Best Management Practices for Raising Dairy Calves from Birth to Weaning

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ABSTRACT

There are many different ways to raise calves on dairy farms in the United States. The way calves are raised can depend on the resources, natural environment and operation of the farm. There is no right or wrong way to raise calves. However, the aim of raising calves is to find the best way to raise a healthy calf so that she will become a productive cow. The objective of this literature review was to determine the ideal management practices for raising a healthy calf from birth to weaning. This literature analyzed numerous articles that covered all aspects of calf management to determine the best practices for raising a dairy calf from birth to weaning. Raising calves can be a difficult task for someone who does not understand the different elements that compose calf management. Articles were reviewed analyzing the best practices for post-partum protocols and colostrum management. Followed by the analysis of environment, water, liquid and dry nutrition, weaning, diseases, vaccinations and dehorning methods. The analysis in this literature review was to determine the best management practices for calves from birth to weaning, especially on dairy farms in California. Following the determination of the best management practices for raising dairy calves, a series of case studies were conducted to determine how farms in California raise their calves. Since California was the main focus for the literature review, the dairies analyzed in the case studies were dairies in the Central Valley. The case studies were brief and only basic questions were asked to determine the vaccination, colostrum, environment, nutrition and weaning protocols. A calf death loss was also provided for the evaluation of productivity and success.

Keywords: dairy calves, nutrition, calf management

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INTRODUCTION

Raising calves on most dairy farms in the United States is a very important, detailed and expensive task. Having a successful calf raising operation is not only important financially, but also important for the future of the herd. Many farms calf-raising operations depend on the resources, natural environment and overall management of the farm. With all the minor and major details that go into raising calves it is difficult to determine the ideal way to raise calves.

In recent years, farmers have questioned what the best management practices are for raising dairy calves. With research, it has been proven that providing a calf with a healthy life can to lead to a successful and productive life once entering the milking herd. Therefore, figuring out the best way to raise calves in each aspect of their life is crucial. Many studies have been conducted throughout the years to define the best practices for all aspect of a calf's life. Due to the high cost of raising calves, it is important that farmers find the most efficient way to ensure that it is in a financially beneficial in the long run. Deciding that right practices for the cow and the calf immediately after birth, the proper nutrition for the young calf and the best way to keep the calf happy and healthy are all very difficult decisions without research.

The objective of this literature review was to determine the best management practices for raising dairy calves starting from birth. Simple steps were suggested for when calves are first born, followed by a breakdown of colostrum and colostrum management. Housing and environment options were also evaluated to ensure the calf is comfortable and healthy. Pre-weaning nutrition, diseases and vaccinations are also discussed to determine the best way to maintain and sustain a healthy calf.

LITERATURE REVIEW

Neonatal Calf Care: Immediately Post-Partum

It is estimated that 75% of perinatal mortality happens within the first hour post-partum (Nagy, 2009). Therefore, immediately after the calf is born there are a few critical tasks that must take place. First, assess the vital signs of the calf to ensure it is alive. Check its breathing, heart rate and movement. This movement does not have to be much, but enough to show that the calf is functioning. Second, in order to get the calf's air passageway cleared and flowing through the nasal receptors use straw or a finger. Then, suspend the calf upside down for a few seconds to stimulate postural drainage of pulmonary fluids. It also helps with the stimulation of pulmonary gas exchange and acid-base balance to prepare the rumen for immunoglobulin absorption (Mee, 2008). However, do not suspend the calf by the rear legs for a lengthy period of time or swing and shake them around by their rear legs. Swinging and shaking the calf can be unsafe for both the calf and the handler. Finally, place the calf in the sternal recumbency position. Sternal recumbency helps maximize a patent airway by allowing expansion of the lungs. Studies show that proper body positioning of calves can have a positive impact on the calf's ventilation and respiratory system (Nagy, 2009). Figures 1 and 2 exhibit the proper full body positioning of the calf in the sternal recumbency position. Note the positioning of the legs, and particularly the upright positioning of the calf's sternum.

Figure 1. Example of the sternal recumbency position from the side view.

Figure 2. Example of the sternal recumbency position from the front view.

Cow and Calf Separation

On most North American dairy farms, calves are separated from their mothers within hours of being born. However, natural conditions suggest that calves are to stay close by their mothers until two weeks of age, and slowly distance themselves until being

completely weaned at six to eight months of age. Many reasons such as economics, health and compassion support early separation of the cow and calf. With early separation the calf's colostrum consumption, milk and solid food intake and health can be more easily monitored. Early separation is less distressing on both the cow and calf, and minimizes the amount of bondage between the two. Although some bonding can occur within the first five minutes of life, the bond only gets stronger the longer the cow and calf are together. On the contrary, there are also potentially negative social effects on the calf when separated at an early stage. This is especially true when calves are housed individually because they spend much time alone with little to no interaction with other calves. Overall, evidence supports separation of the cow and calf just hours after parturition.

A study by Flower and Weary (2001) was conducted to support early separation of the cow and calf within 24 hours of parturition. 24 Holstein cows and their calves were used to conduct the study. Early separation was considered when the calf was removed from its mother within 24 hours post-partum. Late separation was when the calf was removed from its mother after two weeks. After separation calves were housed alone, but could see neighboring calves for socialization. They were bucket fed milk replacer at 5% of their body weight twice daily, and had calf starter and hay ad libitum. An analysis was done to measure the amount of stress that took place on the cow and calf after separation. The analysis measured the number of times the cow and calf called, placed their heads outside of the pen and tracked their movement by observation. For cows, daily milk yields were measured and analyzed in the parlor from days four to 150. For calves, body weights were also measured for average daily gain analysis on day 14 and 28. Lastly, a

social behavior test was conducted on nine random calves from both separation groups at six weeks old (Flower and Weary, 2001).

The results showed that immediately after separation both groups of cows called, moved and stuck their heads outside of their pens more frequently. During hours 18 and 24, late separation cows called and moved at considerably higher rates compared to those of the early separation group. The amount of time that the cow spent standing peaked at zero and 18 hours post-separation, but the late separation cows stayed standing significantly longer at 24 hours. The daily milk yields showed a higher average in the early separation group by approximately 41% in four to 14 days in milk. The following 135 days showed the late separation group had a higher average by approximately 1%. Overall the milk yield difference was a total 574% increase within the first 14 days for the early separation cows, and a total 135% increase within the last 135 days for the late separation cows. This came out to a total increase of 439% that the early separation cows had over the late separation cows (Flower and Weary, 2011).

