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The Relationship between Chute Behavior and Morbidity in Cattle

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Abstract

Most cattle see a handling chute at least once in their lives. Handling plays a huge role in cattle management, whether it's for transportation, auction sales, deworming, medical treatments, or AI purposes. Morbidity related to Bovine Respiratory Disease (BRD) is one of the biggest causes of economic loss for ranchers and can be related to handling stress. Auction-derived calves (ADC; n=92) were brought to the University of Arkansas Savoy Research Facility for processing and monitoring for behavioral cues and disease. The objective of this study was to find a relationship between the calves' behavior in the chute and morbidity. The goal was for this relationship to be used to predict morbidity in ADC. Historically changes in feeding behavior and weight gain have been found in cattle infected with BRD. Chute behavior was recorded in an ethogram on two separate days of the study. Blood samples were obtained from a randomly chosen portion of the calves on day 0, 14, 28, and 41 for a haptoglobin ELISA test. Additionally, body weights were recorded for days -1, 0, 14, 28, and 41. The final measure used in the study was the number of antibiotic treatments each calf was given. These were sorted into treatment groups of Once (1 treatment), Twice (2 treatments), Thrice (3 treatments), and Chronic (4 treatments). This study determined that there was no significant relationship between chute behaviors and morbidity in this group of cattle. However, serum haptoglobin concentrations were correlated with morbidity, and body weight was shown to be lower in cattle that required antibiotic treatments for disease. Further study is required to find a measurable link between behavior and morbidity in cattle. The faster producers and veterinary professionals can detect disease, the less it impacts the producer and the better the animal's welfare. The animal production industry must promote better welfare practices and improve the food industry for producers, animals, and consumers alike.

Acknowledgments

I'd like to begin by thanking everyone who made this project possible. Starting with my amazing husband. His encouragement and genuine interest in my project kept me going when it all felt overwhelming. His steadfast support and unwavering faith in my ability to succeed carried me through these last three years.

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Finally, thank you to my committee members, Dr. Powell and Dr. Kegley. They saw potential in my ideas and helped me to expand this project into what it is today.

Table of Contents

Introduction

Background and Need

Animal welfare is a subject that continues to rise in popularity throughout society. Farmers, ranchers, and consumers want the best for the animals they care for and consume. The American Veterinary Medical Association (AVMA, 2023) defines animal welfare as an animal's state of being and ability to cope with its conditions. The AVMA states that proper disease prevention, veterinary care, nutrition, management, shelter, humane handling, and slaughter are necessary to promote good animal welfare. Disease prevention is especially important in the cattle industry as many cattle are transported to different areas throughout their lifetime. Most cattle are handled by humans at least once, which typically involves handling equipment. Running cattle through these handling facilities with human contact is a critical management practice. Aside from routine exams, cattle may need vaccinations, to be castrated, or to be bred through artificial insemination. All these processes require restraining the animal for a period of time.

Handling facilities and cattle chutes have been designed to aid in animal restraint, care, and processing. These facility designs were improved by animal behaviorist Temple Grandin (1980). In her research, Temple Grandin (1980) found that circular races and low-contrast color choices in handling facilities allow cattle to exhibit natural movement and thus remain calmer. Keeping the cattle as calm as possible is key to disease prevention. Stress incurred from factors including handling, transport, and feed changes that calves experience as they grow up within the production industry can lead to immunosuppression (Richeson, 2011). Additionally, the economic effects of handling and cattle temperament come into play.

Temperament is associated with many factors in cattle production, including animal health and production levels. The relationship is so significant that it has been suggested that cattle be evaluated for temperament to establish a breeding standard to improve herds (Jaśkowski et al., 2023). Essentially, selecting more behavioral-conscious traits, such as temperament during breeding, will improve these animals' health, safety, and production. Farmers and ranchers make their living through their livestock. They prioritize maintaining their animals to the best of their ability to have the healthiest, most productive animals possible. It has been found that the handling and processing stress on cattle has detrimental economic effects reflected in higher costs of raising the animals and, ultimately, higher retail costs (Burdick et al., 2011). These inflated costs stem from the higher concentrations of stress hormones in more temperamental, excitable cattle that negatively impact their daily weight gain and immune capacity (Burdick et al., 2011). The biggest concern with weakened immune capacity is the higher incidence of BRD. (Mijar et al, 2023). Relating back to economic effects BRD is a major contributor to monetary loss for cattle ranchers (Mijar et al, 2023). In short, temperamental cattle and stressed cattle are more susceptible to disease and are less productive than their tamer counterparts.

Problem Statement

The safety and health of livestock should be at the forefront of the cattle production industry. Healthy animals lead to better animal welfare as well as better profits. Calves go through several unavoidable stressors throughout their lives due to standard management practices. This impacts their physical health, which can, in turn, affect their behavior. Behavioral changes may be an early indicator of illness that can aid producers in managing their animals better. Continuing this research is critical to bettering the livestock industries of tomorrow. This study aims to find a measurable relationship between chute behavior and cattle's incidence of disease, most notably BRD.

Purpose Statement

The purpose of this study was to investigate the relationship between chute behavior and morbidity in cattle.

Research Objectives

The following objectives were evaluated in this project:

1. Determine if a relationship exists between chute behavior and morbidity.
2. Determine if behavioral cues can predict future morbidity
3. Identify links between our other measures (exit velocity, haptoglobin, body weight) and morbidity

Literature Review

Overview

Temple Grandin (1980) has changed the design of cattle handling equipment to promote the welfare of the cattle. Significant work has also been done in researching cattle temperament, behavior, and disease. The main focus topics for this literature review were common diseases in auction cattle, ways to study cattle behavior, and how cattle behavior relates to morbidity.

