Morbidity and Mortality Rates Based on Stress Levels in Dairy Calves

A Senior Project

presented to

the Faculty of the Dairy Science Department

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

by

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March, 2012

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Abstract

The objective of this project was to determine if increased stress levels could affect morbidity and mortality rates in calves. The source for this study was a group of 132 calves at the Cal Poly Dairy available for observation. For each test day, calves were scored on a scale of 1-3 based on how stressed the calf was. After all the data were collected, relationships between age, sex, breed, and observation day were determined in SAS using a Proc Probit method. The effects of breed and sex were not significant in the analysis. However, one of the observation days (January 17th, 2012) may have been significant, which led me to determine if weather affects the results. When observing the raw data, more calves scored a 2 or 3 on days when the weather changed. Although this method proved to not be very effective when determining stress levels in calves, I was able to pinpoint reasons as to why morbidity and mortality rates may increase on large dairies. Muddy, wet conditions have proven to be the source of increased morbidity because disease-causing bacteria can grow rapidly in these conditions. On days when the calf hutches were surrounded by mud, scores went up. Some practices that could be implemented to improve calf hutch conditions could be regular cleaning and keeping calves in a dry, draft-free area. Calf maintenance is crucial on any dairy to keep animals healthy and prevent economic loss.

Introduction

Morbidity and mortality rates can be a big problem in dairy herds. There are thousands of pathogens in the dairy cow's environment that a newborn calf cannot handle, costing dairymen more money on treatment and labor to keep calves alive. Disease prevention may start with observing stress levels and comparing that to the calf's environment. This could help dairymen determine what factors may decrease immune response as a result of stress. Clear signs of high stress levels in dairy cows are decreased production and fertility, reduced feed intake, increased water intake, standing rather than lying down, increased respiratory rate, increased body temperature, and decreased conception rates. The objective of this project was to determine if increased stress levels could affect morbidity and mortality rates in calves. The visual signs, including standing rather than lying down, were observed in the calves at the Cal Poly dairy. A visual score for each calf was worth exploring because it is a simple way to diagnose an issue. If the visual scores could be implemented, the process could help reduce the amount of sick calves by allowing dairymen to treat calves earlier and faster.

Review of Literature

Calf Diseases

Calves at a young age are very susceptible to disease caused by a variety of different hazards. The vital role of the mammary gland in a dairy cow is to provide local host defense and passive protection to newborns. The calf is born with a functioning immune system and is capable of responding to certain antigenic stimuli, but the system does not yet operate at optimum capacity. In an article titled, "Alteration in Immune Responsiveness during the Peripartum Period and its Ramification on Dairy Cow and Calf Health," it states that passive immunity is highly dependent on mechanisms that allow the transport of antibodies from the blood across the endothelium and into epithelial tissue. The immune status of the peripartum cow has an important influence on calf health. The question of whether the cow has been vaccinated, exposed to infectious disease, has produced protective antibodies or has transported these into the gland determines colostral quality and calf health. (Mallard, 1998)

Failure of passive transfer of immunity (FPT) is also described in the article, "Prevalence of failure of passive transfer of immunity in newborn heifer calves and associated management practices on US dairy operations." (Beam, 2009) "FPT in dairy replacement calves has been linked to increased neonatal morbidity and mortality and long-term decreases in productivity." (Beam, 2009) In the study, both colostrum pooling and nursing were taken into consideration with FPT. Colostrum pooling refers to the practice of collecting colostrum from multiple cows and pooling all of it together to feed all the calves in the herd. Nursing refers to collecting colostrum from the calf's mother and feeding that directly to the calf either by bottle or through an esophageal tube. The

study by Beam (2009) discourages pooling of colostrum because immunoglobulins in the pooled colostrum may be diluted by high volume combined with low immunoglobulin levels. In addition, pooling can increase calf exposure to colostrum-borne pathogens. This also presents a significant relation between colostrum pooling and FPT in calves. Increased risk of FPT is also connected to calves that nurse because the calf may not ingest enough colostrum in a timely fashion. Also, calves allowed to nurse may ingest more bacteria from manure on the teats.