The late separation calves called at higher rates than the early separation calves at 18 and 24 hours post-separation. There was no significant difference in the calves sticking their heads outside of the pens for either group. Calves in both groups stuck their head out of their pens frequently with an activity peak at 18 hours. Late separation calves spent a significantly longer amount of time standing within the first hour of being separated. At 14 days the late separation calves weighed approximately 21% more then the early separation calves. At 28 days the weight advantage of the late separation calves was still maintained, but only by roughly 19%. The weight advantage was extremely significant, but the analysis stopped at 28 days causing a potential skew for a later calf

weight. Lastly, the social behavior test showed most of the calves in the late separation group socialized more frequently than the early separation calves (Flower and Weary, 2011).

When analyzing all of the findings, it is clear that for the most economical and least stressful route for both the cow and the calf is to separate them within 24 hours post-partum. For the cow, early separation showed less stress within the first 24 hours of separation, and an overall higher milk yield throughout her lactation. For the calf, the early separation group results showed a significantly lower amount of stress within the first 24 hours of separation, but an overall lower weight gain by 28 days old. Because body weights stopped being taken at 28 days old, it is unclear if the weight differential would stay consistent or not. A suggestion for future research would be to measure calf weights until breeding age, which would indicate the probable age at first calving. In closing, it is in the cow and producers best benefit to separate the cow and the calf within 24 hours post-partum.

Naval Antisepsis

Antisepsis of the calf's naval, or umbilicus, is an extremely important protocol that should occur immediately after the calf is born. An exposed naval is a major passage way for a plethora of bacteria and harmful pathogens to enter the calf's body. To prevent naval ill, or infection through the naval, it is best to keep the maternity pen clean, reduce the time the calf is in an unhygienic area, ensure intake of quality colostrum and naval antisepsis (Lorenz et al., 2011). An untreated naval can lead to infection, illness and reduced growth factors. There are many benefits that come from naval antisepsis including, but not limited to, preventing mycoplasma and respiratory diseases resulting in

a lower calf morbidity and mortality rate. With each passing minute that the naval is exposed the calf has an increased risk of naval ill (Mee, 2008). Proper naval antisepsis has been shown to reduce the calf death loss in half. The best practices are to dip the naval into a clean vessel containing fresh iodine for disinfecting both the internal and external surface of the umbilicus (Gorden and Plummer, 2010). When treating a naval using a mild antisepsis helps clean the area and dry up the naval. Using a strong antisepsis may cause over drying, irritation and inflammation of the naval and surrounding areas (Nagy, 2009).

Colostrum

Proper colostrum management is one of the most crucial aspects of a calf's life, but can also be one of the most neglected. Calves are born agammaglobulinemic, meaning they are born with little to no antibodies, and an immature immune system. Full maturity of the calf's immune system does not occur until five to eight months of age. There is a lack of immune system making them more susceptible to harmful pathogens and diseases. In order to develop their immune system they must obtain antibodies which they ingest through colostrum, and then absorb the immunoglobulins across the small intestine. Colostral protein absorption occurs in the epithelial cells that line the digestive tract, which is called pinocytosis (Lorenz et al., 2011). This process of absorbing immunoglobulins is called passive transfer. Optimal passive transfer occurs within the first four hours post-partum and gradually declines until hour 24 when it stops. Feeding calves colostrum throughout the first 24 hours is ideal to ensure they receive as many immunoglobulins as their gut will absorb. Effective passive transfer has proven to lower mortality rates in neonatal and pre-weaned calves. Having successful passive transfer can

also reduce mortality in the post-weaning periods, increase the rate of gain complemented by reduced age at first calving and improving the first and second lactation production (Godden, 2008).

Colostrum is made up of many elements that are beneficial to the immediate health of the neonatal calf including, but not limited to immunoglobulins, nutrients, cytokines and growth factors. Immunoglobulins play the most crucial role in the complete development of the calf's immune system (Conneely, 2013). There are three main classes of immunoglobulins present in colostrum. "IgG, IgA and IgM accounting for approximately 85% to 90%, 5%, and 7%, respectively" (Godden, 2008). "…The relationship between IgG concentrations and calf health is best understood; thus, the concentration of IgG in colostrum is considered the hallmark of evaluating colostrum quality" (Conneely, 2013). Nutrients are the second benchmark and most important element of colostrum. Crude fat and casein are at significantly higher levels in colostrum increasing the energy content which is critical in thermogenesis, or heating of the body. The exact cytokines and growth factors in colostrum are present and important, but not completely understood or measured. Bacteria are also present in colostrum adding contamination and potential immunoglobulin absorption blockage. In order to minimize the amount of bacteria and increase the quality it is best to pasteurize the colostrum. Pasteurization of colostrum increases the IgG absorption levels in calves resulting in a higher effectiveness of the colostrum. The best pasteurization protocols for colostrum is a low temperature long time approach at 140°F for 60 minutes (Godden, 2008). If colostrum is going to be batch pasteurized, it is best to maintain the optimal quality of the colostrum.

All of the colostrum being harvested may not be used right away; therefore it is best to store the colostrum for future use. All high quality colostrum should be frozen or refrigerated for future use. When in a clean covered container, colostrum can be refrigerated for up to a week and frozen for up to a year, assuming it does not get reheated. However, when refrigerating colostrum there is potential for high concentrations of bacteria to accumulate within the first two days. It is best to freeze colostrum until further use to minimize that bacteria counts stay low. Storing colostrum in cold environments decreases the survivability of pathogens and the possibility of pathogenic incubation (Stull and Reynolds, 2008). When thawing colostrum, avoid temperatures greater than 140°F to ensure colostrum does not overheat. If temperatures rise above 140°F denaturing of the immunoglobulins can occur decreasing the optimal quality and absorption of antibodies (Godden, 2008).

A calf must obtain an adequate and sufficient amount of immunoglobulins, and its open gut must successfully absorb the molecules in order to achieve successful passive transfer. A sufficient amount of immunoglobulins would be greater than 50g/L of colostrum. At this level, colostrum would be considered high quality and the best colostrum for the calf. In order to find the quality of the colostrum it is best to use a colostrometer, which is cow-side colostrum testing method. The colostrometer uses gravity to estimate the IgG and solids concentration in the colostrum. The test can differentiate from high to low quality colostrum in just a few second. Temperature can affect the colostrometer reading; therefore, it is suggested to test all colostrum at a consistent temperature for the most accurate reading (Godden, 2008). After the test is done, colostrum that is detected as low quality should be fed to bull calves or thrown

away. Also, any colostrum that looks bloody or has a tint of pink should be thrown away immediately as it is high in red blood cells. Colostrum high in red blood cells has the potential to cause diarrhea due its makeup of gram-negative bacteria (Lorenz et al., 2011).