Disease in Cattle

Calves are exposed to many locations and herds throughout the production system. Knowing the potential sources or causes of disease would help producers begin to implement practices to prevent the spread of disease. A good place to start is determining what makes an animal more likely to suffer from illness. It has been found that more temperamental or higher-stress animals have a lower immune response and often die earlier compared to their calmer, less-stressed counterparts (Burdick et al., 2011). It has also been determined that the comingling of calves or cattle from different sources leads to a higher incidence of disease (Campbell, 2022).

Bovine Respiratory Disease

Bovine respiratory disease (BRD) is a broad term for a prevalent respiratory disease in cattle that can be caused by viruses or bacteria (Campbell, 2022). These pathogens can even coinfect their host creating a more substantial effect on the animal (Fulton, 2009). Bovine Respiratory Disease is the primary disease concern for cattle ranchers in North America. It takes an enormous economic toll on ranchers every year (Mijar et al., 2023). It has been found that the most effective way to lower costs related to treating BRD is to prevent the infection entirely (Dubrovsky et al., 2020). Concerns relating to BRD are particularly important for auction-derived calves (ADC). Auction-derived calves have higher morbidity and are more likely to require veterinary treatment than calves sourced from one ranch (Mijar et al., 2023). This is due to the many factors contributing to BRD's etiology. These factors include travel stress, dust, poorly ventilated housing, and comingling of calves from different sources (Campbell, 2022). Auction Derived Calves are exposed to these factors more than ranch-sourced calves. Grouping the calves up in large mixed herds leads to a morbidity percentage in feedlots and sale barns reaching 50% (Campbell, 2022). According to published data identifying the signs of infection early in cattle is difficult, but recognizing the infection early is crucial to achieving positive treatment outcomes (Griffin, 2014). The most significant contributing factor to the pathogenicity of BRD is how cattle are managed (Richeson, 2011). As stated previously, this is mainly due to the large mixed groups of calves in feedlots, stockyards, and sale barns. Studies have shown that preconditioning can lower the incidence of BRD in cattle sent to sale barns, feedlots, and stockyards (Richeson, 2011). Preconditioning involves training and exposing cattle to eating and drinking from feed bunks and performing stressful management practices before transport (Mijar et al., 2023). Adjusting to these stressors before adding the stress of transport helps lower the incidence of BRD.

Temperament in Cattle

Cattle temperament has been defined as their reaction to novel stimuli or human presence and interaction (Burdick et al., 2011). Measuring temperament in cattle can be done in several different ways. Most commonly a scoring system is used. These systems include chute exit velocity and behaviors, chute score, milking behavior, and more (Jaśkowski et al., 2023). Common practice is to use multiple scores to evaluate the cattle. An example is the subjective chute score scale of 1 – 6. A score of one indicates that the animal stood perfectly still in the chute without shifting or moving their legs. In contrast, a score of six indicates a potentially dangerous unmanageable animal fighting to escape hard enough to move the chute if not anchored to the ground (MacKay et al., 2013).

Temperament in Relation to Disease

It has been found that more temperamental cattle have a more difficult time with the everyday stressors that production cattle experience. Grandin (1992) explains that temperamental cattle are more likely to become stressed. This leads to how temperament can cause susceptibility to illness. A study on transportation and cattle found that the stress of transportation often results in BRD cases (Buckham Sporer et al., 2008). Transportation is only one source of stress. Calves brought to auction must adapt to unfamiliar environments and are exposed to other herds. Once at their destination, handling by their new producer becomes another stressor, particularly if it includes a surgical procedure like castration (Uddin et al., 2023). Knowing that transportation and acclimation to new environments can be stressful, ranchers can use that information to improve the cattle industry. One study deemed that looking at how cattle with different temperaments' immune systems function would be beneficial for choosing cattle that would be suitable to live in feedlot environments (Jaśkowsky et al., 2011). Feedlots can contain large numbers of cattle sourced from different farms. This brings a variety of potential biological hazards into one area. Knowing if a herd is more susceptible to illness could help producers decide on preventative measures to protect their herds from disease. It is also worth noting that changes in feed intake and feeding behavior have been used to successfully identify cases of BRD in individual animals (Heinen et al., 2022).

Behavioral Analysis

Behavior is a difficult concept to study. Understanding what different reactions, movements, and vocalizations mean to the animal is critical in studying an animal's state of well-being. Each slight behavior change can be a crucial indicator of why the animal behaves a certain way in response to stimuli. In other words, the behavior of cattle offers clues we can use to decipher its emotional or mental state. One way to ensure nothing is missed is to record data continuously from video recordings during an experiment. Another way to record behavioral data continuously during a study is by using data sheets (Colditz et al., 2014). Data sheets are simply notebooks that investigators use to record data. In one study, the researchers made an ethogram, or list of behaviors and their definitions, like jumping (all four feet off the ground) or jerking (small sudden jump), and recorded each occurrence of the behavior. They also directly observed the subjects at predetermined intervals to help maintain objectivity (Colditz et al., 2014). As stated earlier, researchers have previously determined behaviors believed to show temperament in cattle. More excitable cattle tend to be more restless in the chute and have faster exit velocities (Burdick et al., 2011). Another side to this coin is behaviors that may be caused by painful experiences such as castration or branding. Adcock et al. (2020) determined behaviors consistent with pain, including head shaking, ear flicking, tail flicking, head rubbing and scratching. To substantiate behavioral signs of stress, physiological indicators should be recorded. In some cases, behavioral signs can be ambiguous making physiological signs and processes important to record alongside behavioral changes. It is also important to note that these painful procedures may affect weight gain and the animal’s long-term behavior. Ballou et al. (2013) looked at the amount of feed Holstein calves ate after castration and dehorning, with and without pain relief measures. They found that cattle treated with pain medication spent more time eating post-treatment. This indicates that pain can cause a decrease in growth due to a lack of appetite due to discomfort.

