Methods to reduce morbidity in feeder calves
by Dennis James Fennewald

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal and Range Sciences
Montana State University

Abstract:
One thousand, eight hundred and thirty-six calves from eight ranches were individually identified to evaluate if a standardized weaning protocol following prescribed vaccinations, nutrition and 45-d of backgrounding could reduce morbidity from weaning until harvest. Freshly weaned calves were allotted to either 1) Present Ranch Management (PRM) which was defined as present weaning practices (779 calves) or 2) MSU Protocol (MSU) in which calves (1057) were fed either 1.82 kg/d of a wheat middlings-based pellet or 0.45 kg/d of liquid supplement for 28 d containing additional levels of Cu, Zn, Mn, CP, vitamins A, D and E and a coccidiostat. Ranchers chose clostridial and viral vaccines (MLV or killed) and described pre- and post-weaning management. Morbidity was 3.5% (64 of the 1836 calves) and was 2.7% for calves on the MSU protocol compared to 4.5% for calves on the PRM protocol ($P < .05$). MSU protocol may be applied to reduce morbidity in the backgrounding period. A companion study which involved calves destined for a branded beef program was conducted to more fully explain the effect of ranch management (minerals, vaccinations, backgrounding, etc.) on morbidity, ADG, hot carcass weight (HCW) and quality grade. Pen data were collected on seventy pens from four feedlots with a total of 14,140 steers and heifers from 40 ranches in 7 states bom between December 1999 and April 2000 and harvested between October 2000 and September 2001. Commingling calves increased ($P < .05$) morbidity by 6.7 percentage points. The weight of the calves entering the feedlot (In Wt) influenced ($P < .05$) the percent morbidity in a pen, death loss and HCW and indirectly influenced ADG through its relationship with the death loss. The cumulative effect of an additional 10 kg of In Wt due to a reduction in the percent morbidity ($0.14/hd), the reduction in mortality ($0.40/hd), the increase in ADG ($7.97/hd), the increase in HCW ($3.63) and the increase in the percent of carcasses that graded Choice ($0.28/hd) was $12.42/hd or $3105.00/250 hd.

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APPROVAL

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Dennis James Fennewald

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency and is ready for submission to the College of Graduate Studies.

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ABSTRACT

One thousand, eight hundred and thirty-six calves from eight ranches were individually identified to evaluate if a standardized weaning protocol following prescribed vaccinations, nutrition and 45-d of backgrounding could reduce morbidity from weaning until harvest. Freshly weaned calves were allotted to either 1) Present Ranch Management (**PRM**) which was defined as present weaning practices (779 calves) or 2) MSU Protocol (**MSU**) in which calves (1057) were fed either 1.82 kg/d of a wheat middlings-based pellet or 0.45 kg/d of liquid supplement for 28 d containing additional levels of Cu, Zn, Mn, CP, vitamins A, D and E and a coccidiostat. Ranchers chose clostridial and viral vaccines (MLV or killed) and described pre- and post-weaning management. Morbidity was 3.5% (64 of the 1836 calves) and was 2.7% for calves on the MSU protocol compared to 4.5% for calves on the PRM protocol ($P < .05$). MSU protocol may be applied to reduce morbidity in the backgrounding period. A companion study which involved calves destined for a branded beef program was conducted to more fully explain the effect of ranch management (minerals, vaccinations, backgrounding, etc.) on morbidity, ADG, hot carcass weight (HCW) and quality grade. Pen data were collected on seventy pens from four feedlots with a total of 14,140 steers and heifers from 40 ranches in 7 states born between December 1999 and April 2000 and harvested between October 2000 and September 2001. Commingling calves increased ($P < .05$) morbidity by 6.7 percentage points. The weight of the calves entering the feedlot (**In Wt**) influenced ($P < .05$) the percent morbidity in a pen, death loss and HCW and indirectly influenced ADG through its relationship with the death loss. The cumulative effect of an additional 10 kg of In Wt due to a reduction in the percent morbidity ($0.14/hd), the reduction in mortality ($0.40/hd), the increase in ADG ($7.97/hd), the increase in HCW ($3.63) and the increase in the percent of carcasses that graded Choice ($0.28/hd) was $12.42/hd or $3105.00/250 hd.