Attaining adequate consumption of high quality colostrum in a timely manner is considered the most important colostrum management factor to ensure the survival of the calf and success of the future cow. During the calving process the calf is under stress due to the release of corticosteroids, therefore her immune system suffers making it vital for the calf to consume good quality colostrum as soon as possible (Lorenz et al., 2011). The amount of high quality colostrum that should be fed to a calf is approximately 10% to 12% of their birth weight; therefore a 90-pound calf would be fed 4L at zero hours. At 12 and 24 hours calves should be fed 2L of colostrum for a total of 8L of colostrum in the first 24 hours, or the equivalent depending on their body weight. It is best to hand feed the calf instead of letting her suckle from the dam. Failure of passive transfer has proven to be higher in calves that were left to suckle from the dam (Stull and Reynolds, 2008). Hand feeding provides the exact measures of colostrum that the calf has consumed. In order for the esophageal groove reflex to properly trigger and absorb the molecules, it is suggested to nipple bottle-feed the calf versus esophageal tube feeding. Because there is a known amount of colostrum that the calf should be fed, it is best nipple bottle-feed as much of the bottle as the calf will drink (Godden, 2008). Esophageal tube feeding should only occur if the calf does not finish her bottle or does not want to suckle at all. It may be a faster way to feed the calf, but it can lead to an upset stomach and improper absorption of nutrients. Nipple feeding also acquaints the calf with a bottle from the start minimizing

any future teaching that may be necessary if the calf does not take to the bottle when being fed milk.

Housing and Environment

Within the first 24 hours of life calves should be removed from the mother and housed alone in a clean, dry and warm environment where they can adapt the outside world. Once the calf is moved from its mother, studies have shown that calves experience dramatic temperatures changes due to the change in their environment. If calves are immediately removed from their mother's post-partum, studies have shown that infrared heaters for the first 24 hours of life can reduce the dramatic change in temperature. The infrared heaters seemed to have a benefit on the calf's overall health and adaptation to the new environment. The calves under heaters also spent less energy trying to stay warm, and more energy improving and developing their respiratory and digestive systems (Nagy, 2009).

Having a sustainable housing environment for the calf is beneficial to their thermal, physical and behavioral comfort. Being in a stressful environment can cause predisposition of the calf's health comprising their immune system and affecting their growth rates. Unsafe and frustrating environments can cause stress on the calf resulting in a negative impact on their immune system. Calves should also be housed individually to minimize the spread of diseases and reduce pathogen transmission. Isolated housing provides easier observation for the calf feeder to maintain the health and provide any necessary medical attention for each individual calf (Stull and Reynolds, 2008). Group housing is an option, and may be used when necessary. However, group housing often

leads to cross contamination. Cross contamination is a major factor in spreading diseases from calf to calf, and makes it difficult to get rid of the bacteria throughout the herd.

The most common and ideal form of individual housing is a calf hutch with a perimeter fence. Calf hutches are four-sided fiberglass structures with an opening on one side that leads to the outside into the perimeter fence. Hutches should be placed on surfaces that provide both ample drainage and ventilation. Hutches with perimeter fences give the calf the option to be inside or outside depending on the weather. The perimeter fence also blocks cross contamination between calves because it is more difficult for them to access each other. The fiberglass hutch and perimeter fence detach from each other making them easy to relocate. It is also very simple to sanitize and wash the hutches because they can easily be maneuvered.

Another common form of individual housing is a wooden hutch. Wooden hutches are usually built directly next to each other usually in groups of three or four. These wooden hutches are usually elevated above a flush system with a wooden slatted floor for the removal of waste products. Wooden hutches also take up less space due to their smaller structure making it a space safer on smaller farms. The discretion against wooden hutches, however, is that cross contamination is more accessible, and there is less room for the calf to move around potentially creating joint issues. There is usually no bedding causing a draft and creating a less comfortable environment for the calf. Wooden hutches are also difficult to relocate because of how heavy they are. The porous nature of wooden hutches also makes it difficult to sanitize.

The most important benefit to a sustainable environment is thermal comfort. Thermal comfort ensures that the calf is kept at a temperature that is neither too cold nor

too hot, especially during times of weather of intensity. Thermalneutral zone is the optimal temperature ranging from 59°F to 77°F for calves up to three weeks of age. After three weeks of age, calves are more competent to withstand temperatures as low as of 41°F (Drackley, 2008). If temperatures reach below thermalneutral zone the calf must divert energy to maintain the optimal body temperature (Stull and Reynolds, 2008).

Physical comfort is the second most important aspect of the calf's environment focusing on the quality and conditions of the space available. The open space should be approximately 32 square feet of space for calves to be able to exercise and move around their pen at their leisure. Calves spend much of their time lying down especially at younger ages, therefore, the dryness and cleanliness of their resting area is important. Straw, sand or shavings should be added to the inside of the hutch as bedding for the comfort of the calf. During the colder winter months, housing deeply bedded in straw and shavings are the best to maintain warmth within the hutch. During the warmer summer months sand bedding can be used to cool calves (Drackley, 2008). Sand can also be beneficial to their health due to its organic composition, which reduces the spread of bacteria if properly maintained and cleaned. Regardless of the season or the bedding, wet or soiled bedding should be removed and replaced with clean bedding once or twice weekly. Even more frequently during the rainy season (Stull and Reynolds, 2008). Keeping the hutches away from muddy areas during the rainy season will also help with minimizing how wet the bedding gets resulting in lower cold stress on the calf.

Behavioral comfort is the last key quality in sustaining the environment in which a calf is housed. Feed and water should be easily accessible for the calf to minimize any frustrating situations. Ensuring the safety of the calf will also help with preventing

negative behavior. It is also beneficial for the caretaker to provide personal interaction with the calf to provide future social assistances for the forthcoming herd interactions (Stull and Reynolds, 2008). When the caretaker knows the general personality of each calf they can also more easily detect the first signs of a calf being sick.

A study done by Hill et al. (2011) was conducted to compare the best housing, bedding and cooling options for calves. The study showed proof that calves housed in a nursery type setting inside of hutches had a greater average daily gain of about 4% compared to those calves in hutches outside. Calves bedded with straw also showed a greater average daily gain of 11% versus calves bedded with sand. Straw bedding also maintained a greater dry matter content of about 81%. The calves bedded with sand seemed to get colder at night making it more difficult for them to get comfortable and curl up to sleep. These calves also showed more scours and required more medical attention when compared to calves bedded on rice hulls, shavings or straw. One negative about straw bedding is the fly population especially in the warmer weather. Flies can carry and spread diseases, which is something to keep in mind when straw bedding is used, especially during a chronic outbreak. Calves that were in the nursery and cooled with fans had a 23% average daily gain and 20% greater feed efficiency than those not cooled with fans during the warmer weather. The temperature that fans are turned on in the nursery was not specified for this study (Hill et al., 2011).