Summary

Previous research indicates that cattle temperament plays a role in their morbidity. However, researchers believe there is value in diving deeper into how temperament and morbidity are related. Therefore, the objective of this study is to record behaviors, weight gain, serum haptoglobin, and antibiotic treatments for a herd of ADC to look for a link between behavior and morbidity. The specific behaviors to be considered, like head tossing, vocalizing, and fast exit velocities are indicators of stressed cattle. The more producers know about the animals they raise the better they can provide for their livestock, and the better their livestock can provide for them.

Methodology

Animals and Housing

Ninety-two mixed-breed bulls (n=80) and steers (n=12) were sourced from an auction and delivered to the Arkansas Agricultural Experiment Station, Savoy Research Complex in Fayetteville, Arkansas. The calves were processed through a round race chute on two separate days. All procedures were approved by the University of Arkansas IACUC. On day -1 (Oct. 31, 2022), each animal was processed through a semi-circular race and weighed on a scale. After the scale, the calves walked into the chute. Once caught in the squeeze chute, the calves were tagged and ear-notched before release. Overnight cattle were held with access to hay and water. On day 0 (Nov. 1, 2022), the calves were again randomly ordered through the semi-circular race chute. The animal weights were recorded once again before they entered the squeeze chute. Once caught, the calves were dewormed with an oral syringe system filled with Valbazen dewormer (Zoetis Inc., New York, NY) and vaccinated with two milliliters Calvary 9 (Merck Animal Health, Rahway, NJ) and Bovishield Gold 5 (Zoetis Inc) administered to each animal subcutaneously on the right side of the neck. Each animal was also hot iron branded on their right hip. All the bulls were castrated with a band except for two cryptorchids, who were castrated surgically. Calves were sorted by body weight into 8 pens and housed in 4 groups of 11 and 4 groups of 12.

Measures

Body Weight

Each animal was weighed before entering the squeeze chute. Body weight (kg) was collected with a livestock scale and recorded on days -1, 0, 14, 28, and 41 of the study.

Serum Haptoglobin

A portion of the selected cattle was bled for serum haptoglobin levels (ng/mL) from their right-side jugular vein (n=47) on days 0, 14, 28, and 41. Blood was collected in serum separator tubes and spun at 2095 xg for 20 minutes at room temperature. The serum from each sample was separated and stored at –80°C until the serum haptoglobin ELISA test was performed.

Behavior

Recording equipment, including chute exit velocity timers and video cameras, was set up before the beginning of each data collection day (d-1, d0, d14, d28, d41).

Upon exiting the chute, exit velocities (m/s) for each animal were recorded on a Polaris Multi-Event Timer. This exit velocity timer was set up 1.8288 meters from the front of the chute. The cattle were filmed in the chute from two different angles with GoPro Hero (San Mateo, CA, USA) video cameras. The first camera was placed on a tripod in front of the event timer. The second camera was hung above the chute off the right side as if you were standing in the chute (**Figure 1**). Once the data was collected and digitalized into the data-sharing website Box, analysis began. Video recordings were divided by the software into 17-minute, 38-second

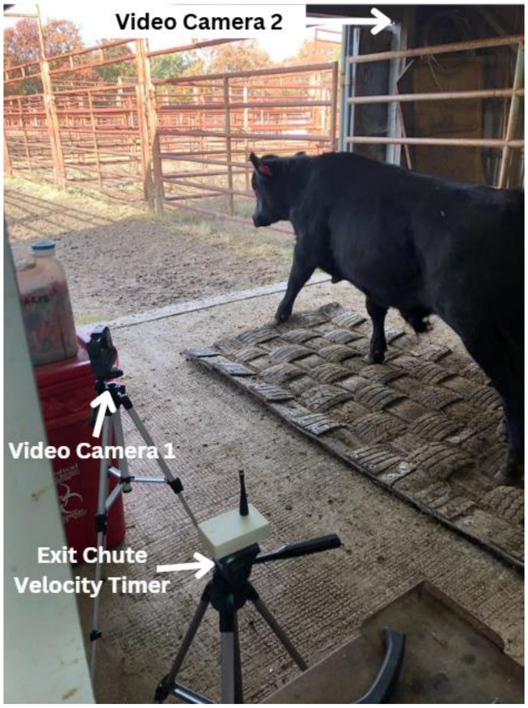

Figure 1. Video camera and exit velocity timer set up to record cattle chute behavior.

segments. Each video was labeled by the angle of the camera, date of recording, and tag number of the first and last animal recorded in the video. Each segment of the video for each animal's time spent in the chute was watched at least three times. At the beginning of each segment, the start time was recorded first. The start time for each animal was the time indicated on the video when the animal's head was caught in the chute. Next, the tag number of the observed animal was determined and recorded. The first playthrough of each video segment was used to count vocalizations. The second playthrough was used to record predetermined behaviors on an ethogram. These behaviors include pushing, thrashing, down in chute, front end down, rear end down, vocalizing, head tossing, visible whites of eyes, and salivating or nasal discharge, described in **Table 1**.

Table 1: Ethogram of behaviors.

Behavior	**Definition**
Pushing	The animal pushes its shoulders into the headgate of the chute
Thrashing	Any time the animal jumps, twists, or throws its entire body in the chute
Down in chute	The animal's legs are folded underneath it, and its chest, abdomen, and hindquarters are in contact with the bottom of the chute
Front end down	The animal's chest is either on or close to the ground and is lower than the animal's midsection and hindquarters
Rear end down	The animal's hindquarters are on or close to the ground and are lower than the mid-section and front-end
Vocalizing	The animal made a mooing, lowing, or bellowing sound
Head tossing	Any rapid up-and-down movement of the animal's head that is typically repeated multiple times
White of eyes visible	Any incidence of a portion of the whites of the animal's eyes being visible
Salivating or nasal discharge	Any bodily fluids draining from the mouth or nose not related to dewormer being administered

Adapted from Colditz et al., (2014).