INTRODUCTION

At the 1995 National Cattlemans Beef Assoc. Strategy Workshop (NCBA, 1995), the emphasis on overcoming beefs shortcomings included the following: 1) assisting producers with use of selection and management techniques to produce cattle that fit customer expectations for marbling, red meat yield and weight; 2) develop a cattle identification system that facilitates data collection and information feedback and reduced reliance on hot-iron branding; 3) continue to develop and apply technology to enhance the quality of beef and 4) identify breeding systems that optimize production, palatability and profitability.

Source verification of individual cows and calves, feedlot performance and carcass characteristics is necessary for producers to; 1) establish a baseline for comparison of their herd to the global population, 2) effectively evaluate the potential need for adjustment of their genetics or management to more readily meet consumer demands and 3) document food safety management practices. Source verification lends itself to using a systems-approach to measure profitability as a result of having analyzed cow-calf, feedlot and carcass net returns. The first research project was aimed at individually identifying weaned calves in an attempt to track them through the production channels and to determine if a nutrition and health management protocol would reduce morbidity and mortality of weaned calves. The second, survey-study evaluated calves destined for a branded beef program and was conducted to more fully explain the effects of ranch management practices on morbidity, average daily gain, hot carcass weight and quality grade.

LITERATURE REVIEW

BQA

Deming (1986) recommended that industries "cease dependence on inspection to achieve quality" and "eliminate the need for inspection on a mass basis by building quality into the product in the first place". Lowry (1990) quoted Bob Reed from the Llano Estacado Winery, "Once the grapes hit the dock, it's too late for us to correct the fruit. You can make good or bad wine from good grapes, but you can't make good wine form bad grapes. So we try to help farmers grow premium grapes for our wines."

These statements illustrate the need to implement Total Quality Management (TQM) to ensure a "quality" product is provided to consumers. If any part of the system fails to do its part in TQM, product quality can be compromised. The beef industry uses the acronym BQA (Beef Quality Assurance) to describe the TQM process of minimizing losses of normal management practices such as vaccination and branding prior to weaning. The objectives are to ensure quality, consistency, safety and source and process verification (Montana Beef Network manual, 2001). Forty-seven states currently have BQA programs.

BQA includes proper handling of cattle to reduce stress and proper use of antibiotics, virals and feed additives. Unfortunately, the beef industry continues to have problems with inconsistency in the final product. Injection site blemishes are a problem in the beef industry that can affect tenderness three inches away from the site, even when the injection was given at birth (Beef, 2000). A 1994 Colorado State University study showed shear force values of 13.9 kg at the lesion, 5.8 kg three inches from the lesion vs. 4.0 kg in normal steaks. (Beef, 2000). Proper injection procedures can help prevent reduced tenderness in higher value cuts. Bruises also cost the beef industry $23 million/yr for fed steers and heifers and $117 million/yr for cows and bulls, according to the NCBA 2000 National Beef Quality Audit (Montana Beef Network, 2001).

According to the National Beef Quality Audit (NCBA, 1995), the top concerns of packers, purveyors, retailers and restaurateurs with regard to beef quality were: 1) low overall uniformity; 2) inadequate tenderness; 3) low palatability; 4) excessive external fat and 5) beef's price was perceived to be too high for the value received. It was estimated that excessive external fat, seam fat and beef trim fat cost the beef industry $47.76/hd marketed.. Inadequate palatability, marbling, hard-boned carcasses and bullocks added an additional $38.30 in lost income. And finally, controllable management issues (hide defects, offal condemnation, injection site blemishes, bruising, dark cutters and grubs) contributed an additional loss of $47.10/hd marketed. Management concerns which increased between 1991 and 1995 were more horned cattle, more bruising on carcasses, and more condemnation of livers, tripe and tongues. Although these defects have been documented, less effort has been aimed at developing programs that provide feedlot performance and carcass merit back to the cow/calf producer so that changes can be adapted in breeding, health and financial management.

It is important for producers to know what they are producing. Monfort Packing Co. started providing producers carcass information free of charge starting in 1998. Tim Schiefelbein, (personal communication) Monfort's value-based procurement manager, said

"We can't expect producers to make changes if we don't give them any feedback". According to Colorado State University animal scientist Tom Field, (personal communication) beef quality won't fully improve until everyone in the industry has an economic incentive to make it happen. Field also stated other beef quality components, like tenderness or yield grade, won't improve until all producers have a shared economic interest in the outcome of beef.