Another article, which describes the importance of dry cow management, states that, "calves born from dams with inadequate protein intake before parturition might be more susceptible to morbidity and mortality." ("Nutrient and Immunity Transfer from Cow to Calf Pre- and Postcalving", Quigley, 1997) Dystocia is another problem with dairy calves postcalving. Dystocia is a condition that has various factors, including size and weight of the calf, sex of calf, and body condition. The article states, "Calves that were born from cows with Dystocia also have a higher rate of mortality and slower rates of birth weight gain. The prepartum diet effects colostrum quality. "When calves were fed colostrum that was obtained from cows that were fed restricted amounts of energy and crude protein, absorption of IgG was reduced by 21.8%." (Quigley, 1997) Dietary restriction, however, has no proven affect on the transfer of passive immunity to calves.

In the article, "Factors affecting susceptibility of calves to disease," (Roy, 1980) the quantity of each class of immunoglobulin (Ig) ingested and the time after birth that ingestion occurs are vital factors in determining the immunological status of the calf. The article states, "As little as 14g Ig administered within 12 hours postpartum will protect the m ajority of calves against a septicemia, but 300 to 400g Ig are required to

ensure complete protection of calves against a heavy challenge of infection with entero-pathogens." The quantity of colostrum is important also, where complete protection normally requires 1.7kg/feed in four feedings over the first 36 to 48 hours of life. The quantity of colostrum has been considered to be of greater importance than the time between birth and the first feeding of colostrum.

Calf Disease Physiology

Many of the published articles compared stress to inadequate consumption of colostrum, which affects absorption of immunoglobulins. Without colostrum, a calf cannot survive. From the article, "Does a calf's motivation to ingest colostrum depend on time since birth, calf vigor, or provision of heat?" (Vasseur et al., 2008) poor colostrum intake is stated as one of the main causes of high morbidity and mortality rates. It also states that a calf's willingness to consume colostrum may be affected by the time since birth and cold stress. Cold temperatures lead to increased calf mortality and an impaired absorption of immunoglobulins from colostrum (Vasseur et al., 2008).

As explained in the article by Arthington, (1999) passive immune protection is achieved by the transport of macromolecules found in colostrum through the intestinal epithelium, which remains permeable for approximately 24 hours after birth. Absorbed Ig is then transferred through the lymphatic system into peripheral circulation. This remains an effective protective mechanism until the specific immune system of the calf matures. Therefore, to ensure adequate protection against disease, calves rely on the consumption of an adequate amount of quality colostrum within a few hours of birth. Factors affecting passive immunity include colostral Ig concentration, colostrum volume, age at which colostrum is consumed, and calf stress. "Low blood Ig concentrations are

directly related to calf morbidity and mortality," according to the article by Arthington (1999). Colostrum may be collected, tested for quality, and stored frozen for later use. This is a common method for successful passive immunity to newborn calves, although the procedure requires careful attention to details to ensure the collection, storage, and delivery of a quality colostral source. Since colostrum quality drops rapidly with subsequent milkings, it is important to collect from the first colostral milking following parturition. In the conclusion of this study, "stress conditions on both the cow and calf may directly impair the ability of calves to acquire adequate passive immune transfer." In the article, "Nutrient and immunity transfer from cow to calf pre- and postcalving," calves that were fed colostrum obtained from cows that were fed restricted amounts of energy and crude protein had reduced absorption of IgG by 21.8%. Colostrum is an excellent source of nutrition for the neonate, providing large amounts of crude protein, energy, vitamins, and minerals for the calf immediately after birth. The serum IgG concentration can provide an indication of the susceptibility of the calf to disease. There is a strong correlation between calf mortality and metabolic or respiratory acidosis. Mild acidosis occurs frequently, but can be problematic if it persists because it affects passive immunity.