All behaviors were recorded as present or not present except for vocalizations, which were recorded as the number of occurrences. The third playthrough determined a subjective chute score **(Table 2)** based on the intensity and number of previously recorded behaviors.

Table 2: Ethogram of chute scores and their definitions.

Chute Score	Definition
1	No movement
2	Restless shifting
2.5	Restless shifting with one episode of a chute score 3 behavior
3	Squirming and occasional shaking of the chute
3.5	Vigorous shaking of the chute with brief pauses
4	Continuous vigorous shaking of the chute
5	Rearing, twisting, and violently struggling

Adapted from Grandin (2018).

The chute end time was recorded at the end of the final playthrough and the end time corresponded to when the animal's head was released from the chute.

Antibiotic Treatment

Over the next 42 days, cattle with clinical signs of morbidity were treated with antibiotics. The antibiotic Nuflor (categorized as "Once") was given first. Further treatments were given if the calf continued to show clinical signs after the previous treatment. Next was Baytril (categorized as "Twice"). The third treatment was Excenel (categorized as "Thrice"). The fourth treatment was Draxxen (categorized as "Chronic"). Antibiotic doses were given according to body weight, and the antibiotic name, dose, and calf they were administered were recorded throughout the study. The data on each calf was categorized into four treatment groups: None (no antibiotics, N=14), Once (treated with 1 antibiotic [Nuflor], N=46), Twice (treated with 2 antibiotics [Nuflor and Baytril], N=10), and Chronic (treated with 3-4 antibiotics [Nuflor, Baytril, Excenel and Draxxen], N=18). Mortalities (N=4) were excluded from the data.

Statistical Analysis

Incidence of antibiotic treatments were categorized into a dependent variable, “antibiotic treatment category” with four levels (None = no antibiotic treatments, Once = 1 antibiotic treatment, Twice = 2 antibiotic treatments, Chronic = 3-4 antibiotic treatments). Statistics were conducted in Rv4.4.1 and R Studio v2024.04.2 using the packages “lme4”, “emmeans”, “survival”, and “survminer”. Data were assessed for normality before linear mixed-effects models were used to analyze the interactions of trial day and antibiotic treatment category, with sex as a covariate for body weight, average daily gain, haptoglobin, exit chute velocity, and the number of vocalizations occurring. General linear mixed effects models with a binomial distribution were used to assess the probability of pushing, thrashing, front end down, vocalizing, and head tossing occurring in the chute. All other behaviors occurred too infrequently to analyze statistically. Pen was used as a random factor for average daily gain, haptoglobin, and pushing, but didn’t contribute variation to the other models so was removed. Ear tag number was used as a random factor to account for repeated measures. Exit chute velocity and number of vocalizations in the chute were square root transformed and haptoglobin was log-transformed to increase model fit. Back-transformed estimated means for transformed data are presented. Cox proportional hazard and Kaplan-Meier survival curves were used to observe the effects of sex and antibiotic treatment category on the time until first and second antibiotic treatment.

Results

Body weight

Results indicated an interaction between antibiotic treatment category and trial day ($p<0.0001$) on calf body weight. **Figure 2** shows the interaction by trial day and antibiotic treatment category with body weight. There was no effect of sex detected ($p=0.49$). However, the antibiotic treatment category had an effect ($p=0.004$). The effect shown indicates that the Chronic antibiotic treatment category calves weighed significantly less than the None category calves at the end of the study. Day ($p<0.0001$) also had a significant effect on the calves' body weight. Overall calves gained weight throughout the trial.

