INCREASING VENTILATION IN COMMERCIAL CATTLE TRAILERS TO DECREASE SHRINK, MORBIDITY, AND MORTALITY

A Thesis

by

NICOLE MARIE GIGUERE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2006

Major Subject: Animal Science

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Approved by:

Chair of Committee, Theodore Friend
Committee Members, Robin Anderson
Steve Wikse
Head of Department, Gary Acuff

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ABSTRACT

Increasing Ventilation in Commercial Cattle Trailers to Decrease Shrink, Morbidity, and Mortality. (August 2006)

Nicole Marie Giguere, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Theodore Friend

A practical method of reducing aerosolized pathogens and environmental contaminants during commercial transportation could prove beneficial to the health and value of cattle. Having previously determined that there was very limited airflow within moving livestock trailers, an experimental treatment that increased cross-ventilation within commercial cattle trailers by installing aluminum scoops to punch-hole trailers was evaluated. Environmental factors including temperature, ammonia and carbon dioxide concentrations, and percent dry matter of excreted urine and fecal matter were evaluated, along with physiological factors, including complete blood count, serum electrolyte concentrations, percent weight loss, the presence of *Salmonella, Escherichia coli,* or *Mannheimia haemolytica*, and 30 day health data. The experiment consisted of two trials, each with two truckloads of 80 cattle each, for a total of 320 cattle. Temperature was evaluated in the center compartments of each trailer at five minute intervals throughout both trips. Ammonia concentrations were measured using passive dosimeters. Jugular blood samples, fecal grab samples, swabs of the terminal rectum and nasal swabs were obtained 8.5 to 10 hours post-transport from 20 cattle from each trailer. Increased ventilation resulted in lower temperatures and ammonia concentrations on both trips. Percent dry matter of excreted urine and fecal matter were inconclusive. There were no treatment effects for complete blood counts or electrolyte and basic chemistry panels, possibly because the cattle had access to both hay and water between transport and sampling, which allowed for recovery. Cattle in the ventilated trailer had an average weight loss of 4.7%, compared with 5.75% for the cattle in the control trailers. Sampling for *E. coli* O157:H7, *Salmonella*, and *M. haemolytica* showed very few positives, likely due to the good condition of the cattle prior to transport. During the 30 days post-transport, no cattle from either treatment required veterinary attention related to transport. The results indicate that increasing ventilation through the use of external air scoops has the potential to improve the health and well-being of cattle during transport.

DEDICATION

To Andy, whose love and support kept me sane. Without him, none of this would be possible. How he puts up with me is beyond my comprehension, but greatly appreciated!

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Ted Friend, and my committee members, Dr. Robin Anderson and Dr. Steve Wikse. Without their knowledge, guidance, and support, this research could never have been conducted. Their patience and wisdom has been much appreciated.

I would also like to thank my colleagues in the Applied Ethology/Welfare group. Their advice, support, and most of all, labor, allowed this project to succeed. They provided encouragement, sympathy, and a helping hand whenever I needed it.

I wish to extend an extra thanks to Dr. Anderson, whose lab provided the materials and labor to analyze all of our microbial samples. I also owe thanks to Grimes St. Joseph Health Center, who donated the laboratory analysis of our blood samples. Without this assistance, our limited budget would have prevented the use of these measures.

Finally, thanks to my mother and father, who encouraged and supported me throughout my life. Also, last, but by no means least, thank you to Andy Wheeler, my fiancé, who had to deal with me on a daily basis throughout this project. His patience and love kept me going.

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INTRODUCTION

Transportation of cattle is considered to be one of the most stressful aspects of beef production. There are many costs that may be related to stress, including weight loss and increased morbidity and mortality resulting from stress and exposure to pathogens. A large body of research exists regarding the effects of transportation on livestock, including the evaluation of supplements (Archer, 2005), density within the trailer (Whiting, 2000), and spread of pathogens (Barham et al., 2002). However, while the air quality within cattle trailers has been assessed (Wikner et al., 2003), there have been no studies conducted to assess methods of improving air quality and environmental conditions during transportation, although such research has been called for (Tarrant and Grandin, 2000).

Preliminary research conducted on commercial semi horse trailers by this lab in 2004 showed minimal air movement (2 to 3 miles per hour) within the trailer, even when head winds were in excess of 70 miles per hour. In fact, these experiments showed that trailers parked crosswise to a strong breeze had greater ventilation levels within the trailers than those traveling down the highway.

While commercial cattle trailers are designed slightly differently than the single-deck trailer used in the preliminary study, there is no reason to believe that there is a significant difference in the amount of ventilation within the trailers. This would imply that cattle trailers have poor internal ventilation, exacerbating the environmental conditions within the trailer.

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This thesis follows the style of the Journal of Animal Science.

Increasing cross ventilation in cattle trailers has great potential of being a simple, efficacious method of improving animal comfort and decreasing weight loss, shipping fever (bovine respiratory disease) and the transmission of *Escherichia coli* O157:H7, *Salmonella*, and *Mannheimia haemolytica*. The very poor ventilation that presently exists in commercial trailers could cause heat stress, high concentrations of ammonia, and possibly high concentrations of aerosolized pathogens.

Two trials, each consisting of one load of cattle in a control and one in a ventilated trailer, were conducted to evaluate cross-ventilation as a potential technology to improve environmental conditions such as temperature, ammonia and carbon dioxide concentrations within the trailer, and desiccation of manure. Changes in animal health due to increased ventilation will be evaluated through weight loss, complete blood counts, and serum electrolyte concentrations. If the trials are successful in showing that increased ventilation decreases weight loss and post-transport morbidity and mortality, the cattle will be used as a model for other livestock species and future studies.

LITERATURE REVIEW

Weight Loss

Weight loss, also known as shrink, is a significant problem in transported cattle. Increased consolidation of the feedyard and slaughter industries has resulted in longer transport times (Speer et al., 2001), and the majority of cattle in the United States will be transported at least once (Swanson and Morrow-Tesch, 2001). While fasting alone results in the loss of approximately 1.0% of body weight per hour for the first 3 to 4 hours, and weight loss decreases sharply after that point (Brazle and Ishmael, 2004), the addition of transport to fasting causes a significant increase in weight loss (Cole et al., 1988). Many factors can influence weight loss during transport, including mode of transportation, distance transported, transit time, temperature, sex, weight, and method of preconditioning, although inconsistent results imply that the causes of weight loss during transport are complex (Camp et al., 1981). Additionally, Camp et al. (1981) showed significant differences in weight loss between cattle shipped on different dates. While those researchers believed that this was likely due to differences in truck drivers and handling personnel, weather probably had some influence. Location of calves within the trailer, however, was not shown not to be significant (Camp et al., 1981).

Weight loss during transport is due to loss of gut fill, emptying of the bladder, dehydration and loss of tissue. Weight loss due to loss of gut fill occurs through urination and defecation, and increases due to a nonspecific stress response caused by transportation (Phillips et al., 1991). Loss of gut fill and urine occurs first, but during long hauls, tissue shrink will occur (Barnes et al., 1999). Actual tissue loss can account for up to 60% of the total weight loss during transport (Coffey et al., 2001). This additional weight loss was likely due to increased respiratory loss through panting (Coffey et al., 2001) and the drawing of water and nutrients from the cells (Sowinski, 1998). Decrease in blood volume due to dehydration also occurs (Barnes et al., 1999). While highly variable, tissue lost during transportation must be replaced, at cost to the feeder. Gut fill can be replaced quickly, but actual tissue loss can take weeks to be replaced (Barnes et al., 1999, Sowinski, 1998). In a study of 4,685 cattle, shipped in groups with average weights ranging from 230 kg to 339 kg, recovery time varied from 3 to 30 days (Self and Gay, 1972). Furthermore, continuing sources of stress such as illness, new rations, and commingling can increase during this time (Barnes et al., 1999).

It is generally accepted that increased heat stress results in increased weight loss from dehydration. Weight loss may be increased by up to 2 percentage units when poor environmental conditions, such as high temperatures, are present (Coffey et al, 2001). In a thermal heat index developed for dairy cattle, the degree of stress is dependent on the temperature and the relative humidity, with stress increasing as these two measures increase (Pennington and Van Devender, 2004). According to this formula, by decreasing air temperature and relative humidity within a trailer, the temperature-humidity index would be decreased, and the cattle would be subjected to less heat stress. Therefore, the lack of ventilation within commercial cattle trailers likely results in higher temperatures and humidity within the trailers and contributes to heat stress problems.

In addition to the costs of replacing lost tissue, percent weight loss has been linked to morbidity and mortality (Griffin, 1983). Through the use of regression analysis on over 6,000 cattle weighing from 226.8 kg to 317.5 kg, Griffin (1983) determined that there is an increase in morbidity by 25.6% for each 1% increase in percent weight loss over 4.7%. Death loss, while not as drastic, also increases with shrink, with a .24% increase in mortality for each 1% increase in percent weight loss over 5.4%. Finally, cost of gain increases with every 10% increase in morbidity, implying that increases in percent weight loss also directly affects the cost of gain. Finally, weight loss may be more important in the fall, which is when high-risk cattle are typically transported. Therefore, any technique to decrease percent weight loss below 4.7% would greatly benefit the beef industry.

Environmental Conditions

The lack of air circulation near the deck inhibits manure and urine from drying. Wet manure greatly reduces footing within trailers and contributes to increased injury or death during travel (Tarrant and Grandin, 2000), which has led to the recommendation by Tarrant and Grandin that water be withheld for 6 hours or more prior to transportation. However, this practice likely exacerbates weight loss through dehydration. Wet manure and the lack of air circulation may also combine to form a reservoir for pathogens of public health concern, such as *E. coli*, *Salmonella,* and *M. haemolytica,* which are very costly to the American economy.

There is minimal data on air quality and its effects on livestock within livestock trailers during transport, and no published studies regarding efforts to alter the conditions within trailers exist. Most studies regarding transport evaluate the effects of density and duration of transport, or evaluate physiological markers post-transport to determine various health effects. Wikner et al. (2003) evaluated air quality within commercial cattle transport vehicles in both summer and winter in Sweden. They measured temperature, humidity, and concentrations of methane, carbon dioxide, oxygen, and ammonia. However, that study did not accurately replicate the conditions found in commercial cattle trailers in the United States, as the vehicle used in that study could only accommodate 16 cattle, compared with the 80 cattle per trailer common in the U.S. Also, the density of cattle in that experiment was a little less than half of that found in the U.S. Increased number and density of cattle, as well as trailer design, would have a great effect on environmental conditions within the trailer.

A study on mechanically ventilated pig buildings by Wang et al. (2002) found that ventilation is effective in clearing gaseous wastes from buildings, but there were mixed results regarding dust removal. Dust transport behavior in a ventilated space is very complicated due to the number of factors that can influence air flow. However, in an unpublished preliminary trial conducted with a commercial horse trailer, the cross ventilation scoops greatly decreased the amount of time required for smoke to clear within the trailer (Friend, unpublished study).

Pathogen Importance and Transmission

Escherichia coli is responsible for 73,000 cases of human infection annually, with the O157:H7 strain being of special concern. *Escherichia coli* O157:H7 and *Salmonella* together are believed to cost the U.S. economy more than $3.5 billion dollars a year (Branham, 2005). Cattle are considered to be the primary reservoir for this pathogen (Gansheroff and O'Brien, 2000, Natero and Kaper, 1998). The incidence of *E. coli* O157:H7 in cattle is as high as 75% during warm weather (USDA Agricultural Research Service, 2000), with the peak time of infection occurring when cattle are 3 to 18 months of age, which is when cattle are typically sent to feedyards. Transportation is of special concern because cattle are placed in stressful conditions, and exposed to pathogens through contact with other animals.

The terminal rectum is the principle site of colonization of *E. coli* O157:H7 (Naylor et al., 2003, Low et al., 2005). The Naylor et al. study found that concentrations of *E. coli* O157:H7 were at least 10 times higher at the terminal rectum than on any other surface in the gastrointestinal tract. Additionally, fecal samples taken from the gastrointestinal tract proximal to the terminal rectum had significantly less bacteria present than fecal samples that had been excreted. Excreted feces had an uneven distribution of *E. coli*, presumably because only the surface was exposed to the bacterial colonies as it passed through the rectum. In a follow-up study to further determine a more precise location for colonization of *E. coli*, researchers found that more positive results were obtained from sampling at the site 1 cm proximal to the recto-anal junction than at a site 15 cm proximal to the recto-anal junction (Low et al., 2005).

Salmonella is responsible for causing illness in 1.3 million people each year, resulting in 15,600 hospitalizations and 550 deaths. It is the most frequently reported food-borne illness in the United States. The exact prevalence of *Salmonella* in cattle is difficult to determine; one study of prevalence at slaughter detected *Salmonella* in 6.8% of the fecal samples tested (Fegan et al., 2004), while another study found 1.4% of its samples to be positive for *Salmonella* (USDA Center for Epidemiology and Animal Health, 2001a). A test of U.S. feedyards found that 22.3% of pens had one or more positive samples when tested twice a year (USDA Center for Epidemiology and Animal Health, 2001b). A study of dairy cows, however, found that greater than 90% of herds tested had at least one positive fecal sample at some time during the experimental period (Fossler et al., 2004). There is a wide range of estimates for the incidence rate of *Salmonella* in cow-calf operations depending on geographic region. One study found at least one positive sample for *Salmonella*, from 2.7% of all operations in the north central region of the United States, to 21.4% of all operations in the south central region of the United States (USDA Center for Epidemiology and Animal Health, 2001b). Determining the costs of *Salmonella* is difficult, since many cases of human illness are not reported. The USDA estimates that 95% of salmonellosis in humans are foodborne and costs over $500 million due to medical care and lost productivity (Frenzen and Riggs, 1999). In a 1990 study on the effects of marketing stress on fecal excretion of *Salmonella* spp in feeder calves, Corrier et al. (1990) followed a total of 205 feeder calves from farm to market to feedyard. The study included a 24-hour transport. Corrier et al. found that fecal excretion of *Salmonella* did indeed increase as feeder calves were processed from the farm to the feedyard. Several other recent studies have utilized fecal sampling to test for *Salmonella*. In Fossler et al.'s (2004) study, samples were collected from live dairy cattle through rectal retrieval, with a new glove being used for each animal. Fossler et al. also evaluated *Salmonella* prevalence through environmental and milk sampling, although those techniques are not applicable to this study. Nielson et al. (2004) also evaluated fecal samples obtained rectally from live dairy cattle, while also evaluating blood and milk samples. Fegan et al. (2004) used fecal sampling to detect *Salmonella* prevalence in beef cattle at slaughter, and found that the prevalence suggested through this manner of sampling matched the levels found in similar studies using other sampling methods. However, these samples were collected post-mortem by cutting the intestine and removing fecal matter from the first 15 to 30 cm from the anus. There is no reason to suspect that obtaining samples from the same site in live cattle would produce different results.

Shipping fever, caused primarily by *M. haemolytica,* is estimated to cost the beef industry over $1 billion in losses annually (USDA Agricultural Research Service, 2003). Losses due to morbidity associated with bovine pneumonic pasteurellosis (BPP) in cattle in the United States are estimated to be $800 million annually (Weekley et al., 1998). Furthermore, due to increased mortality, reduced feed efficiency, treatment costs, and reduced product quality, the bacteria that cause pasteurellosis continue to be the major cause of loss (USDA Economic Research Service, 2002). *M. haemolytica,* the most common bacteria isolated from shipping fever in beef cattle, is opportunistic, and infection with viruses such as IBR, PI_3, BRSV, or BVD increases the likelihood of infection with *M. haemolytica*. Furthermore, when cattle are exposed to stress, *M. haemolytica* can explosively proliferate (Briggs et al., 1998). It seems likely that decreasing heat stress by increasing ventilation will decrease post-transport *M. haemolytica* infection and also increase immune function and the efficacy of any vaccinations given prior to transport. In addition, the high concentration of ammonia common in livestock trailers compromises the integrity of lung tissue predisposing cattle to respiratory disease. Increased cross ventilation should help clear the buildup of ammonia within the trailer, therefore decreasing potential lung damage. Since *M. haemolytica* is spread via inhalation of aerosol droplets and is easily spread when livestock are crowded or closely confined, increasing the air flow under the bodies of the cattle, the zone where most cattle maintain their heads during long distance transport, should greatly decrease transmission.