In the article, "Nutrient and Immunity Transfer from Cow to Calf Pre- and Postcalving," the effects of ambient temperature decrease colostrum quality. Heat stress can affect colostral composition and Ig content, but has not proven to affect colostrum yield. Total fat, lactose, energy, crude protein, IgG, and IgA were lower than those for heifers maintained in a thermoneutral environment. (Quigley, 1997)

Factors of Calf Health

The physical environment is also considered when observing calf health. The article states, "…in California, increases in calf mortality were associated with cold, wet, and windy weather in winter, and with hot, dry weather in summer," (Roy, 1980). Good management practices, such as feeding 300 to 400g Ig from colostrum to a calf soon after birth, as well as using well ventilated but draft-free buildings could result in lower morbidity and mortality rates on a dairy farm. Enzootic pneumonia of calves is common in winter months (Lago et al., 2006), and is traditionally associated with poorly ventilated housing conditions. However, the requirements for naturally ventilated calf barns are frequently compromised by the need to avoid cold stress for the calves. Most calf barns have sidewall openings that allow wind to force fresh air throughout the building. Operators tend to close these sidewalls and prevent ventilation because of cold weather. Although the relationship between pen bacterial counts and prevalence of respiratory disease was significant in this study, it does not prove a causal relationship. Filtered air was believed to be directly related to reduced incidence of respiratory disease.

In the article, "Effects of chronic environmental cold on growth, health, and select metabolic and immunologic responses of preruminant calves," (Nonnecke, 2009) the author states that a study by Godden et al. (2005) showed that the morbidity rate of calves born in the winter was 52% compared with 13% for calves born in the summer. Also, calf mortality was significantly higher in winter than in summer. This article also discusses a study performed that controlled the environment of 2 groups of calves. One group was maintained in a 35°F wet environment and the other was controlled at 60°F for 49 days. The calves housed in the colder environment grew thicker coats which reduced

the LCT (lower critical temperature). The study concluded that both groups of calves had similar growth rates and immune response was unaffected by cold. Since all the calves were provided adequate nutrition, it is suggested that successful adaptation of dairy calves to sustained cold may be linked to the availability of adequate nutrition. A similar article included the results of a study where calves were contained in controlled environments for 2 weeks. Blood samples were analyzed after the duration of the study and mortality rates were recorded. 12% of the calves in the thermoneutral group died during the experiment period. 20% of the cold-exposed and 19% of heat-exposed calves died during this same time. Necropsies were conducted on the dead calves, which showed that most of them died of bronchopneumonia (Kelley et al., 1982).

In the article, “Precipitation and temperature effects on mortality and lactation parameters of dairy cattle in California,” (Stull et al., 2008) calf mortality rates were compared to monthly average daily temperatures. The study found an increase in death rates for the high and low extremes of temperature in the Hanford, Merced, and Sacramento regions. The results showed that when the average daily temperature fell below 14°C, mortality rates increased. The study suggests that calves may benefit from management practices to lessen cold stress such as providing extra energy in the form of feed and maintaining a dry environment to decrease the moisture content in the calf’s coat. When comparing this article to Vasseur’s (2008), a common statement would be that at extremes in temperature, the mortality of calves may be explained by their less developed immune system and consequently greater susceptibility to diseases (Stull et al., 2008).

Calving management factors stated in the article by Beam (2009) were associated with FPT. The odds of FPT were higher for calves on operations that did not provide a heat source during cold weather.

Another factor of calf mortality is genetics. In the article, “Genetic Analysis of Calf and Heifer Losses in Danish Holstein,” the mortality rate of Jersey heifers was 12.5% up to an age of 180 days. The mortality rate of Holstein heifer calves was 3.23%. (Fuerst-Waltl, 2010) The study indicates that different genes control mortality in the early and late postnatal stages. In a similar study by Hansen (2002), genetic variation for postnatal mortality exists. It also suggests that different genes affect early and late postnatal mortality. (“Genetic Parameters of Postnatal Mortality in Danish Holstein Calves”) Postnatal mortality for males and females had a very high genetic correlation, with direct heritability being highest for males.