Proper management prior to and at weaning should reduce morbidity in the feedlot which generally reduces quality grades (Roeber et al. 2000). Tatum et al (1998) reported that the sole use of post-harvest technology is not adequate to ensure tenderness and must be used in conjunction with proper genetic inputs and management. These statements reflect the need for using BQA techniques as part of a progressive management strategy to increase consistency and consumer demand. However, this system must also reward and encourage ranchers to produce the product. Schiefelbein (personal communication) believed no system was in place to reward guaranteed tender steaks. "The present economy showed more consumers eating out and even though 1 in 4 steaks was not considered "a good eating experience", restaurant owners were enjoying the demand and not demanding a guaranteed tender steak every time."

Source Verification

According to the NCBA's 1995 National Beef Quality Audit, (NCBA, 1995) one of the strategies for overcoming beef's shortcomings was "the development of a cattle identification system that facilitates data collection and information feedback, and reduces reliance on hot-iron branding". Smith et al. (2000) indicated there are currently five major reasons why the beef industry is interested in source verification or trace-ability of cattle: 1) ascertaining ownership of the animal, 2) identifying parentage of the animal, 3) improving palatability of the product, 4) assuring food safety and 5) determining compliance in branded-beef programs and alliances.

The National Animal Health Monitoring System (NAHMS, 1994) found, however, that only 53.1% of cow-calf producers individually identify (ID) their calves. When calves were ID, the most commonly used methods were plastic ear tags (55.9%), brucellosis tags (30.4%), hot iron brand(s) (22%), ear tattoo (13.6%), freeze branding (0.9%) and microchips (0.4%). On a regional basis, 98.7% of ranchers in the western states identified beef cows compared with 89.9% for north central states, 44.2% for central states, 84.5% for south central states and 47.3% for southeast states. John Wiemers, a director for USDA's Animal and Health Plant Inspection Service, stated "the private sector will have three years to develop livestock ID systems that work...At the end of three years, livestock ID will become mandatory unless the industry has evolved to where it is already doing it as a course of business" (Smith, 2000).

Among the different identification systems currently being discussed include retinal scan (McMahon, 2000), electronic implants or electronic ear tags (Allen et al. 1994). Electronic ear tags appear to be the most successful with a lower failure rate than electronic implants (Allen et al. 1994). Ishmael (1999) indicated that EID has been discussed in the press for more than 20 yr and could be part of an overall system of producing and tracking cattle. It could simply be a closed-loop system that only operates within the boundaries of a ranch to track cattle performance or it could be used as part of a nationwide system that takes in fragmented information for each link in the entire production chain and provides performance and process verified animal histories from birth to carcass.

Three additional factors also drive the growing interest in individual animal ID: 1) the need for more effective management through information sharing, 2) consumer confidence in beef safety worldwide and 3) desire to ensure the integrity of the U.S. animal health system (Ishmael, 2000). Wiemers cited six reasons for development of individual ID: 1) disease control and eradication 2) disease surveillance and monitoring 3) emergency response to foreign animal diseases 4) global trade 5) livestock production efficiency, 6) consumer concerns over food safety and emergency management programs. Ranchers hesitate to involve the federal government because the disease problems in England led to mandatory individual identification of cattle that is costing $12 million annually with about 350 bureaucrats administrating the program (Stough, 2001). But, producers who want to compete in world markets can no longer do so anonymously (Peck, 2000).

Cross (1998) reported that both governments and customers concerns would drive individual animal identification and traceback over food safety. Traceback is viewed as a means of recapturing consumer confidence, especially among European nations who have dealt with Bovine Spongiform Encephalopathy (BSE) and Foot and Mouth Disease (FMD). Smith et al. (2000) indicated that traceback could also be used to improve beef palatability and will be used in branded-beef programs.

Source Verification Worldwide

Great Britain has actively pursued individual identification and tracking of livestock (passport system) in the aftermath of BSE. Within 15 d of tagging, a passport application must be accurately completed and sent to the British Cattle Movement Service. Italy has "smart card" technology that permits consumers to check the background of a farm animal before they buy a cut of meat. A French supermarket provides consumers the ability to access information on the animal as well as a photo of the producer. Starting Jan. 1, 2000, all livestock in the European Union must be tagged with one ID tag in each ear within 20 d after birth.

Australia has the National Livestock Identification Scheme, a voluntary program being introduced on a state-by-state basis with government funding. Argentina also has a National Task Force on Identification looking at that country's ID needs in the global marketplace and Mexico (CNG) is working with an American company that facilitates the adoption of individual animal ID (Ishmael, 2000).