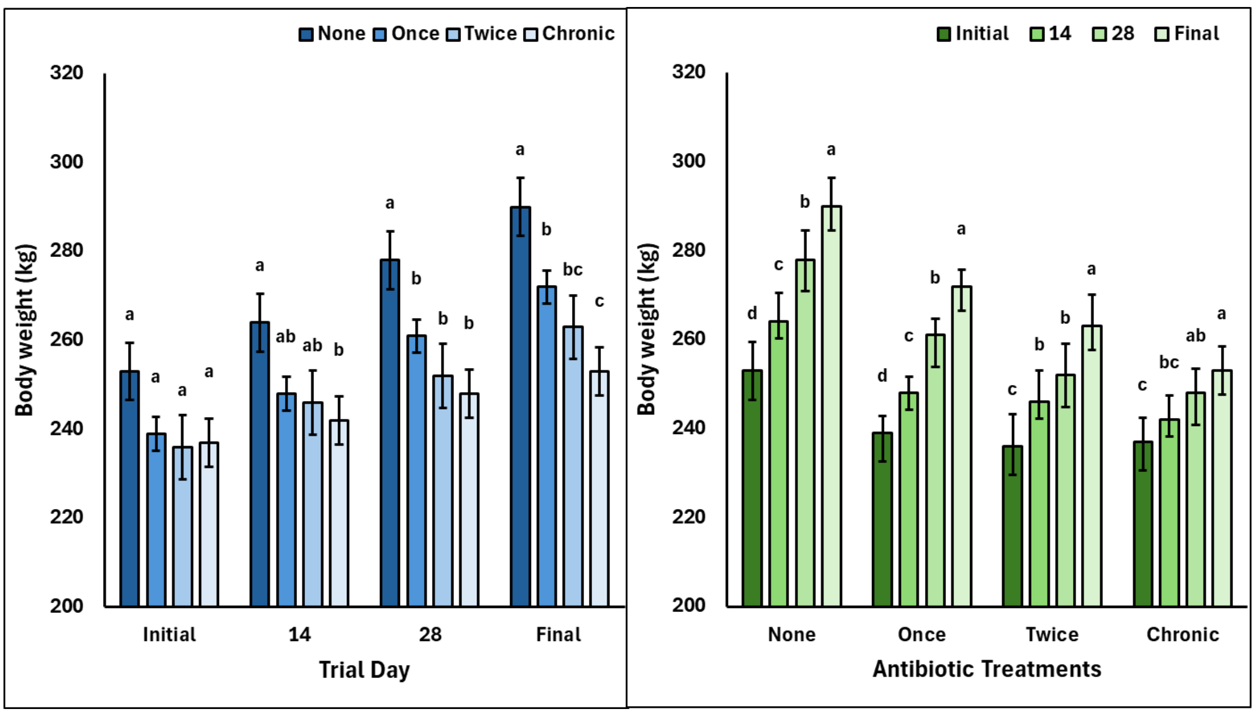

Figure 2: The effect of trial day and antibiotic treatment category on body weight ($F=5.40$, $p<0.0001$) of bulls ($n=80$) and steers ($n=12$) after arriving at a grow out facility, ear tagged and ear notched (d-1), and undergoing vaccinations, branding, castration (bulls only), deworming and blood sampling (d0). The graphs show pairwise comparisons grouped by (A) trial day and (B) antibiotic treatment categories where none = no treatments ($n=14$), once = 1 treatment ($n=46$), twice = 2 treatments ($n=10$), and chronic = 3-4 treatments ($n=18$). Significant pairwise comparisons ($p<0.05$) within (A) day or (B) antibiotic treatment categories are shown with different superscript letters.

Average Daily Gain
There was an effect of antibiotic treatment category on average daily gain (ADG) shown in **Table 3**. The Chronic calves had significantly lower ADG than the None and Once category calves. There was no effect of Day (p=0.80) or Sex (p=0.23) on ADG. There also was no interaction between antibiotic treatment category and Day (p=0.91).

Table 3: Linear mixed-effects models exploring the interaction between trial day and antibiotic treatment category with sex as a covariate were used to generate estimated means and standard errors or average daily gain of recently castrated bulls (n=80) and steers (n=12). Calves are grouped by the number of antibiotics administered over the following 41 days where none = no treatments (n=14), once = 1 treatment (n=46), twice = 2 treatments (n=10), and chronic = 3-4 treatments (n=18).

Sex		**Trial Day**		**Antibiotic Treatment Category**		**Trial Day * Antibiotic Treatment Category**	
Bull	0.63 ± 0.06	14	0.67 ± 0.09	None	0.89 ± 0.13^{a}	14 * None	0.80 ± 0.15
Steer	0.77 ± 0.12	28	0.71 ± 0.09	Once	0.80 ± 0.08^{a}	14 * Once	0.74 ± 0.09
		41	0.72 ± 0.09	Twice	0.70 ± 0.14^{ab}	14 * Twice	0.75 ± 0.17
				Chronic	0.42 ± 0.11^{b}	14 * Chronic	0.42 ± 0.13
						30 * None	0.94 ± 0.15
						30 * Once	0.83 ± 0.09
						30 * Twice	0.64 ± 0.17
						30 * Chronic	0.43 ± 0.13
						41 * None	0.92 ± 0.15
						41 * Once	0.83 ± 0.09
						41 * Twice	0.69 ± 0.17
						41 * Chronic	0.42 ± 0.13
F = 1.457 p = 0.231		F = 0.226 p = 0.798		F = 5.030 p = 0.003		F = 0.352 p = 0.908	

Serum Haptoglobin
Moving on to serum haptoglobin there was an interaction between antibiotic treatment category and trial day (p=0.021). **Figure 3A-B** shows the interaction by trial day antibiotic treatment category with serum haptoglobin levels. There was no effect of starting sex (p=0.63). An effect of the antibiotic treatment category (p=0.003) was found on serum haptoglobin levels. The results show that the Chronic antibiotic treatment category calves had greater haptoglobin

than None and Once calves indicating a greater inflammatory response in the animals that required more antibiotic treatments. An effect of day (p<0.0001) was also shown in the results. Haptoglobin concentrations were greater on Day 0 than all other days and were greater on Day 14 compared to Day 41.