Materials and Methods

Animals and Housing

A. Cal Poly Dairy

The Cal Poly Dairy is located in San Luis Obispo, CA near the college campus. The current milking herd consists of approximately 100 registered Holsteins and 100 registered Jersey cows. All the cows at the Cal Poly Dairy are purebred animals. Students operate both the processing plant and the dairy, participating in milking, feeding, calf care, and processing of dairy products. The cows are milked twice daily by students and fed a total mixed ration twice daily.

The cows are housed in freestall barns, consisting of cement walkways and automatic head locks. The cows are separated into two sides, one with Jerseys and the other with Holsteins, and are then separated into different pens based on age.

When calves are born, the cow ID number, date, time, calving ease score, sex, and calf ID number are recorded. The calf is then given a navel dip, vaccinations (TSV2 and E-colizer), and fed colostrum. The calves are required to consume 4 quarts of colostrum within 4 hours of birth, and the quality of the colostrum is recorded. This is done a second time for the next feeding.

When performing behavioral studies, the cows and calves may react differently than other dairies due to constant human interaction. Lots of people visit the dairy on a daily basis, whether it is through a group tour, or just for observation. The facility is very wide open, allowing people to freely explore the different buildings. The University also allows classes to be held at the dairy, so students are constantly involved with the cows, whether it is artificial insemination, milking, or helping provide medicine to calves.

B. Hutches

The calves at the Cal Poly Dairy were housed in individual hutches, spaced approximately six inches apart. During data collection, the hutches were located outside on a dirt lot. The calves were separated into two groups; one group consisted of calves from 1 to 3 weeks of age and the other group consisted of calves from 4 to 9 weeks of age. Among the groups, there were Jerseys and Holsteins, both male and female, and males were kept intact. The bedding inside the hutches consists of straw hay. Calves are fed twice daily and are given milk replacer with a grain mixture and provided clean water.

C. Scoring System

A Calf Response Score was developed to measure stress levels of each calf in the duration of the study. Each calf was observed by walking toward the hutch from 10 feet away, standing directly in front of the hutch, and ranking the initial behavior on a scale of 1 to 3 based on how strong the calf's reaction was. A score of 1 meant that the calf had no reaction to a person walking toward the hutch, and remained calm. A score of 2 indicated that the calf had a slight reaction to a person walking toward the hutch, but eventually calmed down and may have reacted to sudden movements. A score of 3 indicated that the calf had an obvious reaction when approached, including running away, reacting to sudden movements, and showed no signs of calming after the person stood in front of the calf for a minute.

Data Collection

The Calf Response Scores from the Cal Poly Dairy were collected from January 17th until February 7th 2012 weekly for four weeks. Calves housed individually in hutches were involved in the study to avoid group situations. The breed, sex, and identification of

each calf was recorded along with each score that the calf was assigned. Weather data were also collected for each day, showing the high, low, and average temperatures. The conditions of each hutch, including muddy, dry, and wet environments were recorded. Data showing the age of each calf were also obtained at the Cal Poly Dairy. Calves that died from August 2011 to December 2011 were also recorded with the identification number, sire number, dam identification, and the sex of the calf. This information was used to compare morbidity and mortality rates with the scores obtained in the data collection.

Morbidity

The protocol for sick calves at the Cal Poly Dairy involves treating the most common diseases found on dairies. For Scours, 2 scoops of Deliver Scour is mixed with 4 pints of water at the first feeding, 1 scoop at the second feeding, and 1 scoop mixed with milk at the third feeding. If the calf is not eating, 5cc of Excenel IM is given once. If the calf has severe scours and is dehydrated, the treatment stated above is given, and 4 hours later electrolyte formula is mixed with 4 pints of water. To diagnose Pneumonia in calves, the signs include: temperature greater than 103°F, runny nose, panting or heavy breathing pattern, glassy glazed over eyes, and no appetite. If these signs are detected, treatments include 5cc of Excenel, 5cc LA200, or Polyflex for young calves. For older calves, 10cc Polyflex, 3cc Mycotil, or 3cc Nuflor is given. All injections are given in the center of the thigh muscle.