Canada tested 20 types of tags in 80 herds, totaling 30,000 tags in the field. The Canadian Cattle Identification Agency, charged with developing and implementing a national system of individual ID and traceback, implemented the mandatory program Dec. 31, 2000 (Gordon, 1999).

Source Verification in the USA

Three programs including the USA Cattle Information Service (USA-CIS) from NCBA, Iowa Quality Beef Initiative and the Montana Beef Network are examples (there are several more) using EID in systems of beef cattle production. According the Ishmael

(2000), there are at least 25 feedlots, 25 alliances, six packing facilities, three auction markets and an unknown number of ranches currently utilizing some form of EID technology.

Sharing Data through the System.

Increasing demand for beef has been a major focus in recent years. New technology such as ultrasound and expected progeny differences (EPDs) have allowed for more accurate selection of growth and carcass traits. In addition, packers have created carcass grids to give feedlot and ranchers more options to market cattle and reward production of cattle that hit specified targets. Sharing that carcass information will become critical for alliances to supply a branded, case-ready product that is source and processed verified.

Behrends et al. (2001) surveyed thirty-one feedlot managers who participated in a Certified Angus Beef Supply Development Conference to determine their current and desired levels of knowledge about several characteristics associated with the cattle they feed. Vaccination schedule and single versus multiple herd sources were known for just over one-half of the cattle currently being fed and none of the other traits analyzed were known by more than 50 percent of the feedlot owners. In general, more information was available for health and management history than for genetic origin or feedlot and carcass performance. This illustrates the lack of information currently being shared throughout the beef industry.

The top traits feedyard managers would like to have information about include yield grade (100%), quality grade (96.8%), nutritional management (96.8%), feedlot gain

(96.8%), vaccination schedule (93.5%), implant history (93.5%), breed composition (93.5%), health products used (90.3%), morbidity and mortality history (90.3%) and percent "outs" (90.0%) (Behrends et al. 2001).

When these feedyard managers were asked what traits they were willing to pay a premium for, they responded; vaccination schedule (83.3%), quality grade (80%), sire and associated performance data (79.3%), feedlot gain (76.7%), breed composition (72.4%), yield grade (70%), and implant history (66.7%). All other traits were below 55 percent in terms of the respondent's willingness to pay premiums.

Producing a Healthy Weaned Calf

Perino (1997) suggested that inadequate passive transfer of colostral immunoglobulins occurred in 10 to 25% of newborn beef calves. Skrzypek and Szetag (2000) reported that passive immunity (acquired by a newborn calf from its dam) was important in sustaining the health of the young calf. Cows were bled 7-8 wk prior to calving and calves were bled at birth and 5 d of age to measure total protein, globulins and gammaglobulins. Dams that experienced dystocia had significantly higher blood serum constituents (total protein, globulins and gammaglobulins) than dams that did not experience dystocia. Calves born to cows experiencing dystocia had significantly lower concentrations of all three blood constituents (total protein, globulins and gammaglobulins) compared to calves born to cows that did not experience dystocia.

Bernardini et al. (1996) analyzed inbred and outbred populations maintained at the Northern Agricultural Research Center near Havre, MT and found increased incidence of scours and respiratory illness in inbred calves born to 2-yr-old dams (47 and 37%, respectively). This was greater than for older cows and outbred animals. Mean incidence of scours and respiratory illness were 35 and 22%, respectively, over all years. There was a 9 and 12 kg reduction in weaning weight and final weight, respectively, for the calves which contracted scours and respiratory illness. Economic losses per calf over all years averaged $39.80 for calves which contracted respiratory illness.

The innate immune system is the first line of defense against germs and disease. It includes small hairs in the nose that help filter germs from the air and the membranes of the respiratory tract which are covered with sticky mucous. The alveolar macrophage in the lower respiratory tract engulfs any germs that make it past the defenses in the upper respiratory tract. The innate defense system may be compromised by poor husbandry practices that produce excessive stress or dehydration. The innate defense system must be overcome before the animal uses the acquired immune defense (Perino, 2001).

Acquired immunity is the immune response mediated by white blood cells called lymphocytes. Key features include 1) previous exposure to the pathogen is required, 2) the response is directed only at the pathogen stimulating it and 3) the response to a pathogen is enhanced by previous exposure to the same germ. This is why it is critical to vaccinate cattle prior to the stress so as to enable the immune system to build a defense (Perino, 2001).