Objectives

The major objective of this project is to determine if increasing cross-ventilation in commercial cattle trailers improves the wellbeing of the cattle, through reduced weight loss and reduced post-transport morbidity and mortality, and therefore decreases the costs of transportation to the cattle industry. This project took a multi-disciplinary approach to evaluate both environmental conditions within the trailers and physiological markers of stress within the cattle. If positive results are found, future studies can concentrate on determining the optimal design and orientation of the ventilation scoops.

MATERIALS AND METHODS

Trailers

Two punch-panel Wilson cattle trailers (Sioux City, IA), a 15.54 m and a 16.15 m long model, were used. The trailers were divided into 5 compartments. The compartments in each trailer were designated one to five, with one being the foremost compartment, two being the lower center compartment, three being the upper center compartment, four being the lower rear compartment, and five being the upper rear compartment, or "doghouse." In the 15.54 m trailer (Fig. 1), the dimensions (length X width X height) of Compartment 1 were 2.81 m x 2.55 m x 1.88 m, Compartment 2 were 8.94 m x 2.55 m x 1.93 m, Compartment 3 were 8.94 m x 2.55 m x 1.78 m, Compartment 4 were 3.1 m x 2.55 m x 1.57 m, and Compartment 5 were 3.1 m x 1.35 m x 1.26 m. This trailer had a total floor area of 65.65 square meters. In this model, Compartments 2 and 3 could be divided into two sections by gates.

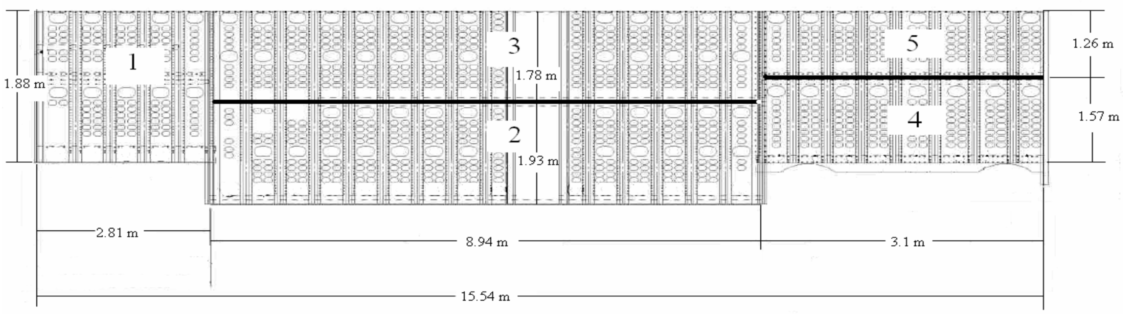

Figure 1. Schematic of 15.54 m Wilson cattle trailer, used as the control trailer. Width of trailer is 2.55 m and uniform throughout, except in Compartment 5. Compartment 5 had a width of 1.35 m, and was shifted to the passenger's side of the trailer due to an internal ramp.

In the 16.15 m trailer (Fig. 2), the dimensions (length X width X height) of Compartment 1 were 3.1 m x 2.55 m x 1.93 m, Compartment 2 were 9.55 m x 2.55 m x 1.83 m, Compartment 3 were 9.55 m x 2.55 m x 1.75 m, Compartment 4 were 3.05 m x 2.55 m x 1.57 m, and Compartment 5 were 3.04 m x 1.42 m x 1.3 m. This trailer had a floor area of 68.78 square meters. Compartments 2 and 3 could be divided into three sections by gates.

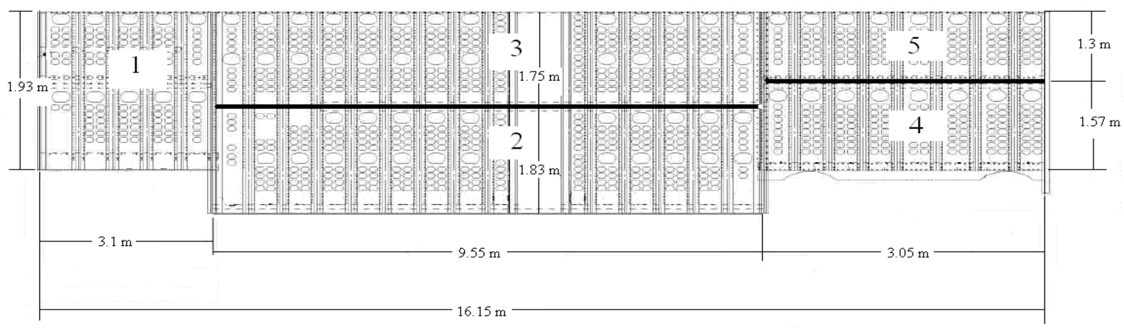

Figure 2. Schematic of 16.15 m Wilson cattle trailer, used as the ventilated trailer. Width of trailer was 2.54 m and uniform throughout, except in Compartment 5. Compartment 5 had a width of 1.3 m, and was shifted to the passenger's side of the trailer due to an internal ramp.

Treatment

The 16.15 m model served as the ventilated trailer. Aluminum ventilation scoops were attached to the rear bottom two punch holes of every other punch panel in the trailer, except when built-in features prevented such spacing (Note irregular spacing in Fig. 3). In those cases, the scoops for that panel were moved either forward one panel or back one panel, depending on other features of the trailer. Also, scoops were not placed on Compartment 5, as the truck drivers did not plan on utilizing that space. Intake scoops were oriented so that the mouth of the scoop was facing forward, while the mouth of the exhaust scoops was facing the rear of the trailer. Based on weather forecasts made two days prior to the actual shipments, the intake scoops were placed on the passenger's side of the trailer, and the exhaust scoops were placed on the driver's side. The placement was intended to have the forecasted north wind strike the trailer on the side with the intake scoops to help increase the efficiency of the limited number of scoops. The direction of travel for approximately the first third of the trip was west, the middle third was west-northwest, with the last third being northwest.

The scoops were formed out of 2.5 mm thick aluminum. The base of the scoops was 18 cm x 23 cm, and the top of the scoops was 14 cm x 14 cm, with a flared edge on the front of the scoops that extended 2 cm at a 45 degree angle (Fig. 4). The scoops protruded from the trailers 7 cm, with the flared edge protruding 8.5 cm. Each scoop was attached to the trailer by 2 non-metric u-bolts, ¼ inch x 4 ½ inches, which were secured using lock nuts (Fig. 4 & 5). A 12.5 cm x 3.9 cm x 0.4 cm steel plate was inserted between the u-bolt and the trailer to better distribute the forces applied by the scoops (Fig. 5). The edges of the plate were beveled to prevent any injury to the cattle, and four locations where the u-bolts rested on the plates were beveled to keep the plate from shifting under the u-bolts. Three layers of duct tape were applied to each edge of the scoop that came in contact with the trailer to prevent scuffing or other damage to the trailer.

Figure 3. Scoop placement on the ventilated trailer. Scoops were placed on every other panel except when built-in features prevented such spacing. Note scoops are in exhaust orientation.

Figure 4. Ventilation scoops secured to the trailer.

Figure 5. Steel plates used to distribute forces applied by scoops.

Subjects

The cattle were mixed breed spring calves, approximately one-quarter Brahman crossed with angus and charolais, which had been weaned several months prior to being transported and had been kept together in the same pasture since weaning. The cattle were rounded up from pasture and brought up to sorting pens the morning of shipment. Those transported during Trial 2 were handled on the morning of both trials, which were separated by 2 days, as they had to be sorted from those being shipped during Trial 1. Once in the sorting pens, the cattle were sorted using horse-mounted riders and separated into groups of appropriate size to be loaded into each individual compartment of each trailer. The cattle were driven up the loading chute and into the trailers by handlers on foot with electric cattle prods and other handling tools, with the ventilated trailer being loaded first. Trailers were then driven to scales and weighed. Each of the two trailers involved in the project was loaded with 80 calves, resulting in slightly different densities. The control trailer had a density of 0.821 square meters per calf, while the ventilated trailer had a density of 0.860 square meters per calf. During Trial 1, the average weight per calf was 278.39 kg for the control trailer and 277.99 kg for the ventilated trailer. During Trial 2, the average weight per calf was 280.51 kg for the control trailer and 271.76 kg for the ventilated trailer. Therefore, for Trial 1, the average weight density in the loaded trailer pre-transport was 339.24 kilograms per square meter of floor space for the control trailer versus 323.34 kilograms per square meter for the ventilated trailer. For Trial 2, the average weight density was 341.82 kg per square meter for the control trailer and 316.09 kilograms per square meter for the ventilated trailer.

The shipment originated near Gin City, Arkansas. The cattle were transported to either Palo Duro Feeders in Canyon, TX (Trial 1, 12 hour transport) or to Texas Beef Feeders in Dumas, TX (Trial 2, 11 hour transport).

Temperature

Temperature was measured using HOBO temperature data loggers (Model H08-007-02, Onset Computer, Bourne, MA). Four data loggers were placed in each trailer, attached to the gates mounted on the walls, with two loggers in Compartment 2 and two in Compartment 3. By mounting the HOBOs on the center of the gates, which the investigators believed were going to be closed during transport, conditions in the center of the compartments could be measured. However, as the cattle were loaded for Trial 1, the investigators were told that only the gate in Compartment 3 of the control trailer would be closed. At that point, it was too late to reposition the HOBOs. Because the ventilated trailer had two gates in the center compartments and each gate was mounted on opposite sides of the compartment, the HOBOs ended up on opposite sides of the trailer which allowed measurement of temperatures from the intake and exhaust sides of the trailer (Fig. 6). In Compartment 2, the intake HOBO was placed 4.01 m back from the front of the compartment, and the exhaust HOBO was placed 7.34 m back from the front of the compartment, both with a height of 0.33 m and 0.063 m into the compartment. In Compartment 3, the intake HOBO was placed 4.76 m back from the front of the compartment, at a height of 0.33 m and 0.063 m into the compartment, and the exhaust HOBO was placed 4.24 m back from the front of the compartment, at a height of 0.33 m and 0.063 m into the compartment. In the control trailer, two HOBOs were placed on the gates in Compartments 2 and 3, and two were placed on the back of the compartments, on the dividing gate between the center compartments and Compartments 4 and 5 (Fig. 7). In Compartment 2, the HOBO on the gate was placed 5.18 m back from the front of the compartment, with a height of 0.34 m and 0.063 cm into the compartment, and the HOBO at the back of the compartment was placed at a height of 1.2 m due to structural components, and 1.29 m into the compartment when measured from the passenger's side of the trailer. In Compartment 3, the HOBO on the gate was placed 3.89 m back from the front of the compartment, with a height of 0.34 m and 1.29 m into the compartment, and the HOBO at the back of the compartment was placed at a height of 1.2 m, 1.29 m into the compartment. The HOBOs were programmed to take measurements at 5-minute intervals throughout the duration of the project. HOBOs were visually checked between trials to assure that they had not been damaged or displaced. Upon completion of both trials, data was downloaded from the HOBOs using BoxCar Pro software and was then exported into Microsoft Excel.

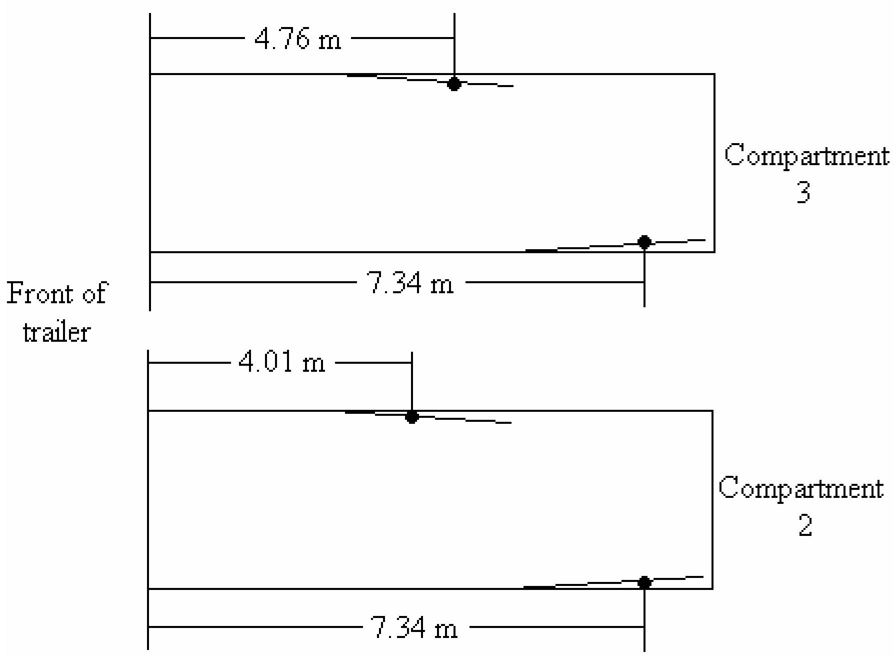

Figure 6. HOBO placement in the ventilated trailer. Black dots represent HOBOs.

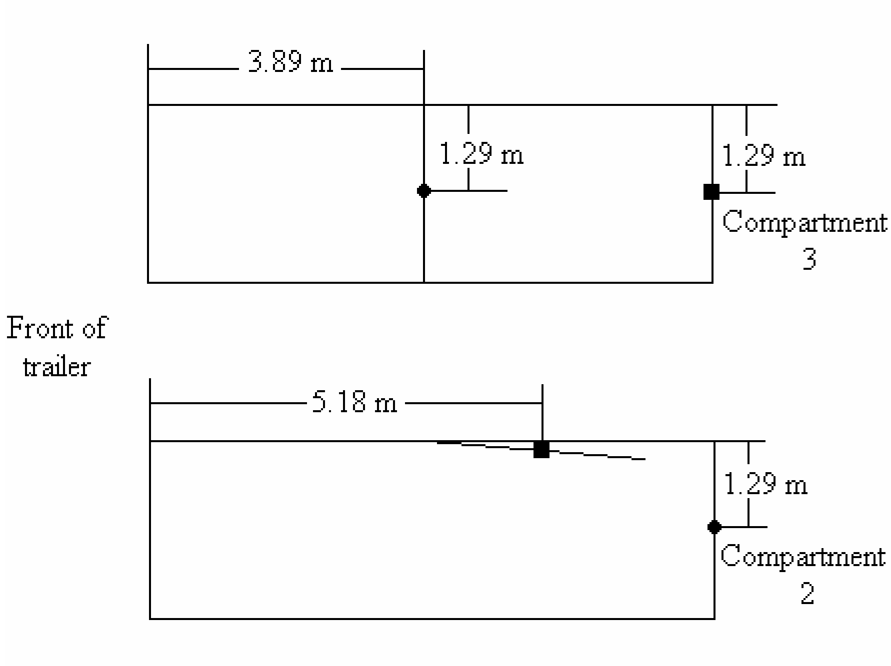

Figure 7. HOBO placement in the control trailer. The gate that divided Compartment 3 was closed, while the gate in Compartment 2 remained opened. Black dots represent HOBOs. HOBOs that eventually malfunctioned are marked with a square.

