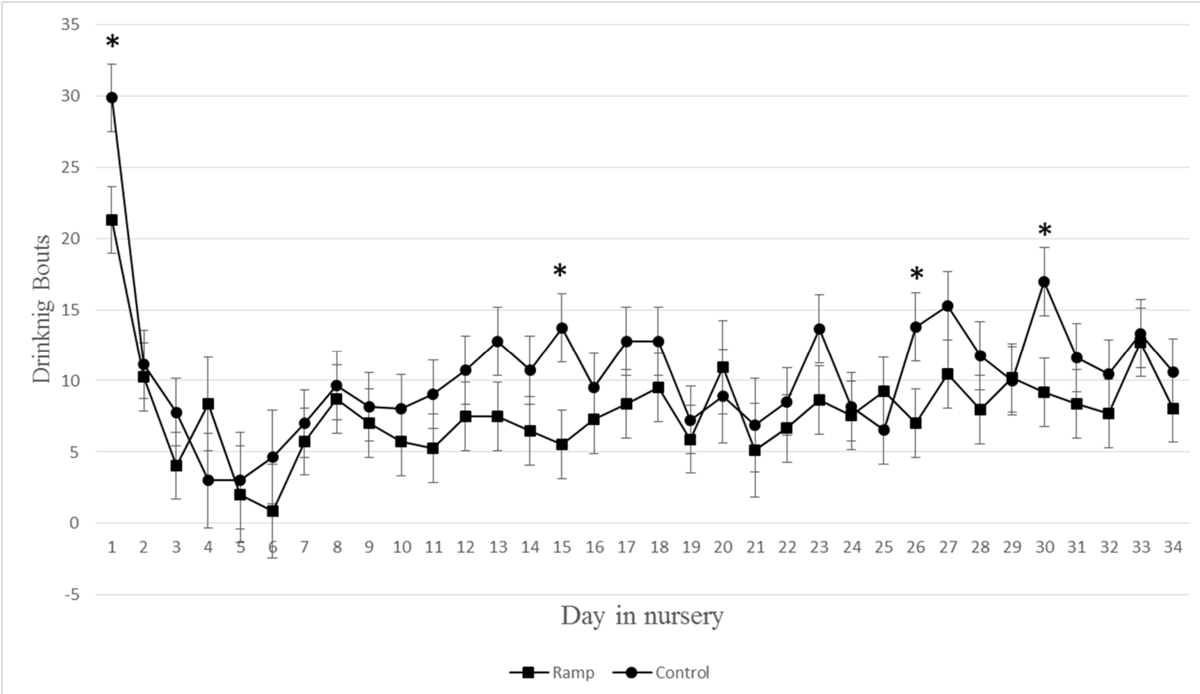

Figure 3.3. Mean ± SE FLAT and RAMP observed drinking behavior frequency across time. Observed behaviors were counted when animal was standing in close proximity to the waterer or was visibly biting on the waterer. Significant differences between treatment group means are represented by asterisk (*) ($P < 0.05$).

Fighting.

Fighting bouts significantly differed between treatments on days 7 and 17, ($P = 0.02$) and ($P = 0.04$), respectively. Observed fighting bout frequency (number of bouts of fighting per day) for FLAT and RAMP on day 7 was (3.25 ± 0.61 bouts) and (1.25 ± 0.61 bouts), ($P = 0.02$). Day 17 fighting frequency between treatments was FLAT (2.25 ± 0.61bouts) and RAMP (0.5 ± 0.61 bouts), ($P = 0.04$). Fighting behavior frequency shown in figure 3.4.