Data Processing

The data were processed in SAS® software using a Proc Probit method of analysis. The dependent variable of Calf Response Score was analyzed as a categorical trait using

a probit model. Independent effects included in the model were observation date, breed, sex, and age of the calf. The age of the calf was analyzed as a three degree polynomial (linear and quadratic effects).

Results and Discussion

The first data collection, performed on January 17th, 2012, resulted in low variation of scores between calves that were observed. Twenty-seven calves were scored, 14 Jerseys and 13 Holsteins. 22 calves received a score of 1 and 5 calves received a score of 2. No calves received a score of 3. Of the 22 calves that received a score of 1, 11 were Jerseys and 11 were Holsteins. Of the 5 calves that scored a 2, 3 were Jerseys and 2 were Holsteins. When observed, 5 calves were laying in the hutch, indicating low amounts of observable stress. The weather data for that day indicates that the high temperature was 16°C, and the low temperature was 0.5°C, with the high average being 16°C and low average being 6.6°C. The general conditions throughout the day were partly cloudy.

The second data collection was performed on January 24th, 2012. The scores were slightly more varied, with 34 calves being observed. Of the group, 19 calves were Jerseys and 15 were Holsteins. Twenty-six calves scored a 1, 6 calves scored a 2, and 2 calves scored a 3. Of the 26 calves that scored a 1, 15 were Jerseys and 11 were Holsteins. Of the 6 calves that scored a 2, 3 were Jerseys and 3 were Holsteins. Of the 2 calves that scored a 3, 1 was a Jersey and 1 was a Holstein. The ground was extremely wet in and around the hutches. The high temperature for that day was 17°C, and the low temperature was 8.3°C. The average high temperature was 16°C and the average low was 6.6°C. The weather data also states that it was partly cloudy throughout the day.

The third data collection was performed on January 31st, 2012, with similar results as the week before. Of the 36 calves observed, 25 scored a 1, 7 scored a 2, and 4 calves scored a 3. On this collection day, the calves were observed in a randomized order. Instead of looking at each calf one at a time down a row, I moved to different hutches in a

random order to determine if the calves responded differently when approached at random instead of being approached after seeing a person standing next to another hutch. The order was determined by shuffling the Calf ID numbers from the previous data collection. Of the 25 calves that scored a 1, 12 were Jerseys and 13 were Holsteins. Of the 7 calves that scored a 2, 3 were Jerseys and 4 were Holsteins. Of the 4 calves that scored a 3, 3 were Jerseys and 1 was a Holstein. The temperature rose to a high of 21°C that day and the low temperature was 7.7°C. The weather conditions were windy throughout the course of the data collection.

The fourth and final data collection was performed on February 7, 2012. Of the 35 calves observed that day, 21 received a score of 1, 11 received a score of 2, and 3 received a score of 3. Of the 21 calves that scored a 1, 10 were Jerseys and 11 were Holsteins. Of the 11 calves that scored a 2, 5 were Jerseys and 6 were Holsteins. Of the 3 calves that scored a 3, 2 were Jerseys and 1 was a Holstein. Calves were also observed in a random order by shuffling the Calf ID numbers of the previous data collection. The weather data for that day shows the high temperature at 18°C, and low at 11°C. It also rained before the data was collected, leaving the hutches extremely muddy.

Table 1 shows the number of calves observed on each collection date. A total of 132 calves were observed during the four-week study. There were 34 Holstein females, 30 Holstein males, 33 Jersey females, and 35 Jersey males observed throughout the study.

Table 1. Number of calves observed by date, breed, and sex					
	Holsteins		Jerseys		
	Females	Males	Females	Males	Total
January 17th 2012	7	6	7	7	27
January 24th 2012	6	9	9	10	34
January 31st 2012	11	7	8	10	36
February 7th 2012	10	8	9	8	35
Total	34	30	33	35	132

Figure 1 shows the percentage of calves that were observed and how many scored a 1, 2, or 3.