Ammonia and Carbon Dioxide

Ammonia and carbon dioxide concentrations were measured using Gastec passive dosi-tubes (Gastec Corporation, Japan). Ammonia was measured using both low-range, with a range of 0 to 10 parts per million (ppm), and high-range tubes, with a range of 2.5 to 1000 ppm. The carbon dioxide dosi-tubes had a range of 0.02 to 12 percent-hours. Dosi-tubes were placed in ¾ inch PVC pipe, which was cut to the length of the dosi-tubes, with one end angled to allow more air flow. The PVC pipe was then stuffed with polyester fibers for cushioning, and duct tape was used to secure the dosi-tubes within the PVC pipe. The PVC pipe holders were secured to the gates and compartment dividers within the trailers using duct tape (Fig. 8). In the ventilated trailer, there were two gates in both Compartments 2 and 3, and dosi-tubes were positioned on each gate so as to receive maximum airflow from both sides of the gate, with the expectation that the gates would be closed during transport. As discussed earlier, however, only the gate in Compartment 3 of the control trailer was closed during transport, so the readings from the dosi-tubes on these gates were not comparable. In Compartment 2 of the ventilated trailer, the ammonia and carbon dioxide tubes were placed in two locations on each gate. On the front gate, which was open, the ammonia and carbon dioxide tubes were placed both 4.39 m back from the front of the trailer and 4.79 m back, and the ammonia and carbon dioxide tubes on the rear gate, which was also open, were placed 7.14 m back and 7.64 m back (Fig. 9). In Compartment 3, the ammonia tubes were also placed in two locations on each gate. On the front gate, the ammonia tubes were placed 4.34 m back and 4.76 m back from the front of the trailer, and on the rear gate they were placed 7.13 m back and 7.64 m back. All dosi-tubes on gates of the ventilated trailer were placed 0.063 m into the compartment. The ammonia tubes on the front and rear of the center compartments were placed 1.22 m into the compartment, when measured from the passenger's side of the trailer. In the control trailer, there was only one gate per center compartment. Additionally, this gate was more solid than those in the vent trailers. Dosi-tubes were positioned at the punch holes on the gate to ensure maximum air flow. In Compartment 2, the ammonia and carbon dioxide tubes were placed on the gate, 4.89 m back, and 0.063 m into the compartment (Fig. 10). In Compartment 3, the ammonia and carbon dioxide tubes on the gate were placed 3.89 m back from the front of the trailer, and 1.29 m into the compartment. The ammonia and carbon dioxide tubes at the back of Compartment 2 were placed 1.29 m into the compartment when measured from the passenger's side of the trailer and the ammonia and carbon dioxide tubes at the front of the Compartment 3 were placed 0.64 m into the compartment when measured from the passenger's side of the trailer. With the exception of the Compartment 3 gate in the control trailer, all gates were left open during transport. The dosi-tubes were opened immediately prior to loading the trailers. During Trial 1, tubes were opened by the researchers, and during Trial 2, the truck drivers were instructed to open the tubes, since the researchers had to remain behind at the feedyards to obtain samples. The dosi-tubes were read as soon as possible after the trailers were unloaded at the feedyards. Tube reading time was recorded for each tube to correct for the time differences in recording the ammonia or carbon dioxide concentrations. Ammonia and carbon dioxide concentrations were determined based on color change in the detecting agent within the dosi-tubes. The dosi-tube reading, which was shown in a percent-hour scale on the tube, was divided by the actual sampling time in hours to give the average concentration. New dosi-tubes were inserted into the PVC holders in between trials.

Figure 8. Dosi-tubes in PVC holders, secured to the center of the front divider of a compartment using duct tape.

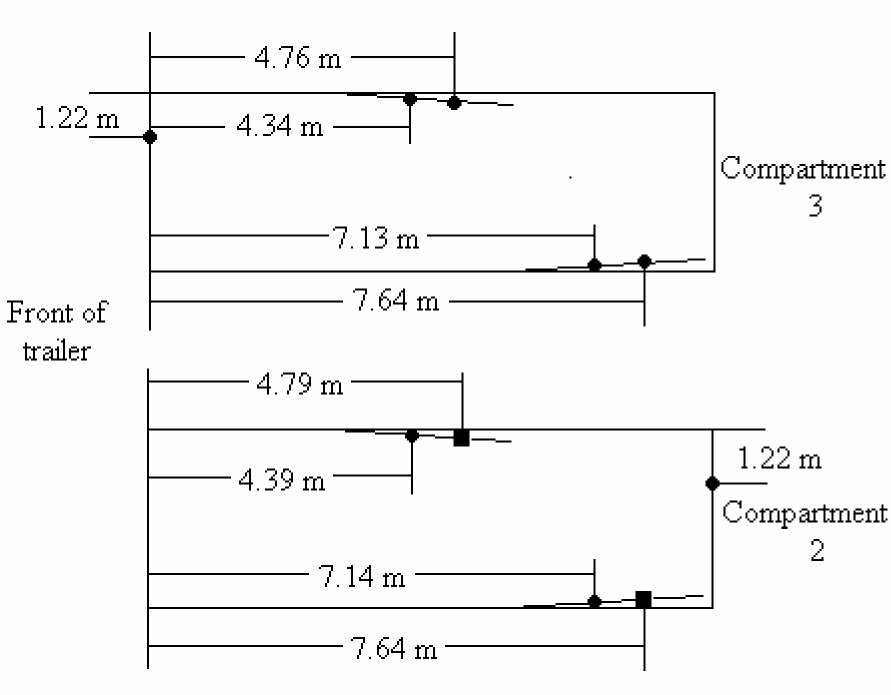

Figure 9. Dosi-tube placement in the ventilated trailer. Black dots represent ammonia tubes; squares indicate placement of low-range ammonia and carbon dioxide tubes.

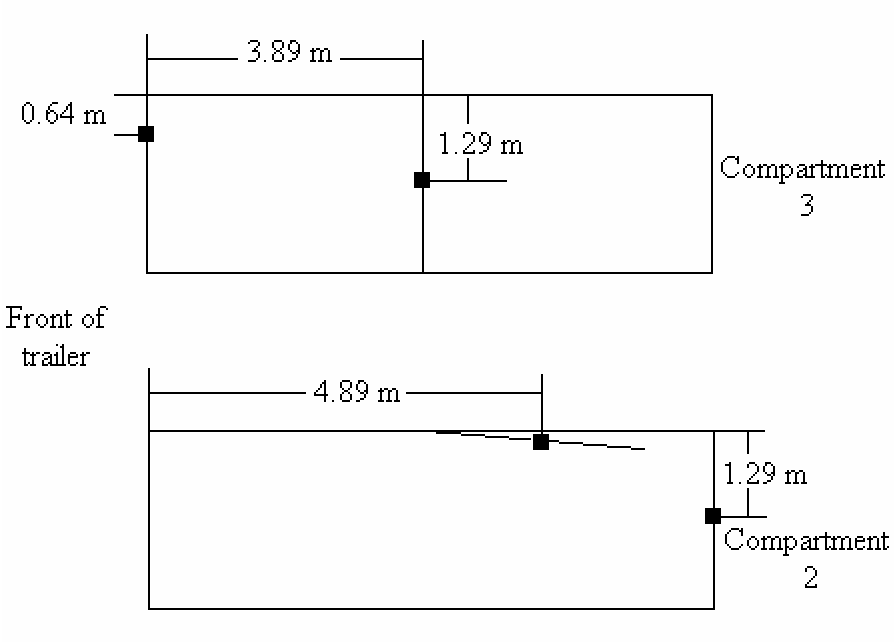

Figure 10. Dosi-tube placement in the control trailer. Black squares indicate placement of both ammonia and carbon dioxide tubes.

Liquidity of Manure

After the cattle were offloaded from the trailers, fecal matter was obtained from Compartments 2 and 3 of each trailer. Fecal matter in each compartment was mixed using a clean shovel in order to reduce the influence of a single urination or defecation on a single sample. Samples were obtained from 4 separate areas within each compartment, which were matched between compartments and trailers. The trailers were shoveled out after Trial 1 to decrease contamination of samples from the next load. Twelve samples obtained from Trial 1, and 16 samples obtained from Trial 2, were later evaluated for percent dry matter to determine the liquidity of the manure.

After completion of both trials, fecal samples were evaluated for dry matter content by placing the samples into pre-weighed drying pans and baking them for 24 hours at 100 degrees Celsius (°C). Selected samples were then placed into a sealed container to cool, were reweighed, and returned to the oven. Those samples were removed, re-cooled after an additional two hours of drying, and reweighed again. If there was a difference between the dried weights, the samples were returned to the oven for another 24 hours, because a difference indicated that water was still evaporating from the samples. After the second long drying period, the samples were rechecked for weight differences. This continued until there were no differences between the weights for the 2 hour periods. To obtain percentage dry matter, the dried weight was divided by the initial weight, and multiplied by 100 to get a percentage.

Subject Handling and Sampling

At destination, the cattle were unloaded and weighed by compartment. The four cattle kept in the Compartment 5, termed the “doghouse,” were marked and not included in the blood or swab samples because no ventilation scoops were installed on that compartment. However, these cattle had to be included in the weight loss data, since their weight prior to transport was not known since the cattle were weighed by the truckload prior to transport due to limited facilities. The investigators were initially informed that cattle would not be loaded into that compartment, so the doghouse scoops were installed elsewhere on the trailer to maximize ventilation. The cattle were then placed in holding pens by trailer load pending processing the next morning, approximately 10 hours after arrival for Trial 1 and 8.5 hours after arrival for Trial 2. The cattle had access to hay and water while in the holding pens. Weight loss that occurred during transportation was determined by dividing the arrival weight of the cattle by the weight immediately after loading.

During standard feedyard processing the morning after transportation, the following samples were obtained. Blood samples for complete blood counts and serum electrolytes and basic chemistry were drawn from the jugular vein, centrifuged, and placed on ice. Incidence of *M. haemolytica* was determined from nasal swabs. In a previous study (Frank et al., 1996), reporting on the incidence of *M. haemolytica* and respiratory tract disease, samples were obtained through aspiration of nasal secretions and then supplemented with 15% glycerol. However, due to limitations in the ability to handle the cattle in the present experiment, nasal flushes did not seem practical. Therefore, nasal swabs were obtained from each nostril, using the same cotton-tipped swab for both nostrils. A new swab was used for each calf. The swabs were inserted into each nostril and dragged along the mucus membranes inside the nostril. The swabs were then placed into sealed containers. After processing was complete, and all other samples had been obtained, the nasal swabs were plated on blood agar, and the plates were stored in a cooler with ice until they could be returned to College Station, TX, for incubation. To sample for *E. coli*, rectal swabs were taken at the recto-anal juncture, and then placed in sealed containers and placed on ice. Rectal sampling was determined to be most efficacious in this study, so fecal grab samples were also obtained, in a manner similar to Fossler et al. (2004), and placed on ice.

Serum blood samples were evaluated for complete blood count and electrolytes and basic chemistry at the Grimes St. Joseph Hospital laboratory in Navasota, TX, by laboratory technicians. The nasal swabs, fecal swabs, and fecal grab samples were evaluated by Dr. Robin Anderson's laboratory at the USDA Agricultural Research Service in College Station, TX. The nasal swabs, plated at the sampling site, were incubated for 24 hours and evaluated for beta-hemolysis. When colonies with beta-hemolysis were observed, they were tested for oxidase activity. If the colonies were positive for oxidase activity, they were Gram stained. Colonies of *M. haemolytica* would be both oxidase positive and Gram negative. The presence of *E. coli* was determined using immunomagnetic separation. *Salmonella* samples were treated with Rappaport-Vassiadias broth and then plated on XLT-4 agar to select for the *Salmonella*. Any positive samples showing either *E. coli* or *Salmonella* were quantitatively cultured using XLT-4 agar or an immunomagnetic separation of serial 10-fold dilutions.

Thirty-day health data was collected by the feedyards and was evaluated for differences between the control and ventilated groups. Differences in antibiotic administration levels, incidence of illness, and mortality were noted.

Statistics

Treatment effects for liquidity of manure on the trailer floor, components of the complete blood counts, serum electrolytes, and basic chemistries were determined using a univariate model within the general linear model (SPSS 12.0.1, SPSS Inc., Chicago, IL). The factors included in the model were treatment, trial, and trial by treatment interactions. An independent-samples T test, using either treatment or trip and treatment as the grouping variable, was then used to further determine if there were significant differences between means of treatments ($P < 0.05$).

The temperature, ammonia, carbon dioxide, liquidity of manure, and weight loss data could not be analyzed statistically due to low sample size, so only descriptive statistics are given for those data.

RESULTS

Trial 1

General Weather Conditions. Weather conditions during the course of the shipment were reconstructed using climatic data from weather stations along the route. In Texarkana, AR, which was the National Climatic Data Center station closest to Gin City, AR, sky cover was broken at the start of the trial. The relative humidity was 76% at 09:43, with winds from the south-southwest at 17 miles per hour (mph). In Wichita Falls, TX, through which the trucks passed at approximately 14:00, or 4.5 hours into the trial, skies were clear and humidity was at 22%. Winds were blowing at 14 mph, from the west-southwest. When the trucks passed through Childress, TX, approximately 18:00, or 8.5 hours into the trial, taking into consideration the rest stop between Dallas and Childress, skies were clear and humidity was at 20%. Between Wichita Falls and Childress, the wind shifted to a northerly wind. In Childress, the wind was blowing at 9 mph when the trailers passed through. Finally, in Amarillo, TX, the nearest National Climatic Data Center station positioned near the route to both feedyards, at approximately 20:00, or 10.5 hours into the trial, there was scattered cloud cover, the relative humidity was 52%, and winds were 12 mph from the east-northeast. These conditions persisted until the end of the trial.

Temperature in the Ventilated Trailer. Measurements from the two HOBOs on the passenger's side of the trailer were averaged to provide an overall measure for the intake temperatures, while measurements from the two HOBOs on the driver's side of the trailer were averaged to provide an overall measure for the exhaust temperatures.

During Trial 1, the temperature on the intake side of the ventilated trailer was generally cooler than the exhaust side for both Compartments 2 and 3 (Fig. 11 and Fig. 12). This was particularly evident in the temperatures for Compartment 3. The spike in the intake temperature between 14:55 and 15:55 is due to a rest stop so that the drivers could get a meal. The trailers were parked with the intake side facing the sun, and therefore that side registered a large temperature spike. When this spike is removed from the calculations, the average difference between the intake and exhaust sides for Compartment 2 was 0.083 °C, and for Compartment 3 was 0.822 °C, with the intake being cooler.

Figure 11. Intake versus exhaust temperature for Compartment 2 of the ventilated trailer for Trial 1. Vertical lines indicate the rest stop.

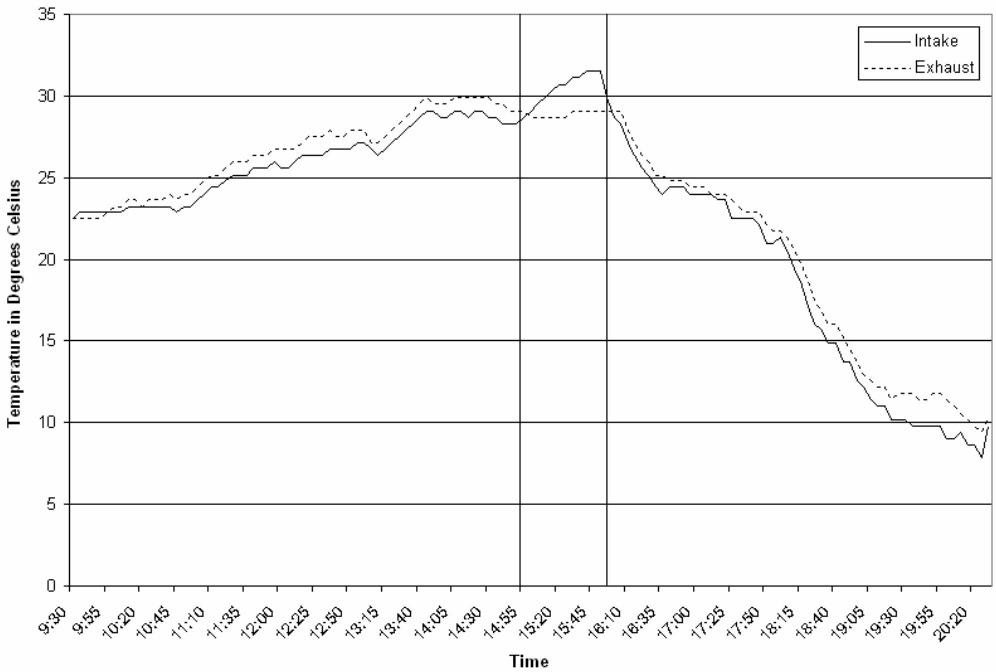

Figure 12. Intake versus exhaust temperature for Compartment 3 of the ventilated trailer for Trial 1. Vertical lines indicate the rest stop.

Temperature in the Control Trailer. One of the HOBOs malfunctioned, and did not provide any useable data for the front of Compartment 2 of the control trailer. Due to this malfunction, a comparison between air flow across the middle of the trailer and the back of the center compartments, where the HOBOs were located, could not be made. Additionally, the positioning of the HOBOs in this trailer prevented a comparison between sides of the trailer.

Temperature Comparison Between Trailers. Temperatures for this comparison were determined by averaging all four HOBOs in the ventilated trailer and all three in the control trailer, as this was the best available method given the differences in HOBO location.