Behavior of sick animals is an adaptive strategy to conserve energy as opposed to being a product of debilitation (Hart, 1987). The onset of sick behavior and fever were the first lines of defense until the immune system was activated. However, the animal's metabolism must be increased by 10 – 13% to accommodate a 1° C increase in body temperature. Thus, a sick animal's behavior is related to the high cost of producing a fever, which suppresses the growth of disease causing viruses and bacteria. Reducing feed intake and showing depression are symptoms seen in morbid animals to reduce energy requirements. Sick behavior and fever concentrated all of the animal's resources on recovering from illness (Hart, 1987). As the immune system took over, the fever subsided and the morbid animal became interested in its environment and regained its appetite.

Preconditioning

Preconditioning is the process of preparing calves for the feedlot. Preconditioning gives the producer another opportunity, after ensuring the newborn has received high quality colostrum, to improve the immune status of calves. The benefits of backgrounding and preconditioning include; 1) minimizing shipping stress, 2) giving more predictable feeding results, 3) changing delivery and marketing schedules, 4) reducing morbidity and mortality, 5) reducing risk, 6) increasing predictability, 7) expanding marketing options, and 8) improving the value of the calves (Perez, 2000). In a review of controlled studies of the effect of preconditioning on health of calves, morbidity was reduced from 26.5 to 20.4% and mortality was reduced from 1.44 to 0.74% (Perino, 2001). Unfortunately preconditioning has a different meaning to different ranchers. Some ranchers consider a vaccination program to be adequate while others combine nutrition, vaccinations and 45 d backgrounding (Stough, 1999). Other ranchers criticize preconditioning programs because it was not generally economical for the integrated operations (Peterson et al.

1989). Henderson (2000) reported preconditioned calves are becoming the industry standard due to the need to reduce sickness, death loss, poor performance and quality assurance losses. However, McNeill (Henderson, 2000) indicated preconditioning guidelines are not rigid enough. In his opinion, calves that are preconditioned and backgrounded 30 d do not have the proper immunity to remain healthy and perform as well as calves that have been backgrounded 45 d (Henderson, 2000).

Perino and Apley (1999) found that preconditioned calves were 19.5 times less likely to be sick in the feedlot than nonpreconditioned calves. Cattle shipped directly from the ranch to the feedlot were 5.7 times less likely to be sick in the feedlot than cattle that first went to an auction market and were commingled prior to arrival at the feedlot (Perino and Apley, 1999). Lofgreen (1998) reported that preconditioned calves gained better than non-preconditioned calves during a 28-d receiving period. The ADG, however, between the two groups was not different at the end of the feeding period.

Roeber et al. (2000) found that cattle from two pre-conditioning programs had fewer average number of hospital visits compared to cattle originating from an auction market. In addition, increased morbidity resulted in economic losses due to mortality, reduced performance and increased costs associated with treatment.

NAHMS (2000) data indicated that 73.8% of feedlots received pre-arrival processing information either *always* or *most of the time* or *sometimes.* This communication is important to feedlots because 86.7% considered pre-arrival processing information important and 69.5 % of feedlots at least *sometimes* altered their management or processing of cattle based on this information.

Incidence of Bovine Respiratory Disease

The most economically important disease affecting feedlot cattle throughout North America is bovine respiratory disease (BRD) complex (NAHMS, 2000) which has been reported as the most common cause of morbidity and mortality in feedlots (Perino, 1992). It has been estimated that BRD accounted for approximately 75% of feedlot morbidity and 50% of mortality (Edwards, 1996). Other reports indicate 20% of cattle in feedlots annually contract BRD with a 10-15% mortality rate due to BRD (Perino and Apley, 1999). Kelly and Janzen (1986) indicated that the average rate of morbidity was 15-45% with a range of 0-69%. They also reported the normal average in mortality was 1-5% with a range of 0-15%. NAHMS (2000) reported nineteen percent of feedlot cattle received an antibiotic injection for the prevention or treatment of disease.

Weight gain of morbid calves was 29% slower compared to healthy calves after 56 d in the feedlot (Hutcheson and Cole, 1986). Intake was a problem in newly arrived calves because after 7 d only 83% of the morbid calves had eaten compared with 95% of the healthy calves. Overall feed intake for morbid calves was 11% less than for healthy calves (Hutcheson and Cole, 1986).