It is best to have calves individually housed to decrease any cross contamination no matter what kind of hutch or nursery pen is constructed. From the study done by Hill et al. (2011), it seems that the best route, if possible, is to house calves inside of a nursery setting. Natural ventilation is key to decreasing the stagnant moisture in the air. This can

be accomplished by having a ridge vent on the roof and doors on two sides that go up and down, or openings on at least two sides to allow proper airflow. Having calves in a nursery setting is beneficial in sustaining the environment for the calves during both the summer and winter months. An example of this is in the California Central Valley where it gets an average 100°F or more on a regular summer day it is beneficial for the calves to be cooled. It increases their average daily gain and the overall comfort of their environment. During the winter month's calves inside of a nursery setting get less draft, especially in a barn that has doors on two sides. Pens should be bedded with straw during the winter months to ensure warmth and comfort for the calf. During the summer months when it is warmer and the straw attracts more flies, rice hulls or shavings would be sustainable enough for bedding. They both attract a lower population of flies, are easily maintained and can be warmer then sand in the evenings, but cooler then straw during the day. Maintaining adequate thermalneutral is key in a calf's life so they can continue to grow and stay health (Hill et al., 2011).

Water

The most critical nutrient for calves is water, which is often overlooked on many dairy farms. Calves are required to consume additional water beyond what is already consumed in their liquid diet. There is so much in the calf's life that is affected by the amount of water consumed. For example, the amount starter intake is dependent on the calf's water consumption. Water also helps cleanse the calf internally and continue to help develop the rumen and digestive system. With that being said, the best water management practice for calves is an ad libitum supply of water. Whether a calf is given water through a nipple or open bucket does not affect the total water consumption.

However, calves given water through a nipple received smaller portions compared to portions given through an open bucket. Calves from three to eight weeks of age consume an average 2L of water daily. During weaning the water consumption increases from 2L and continues to increase until just after weaning (Huuskonen et al., 2011).

In cold climates where water may freeze, it is suggested that at minimum calves should have warm water available immediately after each feeding and once midday. It is best to separate the water and dry feed containers physically to decrease the amount of wasted dry feed from calf slop (Drackley, 2008). A study done by Huuskonen et al. (2011) measured the difference of water temperature and how it effects the calf's consumption. The water temperatures were warmer water at 60 to 64°F and the colder water at 42 to 46°F. It was hypothesized that warmer drinking water temperatures would increase the water intake, which subsequently affects the feed intake improving the average daily gain. This hypothesis was correct proving that calves given warmer drinking water consumed 47% more water then that of the calves given colder water. Water during both treatment groups increased during weaning, and calves given warm water drank 8% more post-weaning. Much question arose from this study regarding calves getting sick from the cold water, but this did not seem to be the case. No evidence supported the consumption of cold water being a health risk for the calves. The temperature of the outside environment was also not recorded adding a potential skew to the results found in the study (Huuskonen et al., 2011).

Liquid Diet Nutrition

Calves require nutrients for basic functions such as maintenance, growth and energy. These nutrients keep the calf alive, maintain their body temperature, and sustain

their immune system during infectious challenges that may be stress induced. Growth and energy are accumulated of new body tissue in the skeletal and muscular systems. Tissue growth occurs through protein deposition in the bones and phospholipid fat in the tissues. Triacylglycerol is deposited in the adipose tissues for energy (Drackley, 2008). The best nutrition management in calves maintains a body condition score between 2.5 and 3.75 (Stull and Reynolds, 2008).

The National Research Council has founded energy requirements for metabolizable energy (ME) in calves. ME is calculated by subtracting the fecal energy loss, digestive gasses and urine from the total feed intake energy. The maintenance requirements for calves weighing 45kg, the ME should be 325g of milk solids; therefore the intake would be 2.5L of whole milk. Seeing as milk replacers are a lower content then whole milk calves require 3.0L of milk replacer. On many farms the exact ME content is unknown, therefore it can be estimated by nutrient composition. Whole milk ME requirements would be equivalent 93% gross energy and milk replacers would be 90% (Drackley, 2008).

Protein is required for both maintenance and growth through the source of amino acids. The protein requirements for a calf, according to the NRC (2001), are approximately 30g per day for a 45kg calf, and are determined by the rate of growth. Crude protein is required on a dry matter basis and must increase as the rate of gain increases. Although crude protein is minimal in the maintenance requirements, is it necessary up to approximately 26% of the dry matter intake. After 26% the influence that the crude protein has on the maintenance and growth plateaus. Any excess nutrients, or milk solids other then crude protein, consumed above the maintenance requirements will

be utilized for growth. In order for calves to grow faster they must be fed more milk; greater milk intake receives a response of a greater average daily weight gain. On the contrary, calves fed "accelerated growth" diets often cannot utilize the excessive proteins because the necessary energy required to metabolize the nutrients is limited. Therefore, excess protein and nutrients is degraded and nitrogen is excreted in the urine (Drackley, 2008).

Figuring out the right choice of liquid feed for calves is often difficult. Whole milk is considered to be the nature's most perfect food and the most significant source of nutrients for the calf. Whole milk, however, lacks iron and potentially manganese and selenium, which differ from herd to herd depending on herd counts. Milk replacer nutrients are similar to that of whole milk minimizing the amount of potential nutrient deficiencies. Though, starters do supplement most minerals and fat-soluble vitamins depleting those potential deficiencies. It has been proven that the nutrient intake from milk versus milk replacers increased the milk yield during the heifer's first lactation by 10.3%. Milk replacer does not have the biological factors that are active in promoting growth of the young calf and future cow which is assumed to be a major factor in the increased milk yield (Soberon et al., 2012). Waste milk has also proven to reduce respiratory diseases when compared to a milk replacer of 20% protein and 20% fat. There are other sources of milk replacer that can provide a more adequate diet to also reduce respiratory disease. On many North American dairies, a 20% protein and 20% fat milk replacer is often used in comparison to whole milk because it is the type of milk replacer that is most similar to whole milk (Gorden and Plummer, 2010).

Salable whole milk has a high value to the farmer making it more expensive to feed to calves. On the other hand, waste milk, milk that cannot be sold for human consumption, is often fed on most dairies in North America because of the substantially lower cost to the farm. Waste milk often comes from the hospital pen where fresh cows, mastitis cows and cows on antibiotics get milked. Waste milk can be fed either pasteurized or non-pasteurized. With non-pasteurized waste milk there is a risk of ingesting potential pathogens such as mycoplasma mastitis and the bacteria causing Johne's. It is strongly discouraged by the industry and many veterinarians to feed non-pasteurized whole milk to calves, especially hospital milk. Pasteurization of waste milk inactivates causative bacteria and has proven to increase growth rates compared to non-pasteurized waste milk. Many operations fear the cost and size of a pasteurizer may be too expensive, but this is not the case. It is often assumed that pasteurizers are also difficult to operate for the management team. The cost of the pasteurizer makes it well worth the decrease in causative bacteria and the increased growth in calves. Figure 3 shows the size of a 10-gallon pasteurizer, and the control system at the top.