During Trial 1, there was no data for the front HOBO in Compartment 2 of the control trailer, but the rear HOBOs in Compartment 2, located on the rear gate in the ventilated trailer or in between Compartments 2 and 4 in the control trailer, recorded an average temperature difference between the ventilated trailer and the control trailer of 0.294 °C, with the control trailer being cooler (Fig. 13). The rear of Compartment 2 in the ventilated trailer was cooler than the rear of Compartment 2 of the control trailer 33% of the time. That area was the same temperature in both trailers 13% of the time. Because the gate in Compartment 3 of the control trailer was closed, the data from the HOBOS in the front location could not be accurately compared due to their different locations. The difference for the rear HOBOs in Compartment 3, located on the rear gate in the ventilated trailer or in between Compartments 3 and 5 in the control trailer, was 1.453 °C, with the ventilated trailer being cooler. In general, Compartment 2 showed higher temperatures than Compartment 3. The ventilated trailer was cooler 86% of the time, with both trailers being the same temperature 14% of the time (Fig. 14).

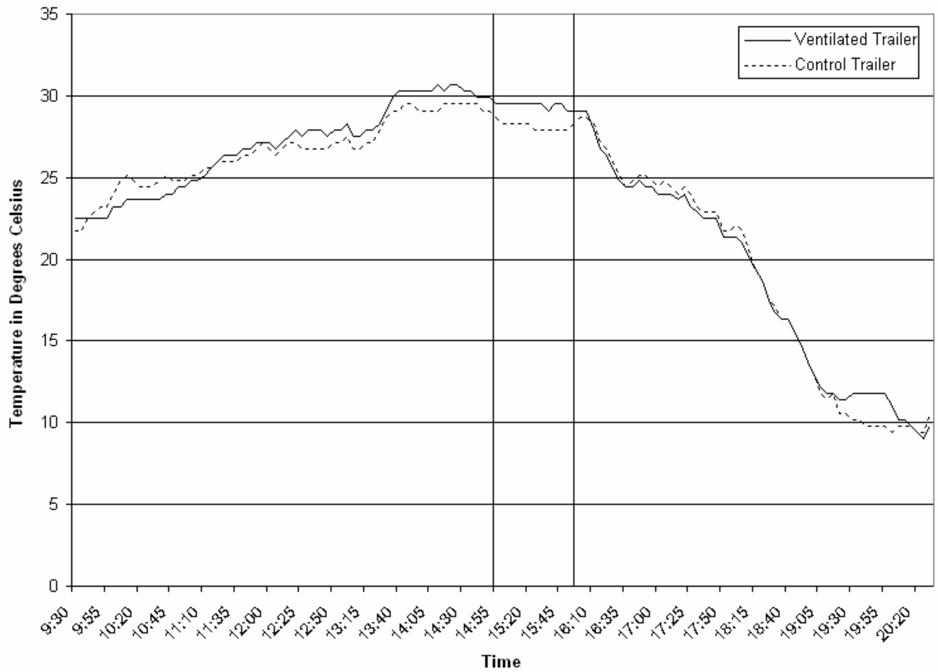

Figure 13. Temperature recorded by the rear HOBOs in Compartment 2 of the ventilated and control trailers for Trial 1. Vertical lines indicate the rest stop.

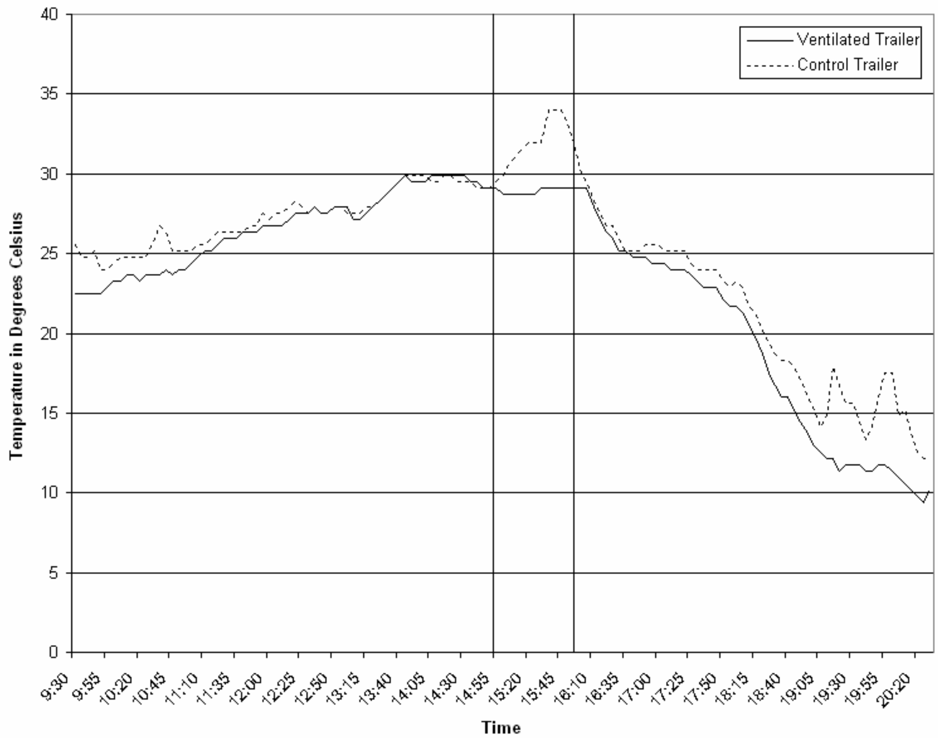

Figure 14. Temperature recorded by the rear HOBOs in Compartment 3 of the ventilated and control trailers for Trial 1. Vertical lines indicate the rest stop.

During Trial 1, excluding the rise in temperatures due to the rest stop from 14:55 to 15:55, the overall average temperature from all four HOBOs in the ventilated trailer was 22.69 °C, while the overall average temperature from the three working HOBOs in the control trailer was 23.33 °C (Fig. 15).

Figure 15. Temperature in degrees Celsius for Trial 1. Temperature was determined by averaging the measurements from all working HOBOs in each trailer. Trailers were parked in the sun from 14:55 to 15:55 during a rest stop, which is indicated by the vertical lines.

Ammonia and Carbon Dioxide. Due to the structural differences of the gates within the trailers, as well as differences in utilization of the gates resulting in differences in airflow, only 2 dosi-tube placements in each trailer were judged to be comparable. These dosi-tubes were placed in the center of the gate dividing Compartment 1 and Compartment 3, and in the center of the gate dividing Compartment 2 and Compartment 4 on the lower levels of each trailer. The low-range ammonia dosi-tubes did not yield any usable data, as the detecting agent in these tubes was completely saturated. However, the high-range ammonia tubes produced usable results. In Trial 1, for the front location, the ammonia concentration in parts per million (ppm) per hour was 4.875 ppm/h for the control trailer and 3.649 ppm/h for the ventilated trailer. For the rear location, the ammonia concentration was 1.778 ppm/h for the control trailer and 0.946 ppm/h for the ventilated trailer. The carbon dioxide tubes were placed primarily on the gates, and several were mistakenly not opened during both trials, and therefore did not yield useable data. During Trial 1, in the control trailer, the rear location had a carbon dioxide concentration of 0.094% and the Compartment 2 gate had a concentration of 0.079%. The tubes in the front location and on the Compartment 3 gate were not opened. In the ventilated trailer, the Compartment 2 front gate had a concentration of 0.076% and the Compartment 2 rear gate had a concentration of 0.071%.

Liquidity of Manure. The average dry matter of the fecal samples obtained from the trailers after Trial 1 was 23.15 percent for the control trailer and 18.87 percent for the ventilated trailer.

Weight Loss. The percent weight loss for Trial 1 was 5.8 percent for the control trailer, with an initial weight of 22,271.39 kg and a final weight of 20,987.72 kg, and 4.3 percent for the ventilated trailer, with an initial weight of 22,239.63 kg and a final weight of 21.278.02 kg.

Physiological Measures. Blood samples were evaluated as indicated (Tables 1 and 2). White blood cell counts were unable to be determined due to degradation of the samples. However, due to the variation in weather during the trials, and the potential affects wind direction would have on the results, the physiological measures for each trial were evaluated independently. There was a significant difference between hemoglobin (HGB) concentrations in Trial 1 (P = 0.045), as well as a significant difference between sodium concentrations (P = 0.049).

Table 1. Means for each ventilation treatment during Trial 1 for items determined by complete blood counts (± SD)

	Ventilation Treatments	
Items	Ventilated	Control
Red blood cells (10^5 cells/cmm)	6.52 ± 0.73	6.22 ± 0.71
Hemoglobin (mmol/L)[a]	11.95 ± 1.28	11.12 ± 1.13
Hematocrit (%)	29.34 ± 3.82	27.95 ± 4.00
Mean cell volume (fL)	44.92 ± 1.79	45.08 ± 1.79
Mean cell hemoglobin	18.36 ± 1.24	18.02 ± 0.95
Mean cell hemoglobin concentration (%)	40.95 ± 3.21	40.04 ± 2.92
Red blood cell distribution width	40.76 ± 5.05	39.33 ± 5.39
Platelets (10^4 cells/cmm)	320.42 ± 130	318.00 ± 167
Mean platelet volume (fL)	6.48 ± 0.96	6.88 ± 0.85
Procalcitonin (ng/ml)	0.206 ± 0.09	0.219 ± 0.11
Platelet cell distribution width	16.24 ± 1.03	16.54 ± 1.04

[a] Significant difference, P = 0.045.

Table 2. Means for each ventilation treatment during Trial 1 for items determined by serum electrolyte and basic chemistry panels (± SD)

	Ventilation Treatments	
Items	Ventilated	Control
Sodium (mmol/L)[a]	145.05 ± 3.04	147.05 ± 3.27
Potassium (mmol/L)	4.80 ± 0.34	4.9 ± 0.56
Chloride (mmol/L)	102.10 ± 3.05	102.20 ± 2.57
Carbon dioxide (mmol/L)	30.24 ± 2.10	29.85 ± 2.62
Blood urea nitrogen (mg/dl)	16.81 ± 2.56	17.27 ± 3.19
Creatinine (mg/dl)	1.49 ± 0.18	1.52 ± 0.27
Glucose (mg/dl)	87.19 ± 15.1	82.35 ± 13.9
Calcium (mg/dl)	9.37 ± 0.32	9.42 ± 0.54

[a] Significant difference, P = 0.049.

Microbiology Measures. None of the samples from Trial 1 tested positive for *Salmonella*. There were no positives for the *M. haemolytica* nasal swabs. One sample from the control trailer and 3 from the ventilated trailer tested positive for *E. coli* O157:H7.

Thirty Day Health Data. Post-transport health was evaluated using 30-day health data from the feedyards. Only one of the calves from the experimental group was treated during this period. However, this animal was treated for an unrelated, pre-existing eye injury.

Trial 2

General Weather Conditions. Weather conditions were again reconstructed using climatic data from National Climatic Data Centers. During Trial 2, skies in Texarkana, AR were overcast, with a relative humidity of 74%. Winds were blowing at 10 mph from the southwest. In Wichita Falls, TX, sky cover was scattered at approximately 15:00, or 4.5 hours into the trial. The relative humidity was 42%, and winds were blowing at 17 mph from the south. At approximately 19:00, or 8.5 hours into the trial, skies were clear in Childress, TX, with a relative humidity of 27%. Wind speed had increased to 20 mph, blowing from the south. Finally, in Amarillo, TX, at approximately 21:00, or 10.5 hours into the trial, there were only a few clouds, and the relative humidity was 37%. Winds were blowing from the south at 8 mph. These conditions persisted until the end of the trial. During this trial, winds were consistently from the south or southwest, which worked against the scoops by blowing in the exhaust scoops.

Temperature in the Ventilated Trailer. Intake and exhaust temperatures were again obtained by averaging the measurements from the two HOBOs on each side of the trailer, with intake temperatures being obtained from the passenger's side of the trailer, and exhaust temperatures being obtained from the driver's side of the trailer.

Temperatures in Compartments 2 and 3 during Trial 2 were similar for the first half of the trial, but then diverged as exhaust temperatures in Compartment 2 became warmer than intake temperatures (Fig. 16 and Fig. 17). In Compartment 3, intake temperatures generally remained cooler than exhaust temperatures. Again, there was a temperature spike due to a rest stop where the trailers were parked in the sun from 14:15 to 15:05. With this spike removed, the average difference between the intake and exhaust sides for Compartment 2 was 0.198 °C, and 0.500 °C for Compartment 3, with the intake side being cooler. The overall average temperature, throughout the entire trial, was 24.14 °C.

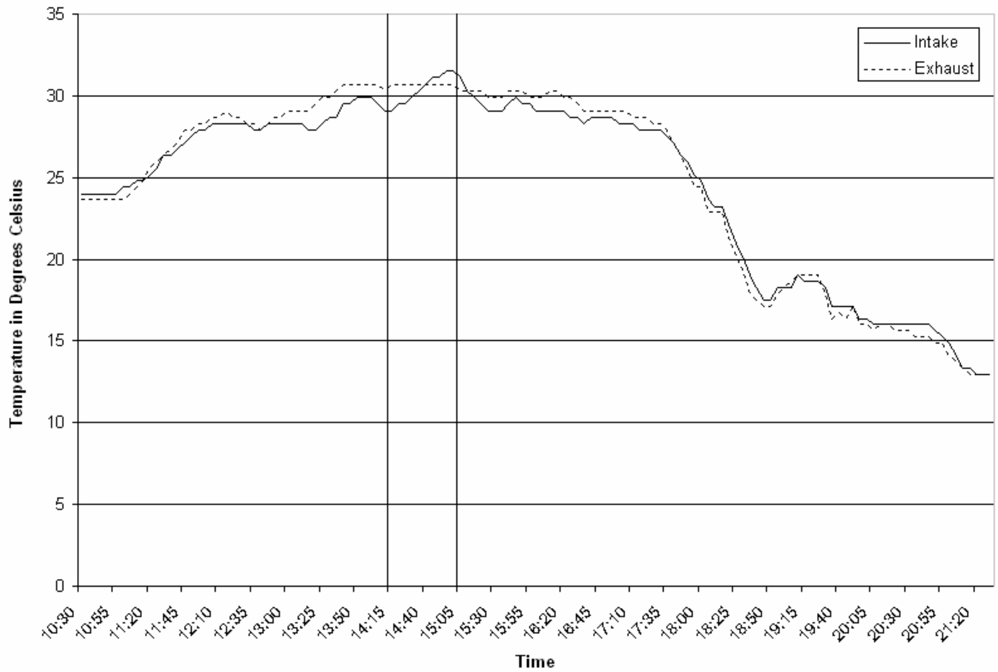

Figure 16. Intake versus exhaust temperature for Compartment 2 of the ventilated trailer for Trial 2. Vertical lines indicate the rest stop.

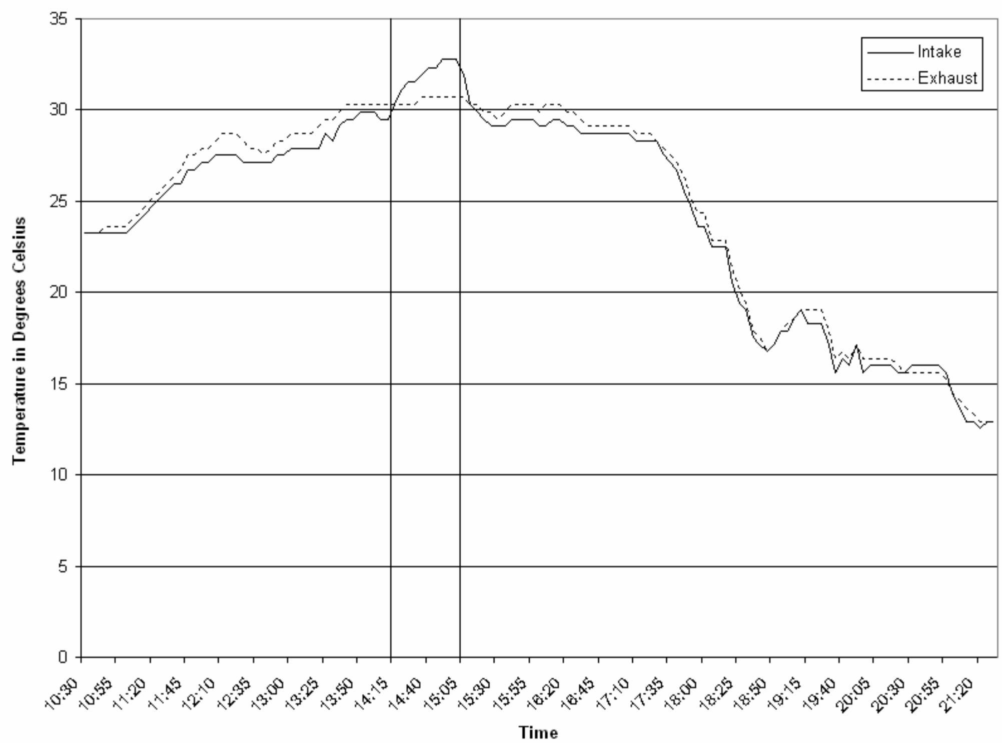

Figure 17. Intake versus exhaust temperature for Compartment 3 of the ventilated trailer for Trial 2. Vertical lines indicate the rest stop.