Sowell et al. (1998) conducted a study in a commercial feedlot in AZ for 32 d using 108 mixed breed calves (ave weight 139 kg). Healthy steers gained 9 kg more and had 28% higher ADG than morbid steers. Morbid steers spent 30% less time at the feedbunk than healthy steers. Morbid steers were also found to spend 23.7% less time at the waterer than healthy steers (Basarab et al. 1996). Perino and Apley, (1999) found that water was the most important nutrient for an animal recovering from respiratory disease. Bud

Williams, noted animal behaviorist, found newly arrived calves are stressed to the point that they often "starve" to death (personal communication). He stated it was critical for calves to eat from day one as morbidity was greatly reduced.

The first 4 d was the critical time period because differences in time at the feed bunk and feeding bouts between healthy and morbid steers were most pronounced during this time (Sowell et al. 1999; Hutcheson and Cole, 1986). These authors found when animals were transported "long distances" it required at least 4 d before all the healthy calves were eating from the feed bunk. Morbid steers spent 30% less time at the feed bunk than healthy steers (Sowell et al. 1998) and this decrease in feeding time occurred 4 d before physical signs of sickness were observed (Basarab et al., 1996: Sowell et al., 1998). Griffin et al., (1993) stated feed consumption in cattle exposed to viral respiratory disease began to decline 48 h before a rise in body temperature could be detected and that this drop in consumption could be as much as 50% 24 h before the animal's temperature began to rise.

Evidence suggested that current methods of BRD diagnosis and treatment were of questionable value. Wittum et al. (1996) evaluated BRD morbidity in 469 crossbred steers born in three consecutive calving seasons at the USDA-MARC in Clay Center, NE. Calves were weaned at approximately 6 mo of age and fed in a feedlot for an average of 273 d. Health records were maintained from birth to harvest. Lungs were collected at harvest and evaluated for gross lesions indicative of active or resolved pneumonia. Thirty-five percent of the steers were treated for BRD but 72% had pulmonary lesions indicative of BRD at slaughter. Pulmonary lesions were evident in 78% of treated steers and 68% of steers not treated for BRD. These findings suggested current methods of treating cattle for BRD are not adequate to prevent production losses.

The Economic Impact of BRD on Performance and Carcass Value

The cost of BRD can be divided into three categories: 1) the cost of treatment, 2) the cost of lost productivity and/or salvage (chronics), and 3) the cost of death loss (Perino, 1992). BRD resulted in losses in all three categories. Perino (1992) estimated the cost of BRD for 100 hd of cattle to be $1700 or $85/sick calf or $17/calf fed.

Griffin et al. (1995) reported the cost for morbid cattle was $111.38/sick animal and that health costs accounted for 8% of the production cost in a feedlot. Morbid cattle gained 3% less and had an 18% higher total cost of gain compared with cattle that did not get sick. Also, it was determined from the Texas Ranch to Rail Summary, that 26% of the cattle incurred no medical cost but 22% of the cattle incurred a medical cost of $10/hd or more.

Gardner et al. (1996) reported that medical costs have been shown to be the most important factor affecting profitability and can be as high as $353/hd. Subsequently, in a survey of nineteen feeding companies, health was listed among the top four cattle traits important to feeders (Northcutt et al., 1996).

Gardner et al. (1998) reported that the net returns for steers without lung lesions were $20.03 more than for steers with lung lesions but non-active lymph nodes. Twenty-five percent of this reduction was medicine costs with the remaining 75% due to decreased carcass value (9.4% more U.S. Standard carcasses and 3.9% less carcass weight). Steers with lung lesions as well as active lymph nodes had a $73.78 less net return than cattle with healthy lungs.

McBeth et al (2001) reported increased performance for heifers treated for BRD once vs. heifers not treated. These authors stated this was probably due to compensatory gain for animals that had seen reduced performance in the receiving period. There were no differences in overall performance or carcass characteristics and concluded that the incidence of morbidity was low, thus had no effect on the animals in this study.

Roeber et al. (2000) reported hot carcass weight, marbling scores, and yield grades were reduced for cattle treated more than once compared to cattle not treated. The Texas Ranch to Rail 1999-2000 Summary included four factors to target a value based marketing system; 1) attainment of premiums – both quality and yield, 2) avoiding, or at least, minimizing discounts, 3) retaining performance and efficiency, and 4) having a sound health program for calves to achieve their genetic potential (McNeill, 2000). Highly profitable steers (top 10% of steers which had average net returns of $304.76) attained returns by quality grade, yield grade, both quality and yield grades, or had exceptional performance without premiums or discounts.