Figure 3. Cal Poly Dairy's 10 gallon pasteurizer.

Milk replacers are also an outstanding source of liquid feed for calves at a substantially lower cost to the producer compared to salable milk. It is less expensive per unit of nutrients, but is more expensive then waste milk. Some farms may have a supply issue when it comes to waste milk making it an advantage to feed milk replacers. If the waste milk supply is consistent it is the best practices to feed pasteurized waste milk to the calves. Consistency is key to calves diets because it decreases the chances of digestive problems that may arise (Drackley, 2008).

The amount of milk fed to calves in North America is typically 1.0% to 1.5% of their birth weight in solids and starter if offered ad libitum right away. An ad libitum milk intake would be approximately 2.0% to 2.5% of the body weight in solids per day.

Restricting the amount of milk has been known to stimulate an earlier intake of starter which results in a lower input cost on a high-value feed. The best feeding practices for the calf and for the cost to the producer is to feed 1.5% of the calves birth weight in solids during the first week of life per day, and increase to 2.0% of the body weight in solids until the week before weaning. According to the NRC feeding approximately a total of 15% of the calf's body weight per day is sufficient enough allowing calves to grow at 50% of their capacity (NRC, 2001). Feeding 15% of body weight is biologically the most near-normal intake for the young calf. Calves should be fed twice daily when being fed 15% of their body weight. If fed once daily the calf's abomasum is at risk for overload, which can cause potential digestive problems Lorenz et al., 2011)

Restricted feeding has proven to encourage early intake of starter concentrations in calves at about three weeks of age. Although the starter intake is delayed, the calves grow at the same rate once the liquid is cut back. Improving this nutrition during the first two or three weeks of the calf's life could increase the age at weaning, improve immune system, increase the age at breeding and increase future milk production (Drackley, 2008). When the calves begin consuming a greater amount of starter concentrations they also begin to grow more rapidly. Because the starter concentration intake increases and the calf begins growing more rapidly it has shown no negative impact on decreasing the amount of milk fed to calves to approximately 10% of their body weight (Lorenz et al., 2011). This is beneficial to the continuous development of the calf's digestive system, and the economic impact the cost of liquid feed has on the dairy.

It is suggested that during the colder weather the amount of nutrients must increase in order for the calf to continue to grow. During the cold months calves use the

ME to stay warm and maintain maintenance. There are many suggestions on how to increase the nutrients during the colder months; the first is to increase the volume of milk at each feeding. Increasing the volume will allow the calf to consume more at each feeding offering the necessary amount of nutrients to hold her over until the next feeding. The second suggestion is offering a third feeding. Although this may be labor intensive, it will provide the necessary energy that a calf may need to make it throughout the day without such a larger timespan between feedings. It also creates less stress on the calf in the hours just before the next feeding because she will not be as low on nutrients. The third suggestion is switching to a higher fat content milk replacer. The higher fat content provides energy for the calf's maintenance without gut overload. Lastly, adding additional total milk solids to each feeding. The increase in milk solids will provide extra energy to the calf, which will be utilized when battling cold stress or potential illnesses (Stull and Reynolds, 2008). However, with the increase in total milk solids provided in the liquid diet, a secondary requirement is to provide ad libitum water because the liquid intake decreases with the increase in solids (Drackley, 2008).

Dry Feed Nutrition

Dry feed availability is important for rumen development and growth in young dairy calves. During rumen development the microbial population and absorptive compartments begin to properly function. The benefit of dry feed is the fermentation of volatile fatty acids, which is necessary to promoting growth and ruminal digestibility (Drackley, 2008). Encouraging consumption of starter at a young age is important in stimulating rumen development. It also helps prepare the calf's digestive system for the transition from a liquid diet to a dry diet during the weaning period. Consuming dry feed

prior to weaning also helps minimizes nutritional stress during that time. A lower intake of dry feed, or starter, prior to weaning may restrict the rumen development and nutrient intake creating problems in the ruminal digestibility and difficulty for the calf during the weaning transition (Stamey et al., 2012). In order for a calf to be weaned it is necessary for them to have a fully functional rumen to maintain digestion and remain healthy. To sustain rumen development calves should be fed a textured starter. A textured starter has proven to be consumed more by young calves resulting in earlier weaning and greater average daily gain before weaning (Stull and Reynolds, 2008). Calves can often times be weaned at a younger age if they can consume a consistent 1kg of starter per day as long as the starter is palatable (Lorenz et al., 2011).

Crude protein is a major factor in deciding which starter should be fed to calves. Often times there are many misconceptions that feeding enhanced growth liquid diets will increase the calf's average daily gain to prepare the calf for an early age at weaning, however, this is not the case. Calves need a sustainable liquid and dry feed diet in order for their rumen to properly develop making the age at weaning younger with a proper growth rate. A sustainable and effective dry feed is one with an adequate crude protein. Deciding which crude protein is best for calves is often difficult when it is not understood which has the best benefit. According to the NRC (2001), the crude protein requirements for calf starter are 18% on an as fed basis and 20% on a dry matter basis. This recommendation has been found to be the lowest possible protein percentage that can be used to have the calf continue to grow at the proper rate of growth. A greater crude protein does have the potential to benefit the calf by sustaining the calf's growth during

the weaning process. It may also have a greater impact on the growth rate of the calf post-weaning (NRC, 2001).

Stamey et al. (2012) conducted a study that exhibits the differences in average daily gain in calves fed a higher crude protein compared to a conventional crude protein dry starter. 89 calves were used to compare the differences of a high crude protein starter and conventional crude protein starter by measuring the calves intake, growth and health. The conventional crude protein starter contained an 18% crude protein on an as fed basis and 20% on a dry matter basis. The high crude protein starter contained a 22% crude protein on an as fed basis and 26% on a dry matter basis. The overall results showed that calves fed the high crude protein diet maintained greater consumption of crude protein resulting in metabolizable energy compared to those fed the conventional starter. The calves fed the higher crude protein starter also had a decrease in growth slump and an easier time transitioning during weaning period, which was also maintained post-weaning. The conventional crude protein starter showed no effective difference on the calf's weight or health during the feeding period prior to weaning. The final concluding lines of this study stated that calves should not begin weaning until they can consume at least 1kg of starter daily to promote continued growth post-weaning (Stamey et al., 2012).