Temperature in the Control Trailer. The HOBO placed in the rear of Compartment 3 of the control trailer stopped recording data at 18:05 during Trial 2. This left 2 HOBOs recording in the control trailer for the entirety of Trial 2, as opposed to four for the ventilated trailer. Temperature comparisons between the sides of the control trailer could still not be done due to the positioning of the HOBOs.

Temperature Comparison Between Trailers. Temperatures for this comparison were determined by averaging the four HOBOs in the ventilated trailer and the three in the control trailer. For Trial 2, data between the ventilated trailer and the control trailer were only compared until 18:05, when the HOBO in the upper rear of the control trailer, between Compartments 3 and 5, stopped recording data. This kept the procedure for comparing the trailers the same for both Trial 1 and Trial 2 until that time.

During Trial 2, the rear HOBOs in Compartment 2, located on the rear gate in the ventilated trailer or in between Compartments 2 and 4 in the control trailer, showed an average temperature difference, calculated from 10:30 to 21:30, of 0.142 °C, with the control trailer being cooler (Fig. 18). During this period, the rear of Compartment 2 in the ventilated trailer was cooler 19% of the time, with both trailers being the same temperature 18% of the time. The average difference between the ventilated trailer and the control trailer, as measured by the front HOBOs in Compartment 2, could not be determined because the front HOBO in the control trailer did not work. From the beginning of the trial until 18:05, the rear HOBOs in Compartment 3, located on the rear gate in the ventilated trailer or in between Compartments 3 and 5 in the control trailer, showed a difference of 1.00 °C, with the ventilated trailer being cooler 88% of the time and both trailers being the same temperature 12% of the time (Fig. 19).

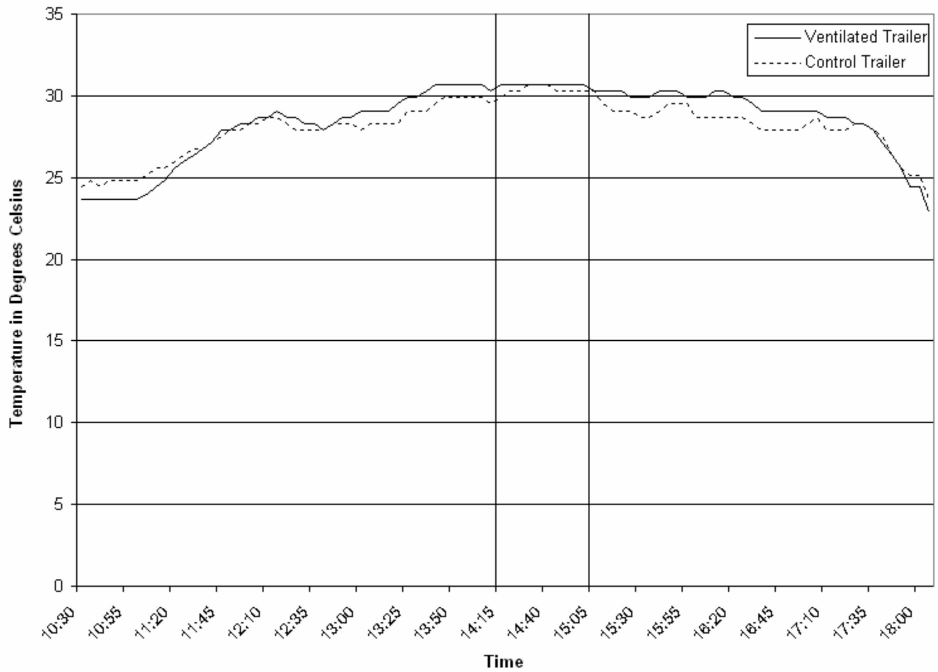

Figure 18. Temperature recorded by the rear HOBOs in Compartment 2 of the ventilated and control trailers for Trial 2. Vertical lines indicate the rest stop.

Figure 19. Temperature recorded by the rear HOBOs in Compartment 3 of the ventilated and control trailers for Trial 2. Vertical lines indicate the rest stop.

Prior to 18:05 and excluding the temperature rise due to the rest stop from 14:15 to 15:05, the overall average temperature, based on measurements from Compartments 2 and 3, in the ventilated trailer was 27.83 °C, while the overall average in the control trailer was 28.25 °C (Fig. 20). When the overall average in the control trailer was calculated using only the two HOBOs that functioned throughout the trial, the average temperature was 24.36. The average temperature in the ventilated trailer for the entire trial is 24.14.

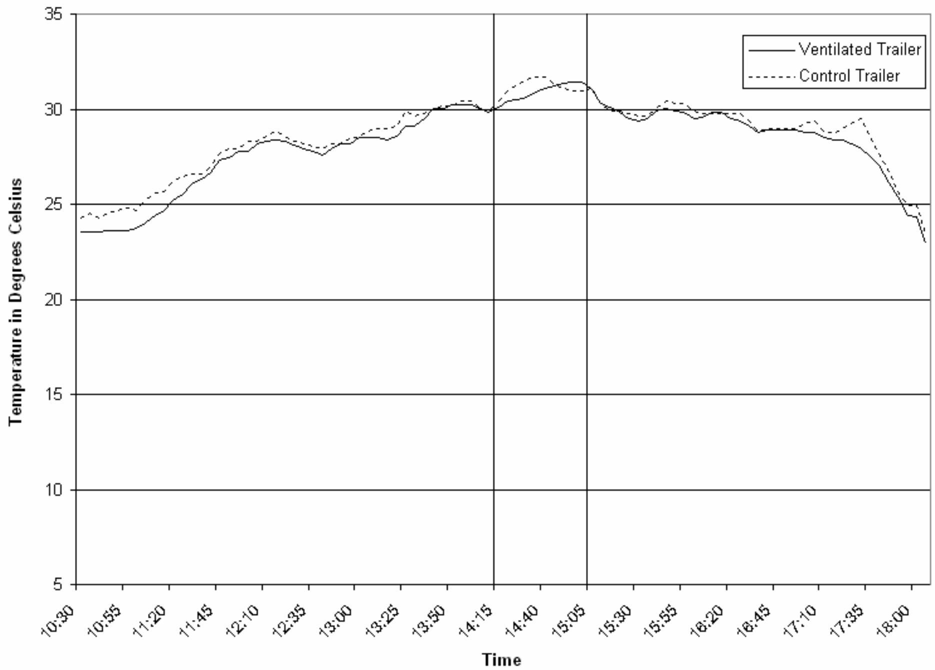

Figure 20. Temperature in degrees Celsius for Trial 2. Temperature was determined by averaging the measurements from all working HOBOs in each trailer. Trailers were parked in the sun from 14:15 to 15:05 during a rest stop, indicated by the vertical lines. Transport continued until 21:30, but temperatures recordings in the control trailer were cut short at 18:05 due to a malfunctioning HOBO.

Ammonia and Carbon Dioxide. As in Trial 1, the ammonia concentrations were too high for the low-range tubes. However, the high-range tubes did produce results, although again only two locations where the tubes were placed were judged to be comparable across treatments. For the front location, between Compartments 1 and 3, the ammonia concentration in ppm per hour was 6.045 ppm/h for the control trailer and 5.943 ppm/h for the ventilated trailer. For the rear location, between Compartments 2 and 4, the ammonia concentration was 2.110 ppm/h in the control trailer and 2.000

ppm/h in the ventilated trailer. During Trial 2, carbon dioxide tubes registered measurable CO_2, although the control and ventilated trailers could not be compared because so many of the tubes were mistakenly not opened by the truck drivers. In the control trailer, the Compartment 2 gate, which was open during transport, had a concentration of 0.094%, the Compartment 3 front location had a concentration of 0.107%, the Compartment 3 gate, which was closed during transport, had a concentration of 0.084%. The tubes in the front and rear locations were not opened. There was also no data for the ventilated trailer during this trial because neither of the tubes in that trailer were opened by the truck drivers.

Liquidity of Manure. The average dry matter of the fecal samples obtained from the floor of the trailers was 21.92 percent for the control trailer and 24.42 percent for the ventilated trailer.

Weight Loss. The percent weight loss was 5.7 for the control trailer, with a loading weight of 21,740.68 kg, and a final weight of 20,629.38 kg, and 5.1 for the ventilated trailer, with a loading weight of 22,440.58 kg and a final weight of 21,153.28 kg.

Physiological Measures. White blood cell counts were again unable to be determined due to sample degradation. When the trials were evaluated independently of each other, there were no significant differences between the ventilation treatments in Trial 2 for either complete blood counts (Table 3) or serum basic chemistry panels (Table 4), although the mean sodium concentration for the control cattle was still tended to be higher than that of the ventilated cattle.

Table 3. Means for each ventilation treatment during Trial 2 for items determined by complete blood counts (± SD)

	Ventilation Treatment	
Items	Ventilated	Control
Red blood cells (10^5 cells/cmm)	6.27 ± 0.84	6.21 ± 0.71
Hemoglobin (mmol/L)	11.06 ± 1.55	10.89 ± 1.05
Hematocrit (%)	27.87 ± 4.06	27.38 ± 3.13
Mean cell volume (fL)	44.46 ± 1.62	44.14 ± 1.11
Mean cell hemoglobin	17.64 ± 0.72	17.58 ± 0.25
Mean cell hemoglobin concentration (%)	39.73 ± 2.18	39.84 ± 2.58
Red blood cell distribution width	40.17 ± 3.80	41.08 ± 2.92
Platelets (10^4 cells/cmm)	239.45 ± 157	258.84 ± 166
Mean platelet volume (fL)	6.64 ± 0.66	6.97 ± 1.02
Procalcitonin (ng/ml)	0.161 ± 0.11	0.182 ± 0.12
Platelet cell distribution width	16.30 ± 1.29	16.64 ± 1.20

Table 4. Means for each ventilation treatment during Trial 2 for items determined by serum electrolyte and basic chemistry panels (± SD)

	Ventilation Treatment	
Items	Ventilated	Control
Sodium (mmol/L)	146.81 ± 2.79	146.84 ± 3.29
Potassium (mmol/L)	5.63 ± 0.57	5.31 ± 0.58
Chloride (mmol/L)	102.95 ± 2.94	103.58 ± 3.73
Carbon dioxide (mmol/L)	28.52 ± 2.27	29.00 ± 2.45
Blood urea nitrogen (mg/dl)	17.38 ± 2.94	17.12 ± 3.06
Creatinine (mg/dl)	1.61 ± 0.27	1.58 ± 0.16
Glucose (mg/dl)	81.24 ± 14.2	87.76 ± 14.6
Calcium (mg/dl)	9.46 ± 0.34	9.43 ± 0.42

Microbiology Measures. Of the samples tested for *Salmonella*, there was only one possible positive, which was from the control trailer. However, this animal proved to be negative after additional testing of the sample. Therefore, none of the cattle tested via the fecal grab samples were positive for *Salmonella*. Additionally, there were no positives for the *M. haemolytica* nasal swabs. For Trial 2, there were 7 positives from the control trailer and 7 positives from the ventilated trailer for *E. coli* O157:H7.

Thirty Day Health Data. No calves from Trial 2 were treated for 30 days post-transport.

Comparisons Between Trials

General Weather Conditions. During Trial 1, winds were generally from the south-southwest or west-southwest for the first half of the trial, and then shifted, blowing from the north and eventually east-northeast. This shift is visible as the increased difference between the temperatures of the ventilated and control trailers near the end of the trial in Figure 15. Wind speeds reported by the National Climatic Data Centers during the first half of the trial were higher than those during the second half. During Trial 2, the wind was more consistent, blowing from the south throughout the trip, which decreased the efficiency of the scoops. Wind speeds were greatest during the middle segment of Trial 2. Overall, the average wind speed during both trials was approximately the same.

Temperature in the Ventilated Trailers. During both trials, there was a greater difference between the intake and exhaust temperatures in Compartment 3 (the top compartment) versus Compartment 2. However, while the difference between the intake and exhaust temperatures in Compartment 2 was greater during Trial 2, the difference in Compartment 3 tended to be greater for Trial 1. The overall average temperature in the ventilated trailers, excluding the spikes for the rest stops, was 22.69 °C for Trial 1 and

24.14 °C for Trial 2, resulting in a difference of 1.45 °C. The mean temperature for both trials in the ventilated trailer was 23.42 °C.

Temperature in the Control Trailers. A comparison of overall average temperature between Trial 1 and Trial 2, excluding only the rest stops, was made by averaging the temperatures recorded by the two HOBOs in the control trailer that worked throughout both trials. While this comparison must be interpreted with caution due to the limited data, the two HOBOs in the control trailer were positioned in the middle of the trailer, which allowed them to measure the average temperature within the trailer. The overall average temperature in the control trailers, again excluding the rest stops, was 23.33 °C for Trial 1 and 24.36 °C for Trial 2, resulting in a difference of 1.03 °C. The mean temperature for both trials in the control trailer was 23.85°C.

Temperature Comparison Between Trailers. The overall average temperature in the ventilated trailer was cooler during both trials, with a difference of 0.64 °C for Trial 1 and 0.22 °C for Trial 2, based on the temperature throughout the entire trial, excluding only the rest stops. The mean temperature for both trials showed that the ventilated trailers were cooler by 0.43 °C.

Ammonia and Carbon Dioxide. Ammonia concentrations were much greater for both the front and rear locations during Trial 2 than during Trial 1. Additionally, the differences between the ventilated trailer and control trailer during Trial 2 were smaller than the differences between the trailers during Trial 1, although in each case the ventilated trailer had lower ammonia concentrations. However, these differences could not be statistically tested, so it is unknown whether they are significant. For carbon dioxide, the only comparable location between the two trials was the Compartment 2 gate in the control trailer, which showed that carbon dioxide concentrations at this location were less during Trial 1.

Liquidity of Manure. There was a trial by treatment interaction ($P < 0.001$), as well as a trial effect ($P = 0.001$). In Trial 1, the samples from the control trailer had a higher percentage of dry matter, while in Trial 2, the samples from the ventilated trailer had a higher percentage of dry matter. Trial 2 had a higher percentage of dry matter in the manure samples obtained from the floors of both the control and the ventilated trailers.

Weight Loss. The reduction in percent weight loss for the ventilated cattle was greater for Trial 1 than for Trial 2. However, the control cattle in both trials experienced approximately the same amount of weight loss. The average percent weight loss for cattle in the control trailer was 5.75, while the average percent weight loss for cattle in the ventilated trailer was 4.7.

Physiological Measures. When the trials were analyzed together, there were no treatment by trial interactions. There were no significant differences in either complete blood count (Table 1) or serum electrolytes (Table 2). There was a trial effect for the potassium, carbon dioxide (CO_2), and mean cell hemoglobin (MCH), with potassium concentrations being higher in Trial 2, and carbon dioxide concentration and mean cell hemoglobin being higher in Trial 1. Although sodium concentrations were significantly higher in control cattle in Trial 1, chloride concentrations were not significant, either on a trial or a treatment basis, although the control cattle tended to have a higher chloride concentration in both trials.

Microbiology Measures. Neither trial produced any positive samples for *Salmonella* or *M. haemolytica*. However, Trial 2 had a much higher incidence of *E. coli*,, with a total of 14 positives, versus 4 positives for Trial 1.

Thirty Day Health Data. No animals from either trial were treated for transport-related illnesses or injuries.

DISCUSSION

The temperature and humidity loggers, and the ammonia and carbon dioxide tubes were positioned in the trailers with the expectation that the gates would be closed during transport. Closing the gates would have placed those recording devices in the centers of the compartment. However, the truck drivers decided at the last minute to leave the gates open, with the exception of the gate in Compartment 3 of the control trailer, which was closed to increase stability of the trailer by decreasing weight shifts caused by movement of the cattle. While this allowed for the measurement of intake and exhaust temperatures in the ventilated trailer, it did not yield easily comparable results for all compartments, and did not allow for the recording of temperatures within the centers of the compartments.