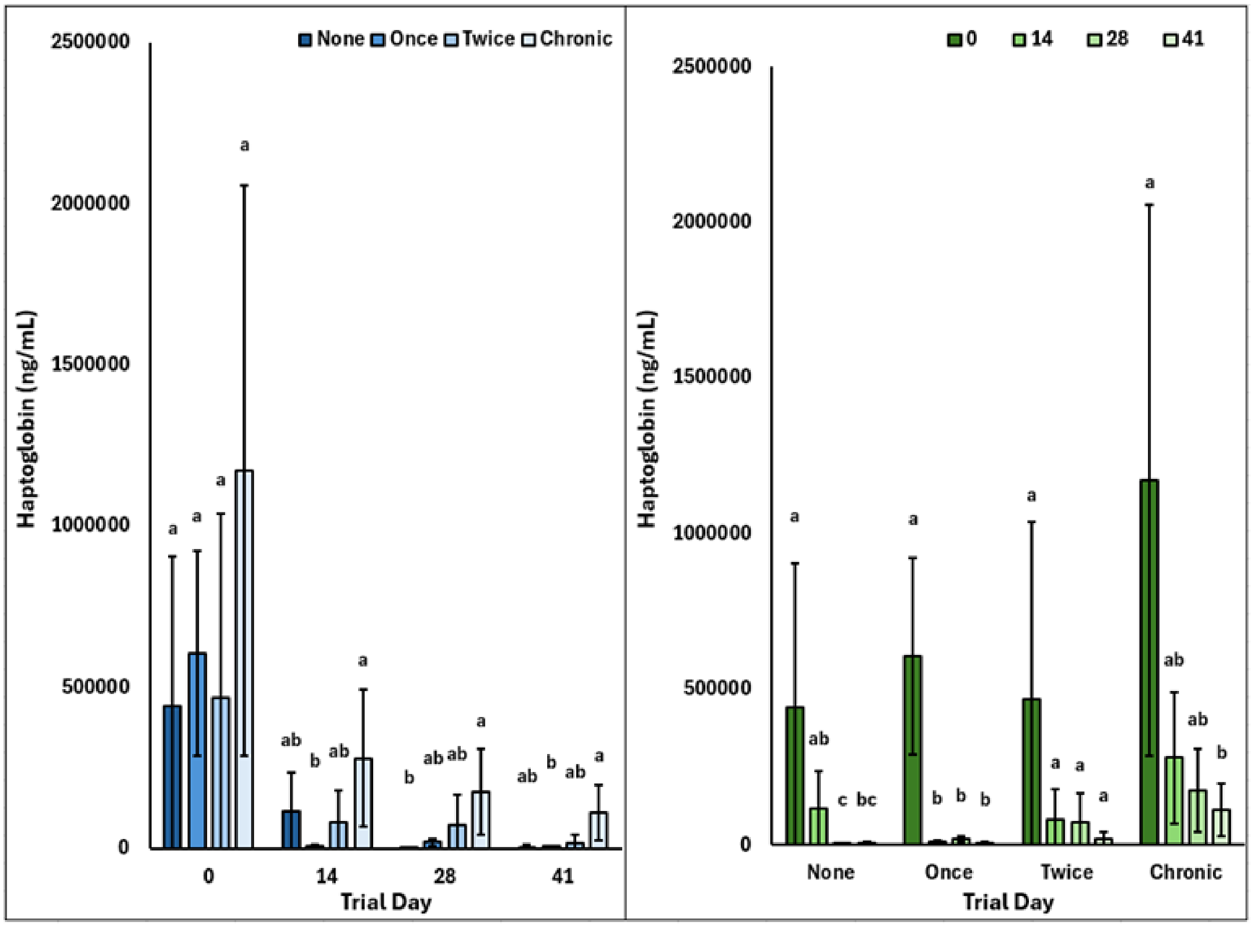

Figure 3: The effect of trial day and antibiotic treatment category on serum haptoglobin concentrations (F=2.29, p=0.02) of bull (n=80) and steer (n=12) calves after arrival. The graphs show pairwise comparisons grouped by (A) trial day and (B) antibiotic treatment categories where; none = no treatments (n=14), once = 1 treatment (n=46), twice = 2 treatments (n=10), and chronic = 3-4 treatments (n=18). Significant pairwise comparisons (p<0.05) within (A) day or (B) antibiotic treatment categories are shown with different superscript letters.

Antibiotic Treatments

Up to 4 antibiotic therapies were administered to the calves for BRD. For antibiotic treatments, there was no effect of sex on the probability of receiving first (p=0.60) or second (p=0.60) treatments. The first treatment (**Figure 4A**) showed that Chronic calves were more likely to receive a first antibiotic treatment before Once (p=0.012) treated calves. Chronic calves did not differ statistically from Twice calves (p=0.20). For the second treatment (**Figure 4B**), Chronic calves did not show a statistical difference from Twice calves (p=0.10). However, the graph shows a visible difference between the two with Chronic calves having a slightly higher probability of receiving the second treatment.