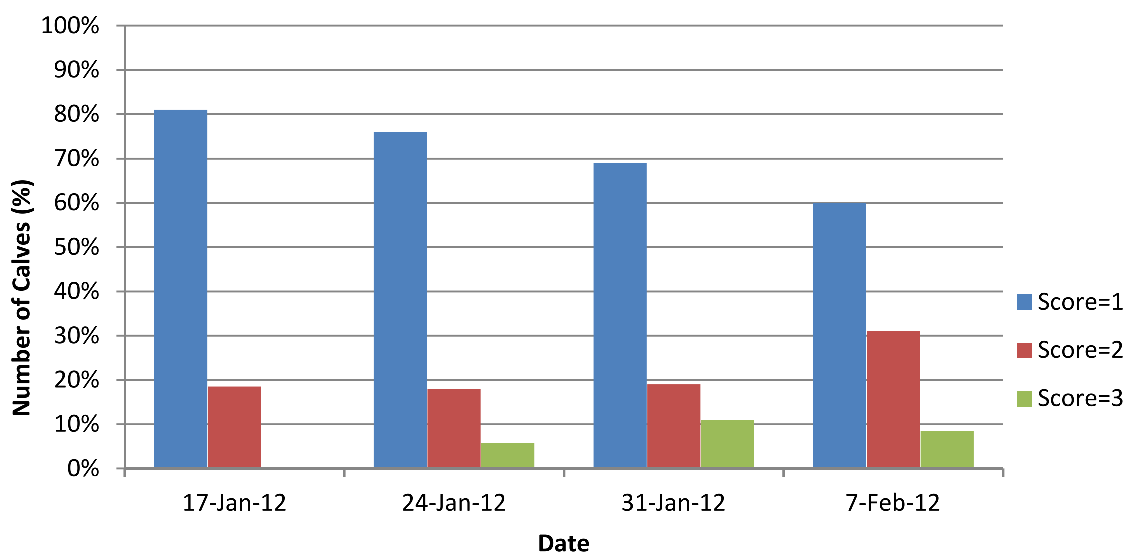

Figure 1. Number of calves as a percentage for each score for the dates of January 17th to February 7th of 2012.

Based on the results of the data collection, it seems that the slight weather change on January 31st and February 7th, which included high winds and slight rain, could have been

the cause of the apparent increase in stress levels. The temperatures were very similar on January 17th and January 24th, making it possible to link weather to stress levels of calves. On February 7th, the calves that were observed were standing in very muddy and wet conditions. In the article, "Precipitation and Temperature Effects on Mortality and Lactation Parameters of Dairy Cattle in California," excessive moisture in the ground or bedding is said to be the cause of various effects on behavior and physiology. "Rainy or wet conditions have been shown to drastically reduce the time dairy cattle spend lying down." (Stull, 2008) If the time lying down was reduced for the calves, it could be associated with higher stress levels from the ground being so muddy. In Stull's article, it states that the heavy rainfall in Southern California in 2005 resulted in a noticeable increase in the number of carcasses picked up from dairies. Some companies had to accumulate the carcasses before processing due to limited capacity of the facility. (2008)

After observing the raw data, it is also possible that the breed of the calves is linked to stress levels. On the first collection, the number of Jerseys and Holsteins that scored a 1 was even. However, more Jerseys scored a 2 than Holsteins. On the second day, more Jerseys scored a 1, but the scores of 2 and 3 were even between the two breeds. On day 3, more Holsteins scored a 1 and 2, but 75% of the calves with a score of 3 were Jerseys. On day 4, similar results appeared with more Holsteins scoring a 1 and 2, but more Jerseys scored a 3 than Holsteins.

The age of the calf is also considered when determining causes of morbidity and mortality rates. Figure 2 shows the calf birth dates, by week, and the average score of those calves throughout the study.