Gardner et al. (1999) reported lung lesions were present in 33% of all lungs and was almost equal between treated (37%) and untreated cattle (29%). Steers that were treated had lower ($P < .05$) harvest weights, ADG, hot carcass weights, less internal and external fat, and better yield grades. Gardner et al. (1999) reported steaks aged less than 7 d from steers with respiratory tract lesions were tougher ($P<0.06$) in shear force and steaks from steers without lung lesions were more tender than steaks from steers with lung lesions. Steaks aged more than 7 d did not differ in tenderness (P>.16).

Stovall et al (2000) reported significant effects on carcass traits, especially carcass value, for cattle requiring one or less anti-microbial treatments. Heifers treated for BRD had 37% fewer carcasses grading Choice. Heifers never treated produced a net return that was $11.48/hd more than heifers treated once for BRD, and $37.34/hd more than those treated two or more times.

Healthy steers had faster ADG (1.33 vs. 1.26 kg/d, respectfully) and 12% more Choice carcasses than cattle identified as sick during the finishing period (McNeill et al., 1996). However, in several studies that relied on clinical evaluation alone as opposed to diagnostic evaluation to determine health status, respiratory caused morbidity during the finishing period failed to depress ADG (Townsend et al., 1989; Griffin and Perino, 1992).

Faber et al. (1999) analyzed data from 2,146 feedlot cattle in 17 feedlot tests from 1988 to 1997 to determine the impact of bovine respiratory disease (BRD) on veterinary treatment costs, average daily gain, carcass traits, mortality, and net profit. Morbidity caused by BRD was 20.6% and the average cost to treat each case was $12.39. Mortality of calves diagnosed and treated for BRD was 5.9% vs. 0.35% for those not diagnosed with BRD. Average daily gain differed between treated and non-treated calves from day 1 to d 28 but were not different from 28 d to harvest. Net profit was $57.48 lower for treated steers with 82% of this value due to mortality and treatment costs. Eighteen percent of the net profit difference was due to improved performance and carcass value of the non-treated steers.

In summary, BRD has been identified as the most economically important disease affecting feedlot cattle (NAHMS, 2000). It has been estimated that BRD accounted for approximately 75% of feedlot morbidity and 50% of mortality (Edwards, 1996). However, only half of the calves that have pulmonary lesions indicative of BRD at slaughter may be treated during their lifetime (Wittum et al., 1996). The cost of BRD may range from $85/sick calf (Perino, 1992) to $111.38/sick calf (Griffin et al., 1995) and includes losses in the cost of the treatment, the cost of lost productivity and the cost of death loss (Perino, 1992). Cattle treated in the feedlot may also have reduced carcass weight and quality grades (McNeill et al., 1996; Roeber et al., 2000; Stovall et al., 2000) and the reduction in quality grades may result in substantial discounts as carcasses move from the Choice grade to the Select grade (Stovall et al., 2000; McNeill et al., 1996) and from the Select grade to the Standard grade (Gardner et al., 1999; McNeill, 2000). Additionally, steaks aged less than 7 d from calves with respiratory tract lesions were tougher in shear force (Gardner et al., 1999). Resuming normal feed consumption in the first 4 d at the feedlot was critical to remaining healthy (Hutcheson and Cole, 1986). Depression and reduced feed intake were symptoms of morbid animals (Hart, 1987) and feed intake began to decline 48 h prior to a detectable rise in body temperature (Griffin et al., 1993).

Pasteurella

Pasteurella is a common but normally noninvasive bacterium. When certain tissues or functions become damaged or stressed, usually by IBR, PI-3, or BRSV, *pasteurella* invades (Richey, 1996). *Pasteurella* is common in the upper respiratory tract and *Pasteurella* infections are easily spread by inhalation of aerosol droplets, by direct nose-to-nose contact, or by ingestion of feed and water contaminated by nasal and oral discharges from infected cattle.

If *Pasteurella* infections go unnoticed, the lungs may become irreversibly damaged, the body temperature drops to below normal and the animal usually dies. If the animal survives, the result is a calf that will never be able to adequately perform to expectations. These calves are referred to as chronics in the stocker and feedyard industries.

When *Pasteurella* alone causes pneumonia, it is commonly referred to as shipping fever. Shipping fever is not the main concern as true shipping fever losses are minimal compared to the larger problem called Bovine Respiratory Disease (BRD), which is the respiratory illness caused by the association of *Pasteurella* and other diseases. *Pasteurella* pneumonia is present in nearly 75% of all diagnosed cases of BRD.