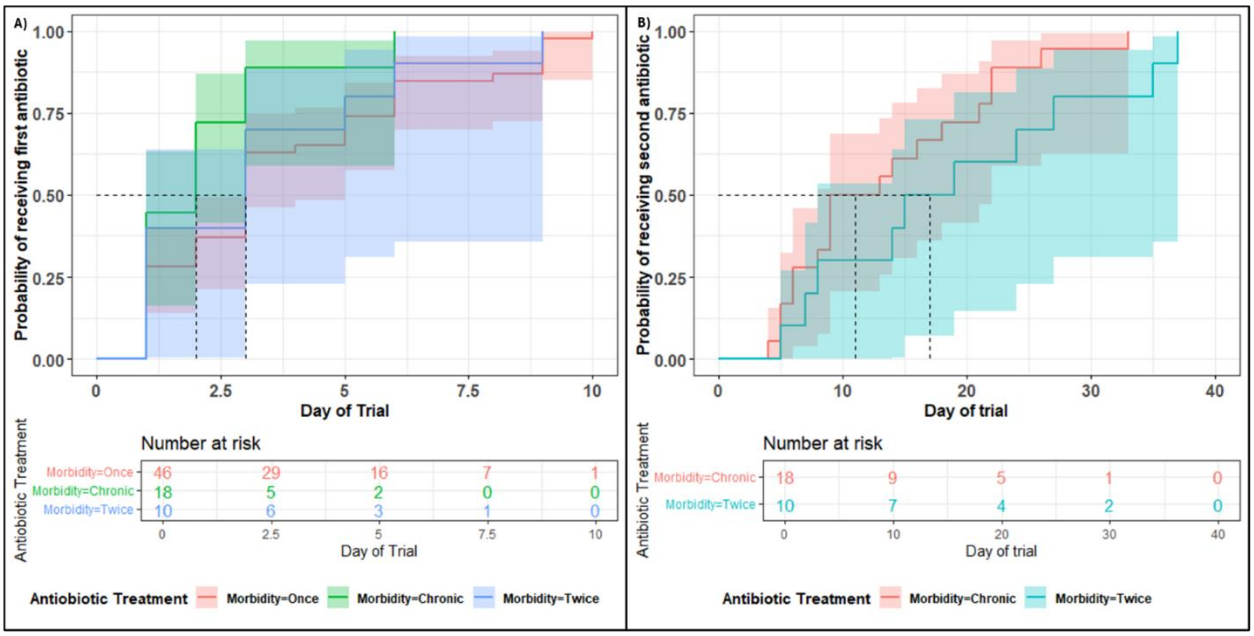

Figure 4: Kaplan-Meier survival curves showing the probability of calves with different morbidity being administered their (A) first or (B) second. Antibiotic treatment categories were assigned as none = no treatments (n=14), once = 1 treatment (n=46), twice = 2 treatments (n=10), and chronic = 3-4 treatments (n=18).

Behavior

There were no interactions of antibiotic treatment category on the probability of any of the behaviors occurring in the squeeze chute on day -1 and day 0 (p>0.05). Calves were 1.84 times more likely to perform pushing on day -1 than day 0 (p=0.027). The calves were 2.36 times more likely to have their front end down in the squeeze chute on day 0 than on day -1 (p=0.082). Lastly, the calves were 6.38 times more likely to vocalize on day 0 than on day -1 (p=0.014). **Table 4** shows the number and percentages of bulls and steers observed vocalizing, pushing, thrashing, down in chute, front end down, head tossing, whites of eyes visible, snot or salivation during their time in the chute on days -1 and 0. **Table 5** shows the effect of sex, trial day, treatment category, and trial day and treatment category on subjective chute score (SCS) and vocalizations per minute. None of these effects were significant. However, it is interesting to note that the Chronic calves did not have the lowest SCS on either trial day. The Once treated calves had the lowest SCS on day -1 and day 0. **Table 6** shows that there was an effect of trial day on chute exit velocity (p<0.0001). Calves exited the squeeze chute fastest on day -1 than any other trial day. The slowest exit velocities occurred on day 28.

Table 4: The number and percentage of calves observed vocalizing, pushing, thrashing, down in chute, front end down, head tossing, whites of eyes, snot or salivation during time in a chute where on day -1 calves were ear tagged and notched and on day 0 calves were vaccinated, bled (carotid), dewormed, branded, and bulls were castrated. Calves are grouped by the number of antibiotics administered over the following 41 days where none = no treatments (n=14), once = 1 treatment (n=46), twice = 2 treatments (n=10), and chronic = 3-4 treatments (n=18).

		Count	Vocalizing		Pushing		Thrashing		Down in Chute		Front End Down		Head Tossing		Whites of Eyes		Snot / Salivation	
Day, Sex	Antibiotics	N	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
-1, Bull	None	14	5	35.7	7	50.0	6	42.9	0	0	1	7.1	6	42.9	0	0	2	14.3
	Once	38	13	34.2	25	65.8	16	42.1	1	2.6	6	15.8	15	39.5	1	2.6	7	18.4
	Twice	9	2	22.2	5	55.6	4	44.4	0	0	2	22.2	5	55.6	0	0	4	44.4
	Chronic	15	5	33.3	9	60.0	2	13.3	0	0	1	6.7	6	40.0	3	20.0	3	20.0
-1, Steer	None	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Once	7	2	28.6	3	42.8	3	42.9	0	0	0	0	2	28.6	0	0	2	28.6
	Twice	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chronic	3	1	33.3	1	33.3	2	66.7	0	0	0	0	1	33.3	0	0	0	0
0, Bull	None	14	9	64.3	7	50.0	6	42.9	0	0	1	7.1	4	28.6	1	7.1	2	7.1
	Once	38	19	50.0	12	31.6	12	31.6	1	2.6	11	28.9	18	47.4	2	5.3	0	0
	Twice	9	7	77.8	3	33.3	7	77.8	0	0	4	44.4	4	44.4	0	0	0	0
	Chronic	15	6	40.0	6	40.0	5	33.3	0	0	2	13.3	4	26.7	1	6.7	0	0
0, Steer	None	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Once	7	3	42.9	5	71.4	2	28.6	0	0	0	0	5	71.4	0	0	0	0
	Twice	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chronic	3	1	33.3	2	66.7	2	66.7	0	0	0	0	1	33.3	0	0	0	0

Table 5: Linear mixed effects models exploring the interaction between trial day and antibiotic treatment category with sex as a covariate were used to generate estimated means and standard errors for subjective chute scores and the number of vocalizations per minute in the chute. Bulls and steers were placed in the chute on day -1 after arriving at the facility where they were ear tagged and notched, and on day 0 where they were vaccinated, dewormed, blood sampled, branded and castrated (bulls). Calves are grouped by the number of antibiotics administered over the following 41 days where none = no treatments (n=14), once = 1 treatment (n=46), twice = 2 treatments (n=10), and chronic = 3-4 treatments (n=18).