The temperatures within the trailers appeared to be greatly influenced by the prevailing winds. The scoops had been set up based on a forecasted weather front from the north. Therefore, the intake scoops were mounted on the passenger or north side of the vehicle, which would have allowed the greatest amount of air flow through the intakes. However, the northern front did not come through as soon as, or last as long as, expected. During Trial 1, there was a strong wind blowing from the south-southwest for most of the day, eventually coming from the north-northeast as the trailers turned north. While not believed to be optimal, winds from the south-southwest did not result in intake temperatures being higher than exhaust temperatures. When the trailers were traveling into the wind with the wind striking the trailer on the intake side during the final leg of the trial, the difference between intake and exhaust temperatures in Compartment 3 increased (Fig. 12) because the wind was blowing into the intake scoops. However, the difference in Compartment 2 actually reverses, with HOBOs on the exhaust side of the trailer recording lower temperatures than those on the intake side (Fig. 11), perhaps due to turbulence closer to the road or heat from the tractor. The overall difference between the ventilated trailer and the control trailer reflects the temperatures recorded in Compartment 3, with the difference in temperatures between the trailers increasing as the trailer turns north and the wind blew from the north-northeast (Fig. 15). This wind change also brought cooler temperatures, as shown by the drops in temperature towards the end of the trial in Figures 11, 12, and 15. During all of Trial 2, the wind worked against the scoop orientation. During the first leg of Trial 2, the winds were again from the southwest or south-southwest, with results similar to that in Trial 1 (Fig 16 and 17). On the second leg of Trial 2, as the trailers turned north, the wind was coming from the south. This worked against the exhaust scoops, decreasing their efficiency. In Figures 16 and 17, this is shown by the narrowing of the difference between the temperatures of the intake and exhaust readings. At times, the exhaust temperature during this second leg of the trial was actually cooler than the intake temperature. However, despite the unexpected weather, the overall average temperature within the ventilated trailer remained cooler during both trials.

On the ventilated trailer, the intake temperatures were generally cooler than the exhaust temperatures, indicating that the intake scoops were increasing air movement and providing some degree of cooling within the trailer. The differences in temperature between the control trailer and the ventilated trailer were greater in Compartment 3 of the trailers, especially towards the rear of these compartments. Presumably, this was because the rear of the trailer was benefiting from all of the scoops preceding that area of the trailer. In preliminary trials evaluating conditions inside of a commercial single-deck trailer, air flow from intake scoops entered the trailer at approximately 45 degrees (Friend, unpublished study). This would support the findings of this experiment, since air entering at that angle would affect areas to the rear of the intake scoop rather than the area immediately adjacent to the scoop.

Ammonia readings also reflected the influence of the ventilation scoops. For both trials, the ventilated trailer had lower ammonia concentrations in the center compartments. Additionally, the back of the compartment, whether ventilated or not, had lower ammonia concentrations. This coincides with the temperature data, indicating that the rear of the center compartments actually received more ventilation than the front of those compartments. The increase in cross ventilation appeared to reduce ammonia within the trailer, which could be important because maximum concentrations of ammonia in livestock houses should be below 20 ppm (Wikner et al., 2003). Total exposure within the both the ventilated trailers and the control trailers exceeded this number, although the ventilated trailer did have lower concentrations. Carbon dioxide concentrations within both trailers remained well below the recommended maximum of .3% in livestock houses (Wikner et al., 2003).

Percent dry matter of the fecal matter on the floor of the trailers post-transport varied greatly between the two trials. The trial effect and trial by treatment interaction were most likely due to the sampling technique. Despite attempts to mix the fecal matter prior to sampling, the samples were still obtained from fixed locations within the trailers, and could be greatly influenced by a single urination late in the trial. Some of the pre-determined sampling locations did not appear to reflect the overall composition of the waste matter on the floor of the compartment. Furthermore, the drivers felt that the cattle had not produced normal amounts of manure, likely due to the lack of available forage at their location of origin.

The differences in percent weight loss were remarkable by industry standards. Wars have been fought over 0.1% weight loss, so if these results are reproducible it would be extremely significant to the industry (Dwayne Thompson, Texas Beef Feedyards, Dumas, TX, personal communication). Furthermore, the cattle in the ventilated trailer had an average percent weight loss of 4.7%, compared with 5.75% in the control trailer. These results place the ventilated cattle well below the 5.4% baseline percent weight loss found in the Griffin study (1983), above which mortality increases rapidly. The ventilated cattle are also right at the baseline percent weight loss above which morbidity drastically increases. Based on these figures, the control cattle should have had a 26.5% increase in morbidity and a greater chance of mortality, compared to the baseline of the ventilated cattle. While this was not evident in the results of the current study, the cattle used in the current study were all well-conditioned, and also came straight off the farm, whereas the cattle used in the Griffin study (1983) came from varying locations and often passed through sale barns, increasing their stress levels and exposure to disease.

The greater difference in weight loss between the ventilated trailer and the control trailer during Trial 1 was consistent with the temperature data. The difference between the temperature in the ventilated trailer and the temperature in the control trailer was greater during Trial 1 than during Trial 2. Percent weight loss has been related to temperature in several studies (Coffey et al., 2001; Phillips, 1991). Additionally, weight loss due to higher temperatures has been attributed to respiratory loss, and therefore body tissue loss, which makes it more costly to producers (Brazle and Ishmael, 2006), as opposed to loss due to the excretion of bodily wastes through feces and urine. Therefore, the decreased temperature recorded by the HOBOs within the ventilated trailer likely influenced the percent weight loss. Since there were recorded differences for temperature and other factors depending on the section of the trailer, it seems likely that weight loss varied as well depending on compartment. However, weighing of individual animals or even compartments at the beginning of the trial was not possible.

The trial effects for potassium, carbon dioxide, and mean cell hemoglobin were likely due to the variability of the effect of the wind on the ventilation scoops, resulting in the control trailer being cooler at times, especially in Compartment 2. The trial effects could also be an artifact, since none of the other blood components showed trial effects. The lack of significant results for complete blood counts or serum electrolytes and basic chemistry panels could have been influenced by two factors. The first is that the cattle received hay and water after being unloaded. Secondly, the cattle were not processed for 10 hours for Trial 1, and 8.5 hours for Trial 2. Therefore, the cattle had time to recover before samples were obtained. The sodium and chloride concentrations in dehydrated horses that underwent transportation return to normal ranges within 4 hours (Friend, 2000), while the Merck Veterinary Manual recommends a 6 to 12 hour rest period for rehydration (2006). Therefore, the delay between transport and sampling likely masked most of the potential differences between the ventilated cattle and the control cattle.

When considered independently of Trial 2, sodium concentrations in Trial 1 were lower for cattle in the ventilated trailer, which suggested less dehydration. This was also reflected somewhat by the chloride concentrations in Trial 1, which, while not significantly different, showed lower means for the ventilated cattle. The hemoglobin concentrations of cattle in the ventilated trailer were significantly higher than those of the control cattle in Trial 1 as well. However, in contrast to the sodium concentrations, which indicated that the ventilated cattle were less dehydrated, increased hemoglobin concentration may indicate dehydration (Jain, 1986). The hemoglobin concentration was still well within the normal range of 8.0-15.0 g/dL for cattle (Kramer, 2000), so this may not be biologically significant, since hemoglobin was not significantly different in Trial 2 or when considered with both trials together. The cattle did receive water during the interval between transport and sampling, which would have affected the sodium and chloride concentrations. However, because weight loss was lower in ventilated cattle, it seems more likely that the hemoglobin concentration was random variation and the sodium and chloride concentrations are more indicative of what was occurring within the cattle. Trial 2 did not yield any statistically significant results. The difference in temperatures between the ventilated trailer and control trailer in Trial 2 was smaller, and since most of the physiological markers were not significant for Trial 1 either, that smaller temperature difference might have been just enough to prevent significant differences. Another factor that may have influenced the significance of the results is that some physiological markers have been shown to vary post-transport depending on density during transport, which may be important in this study since there were small differences in density between the ventilated and control trailers. Stull (1999) found that horses transported at lower densities had significantly smaller changes in white blood cell count, neutrophil:lymphocyte ratio, cortisol, and hematocrit concentrations. However, the differences in density in the Stull study were larger than those in this study, with one density between 1.14 and 1.31 square meters per horse, and the other with a density of 1.40 to 1.54 square meters per horse. Additionally, different physiological markers were evaluated in this study, so it is impossible to know if the differences in density affected the sodium and hemoglobin concentrations.

The lack of differences in the screenings for *E. coli* O157:H7, *Salmonella*, and *M. haemolytica*, as well as that of the 30-day health data, were likely due to the age and condition of the cattle that were used in this experiment. When the cattle were originally chosen, they were categorized as high-risk, meaning that they had just been weaned and were susceptible to infection due to that stress. However, due to higher than normal rainfall, the owner of the cattle decided to hold them on pasture for greater weight gain. By the time the cattle were actually shipped, they had been on pasture for several months, were heavier, and had gotten over the stress of weaning. Therefore, they were not as susceptible to infection as they would have been if they were shipped immediately after weaning.

Future studies should be conducted with high-risk cattle, which are of greatest concern to feedyard managers. These cattle are typically the most stressed, and therefore, the most susceptible to loss of condition and infection. High-risk cattle should benefit the most from increased ventilation. Obtaining absolute control over procedure would also reduce potentially confounding factors, including minimizing the period between transport and sampling of the cattle. Furthermore, full cooperation of the truck drivers and cattle owners would allow investigators to match the density within the trailers by manipulating the number of cattle in each compartment, and also would allow investigators to dictate the positions of the gates and to reposition the scoops between trials to maximize cross-ventilation. However, this type of control would require higher levels of funding than was available for this experiment. Additionally, future studies should be conducted using matched trucks and trailers. This would allow for better comparison by matching density within the trailers and standardizing the locations of equipment such as the HOBOs and dosi-tubes. Furthermore, it would allow for a comparison of gas mileage, which would be important if ventilation scoops are to be adopted throughout the industry. Finally, more experimentation should be conducted regarding scoop design and configuration for maximal effect.

CONCLUSION

Based on the results of this study, it appears that increasing ventilation through the use of external air scoops has great potential to affect the condition of the cattle upon arrival. Weight loss in the ventilated trailers was decreased in both trials when compared with that of the control trailers. This result alone has potential from an industry standpoint. Additionally, cattle in the ventilated trailer during Trial 1 had lower sodium concentrations in their blood, indicating that they were not as dehydrated as the control cattle, even 8 hours post-transport. The investigators believe that these results would be more significant in high-risk cattle, especially since they are typically transported during the late summer. However, any results found in this study must be interpreted in conjunction with the prevailing winds, differences between the size and set-up of the trailers and the status of the cattle used during this experiment. Furthermore, the inability to adjust the ventilation scoops in response to unexpected changes in wind direction reduced their effectiveness. Nonetheless, according to the measures evaluated in this study, the use of ventilation scoops did have positive effects on the cattle.

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APPENDIX

Table 5. Temperature readings from HOBOs during Trial 1

	Ventilated Trailer				Control Trailer		
	Compartment 2		Compartment 3		Compart -ment 2	Compartment 3	
Time	Intake	Exhaust	Intake	Exhaust	Rear	Front	Rear
9:30	22.48	22.48	22.48	22.48	21.71	22.48	25.56
9:35	22.86	22.48	22.86	22.48	21.71	22.48	24.79
9:40	23.24	22.48	22.86	22.48	22.48	23.24	24.79
9:45	23.24	22.48	22.86	22.48	22.86	23.63	25.17
9:50	23.24	22.48	22.86	22.48	23.24	23.24	24.01
9:55	23.24	22.48	22.86	22.86	23.24	23.24	24.01
10:00	23.63	23.24	22.86	23.24	24.01	23.63	24.4
10:05	23.63	23.24	22.86	23.24	24.79	24.01	24.79
10:10	23.63	23.63	23.24	23.63	25.17	24.01	24.79
10:15	23.63	23.63	23.24	23.63	24.79	24.01	24.79
10:20	23.63	23.63	23.24	23.24	24.4	23.63	24.79
10:25	23.63	23.63	23.24	23.63	24.4	23.63	24.79
10:30	23.63	23.63	23.24	23.63	24.4	23.63	25.56
10:35	23.63	23.63	23.24	23.63	24.79	24.01	26.73
10:40	23.63	24.01	23.24	24.01	25.17	24.4	26.34
10:45	23.63	24.01	22.86	23.63	24.79	24.01	25.17
10:50	24.01	24.4	23.24	24.01	24.79	24.01	25.17
10:55	24.4	24.4	23.24	24.01	24.79	24.4	25.17
11:00	24.4	24.79	23.63	24.4	25.17	24.79	25.17
11:05	24.79	24.79	24.01	24.79	25.17	24.79	25.56
11:10	24.79	25.17	24.4	25.17	25.56	25.17	25.56
11:15	25.17	25.56	24.4	25.17	25.56	25.56	25.95
11:20	25.56	25.95	24.79	25.56	25.95	25.56	26.34
11:25	25.56	26.34	25.17	25.95	25.95	25.95	26.34
11:30	25.56	26.34	25.17	25.95	25.95	25.95	26.34
11:35	25.56	26.34	25.17	25.95	25.95	26.34	26.34
11:40	25.56	26.73	25.56	26.34	26.34	26.34	26.34
11:45	25.95	26.73	25.56	26.34	26.34	26.34	26.73
11:50	26.34	27.12	25.56	26.34	26.73	26.73	26.73
11:55	26.34	27.12	25.95	26.73	27.12	26.73	27.52
12:00	26.34	27.12	25.56	26.73	26.73	26.73	27.12
12:05	26.34	26.73	25.56	26.73	26.34	26.73	27.52
12:10	26.34	27.12	25.95	26.73	26.73	27.12	27.52
12:15	26.73	27.52	26.34	27.12	27.12	27.52	27.91
12:20	27.12	27.91	26.34	27.52	27.12	27.52	28.31
12:25	27.12	27.52	26.34	27.52	26.73	27.52	27.91
12:30	27.12	27.91	26.34	27.52	26.73	27.52	27.52
12:35	27.12	27.91	26.73	27.91	26.73	27.91	27.91

Table 5. Continued

	Ventilated Trailer				Control Trailer		
	Compartment 2		Compartment 3		Compart-ment 2	Compartment 3	
Time	Intake	Exhaust	Intake	Exhaust	Rear	Front	Rear
12:40	27.12	27.91	26.73	27.52	26.73	27.52	27.52
12:45	27.12	27.52	26.73	27.52	26.73	27.52	27.52
12:50	27.52	27.91	26.73	27.91	27.12	27.52	27.91
12:55	27.52	27.91	27.12	27.91	27.12	27.52	27.91
13:00	27.52	28.31	27.12	27.91	27.52	27.52	27.52
13:05	27.12	27.52	26.73	27.12	26.73	27.12	27.52
13:10	27.12	27.52	26.34	27.12	26.73	27.12	27.52
13:15	27.12	27.91	26.73	27.52	27.12	27.91	27.91
13:20	27.52	27.91	27.12	27.91	27.12	27.91	27.91
13:25	27.91	28.31	27.52	28.31	27.91	28.31	28.31
13:30	28.31	29.1	27.91	28.7	28.7	29.1	28.7
13:35	28.31	29.9	28.31	29.1	29.1	29.5	29.1
13:40	28.7	30.31	28.7	29.5	29.1	29.5	29.5
13:45	29.1	30.31	29.1	29.9	29.5	29.9	29.9
13:50	29.1	30.31	29.1	29.5	29.5	29.9	29.9
13:55	29.1	30.31	28.7	29.5	29.1	29.5	29.9
14:00	28.7	30.31	28.7	29.5	29.1	29.5	29.9
14:05	29.1	30.31	29.1	29.9	29.1	29.5	29.5
14:10	29.1	30.71	29.1	29.9	29.1	29.5	29.5
14:15	29.1	30.31	28.7	29.9	29.5	29.5	29.9
14:20	29.5	30.71	29.1	29.9	29.5	29.5	29.9
14:25	29.5	30.71	29.1	29.9	29.5	29.5	29.5
14:30	29.5	30.31	28.7	29.9	29.5	29.5	29.5
14:35	29.1	30.31	28.7	29.5	29.5	29.1	29.5
14:40	29.1	29.9	28.31	29.5	29.5	29.1	29.1
14:45	29.1	29.9	28.31	29.1	29.1	29.1	29.1
14:50	28.7	29.9	28.31	29.1	29.1	29.1	29.1
14:55	28.7	29.5	28.7	29.1	28.7	28.7	29.5
15:00	29.1	29.5	29.1	28.7	28.31	29.1	29.9
15:05	29.1	29.5	29.5	28.7	28.31	29.5	30.71
15:10	29.5	29.5	29.9	28.7	28.31	29.9	31.12
15:15	29.9	29.5	30.31	28.7	28.31	29.9	31.52
15:20	30.31	29.5	30.71	28.7	28.31	30.31	31.93
15:25	30.71	29.5	30.71	28.7	27.91	30.31	31.93
15:30	30.71	29.5	31.12	29.1	27.91	30.31	31.93
15:35	31.12	29.1	31.12	29.1	27.91	30.31	34.01
15:40	31.12	29.5	31.52	29.1	27.91	30.31	34.01
15:45	31.52	29.5	31.52	29.1	27.91	30.71	34.01
15:50	31.52	29.1	31.52	29.1	27.91	30.71	33.17
15:55	31.12	29.1	29.9	29.1	28.31	29.9	31.93
16:00	29.9	29.1	28.7	29.1	28.7	28.7	30.31
16:05	29.1	29.1	28.31	29.1	28.7	28.31	29.5
16:10	28.31	27.91	27.12	27.91	28.31	27.52	28.31
16:15	27.52	26.73	26.34	27.12	27.12	26.73	27.52
16:20	27.12	26.34	25.56	26.34	26.73	26.34	26.73
16:25	26.34	25.56	25.17	25.95	25.95	25.56	26.73