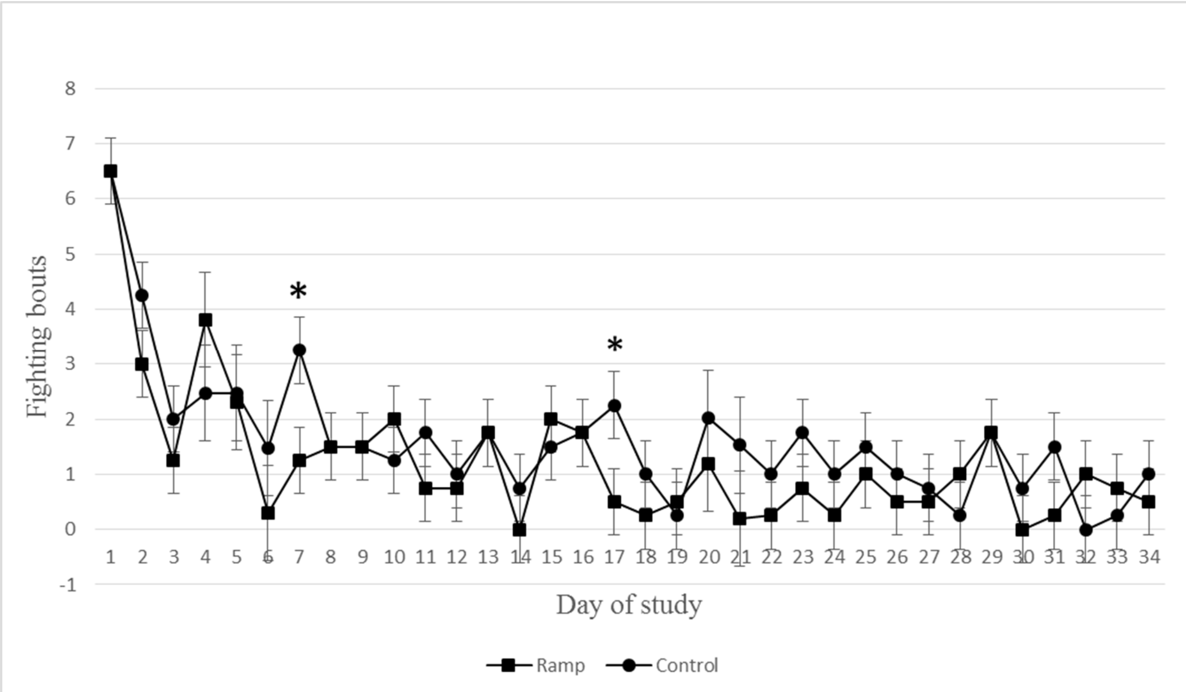

Figure 3.4. Mean ± SE FLAT and RAMP observed fighting behavior frequency across time. Fighting bouts were identified when an animal made aggressive physical contact with pen mate. Significant differences between treatment group means are represented by asterisk (*) ($P < 0.05$).

Loading

Duration on ramp.

There was a significant effect of ramp exposure to loading time. RAMP hogs ascended the ramp in 30.51 ± 10.81 seconds on average and FLAT hogs completed the same distance in and average of 58.87 ± 10.37 seconds, ($P = 0.04$).

Refusals and Encouragements.

There were not significant differences between the number of refusals ($P = 0.40$), and number of encouragements ($P = 0.67$) between the two treatment groups. RAMP hogs refused continuing the ramp an average of 3.10 ± 0.60 times as opposed to FLAT refusing 3.60 ± 0.59. Handler encouragements for RAMP hogs averaged 3.97 ± 0.83 aids and 3.53 ± 0.87 aids for FLAT.

Discussion

The behavioral and physiological effects of split-level housing systems are relatively unmapped at this time. Research has determined that ramp exposure does not have negative impact on growth (Bulens et al., 2017; Phillips and Fraser, 1987), positively affects aggressive behaviors (Bulens et al., 2017), and reduces the number of balks during loading (Goumon et al., 2013). This study evaluated the effects of ramp exposure during the nursery period followed by finishing in a conventional style pen.

Growth results of the current study mirror those of prior research by other investigators. Neither body weight nor average daily gain was significantly affected by ramp exposure. It does appear to have a slight effect in reducing feed consumption. The reduction in feed intake between treatments may be explained in part by the reduced aggressive behaviors of the RAMP hogs. It is possible that the RAMP hogs were less stressed and expended less energy than the more aggressive FLAT hogs, ultimately reducing the need for higher caloric intake.

Phillips and Fraser (1987) suggested an initial negative effect of the ramp implementation as justified by lower 7-d weights of ramp exposed hogs. Nursery body weight data collected during this trial suggests that increasing ramp angle incrementally acclimates hogs to the ramp system, possibly removing the inefficiency effect.