There has been much controversy over supplying calves with the availability to consume forages such as hay in their dry feed diet; however, it depends on the starter being fed. Typically forages can be used to supply nutrients to the young calf when consumed in small amounts. The fiber of forages helps develop the digestibility and gastrointestinal tracts in the calf. Fiber also helps maintain an abrasion throughout the

digestive system to avoid any abnormal ruminal development, especially in the papillae. The fiber and nutrient factors of forages for calves can be supplemented with a complete and adequate starter that is comprised of alfalfa meal, rolled oats, beet pulp and cottonseed hulls. A starter that is complete and adequate will provide enough nutrients and fiber to maintain and promote accurate digestibility and growth for the calf (Drackley, 2008). Many farms provide a complete and adequate starter to their calves to compromise for the use forage due to the cost.

Weaning

Weaning is a critical point in a calf's life because of the amount of stress that takes place during that time. In a recent study done by Soberon et al. (2012), results exhibited that there was a positive correlation between average daily gain in pre-weaned calves and the heifer's first lactation yield. It has also proven to be correlated with age at first calving directly linked to breeding age. Age at first calving and the first lactation milk yield are large factors when deciding to cull heifer's, therefore, providing her the proper nutrients at a young age is key to her productivity on the farm as a cow (Soberon et al., 2012).

In North America the average weaning age is 8.4 weeks (Hill et al., 2009). However, it is suggested that calves only be weaned after they can consistently consume 1kg of starter daily (Drackley, 2008). This usually occurs between five and six weeks of age when consuming a palatable starter (Lorenz et al., 2011). Once weaned calves should be moved into group hutches in small even numbers to help with their transition and development of the socialization skillset. Weaning is a very stressful time in a calf's life. A study done by Budzynska and Weary (2007), focuses on the behavior and stress in a

calf's life during weaning. Dairy calves provide the perfect model for studying weaning because of their independence at such a young age. The study focused on the stress in calves being abruptly weaned from milk versus calves that were provided warm water in the milk feeding system during the first few days of weaning. The measurements of stress that were monitored were weight, intake, vocalization and activity. The data was collected on the day prior to weaning and the following three days, but weight was only measured on the third day post-weaning. Calves were weaned at six weeks of age, which is common in many parts of the country. The results of the study showed that neither group of calves' water intake was affected until after weaning. The water intake of calves in both groups tripled after weaning. Prior to weaning, the average daily gain for the calves was approximately 0.8kg. Calves actually lost that 0.8kg each day creating a reverse effect during weaning. All calves called drastically more during the days of weaning. However, calves that were fed warm water through the milk feeding system did not increase their calling until the water was no longer available. The same results applied for the calves' activities of standing up and walking frequently. Calves deprived of milk spent approximately 30% more time standing compared to those who were substituted water through the milk feeding system (Budzynska and Weary, 2007).

Due to the stress that can be caused on calves during the weaning time, it is suggested that calves have continued access to the milk feeding system during the first few days of weaning. Increasing water intake has proven that it can directly correlate with starter intake, therefore calves being fed water in the milk feeding system for the first week of weaning may increase the starter intake resulting in an increase in average daily gain. In the study conducted by Budynzka and Weary (2007), the average daily gain

results were the same number during weaning, but became an average daily loss. This margin can be minimized through the increase of starter intake. Results also showed less stress and more regular behavior for calves in the experimental group. Providing continued access to the milk feeding system during weaning caused less stress on the calf and a greater increase of starter intake.

The duration of the weaning process also strongly affects the calf's stress levels. Many farmers are unsure of whether to abruptly weaning calves from milk or gradually weaning calves from milk is the most beneficial. The stress of weaning has also been linked to the age at breeding and the heifer's production during the first lactation. Studies have shown that gradually weaning calves decreases the stress during the process minimizing the weight gain or loss margin during this time. On the contrary, studies have also proven that calves being abruptly weaned are stressed for a shorter amount of time. A study was conducted by Sweeney et al. (2010) to find the best duration of weaning for the calf and the future cow. Calves were weaned in four different durations with the final weaning age being 41 days old. Calves weaned on a 22-day duration began weaning at 19 days old, 10 day duration began weaning at 31 days of age, the four day duration calves began weaning at 37 days and the abruptly weaned calves were weaned at 41 days old (Sweeney et al., 2010).

Results showed that calves in all groups did not immediately compensate the decrease in milk intake with starter, which did decrease the digestible energy intake during the first few days of weaning. Calves that were abruptly weaned gained weight until the day that they were weaned. After being weaned these calves lost weight drastically within the few days post-weaning and had a difficult time gaining the weight

back. Gradually weaned calves increased the starter intake during the period of weaning, and minimized the margin of weight gain and loss once calves were weaned. The four-day weaning duration showed similar results to those abruptly weaned due to the shorter period of weaning time. Calves weaned at the duration of 22 days did not loose weight during the days just post-weaning, but had a lower weight gain during the weaning process. The final group of calves that were weaned during the 10-day duration showed the overall best results. These calves had the best weight gain during weaning, and after weaning due to the increased amount of starter intake during those times. When calves were weighed at day 49, the calves weaned abruptly and throughout the 10 day duration weighed more than the calves weaned in the four and 22 day durations. It has been assumed that calves that were abruptly weaned or had a four-day weaning did not have time to adjust to the loss in milk resulting in a greater amount of stress for the calf once milk was completely taken away. Calves in the 22-day weaning seemed to have been given milk for to long, which in turn resulted in a lower intake of starter during the weaning process. Because of this lack of starter intake during weaning the calves did not gain weight during the weaning time (Sweeney et al., 2010).

Calves should be given enough time to adapt to the decrease in milk availability during the weaning period. However, they should not be given to much time because the amount of starter intake continues to stay minimal, as the calf is subject to growth. A 10-day weaning period seems to be ideal as the calf has just enough time to adapt to the decrease in available milk, and begin consuming an increased amount of starter to improve the average daily gain. In the 10-day weaning period calves also had a higher daily digestible energy, which is necessary to sustain a calf's health during a stressful

time. It also allows the calf to decrease the amount of stress during the weaning period, and gets them started on their new diet in a shorter amount of time compared to the 22-day duration. The 22-day weaning duration seemed to have a poor weight gain after weaning that affected the age at calves' age at breeding. Abruptly weaning calves also seemed to have a negative impact on the continued growth of the heifer (Sweeney et al., 2010).