Table 5. Continued

	Ventilated Trailer				Control Trailer		
	Compartment 2		Compartment 3		Compart-ment 2	Compartment 3	
Time	Intake	Exhaust	Intake	Exhaust	Rear	Front	Rear
16:30	25.56	24.79	24.4	25.17	25.17	25.17	25.95
16:35	25.17	24.4	24.01	25.17	24.4	24.79	25.17
16:40	25.17	24.4	24.4	24.79	24.79	24.79	25.17
16:45	25.17	24.79	24.4	24.79	25.17	24.79	25.17
16:50	25.17	24.4	24.4	24.79	25.17	25.17	25.56
16:55	25.17	24.4	24.01	24.4	24.79	24.79	25.56
17:00	24.79	24.01	24.01	24.4	24.4	24.4	25.56
17:05	25.17	24.01	24.01	24.4	24.79	24.79	25.17
17:10	24.79	24.01	24.01	24.01	24.4	24.4	25.17
17:15	24.4	23.63	23.63	24.01	24.01	24.01	25.17
17:20	24.4	24.01	23.63	24.01	24.4	24.01	25.17
17:25	23.63	23.24	22.48	23.63	24.01	23.63	24.4
17:30	23.63	22.86	22.48	23.24	23.24	23.24	24.01
17:35	23.24	22.48	22.48	22.86	22.86	22.86	24.01
17:40	23.24	22.48	22.48	22.86	22.86	22.86	24.01
17:45	23.24	22.48	22.09	22.86	22.86	22.86	24.01
17:50	22.48	21.33	20.95	22.09	21.71	22.09	23.24
17:55	22.09	21.33	20.95	21.71	21.71	21.71	22.86
18:00	22.09	21.33	21.33	21.71	22.09	21.71	23.24
18:05	21.71	20.95	20.57	21.33	21.71	21.33	22.86
18:10	20.95	20.19	19.42	20.57	20.57	20.19	21.71
18:15	20.19	19.42	18.66	19.81	19.42	19.42	21.33
18:20	19.04	18.66	17.14	18.66	18.66	18.66	20.19
18:25	17.9	17.52	16	17.52	17.52	17.52	19.42
18:30	17.52	16.76	15.62	16.76	17.14	16.76	18.66
18:35	16.76	16.38	14.85	16	16.38	16.38	18.28
18:40	16.76	16.38	14.85	16	16.38	16.38	18.28
18:45	16	15.62	13.7	15.23	15.62	15.62	17.9
18:50	15.23	14.85	13.7	14.47	14.85	14.85	17.14
18:55	14.47	13.7	12.55	13.7	13.7	14.09	16
19:00	13.7	12.93	12.16	12.93	12.93	13.32	15.23
19:05	12.93	12.16	11.38	12.55	11.77	12.55	14.09
19:10	12.55	11.77	10.99	12.16	11.38	12.16	14.85
19:15	12.55	11.77	10.99	12.16	11.77	12.16	17.9
19:20	11.77	11.38	10.21	11.38	10.6	11.77	16.76
19:25	11.38	11.38	10.21	11.77	10.6	12.16	15.62
19:30	11.38	11.77	10.21	11.77	10.21	12.93	15.62
19:35	11.38	11.77	9.82	11.77	10.21	13.32	14.47
19:40	10.99	11.77	9.82	11.38	9.82	13.32	13.32
19:45	10.99	11.77	9.82	11.38	9.82	13.32	14.09
19:50	10.6	11.77	9.82	11.77	9.82	13.7	16
19:55	10.6	11.77	9.82	11.77	9.82	13.32	17.52
20:00	10.6	10.99	9.03	11.38	9.42	12.55	17.52
20:05	10.21	10.21	9.03	10.99	9.82	10.99	14.85
20:10	10.21	10.21	9.42	10.6	9.82	10.99	15.23
20:15	10.21	9.82	8.63	10.21	9.82	10.6	13.7

Table 5. Continued

	Ventilated Trailer				Control Trailer		
	Compartment 2		Compartment 3		Compart-ment 2	Compartment 3	
Time	Intake	Exhaust	Intake	Exhaust	Rear	Front	Rear
20:20	9.82	9.42	8.63	9.82	9.42	9.82	12.55
20:25	9.42	9.03	7.83	9.42	9.42	9.42	12.16
20:30	9.82	9.82	9.82	10.21	10.6	10.6	12.16

Table 6. Temperature readings from HOBOs during Trial 2

	Ventilated Trailer				Control Trailer		
	Compartment 2		Compartment 3		Compart-ment 2	Compartment 3	
Time	Intake	Exhaust	Intake	Exhaust	Rear	Front	Rear
10:30	24.01	23.63	23.24	23.24	24.4	23.63	24.79
10:35	24.01	23.63	23.24	23.24	24.79	24.01	24.79
10:40	24.01	23.63	23.24	23.24	24.4	23.63	24.79
10:45	24.01	23.63	23.24	23.63	24.79	24.01	24.79
10:50	24.01	23.63	23.24	23.63	24.79	24.01	25.17
10:55	24.01	23.63	23.24	23.63	24.79	23.63	25.95
11:00	24.4	23.63	23.24	23.63	24.79	23.63	25.56
11:05	24.4	24.01	23.63	24.01	25.17	24.4	25.95
11:10	24.79	24.4	24.01	24.4	25.56	24.4	26.73
11:15	24.79	24.79	24.4	24.79	25.56	24.79	26.73
11:20	25.17	25.56	24.79	25.17	25.95	25.56	27.12
11:25	25.56	25.95	25.17	25.56	26.34	25.95	27.12
11:30	26.34	26.34	25.56	25.95	26.73	26.34	26.73
11:35	26.34	26.73	25.95	26.34	26.73	26.34	26.73
11:40	26.73	27.12	25.95	26.73	27.12	26.73	27.12
11:45	27.12	27.91	26.73	27.52	27.52	27.52	27.91
11:50	27.52	27.91	26.73	27.52	27.91	27.91	27.91
11:55	27.91	28.31	27.12	27.91	27.91	27.91	27.91
12:00	27.91	28.31	27.12	27.91	28.31	28.31	28.31
12:05	28.31	28.7	27.52	28.31	28.31	28.31	28.31
12:10	28.31	28.7	27.52	28.7	28.7	28.31	28.7
12:15	28.31	29.1	27.52	28.7	28.7	28.7	29.1
12:20	28.31	28.7	27.52	28.7	28.31	28.31	29.1
12:25	28.31	28.7	27.12	28.31	27.91	28.31	28.7
12:30	28.31	28.31	27.12	27.91	27.91	27.91	28.7
12:35	27.91	28.31	27.12	27.91	27.91	27.91	28.31
12:40	27.91	27.91	27.12	27.52	27.91	27.52	28.31
12:45	28.31	28.31	27.12	27.91	28.31	27.91	28.31
12:50	28.31	28.7	27.52	28.31	28.31	27.91	28.31
12:55	28.31	28.7	27.52	28.31	28.31	28.31	28.7
13:00	28.31	29.1	27.91	28.7	27.91	28.7	29.1
13:05	28.31	29.1	27.91	28.7	28.31	28.7	29.5
13:10	28.31	29.1	27.91	28.7	28.31	28.7	29.9
13:15	27.91	29.1	27.91	28.7	28.31	28.7	29.9
13:20	27.91	29.5	27.91	29.1	28.31	29.1	29.9
13:25	28.31	29.9	28.7	29.5	29.1	29.5	31.12
13:30	28.7	29.9	28.31	29.5	29.1	29.5	30.31
13:35	28.7	30.31	29.1	29.9	29.1	29.9	30.31
13:40	29.5	30.71	29.5	30.31	29.5	30.31	30.31
13:45	29.5	30.71	29.5	30.31	29.9	30.31	30.31

Table 6. Continued.

	Ventilated Trailer				Control Trailer		
	Compartment 2		Compartment 3		Compart-ment 2	Compartment 3	
Time	Intake	Exhaust	Intake	Exhaust	Rear	Front	Rear
13:50	29.9	30.71	29.9	30.31	29.9	30.31	30.31
13:55	29.9	30.71	29.9	30.31	29.9	30.71	30.71
14:00	29.9	30.71	29.9	30.31	29.9	30.31	31.12
14:05	29.5	30.71	29.5	30.31	29.9	29.9	30.31
14:10	29.1	30.31	29.5	30.31	29.5	29.9	30.31
14:15	29.1	30.71	30.31	30.31	29.9	30.31	31.12
14:20	29.5	30.71	31.12	30.31	30.31	30.31	32.34
14:25	29.5	30.71	31.52	30.31	30.31	30.71	32.76
14:30	29.9	30.71	31.52	30.31	30.71	30.71	33.17
14:35	30.31	30.71	31.93	30.71	30.71	31.12	33.17
14:40	30.71	30.71	32.34	30.71	30.71	31.12	33.17
14:45	31.12	30.71	32.34	30.71	30.31	30.71	32.76
14:50	31.12	30.71	32.76	30.71	30.31	30.71	32.34
14:55	31.52	30.71	32.76	30.71	30.31	30.71	31.93
15:00	31.52	30.71	32.76	30.71	30.31	30.71	31.93
15:05	31.12	30.31	31.93	30.71	30.31	30.71	32.34
15:10	30.31	30.31	30.31	30.31	29.5	30.31	31.12
15:15	29.9	30.31	29.9	30.31	29.1	29.9	30.71
15:20	29.5	30.31	29.5	29.9	29.1	29.9	30.71
15:25	29.1	29.9	29.1	29.9	29.1	29.5	30.71
15:30	29.1	29.9	29.1	29.5	28.7	29.9	30.31
15:35	29.1	29.9	29.1	29.9	28.7	29.9	30.31
15:40	29.5	30.31	29.5	30.31	29.1	30.31	30.71
15:45	29.9	30.31	29.5	30.31	29.5	30.71	31.12
15:50	29.5	30.31	29.5	30.31	29.5	30.31	31.12
15:55	29.5	29.9	29.5	30.31	29.5	30.31	31.12
16:00	29.1	29.9	29.1	29.9	28.7	30.31	30.71
16:05	29.1	29.9	29.1	30.31	28.7	30.31	30.31
16:10	29.1	30.31	29.5	30.31	28.7	30.31	30.31
16:15	29.1	30.31	29.5	30.31	28.7	30.31	30.31
16:20	29.1	29.9	29.1	29.9	28.7	29.9	30.71
16:25	28.7	29.9	29.1	29.9	28.7	29.9	30.71
16:30	28.7	29.5	28.7	29.5	28.31	29.5	30.31
16:35	28.31	29.1	28.7	29.1	27.91	29.1	29.5
16:40	28.7	29.1	28.7	29.1	27.91	29.1	29.9
16:45	28.7	29.1	28.7	29.1	27.91	29.1	29.9
16:50	28.7	29.1	28.7	29.1	27.91	29.1	29.9
16:55	28.7	29.1	28.7	29.1	27.91	29.1	29.9
17:00	28.31	29.1	28.7	29.1	28.31	29.1	30.31
17:05	28.31	29.1	28.7	29.1	28.7	29.1	30.31
17:10	28.31	28.7	28.31	28.7	27.91	28.7	29.9
17:15	27.91	28.7	28.31	28.7	27.91	28.7	29.5
17:20	27.91	28.7	28.31	28.7	27.91	28.7	30.31
17:25	27.91	28.31	28.31	28.31	28.31	28.7	30.71
17:30	27.91	28.31	27.52	27.91	28.31	28.31	31.93

Table 6. Continued

	Ventilated Trailer				Control Trailer		
	Compartment 2		Compartment 3		Compartment 2	Compartment 3	
	Intake	Exhaust	Intake	Exhaust	Rear	Front	Rear
17:35	27.52	27.91	27.12	27.52	27.91	27.91	29.9
17:40	27.12	27.12	26.73	27.12	27.52	27.12	28.31
17:45	26.34	26.34	25.56	26.34	26.34	26.34	27.52
17:50	25.95	25.56	24.79	25.17	25.56	25.17	26.34
17:55	25.17	24.4	23.63	24.4	25.17	24.4	25.17
18:00	24.79	24.4	23.63	24.4	25.17	24.4	25.17
18:05	23.63	22.86	22.48	22.86	23.63	22.86	24.01
18:10	23.24	22.86	22.48	22.86	24.01	22.86	No Value
18:15	23.24	22.86	22.48	22.86	24.01	22.86	No Value
18:20	22.09	21.33	20.57	21.33	22.09	20.95	No Value
18:25	20.95	20.19	19.42	20.19	20.95	19.81	No Value
18:30	20.19	19.42	19.04	19.42	19.81	19.42	No Value
18:35	19.04	17.9	17.52	17.9	18.28	17.9	No Value
18:40	18.28	17.52	17.14	17.52	17.52	17.52	No Value
18:45	17.52	17.14	16.76	16.76	17.14	17.14	No Value
18:50	17.52	17.14	17.14	17.14	17.9	17.9	No Value
18:55	18.28	17.9	17.9	17.9	19.04	18.66	No Value
19:00	18.28	18.28	17.9	18.28	18.66	19.04	No Value
19:05	18.28	18.66	18.66	18.66	19.42	19.42	No Value
19:10	19.04	19.04	19.04	19.04	20.19	19.81	No Value
19:15	18.66	19.04	18.28	19.04	19.42	19.04	No Value
19:20	18.66	19.04	18.28	19.04	19.81	19.42	No Value
19:25	18.66	19.04	18.28	19.04	20.19	19.42	No Value
19:30	18.28	17.9	17.14	17.9	19.42	18.28	No Value
19:35	17.14	16.38	15.62	16.38	17.9	17.14	No Value
19:40	17.14	16.76	16.38	16.76	17.9	17.14	No Value
19:45	17.14	16.38	16	16.38	17.14	16.76	No Value
19:50	17.14	17.14	17.14	17.14	17.52	17.9	No Value
19:55	16.38	16	15.62	16.38	16.38	16.76	No Value
20:00	16.38	16	16	16.38	16	16.76	No Value
20:05	16	15.62	16	16.38	16	17.14	No Value
20:10	16	16	16	16.38	16	17.52	No Value
20:15	16	16	16	16.38	15.62	16.76	No Value
20:20	16	15.62	15.62	16	15.23	16.76	No Value
20:25	16	15.62	15.62	15.62	15.62	17.52	No Value
20:30	16	15.62	16	15.62	16	17.9	No Value

Table 7. Percent dry matter in each fecal sample taken from floors of trailers

Trial 1		Trial 2	
Ventilated	Control	Ventilated	Control
22.66	23.51	25.50	22.83
20.82	23.82	24.88	22.43
22.10	22.88	24.66	21.32
16.59	23.37	25.50	21.18
18.72	23.15	22.02	21.14
15.77		23.36	22.29
15.47		26.22	21.84
18.87		23.18	22.31
		24.42	21.92

Table 8. Individual data from complete blood counts for cattle in the control trailer during Trial 1