Exposure to the ramp system did not improve the number of balks or encouragements when loading, partially conflicting with the results of Goumon et al., (2013). They determined that hogs balked less at the time of loading if they had been previously exposed to a ramp structure. They attribute this to Grandin (1997)'s theory that hogs would become acclimated to the ramp if it became part of their environment. The differing results may be explained by several factors. First, Goumon et al., 2013 simulated the loading process in the finishing room where the hogs were housed, as opposed to the current study which required hogs to be moved off site and handled outdoors. It is likely the hesitation and balking was due to environmental factors and a novel facility as Krebs and McGlone, (2009) determine that novel environments and odors can affect the ease of handling in market hogs. Additionally, hogs in the Goumon et al., 2013 trial had more recent exposure to the ramp structure than those of this study suggesting that familiarity to the ramp decreases over time.

Hogs exposed the ramps navigated the loading ramp in just over half the time required by the control counterparts, in 30.52 ± 10.81 seconds versus 58.87 ± 10.37 seconds. This is possibly due to increased physical fitness of the ramp exposed hogs. Goumon et al. (2015) hypothesized that the added activity from exercise or ramp exposure may improve the cardiovascular and musculoskeletal systems of hogs; however Lewis et al. (2008) states that hogs are unlikely to increase fitness due to conditioning or exercise over a short distance (<100 m). The duration of time between nursery ramp exposure and marketing is quite lengthy when considering the normal lifecycle of a hog. During that time, FLAT hogs would have had the opportunity to gain physical fitness, while RAMP hogs may have been unable to maintain any advantageous gain due to lack of continued conditioning.

Another possible explanation for the reduction of loading time is conditioning and positive reinforcement. Skinner (1969) determined a strong association can be formed between a task and reward in livestock species. It is possible that exposed hogs associated the ramp to receiving feed which made them more willing or motivated to navigate the loading ramp. The ramp was also a source of environmental enrichment for RAMP hogs. Stolba and Wood-Gush (1980) determined that environmental enrichment increases exploratory behavior and reduces stress and fear in growing hogs. The paired effects of positive association and interest in exploration are likely the cause of the reduced loading time.

The results of this study warrant further investigation of the effects of ramp exposure in nursery and market hogs. Future directions should include evaluation of unloading behaviors and social or aggressive behaviors while in lairage. Additionally, stress markers should be considered, as well as carcass characteristics and incidences of lesions to the skin, carcass, and internal organs.

Conclusion

Ramp exposure during the nursery period of growing hogs reduces feed intake, consuming behaviors, and the frequency of aggressive fighting bouts. Exposure to a ramp prior to market handling reduces the loading time of finished hogs and may reduce the stress from loading events.

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CHAPTER 4. CONCLUSIONS AND FUTURE DIRECTIONS

Quantitative methods of behavioral evaluation provide producers and researchers with the means of understanding and improving welfare. The first study presented in this thesis determined that ketoprofen is a viable option for providing pain relief in lame dairy cows. The subjective methods of evaluation, locomotion scores and visual analog scales, are highly correlated methods of lameness evaluation in lame dairy cows but may lack the sensitivity to measure the effects of the NSAID as compared to weight shifting behavior.

From the second study, we can conclude that ramp exposure during the nursery period has a positive effect on loading behavior in market hogs. Acclimation to ramp systems prior to loading events can reduce the handling time and loading stress. Ramp exposure does not have negative effects on growth of hogs and may reduce production input costs.

Future research may include continued validation of objective methods of evaluation. Automating the process of lameness detection for dairy producers would not only improve animal welfare but also production efficiency. The effects of ketoprofen should continue to be evaluated and future pharmacokinetic research may lead to usage approval in dairy cattle in the U.S.

Split-level housing systems have demonstrated positive impacts on the well-being and physical performance of market hogs. This method of housing hogs may be a possible opportunity for producers interested in expanding production numbers by means of added pen space and reducing input expenses. The next step may be measuring the physiological and carcass effects of loading following ramp exposure. The exact time and duration of ramp exposure should be further investigated as it may be possible to implement split-level housing systems just prior to loading while receiving the same benefits.