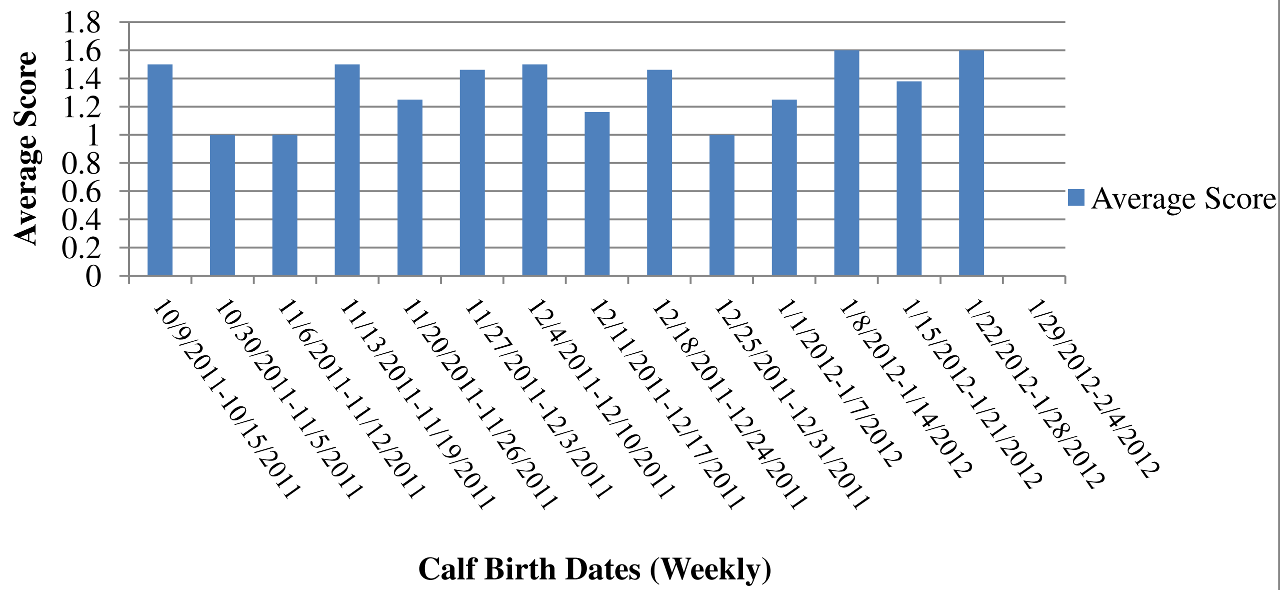

Figure 2: Average Scores Related to Calf's Age

Figure 2 shows no significant difference between the age of the calf and the average score. The scores for older calves may be slightly lower, but the difference is not big enough to prove that age effects stress levels.

Figure 3 shows how many times each calf was observed by observation date. For example, on the first observation date, 27 calves were observed for the first time. On the second observation date, 26 calves were observed for a second time, and 8 calves were observed for the first time. On the third observation date, 21 calves were observed for a third time, 9 calves for a second time, and 6 calves for a first time. On the fourth observation day, 19 calves were observed all four times, 6 calves were observed three times, 5 calves were observed twice, and 5 calves were observed once. This demonstrates the repeated calves in the study, showing that 19 out of the 132 calves were observed on all four observation dates.