Calf ID	Sodium mmol/L	Potassium mmol/L	Chloride mmol/L	CO_2 mmol/L	BUN mg/dl	Creatinine mg/dl	Glucose mg/dl	Calcium mg/dl
36751	148	5.5	103	33	15	1.3	82	10.4
36758	147	4.8	103	27	18	1.5	71	9.9
36761	151	5.4	104	30	18	2.1	75	10.0
58554	151	5.3	103	31	17	1.5	68	9.5
58630	149	5.3	102	31	16	1.5	70	8.7
58662	139	4.5	101	32	15	1.3	77	8.8
58665	147	4.3	99	30	12	1.2	65	9.4
58674	146	4.7	103	31	23	1.1	82	9.9
58685	151	4.4	107	26	21	1.8	107	9.7
58689	149	5.6	104	28	13	1.2	63	8.8
58710	141	5.5	100	33	21	1.3	88	8.8
61569	144	4.2	99	33	19	1.6	76	9.5
61571	145	4.7	98	34	17	2.0	79	9.8
61575	146	5.5	100	31	14	1.4	83	8.4
61585	145	5.0	101	30	23	1.6	91	9.3
61607	146	4.2	100	30	19	1.5	90	9.0
61612	150	5.3	102	29	17	1.5	77	9.7
61613	151	4.2	107	27	13	1.5	102	9.7
61614	147	4.0	106	26	15	1.5	84	9.0
61616	148	5.6	102	25	18	2.0	117	10.0

Table 9. Individual data from complete blood counts for cattle in the ventilated trailer during Trial 1

Calf ID	Sodium mmol/L	Potassium mmol/L	Chloride mmol/L	CO_2 mmol/L	BUN mg/dl	Creatinine mg/dl	Glucose mg/dl	Calcium mg/dl
36768	145	4.5	102	28	16	1.7	97	9.3
36769	147	5.0	102	32	15	1.6	78	9.4
36770	146	4.4	102	33	18	1.7	89	9.1
36772	145	4.8	98	32	17	1.3	93	9.6
36773	141	4.2	99	32	18	1.4	91	9.0
36774	146	4.9	101	32	16	1.3	65	9.4
36777	144	4.6	105	31	9	1.3	99	9.1
58644	142	4.6	101	32	20	1.5	61	9.4
58648	140	4.6	101	30	16	1.3	73	8.8
58696	141	5.0	98	33	21	1.5	89	9.6
58697	145	4.7	104	30	18	1.8	85	9.2
61501	149	4.7	110	28	17	1.9	83	9.9
61505	141	5.8	100	27	17	1.5	128	9.1
61520	146	5.0	101	30	15	1.6	115	9.2
61522	142	4.6	103	27	18	1.6	88	9.4
61524	147	5.1	103	31	20	1.4	92	8.9
61530	147	5.2	100	28	16	1.4	83	9.6
61537	151	4.6	102	33	18	1.3	75	9.3
61547	148	4.8	103	27	14	1.3	89	9.6
61548	144	5.0	100	30	19	1.6	82	9.7
61593	149	4.6	109	29	15	1.3	76	10.1

Table 10. Individual data from complete blood counts for cattle in the control trailer during Trial 2

Calf ID	Sodium mmol/L	Potassium mmol/L	Chloride mmol/L	CO_2 mmol/L	BUN mg/dl	Creatinine mg/dl	Glucose mg/dl	Calcium mg/dl
71945	146	6.3	107	31	19	1.7	71	10.1
71947	148	5.6	102	31	10	1.4	84	9.9
71987	145	5.0	101	31	13	1.3	75	8.9
72015	149	5.0	105	31	15	1.4	79	9.5
72051	146	4.8	101	30	16	1.6	100	9.0
72054	149	6.5	108	29	19	1.8	88	9.8
72061	143	5.2	104	25	X	X	X	X
72091	146	5.2	102	30	20	1.9	87	9.6
72097	146	5.6	105	X	X	X	X	X
99251	151	5.4	108	29	16	1.4	108	9.5
99253	148	5.2	102	31	20	1.5	110	9.9
99260	152	5.9	106	30	20	1.7	81	9.7
99352	148	5.5	101	28	17	1.6	75	9.5
99356	145	4.2	98	29	15	1.6	89	8.5
99376	146	5.4	108	28	18	1.7	63	9.3
99391	150	5.7	108	25	16	1.3	101	9.2
99401	137	4.4	94	33	16	1.7	90	9.0
99402	146	5.1	104	27	23	1.5	77	9.2
99407	149	4.8	104	24	18	1.7	114	9.7

X – No value for this measurement.

Table 11. Individual data from complete blood counts for cattle in the ventilated trailer during Trial 2

Calf ID	Sodium mmol/L	Potassium mmol/L	Chloride mmol/L	CO_2 mmol/L	BUN mg/dl	Creatinine mg/dl	Glucose mg/dl	Calcium mg/dl
71954	147	5.7	102	28	17	2.1	100	9.4
71956	150	6.8	106	31	19	2.1	104	9.7
71957	147	5.5	104	23	19	1.6	108	9.2
71958	149	5.9	104	27	16	1.5	65	8.8
71962	154	5.7	104	24	18	1.7	80	9.2
71974	143	4.7	99	30	19	1.2	72	9.3
72006	148	5.8	103	32	16	1.5	64	9.7
72065	147	5.7	105	28	21	1.8	83	9.7
72066	146	5.6	100	28	20	1.9	89	9.4
72072	148	4.5	103	30	12	1.4	75	10.3
72077	139	4.8	98	27	11	1.4	89	8.8
72074	148	5.3	104	30	22	1.9	106	9.5
72080	146	5.5	101	30	15	1.4	84	9.5
72081	147	6.3	99	28	17	1.5	92	9.5
72086	151	5.4	103	27	13	1.5	77	9.9
99269	147	5.6	106	31	18	1.6	78	9.6
99374	146	5.6	107	30	18	1.5	68	9.2
99375	146	5.9	101	27	18	1.7	69	9.6
99378	149	5.1	109	28	18	1.5	71	9.5
99379	143	6.2	99	29	16	1.1	67	9.2
99392	151	6.6	105	31	22	1.9	65	9.7

Table 12. Individual data from serum electrolyte and basic chemistry panels for cattle in the control trailer during Trial 1

Calf ID	RBC 10^5 cells/ cmm	HGB mmol /L	HCT %	MCV fL	MCH pg	MC HC %	RDW	PLT 10^4 cells/ cmm	MP V fL	PCT ng/ ml	PDW
36751	6.62	11.6	29.4	44.5	17.5	39.4	41.0	365	7.4	0.27	17.5
36758	5.83	10.3	26.9	46.1	17.6	38.2	39.3	89	5.8	0.05	15.4
36761	6.47	11.2	28.7	44.4	17.4	39.1	40.1	48	7.4	0.04	X
58554	5.71	10.4	24.5	43.0	18.3	42.5	40.9	307	7.1	0.22	17.2
58630	5.48	10.3	24.0	43.7	18.7	42.8	41.8	150	5.7	0.09	14.4
58662	X	X	X	X	X	X	X	X	X	X	X
58665	5.41	10.2	23.6	43.6	18.8	43.2	42.2	564	7.3	0.41	16.8
58674	5.59	10.8	24.9	44.6	19.3	43.3	43.6	339	7.1	0.24	17.5
58685	6.44	10.6	29.1	45.2	16.5	36.4	34.6	420	6.7	0.28	17.8
58689	X	X	X	X	X	X	X	X	X	X	X
58710	5.68	10.2	27.2	47.8	18.0	37.6	37.0	692	6.0	0.42	16.2
61569	7.53	12.7	35.4	47.0	16.9	35.8	32.1	225	8.4	0.19	16.5
61571	7.28	13.0	36.4	50.0	17.8	35.7	22.1	383	7.0	0.27	18.1
61575	5.93	9.8	23.4	43.3	18.1	41.7	41.2	211	5.6	0.12	15.6
61585	7.17	12.5	30.9	43.1	17.4	40.3	42.6	475	6.7	0.32	16.2
61607	5.25	9.7	23.6	44.9	18.5	41.2	39.6	469	7.4	0.35	16.9
61612	6.67	12.7	30.3	45.5	19.1	41.9	44.3	292	8.4	0.24	17.2
61613	7.02	12.8	32.0	45.6	18.2	39.9	44.3	207	7.2	0.15	16.6
61614	6.32	10.4	28.5	45.2	16.4	36.3	38.1	167	7.0	0.12	16.6
61616	5.54	11.0	24.3	43.9	19.9	45.4	43.1	321	5.7	0.18	14.7

X – No value for this measurement.

Table 13. Individual data from serum electrolyte and basic chemistry panels for cattle in the ventilated trailer during Trial 1

Calf ID	RBC 10^5 cells/ cmm	HGB mmol /L	HCT %	MCV fL	MCH pg	MCH C %	RDW	PLT 10^4 cells/ cmm	MPV fL	PCT ng/ml	PDW
36768	7.69	13.4	34.1	44.3	17.5	39.4	41.5	461	7.0	0.32	16.0
36769	6.24	12.3	27.5	44.0	19.6	44.5	44.8	189	5.3	0.10	15.3
36770	6.81	12.7	34.4	50.6	18.6	36.8	25.0	380	7.3	0.28	16.0
36772	7.03	12.2	31.3	44.5	17.3	39.0	41.3	194	6.6	0.13	18.0
36773	7.52	12.9	34.9	46.4	17.1	36.9	33.6	201	7.7	0.16	16.3
36774	X	X	X	X	X	X	X	X	X	X	X
36777	6.94	13.0	30.9	44.6	18.8	42.1	45.3	110	5.7	0.06	14.4
58644	5.59	9.7	23.9	42.8	17.4	40.7	41.3	289	5.3	0.15	15.3
58648	5.15	10.9	22.8	44.2	21.1	47.7	43.7	389	5.4	0.21	15.1
58696	6.12	10.4	26.7	43.6	17.0	38.8	39.2	528	6.7	0.35	17.1
58697	5.75	10.2	25.4	44.2	17.7	40.0	41.5	401	5.7	0.23	16.7
61501	7.42	14.0	33.6	45.3	18.8	41.6	43.6	352	5.6	0.20	15.5
61505	7.12	13.2	31.3	44.0	18.5	42.2	44.4	167	8.0	0.13	17.0
61520	6.82	11.8	33.0	48.3	17.3	35.9	33.3	224	8.0	0.18	16.3
61522	X	X	X	X	X	X	X	X	X	X	X
61524	5.94	11.8	26.8	45.1	19.8	44.0	44.3	294	5.7	0.17	15.0
61530	6.81	12.6	30.2	44.3	18.5	41.8	43.7	509	6.9	0.35	17.4
61537	5.35	9.6	23.6	44.1	18.0	40.9	40.6	508	6.1	0.31	18.0
61547	6.78	12.0	30.2	44.5	17.7	39.7	41.6	235	8.0	0.19	16.7
61548	6.58	11.4	29.2	44.3	17.3	39.0	41.4	440	6.1	0.27	17.0
61593	6.24	13.0	27.7	44.4	20.9	47.1	44.0	217	6.1	0.13	15.4

X – No value for this measurement.

Table 14. Individual data from serum electrolyte and basic chemistry panels for cattle in the control trailer during Trial 2

Calf ID	RBC 10^5 cells/ cmm	HGB mmol /L	HCT %	MCV fL	MCH pg	MC HC %	RDW	PLT 10^4 cells/ cmm	MPV fL	PCT ng/ml	PDW
71945	5.50	10.2	24.2	44.1	18.6	42.2	43.5	241	6.3	0.15	15.4
71947	7.16	11.6	31.4	43.9	16.2	37.0	41.1	157	8.8	0.14	18.9
71987	5.96	10.2	26.5	44.5	17.1	38.5	38.2	475	6.6	0.31	17.9
72015	6.79	11.5	31.2	45.9	17.0	36.9	39.6	501	7.6	0.38	16.2
72051	7.53	12.4	32.9	43.7	16.4	37.5	41.9	121	5.8	0.07	15.8
72054	6.30	11.3	28.0	44.5	17.9	40.2	40.8	227	5.6	0.13	15.7
72061	6.62	11.4	28.2	42.6	17.3	40.5	40.7	176	6.8	0.12	17.4
72091	7.09	12.7	31.1	43.8	17.9	40.9	43.1	241	6.6	0.16	17.5
72097	5.85	10.8	26.3	44.9	18.4	40.9	43.3	160	7.4	0.12	17.5
99251	6.86	12.3	30.5	44.5	17.9	40.2	42.9	172	6.2	0.11	15.2
99253	6.04	11.2	26.6	44.1	18.6	42.1	42.3	282	8.4	0.24	18.5
99260	6.58	11.2	28.4	43.2	16.9	39.2	42.4	316	7.9	0.25	17.0
99352	5.31	10.8	23.6	44.5	20.3	45.6	43.2	152	6.1	0.09	15.4
99356	X	10.9	X	X	X	X	42.4	105	6.8	0.07	15.3
99376	5.47	10.3	23.0	42.1	18.8	44.6	40.7	288	7.1	0.21	17.7
99391	5.42	9.5	25.4	47.0	17.6	37.4	30.8	762	6.6	0.51	15.8
99401	5.80	9.8	25.1	43.3	16.8	38.8	40.8	74	5.3	0.04	15.0
99402	5.11	8.4	22.5	43.9	16.3	37.2	X	290	7.8	0.23	16.7
99407	6.36	10.5	28.0	44.0	16.5	37.5	41.8	178	8.7	0.16	17.3

X – No value for this measurement.

Table 15. Individual data from serum electrolyte and basic chemistry panels for cattle in the ventilated trailer during Trial 2

Calf ID	RBC 10^5 cells/ cmm	HGB mmol /L	HCT %	MCV fL	MCH pg	MC HC %	RDW	PLT 10^4 cells/ cmm	MPV fL	PCT ng/ml	PDW
99269	6.75	11.6	28.8	42.7	17.2	40.2	42.0	229	6.5	0.15	16.6
99392	6.16	10.2	26.4	42.9	16.6	38.8	41.3	137	6.3	0.09	15.7
71956	6.93	11.7	32.6	47.0	16.9	36.0	36.9	316	6.4	0.20	16.1
71957	5.92	10.4	25.2	42.6	17.6	41.2	41.6	382	7.4	0.28	17.8
71954	7.81	14.1	36.4	46.7	18.1	38.7	43.5	27	6.1	0.02	12.9
71958	5.66	10.5	24.4	43.2	16.8	43.1	42.2	89	6.3	0.06	15.1
71962	7.14	12.4	33.0	46.2	17.4	37.6	34.9	112	7.1	0.08	16.3
99379	6.06	10.8	26.2	43.3	17.9	41.3	43.5	149	5.5	0.08	15.6
72006	6.08	11.4	26.1	42.9	18.7	43.5	42.3	113	5.6	0.06	14.9
99378	X	X	X	X	X	X	X	X	X	X	X
72074	6.03	10.5	28.0	46.5	17.5	37.6	35.3	64	6.7	0.04	14.3
72077	5.72	9.8	26.3	45.9	17.0	37.1	34.7	531	6.7	0.35	17.5
72086	6.61	12.0	29.1	44.0	18.1	41.1	43.4	309	7.3	0.23	16.9
99374	3.62	6.3	16.5	45.5	17.3	38.0	31.6	585	7.1	0.42	17.3
71974	5.87	10.4	25.8	44.0	17.7	40.3	42.1	93	8.1	0.08	17.0
72072	7.07	13.5	31.6	44.7	19.1	42.6	44.2	352	6.4	0.23	17.5
72080	6.38	11.0	29.9	46.9	17.2	36.8	35.7	257	6.8	0.18	7.0
72066	6.28	11.1	27.6	44.0	17.7	40.3	42.4	424	6.7	0.28	17.7
72081	6.80	11.8	29.9	43.9	17.3	39.4	43.8	157	7.6	0.12	16.9
72065	6.63	10.9	27.8	41.9	16.4	39.0	40.1	305	6.2	0.19	17.4
99375	5.81	10.8	25.8	44.4	18.6	41.9	41.8	158	5.9	0.09	15.4

X – No value for this measurement.

VITA

Nicole Marie Giguere received her Bachelor of Science degree in animal science from Texas A&M University in 2003. She entered the Applied Ethology/Welfare graduate program in September of 2004, and received her Master of Science degree in August of 2006. In the Fall of 2006, Ms. Giguere will be entering the veterinary medicine program at Western University of Health Sciences in Pomona, California.

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