Disease

Diseases in calves have a major impact on the economic vitality on dairies. This economic impact stems from the direct cost of the calf losses and the cost of treatment of the calves, both dead and alive. Often times, treating calves can influence their long-term performance as a cow (Lorenz et al., 2011). Of the numerous diseases related to mortalities in dairy calves, diarrhea or scours is one of the most common. Most cases of diarrhea occur in calves less then 30 days of age. The agents causing diarrhea may change throughout the year depending on the weather for example. It is also variable depending on the age of the calf. For calves affected between five and 14 days old, it is commonly found that rotavirus, coronavirus, *Salmonella* and *Cryptosporidium parvum* are the suspects. For calves affected older then 14 days old, it is commonly found that *E Coli, Salmonella, Eimeria* and *Giardia* are the suspects. The source that can carry these infectious bacteria could be transmitted in a number of ways: caregivers clothing, pets, pests, contaminated bedding, feeds, feeding utensils, etc. The incubation period for enteric pathogens ranges from 12 hours to five days making (McGuirk, 2008). Calf scours can be in many different colors, but the loose consistency of the fecal matter

determines that it is diarrhea. Figure 4 exhibits a lighter color of scours in a younger calf, and Figure 5 exhibits a darker color of scours in an older calf.

Figure 4. Example of diarrhea from a younger calf.

Determining the exact strain of bacteria that is causing the diarrhea is very difficult to determine. However, most if not all strains of diarrhea causing agents can be treated in the same or similar ways. When an enteric pathogen has invaded a calf it is best to change out their bedding frequently to decrease the bacteria counts in the calf's environment. Sustaining the cleanliness and comfort of the environment for the calf during a stressful and unhealthy situation is key to the return of their health. Figure 4

shows how diarrhea can spread throughout the surrounding bedding if it is not removed and replaced with fresh bedding.

Figure 5. Example of diarrhea from an older calf.

There are few vaccines that are labeled for administration to calves aiding the preventing diarrhea due to all the potential environmental causes; therefore, immunity from colostrum is most effective way to protect calves. If a calf has diarrhea, the best way to treat them is to rehydrate them through an electrolyte oral fluid therapy. Diarrhea causes dehydrating and the involuntary release of fluids from the body making it necessary to rehydrate the calf to get them health again. They should also be fed their normal diet to maintain their caloric intake and provide supplemental electrolytes for rehydration. Maintaining their normal diet also helps their digestive enzymes maintain consistency

reducing any potential problems once the calf has an appetite again. If the calf does not take to their normal diet it is best not to force feed, or feed them with an esophageal tube. To encourage sustaining the calf's appetite, dividing the normal feeding into smaller portions offered more frequently throughout the day may be more tolerable for the calf. If the calf seems to have a systemic illness therapeutic antibiotics are recommended. A recommended Nuflor treatment for a 100lb calf is a subcutaneous route of one dose per day for three days. The recommended Excenel treatment for a 100lb calf is an intramuscular route of two doses per day for three days (McGuirk, 2008).

Vaccinations

Due to the complexity and immaturity of the calf's immune and management systems developing an effective vaccination program is essential. Calves are born with a functional yet very immature immune system that responds to antigens as long as maternal antibodies are not present. If maternal antibodies are present it is difficult for the calf to properly respond to the vaccinations. Overcoming maternal antibodies can occur through administering vaccines intranasal. Vaccines administered intranasal help with the development of immune proteins on the mucosal surface. The mucosal surface is a major pathway for potential pathogens to invade the body. The antibody in the vaccine neutralizes the infectious agents at the entry point on the mucosal surface preventing the infection from further transfer into the body. Intranasal vaccines also reduce the interferon release, which provides an antiviral environment in the mucosal surface and possibly stimulates immune system maturation (Gorden and Plummer, 2010).

Deciding when to vaccinate calves may seem simple because it is assumed that the label gives specific directions, but that is not always the case. Some vaccination labels

give suggested directions on when to vaccinate, but the right time may vary from farm to farm. Figure 6 shows the directions on a calf vaccine that is administered intranasal. There are specific directions regarding the storage temperature, but nothing specific to the age at administration.

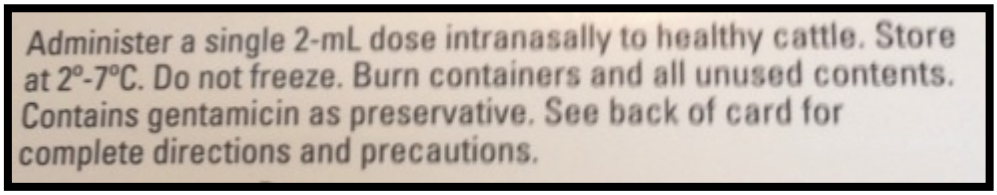

Figure 6. Example of a vaccination labels information regarding administration of vaccines.

The immature nature of a calf's immune system makes the calf very susceptible to harmful pathogens, which is often time why vaccinating occurs. However, calves should not be vaccinated during times where they are easily disease susceptible or stressful times. Vaccinating calves when their immune system may be impaired causes calves to potentially becoming sick. Administering the booster vaccination should also occur prior to any stressful circumstances to ensure that calf can respond to the vaccine. Vaccinating causes stress on the calf internally because it is building up the immune system. Vaccinating calves when they are comfortable, healthy and feel safe in their environment is the best time (McGuirk, 2008).

A study done by Windeyer et al. (2012) showed that vaccinating pre-weaned calves for Bovine Respiratory Disease (BRD) did not reduce the number of incidence of illnesses implying that vaccinations are unnecessary for a young calf. The complexity of the many components of a young calf's immune system inhibits the ability for an immune response to vaccinations. This results in a weaker reaction when the response is able to

occur to the vaccinated exposure of the pathogen. However, in a previous study vaccinating three quarters of the herd reduced the transmission of viral diseases approximately 48%. This reduces the pathogen load throughout the herd resulting in lower cases of infection in the future (Windeyer et al., 2012).

Dehorning

The process of dehorning dairy cattle has been used for years to reduce the risk of injuries to both humans and other animals that may come in contact with those left with horns. Many methods have been used to prevent horn growth in a young calf or stop horn growth in an older cow or calf. These methods include scoop dehorning and chemical or heat cauterization. Heat and chemical cauterization are the methods used for calves within the first eight weeks of age. After that, scooping is used because the calf has already developed a small horn or larger bud. Dehorning a calf can be a very stressful time both physically and psychologically due to the pain associated with the dehorning process (Vickers et al., 2005).

Caustic paste dehorning has been shown to reduce the stress associated with dehorning. Caustic paste burns the surrounding tissue until the active agent is no longer in contact with tissues. The problem that often occurs with caustic paste is that calves can rub it off. Due to the pain related to the use of caustic paste, calves shake and rub their heads to try and reduce the pain. Since pain is associated with caustic paste, but the length of times is unknown. Vickers et al., (2005) conducted a study to determine the responses of calves dehorned using a caustic paste or hot iron with and without local anesthesia. The study documented the time of painful response, effectiveness of the anesthesia and to compare hot iron versus caustic paste dehorning (Vickers et al., 2005).