Sex		**Trial Day**		**Antibiotic Treatment Category**		**Trial Day * Antibiotic Treatment Category**	
Subjective Chute Score							
Bull	2.63 ± 0.07	-1	2.58 ± 0.10	None	2.53 ± 0.16	-1 * None	2.50 ± 0.19
Steer	2.48 ± 0.16	0	2.53 ± 0.10	Once	2.57 ± 0.10	-1 * Once	2.37 ± 0.11
				Twice	2.61 ± 0.17	-1 * Twice	2.69 ± 0.21
				Chronic	2.50 ± 0.13	-1 * Chronic	2.57 ± 0.16
						0 * None	2.45 ± 0.19
						0 * Once	2.62 ± 0.11
						0 * Twice	2.57 ± 0.21
						0 * Chronic	2.50 ± 0.16
F = 0.842 p = 0.362		F = 0.410 p = 0.524		F = 0.121 p = 0.947		F = 0.003 p = 0.999	
Vocalizations/ minute							
Bull	0.68 ± 0.20	-1	0.32 ± 0.20	None	0.50 ± 0.41	-1 * None	0.29 ± 0.34
Steer	0.25 ± 0.30	0	0.58 ± 0.27	Once	0.49 ± 0.24	-1 * Once	0.42 ± 0.24
				Twice	0.46 ± 0.43	-1 * Twice	0.17 ± 0.29
				Chronic	0.33 ± 0.28	-1 * Chronic	0.48 ± 0.38
						0 * None	0.77 ± 0.57
						0 * Once	0.57 ± 0.29
						0 * Twice	0.89 ± 0.68
						0 * Chronic	0.21 ± 0.25
F = 1.140 p = 0.289		F = 2.104 p = 0.151		F = 0.085 p = 0.968		F = 1.456 p = 0.232	

Table 6: Linear mixed-effects models exploring the interaction between trial day and antibiotic treatment category with sex as a covariate were used to generate estimated means and standard errors for exit chute velocity (m/s). Bulls and steers were placed in the chute on day -1 after arriving at the facility where they were ear tagged and notched, and on day 0 where they were vaccinated, dewormed, blood sampled, branded, and castrated (bulls), and at three subsequent days (14, 28, 41) where no procedures were conducted. Calves are grouped by the number of antibiotics administered over the 41-day trial where none = no treatments (n=14), once = 1 treatment (n=46), twice = 2 treatments (n=10), and chronic = 3-4 treatments (n=18). Significant pairwise comparisons are shown by differing superscript letters.

Sex		**Trial Day**		**Antibiotic Treatment Category**		**Trial Day * Antibiotic Treatment Category**	
Bull	2.81 ± 0.11	-1	3.31 ± 0.17[a]	None	2.48 ± 0.26[ab]	-1 * None	2.94 ± 0.31
Steer	2.72 ± 0.25	0	3.28 ± 0.17[a]	Once	2.87 ± 0.15[ab]	-1 * Once	3.43 ± 0.18
		14	2.57 ± 0.16[b]	Twice	3.29 ± 0.28[a]	-1 * Twice	3.84 ± 0.34
		28	2.06 ± 0.16[c]	Chronic	2.42 ± 0.21[b]	-1 * Chronic	3.04 ± 0.26
		41	2.59 ± 0.16[b]			0 * None	3.08 ± 0.31
						0 * Once	3.46 ± 0.18
						0 * Twice	3.74 ± 0.34
						0 * Chronic	2.85 ± 0.26
						14 * None	2.28 ± 0.31
						14 * Once	2.64 ± 0.18
						14 * Twice	3.14 ± 0.34
						14 * Chronic	2.22 ± 0.26
						28 * None	1.75 ± 0.31
						28 * Once	2.13 ± 0.18
						28 * Twice	2.75 ± 0.34
						28 * Chronic	1.61 ± 0.26
						41 * None	2.33 ± 0.31
						41 * Once	2.68 ± 0.18
						41 * Twice	2.99 ± 0.34
						41 * Chronic	2.37 ± 0.26
F = 0.116 p = 0.735		F = 72.853 p < 0.0001		F = 3.273 p = 0.025		F = 0.276 p = 0.993	

Discussion

Current literature indicates that BRD is a major contributor to morbidity in the cattle industry. The best course of action for lowering the economic impact of this prevalent disease is prevention and early diagnosis and treatment. Literature also indicates an interaction between some behavioral measures and morbidity. Thus, this study aimed to find measurable links between behavior and morbidity in cattle, specifically BRD. This finding would aid ranchers in the early detection of morbidity in cattle at auction or within their herds.

The results did not indicate an interaction between behavioral measures and the incidence of disease in the 92 calves in this study. This may be because we did not record behaviors past day 0 or perhaps there simply isn't a correlation between the two. Further study is required to determine the reason. There was not an effect of sex on any of the measures we studied. This was most likely due to working with an unbalanced herd of only 12 steers out of 92 total calves. The study supported that there is economic loss through lessened weight gain in cattle due to disease. Chronic treated calves had a significantly lower ADG than any other treatment category. This loss in production affects ranchers and consumers alike. The heavier calves in this study tended to have less incidence of BRD than their lighter counterparts. We did not know the exact ages of the calves so no conclusions can be drawn about age effects. It was also shown that cattle with clinical signs of morbidity have higher inflammatory responses indicated by serum haptoglobin concentrations. The Chronic category calves had high serum haptoglobin concentrations on day -1 indicating that they may have been sick before arriving at the university facility. There were some differences in serum haptoglobin measures overall which could have been caused by multiple factors. There could have been a variation in basal-level serum haptoglobin concentration. There also could be differences caused by varying travel distances between calves. There was also a higher measure for the None category calves on day 14 which raised the estimated mean and may have indicated some subclinical illness. This is important because it reinforces that cattle displaying clinical signs are physiologically impacted by their disease. This physiological impact is correlated with lower body weights as shown in this study. Finding a method of early detection can help minimize the economic effects of disease on producers.

Conclusion

This study determined that there was not a significant relationship between chute behaviors and morbidity in this group of cattle. However, serum haptoglobin concentrations were correlated with morbidity, and body weight was shown to be lower in cattle that required antibiotic treatments for disease. Further study is required to find a measurable link between behavior and morbidity in cattle. The faster producers and veterinary professionals can detect disease, the less it impacts the producer and the better the animal's welfare. The animal production industry must promote better welfare practices and improve the food industry for producers, animals, and consumers alike.

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