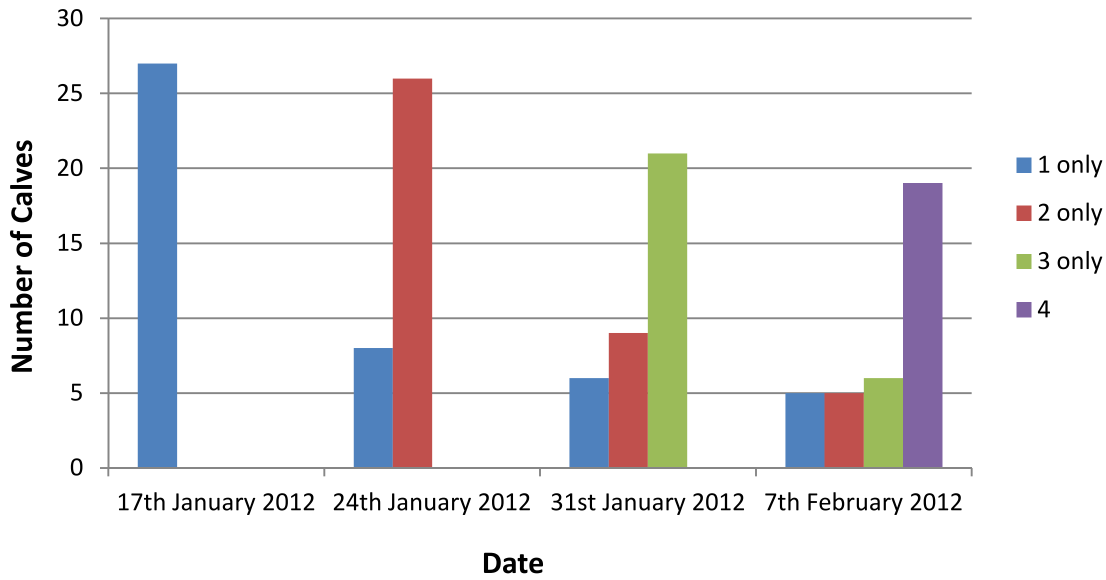

Figure 3. Number of observations per calf per observation date

Table 2. SAS system model information	
Number of Observations Read	132
Number of Observations Used	128
Missing Values	4

Table 3. SAS system response profile	
Score	**Total Frequency**
1	92
2	27
3	9

In the SAS program, there were 132 observations read, 128 observations used, and 4 missing values due to unknown birth dates. In the Response Profile, the total frequency

of scores were 92 for score 1, 27 for score 2, and 9 for score 3. In the Analysis of Effects, the data showed that there were no significant differences between the effects of observation date, breed, and sex. Also, age based on a linear and nonlinear basis was not significant. However, when analyzing the data for each observation date separately, the date of January 17th shows a possible significant difference. This may be caused by the weather for that particular day, or possibly the higher number of calves that scored a 1. The scoring system used in this study proved to be inconclusive when trying to observe stress in calves. Different procedures could potentially improve the use of this scoring system. If the study was performed over a longer period of time, the results may have been different. I think that a 10-week study would have produced better results because the temperatures and possibly even stress levels would have varied more. Also, if the same scoring system was used on different groups of animals on the dairy, it could have shown whether it was useful or not.

Table 4. Number of calves that received treatment prior to observation date

January 17th 2012	6
January 24th 2012	0
January 31st 2012	4
February 7th 2012	1
Total	11

Table 4 shows the number of calves that received treatment during the study. Each date shows how many calves received antibiotics before the observation date. However, when comparing the calves that received treatment, there is no correlation between higher stress level scores and morbidity.

Table 5. Scores of calves that received treatment prior to observation date		
Date	Calf ID	Score
January 17th 2012	10509	1
January 17th 2012	10517	2
January 17th 2012	530	1
January 17th 2012	2536	2
January 17th 2012	10514	1
January 17th 2012	10513	1
January 31st 2012	542	1
January 31st 2012	20445	1
January 31st 2012	2556	2
January 31st 2012	546	1
February 7th 2012	10522	1

Table 5 shows the scores of calves that received treatments. Only 3 calves out of 11 that were treated scored a 2, but none scored a 3. This shows the indirect correlation between the stress level scores and morbidity.

This procedure could produce different results on different dairies for a few reasons. First, the amount of calves in the group is relatively small. With the mean number of calves in each collection being 33 calves, a bigger group could produce more accurate results. Also, because of constant human interaction, bigger dairies may have different results than Cal Poly, where students, professors, and workers are constantly caring for and handling the calves.

Conclusion

In conclusion, the scoring system was not adequate in connecting evidence of stress levels in calves at the Cal Poly dairy to morbidity and mortality rates. The results showed that increased stress levels may have been connected to temperature changes and environmental factors, such as the wet ground or wind. However, stress levels were not connected to the breed, sex, or age of the calves. The scores were also irrelevant to calves that received treatments during the study. As mentioned before, this scoring system would most likely produce very different results on a large commercial dairy because of increased herd sizes and less direct human interaction. Therefore, I believe this scoring system could be improved to be able to study early stages of stress and help large dairies implement better calf management techniques. Observing early stages of stress may help prevent disease and mortality in any dairy herd.

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