The results of the study indicated that calves dehorned with caustic paste showed signs of pain, but the pain did not last nearly as long as calves that was dehorned using a hot iron. Even when a local anesthesia was used for dehorning with a hot iron the pain seemed greater than caustic paste. However, hot iron dehorning using a sedative and local anesthesia may reduce pain if the calf is sedated long enough. A simpler and less invasive caustic paste can result in a decrease in pain for the calves. The results of this study concluded by saying caustic paste is a more humane way to dehorn calves compared to hot iron dehorning them due to the longer periods of pain and stress (Vickers et al., 2005).

CASE STUDIES

A series of two case studies were conducted to determine the management practices for calves on dairies in California. There were many different reasons why the two dairies in the case studies were chosen. The two dairies that were used for the case studies are located on opposite ends of the California Central Valley. The California Central Valley is the home of a majority of California's dairy industry; therefore it was the perfect location for such studies. The dairies chosen for the case studies had calf operations that differed greatly in size when compared. The dairies were chosen to by size see if there was a large variable different in management practices. Personal contact was made with the herdsman from each dairy for a question and answer section about the calf management practices.

Case Study #1

The Dairy #1 in Galt, CA was used for the first case study. On February 17, 2014 personal communication occurred with the herdsman at the dairy regarding the calf raising operation on their farm. A very significant note that came from this visit was the calf death loss being greater than 2%, which is fantastic. Only about 65 calves are in hutches at a time due to the size of their herd. The colostrum protocol is to feed calves two feedings of colostrum at two quarts each feeding. Colostrum is tested using a colostrometer prior to feeding. Once fed the feedings of colostrum, calves were moved to their individual hutches where they will live until they were weaned. Calves were housed in individual fiberglass hutch groups. The hutch groups were three individual hutches connected to each other. In the individual hutches, calves were provided with water and grain ad libitum, and fed milk twice daily. The grain that is provided is a 22% crude

protein starter. Their calves were all fed two quarts of non-pasteurized hospital milk at each feeding. At weaning, calves are cut back to one bottle per day. Calves were weaned at 10 weeks of age, and were then moved to super hutches. At the super hutches calves are provided with a 20% crude protein starter, water and hay ad libitum. As for vaccinations, Dairy #1 uses Inforce 3 Intranasal within hours of birth and again at about four months of age. They also use Bovi-Shield Gold vaccine at two months and four months of age. Overall, the Dairy #1 seems to have done a successful job raising calves to become productive cows.

Case Study #2

The Fernoak Farms Dairy in Woodville, CA was used for case study number two. On February 26, 2014 personal contact was made with the herdsman to find out the different aspects of their calf raising operation. Fernoak Farms has a very low calf death loss averaging from 1% to 2% throughout the year. This dairy also raised approximately 750 calves in hutches at the time showing the significance of such a low calf death loss number. All heifer calves are fed at least two 2 quart bottles prior to being moved into individual hutches. The individual hutches are fiberglass with an outer cage and bedded on sand. Once calves are housed in their individual hutches they are fed pasteurized hospital milk twice daily. During the first ten days, however, calves are fed a smaller 1.5 quart bottle to help stimulate milk absorption without over filling the gut. Calves are provided with water and calf starter ad libitum from the first day they are in the hutches. The calf starter fed is a 22% crude protein starter, and calves are fed this starter until post-weaning. The weaning protocol at this dairy is to feed one bottle at night from day 50-56. After day 56 the calves are weaned and then moved to the training pen. In the

training pen calves are learning how to use headlocks and behave in larger groups. The vaccinations at Fernoak Farms are Inforce 3 and Bovi-Shield Gold. Inforce 3 is administered intranasal at day one with a booster given day 30. Bovi-Shield Gold is given at the age between 120 to 150 days with a booster given at breeding age. Overall it seems that Fernoak Farms has a beneficial and productive calf raising operation with great protocols.

DISCUSSION

The two dairies that were used for the case study had many variances when being chosen for the study. Dairy #1 is located in the Northern part of California's Central Valley, whereas the Fernoak Farms Dairy is located in the Southern part of the same valley. The dairies both differed in size of calf operation. Dairy #1 raised approximately 65 calves in hutches, and Fernoak Farms raised approximately 750 calves. This is a drastic number variance, but both dairies had an incredible calf death loss. This shows that size does no matter when discussing calf death loss. Calves at both dairies are housed individually in fiberglass hutches.

Both dairies fed used similar practices for colostrum management and feeding colostrum. They also feed hospital milk, however, Fernoak Farms pasteurizes their hospital milk prior to feeding it to calves. Dairy #1 does not pasteurize their milk even though they would like to. Both dairies feed bottles the same number of times and the same quantity. Calves are also provided water ad libitum at both operations. Grain is also provided ad libitum at both farms. Dairy #1 feeds a 22% crude protein starter until the calves are weaned and then goes to a 20% crude protein starter. Fernoak Farms sticks with their 22% crude protein starter through the duration of the calf raising process.

At Dairy #1 calves are weaned later than at Fernoak Farms Dairy. Measurements of calf height and weight were not taken; therefore determining why this difference occurs could be based off management preferences. After calves are weaned they are moved to more social settings where they can develop their social skillset with other calves that are also in the midst of transitioning.

The vaccinations that were given on both farms were the same. Fernoak Farms administered the booster for Inforce 3 at 30 days, and Dairy #1 administered it at four months of age. There again was an age differential between the dairies when vaccinating with Bovi-Shield Gold. At Dairy #1 they vaccinate at two and four months of age, but Fernoak Farms vaccinated at about 120 days and administered the booster at breeding age.

CONCLUSION

According to this literature review, determining the best management practices for calves from birth to weaning is difficult. There are so many different variables that can take place during the time of raising a calf. All aspects of a calf's life is crucial, therefore determining the best practices is difficult because they all intermix. Much critical analysis and research was conducted in order to find the best practices that were reviewed in this literature.

Both dairies used in the case studies had significantly low calf death loss proving that their practices are working in a positive manner on their farm. Practices on both farms were also similar to those practices found in the literature review, which was beneficial to see. Regardless of the differences between the case studies and the literature review many different practices seem to be the best practices for raising calves.

The suggested first steps in a calf's life are critical to their future, along with the proper management of colostrum with both quality and quantity consumed. Calves should be individually housed to lower the possibility of disease transmission and fed a supplemental diet. They should also be provided with water at all times, depending on location, and treated when ill. A further study should be conducted to determine the best management practices for raising calves in various locations.

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