Perino and Apley (1999) listed the primary sign of BRD as depression with other symptoms including a decreased flight zone, glazed look, and respiratory character (outstretched head or labored breathing). In their opinion, nasal and ocular discharge along with increased respiratory rate were unreliable signs of BRD when there was the absence of depression. Genetics of the individual animal may also affect the degree which they show clinical signs of BRD.

Pasteurella bacteria can easily develop resistance to antibiotics and because the bacteria are geographically widespread, antibacterial resistance among *Pasteurella* bacteria is very common throughout the United States. While it is easy to find an antibacterial drug against pasteurellosis on the ranch where the calf was raised, it is very difficult to find a drug that will work against pasteurellosis in commingled calves. *Pasteurella* bacteria are easily spread from calf to calf resulting in the harboring of many drug-resistant strains. *Pasteurella* has developed resistance against most of the common over-the–counter antibacterial drugs (Richey, 1990).

BRSV

The feedlot industry identified a respiratory problem in cattle in which a virus was suspected. This virus caused a lung lesion called a syncytium and became known as bovine respiratory syncytial virus or BRSV. BRSV infections are common in the United States and nationwide studies show BRSV is present in 38% to 76% of the beef and dairy herds (Richey, 1990).

BRSV disease occurs in cattle of all ages but most adult animals show little if any signs of the disease. It has been identified as an important disease in both nursing and weaned calves. BRSV can effect February to April born calves in the summer while still nursing their mothers. The number affected is usually low in this early syndrome. Calves that are susceptible can also show respiratory disease a few days after weaning.

The late syndrome typically occurs from three weeks to three months after fall weaning. The disease progresses to a frothy saliva around the mouth and breathing becomes very labored. When the tongue is extended and the neck is stretched as breathing becomes more difficult, preventing death is doubtful. This same late syndrome occurs in feedyard calves but because of the high incidence of secondary infections, many calves may die before the advanced stages of the disease are observed.

BRSV infected cattle appear to be the principal reservoirs of the disease and transmission from one animal to another is thought to be via aerosol droplets from the nose and throat. In confinement situations, the disease can spread rapidly through the cattle in 3-10 days. In pastured cattle it may take several weeks or months to get through the entire herd. Once exposed, it requires 2-4 days for a susceptible animal to begin showing clinical signs. In susceptible herds undergoing a BRSV outbreak, 100% of the animals could become infected with the virus, 20-50% show clinical signs, and less than 5% could die.

Treatment of the virus with antibiotics has no affect on BRSV but can be used to control the secondary bacterial infections. Vaccination of the cowherd provides a barrier by slowing the spread of the virus to other cows and calves in the herd. Unfortunately, maternal antibodies against BRSV passed to the calf via colostrum from vaccinated or infected cows will not protect the calf from BRSV infection. General recommendations are to vaccinate calves over four months of age twice with a minimum of 21 days between the vaccinations and a booster each year.

PI-3

The parainfluenza-3 (PI-3) virus is common in cattle and is found worldwide. By itself, PI-3 is a relatively mild infection but usually works in concert with IBR, BVD, BRSV and pasteurella pneumonia to be a damaging and dangerous disease. Vaccinating the cows to provide maternal antibodies to the newborn and vaccinating before weaning and/or shipping can enhance immunity in calves (Richey, 1990).

IBR

Infectious bovine rhinotracheitis (IBR) results from bovine herpesvirus 1 infection (NAHMS, 2000) and is capable of attacking many different tissues in the body and producing a variety of clinical disease forms according to those tissues (Richey, 1994). These infections can be grouped as 1) respiratory tract infections, 2) eye infections, 3) abortions, 4) genital infections, 5) brain infections and 6) a generalized infection of newborn calves.

The IBR infections are usually confined to the upper respiratory tract (nose, throat, and wind-pipe). If the infection becomes severe, the nostrils become encrusted. If the crusts on the nostrils are rubbed off, the nose looks very red and inflamed, a condition known as "red nose".

Concentrating susceptible cattle provides an ideal situation for the rapid spread of the shedding IBR virus. Most feedyards (97.5%) vaccinate cattle against IBR with either an intranasal or injectable vaccine (NAHMS, 2000). It requires about one week following infection for the initial signs of the disease to appear and will last 10-14 days. In general, the respiratory form of IBR does not cause death but may reduce the resistance to other infections, which can cause death.

Proper vaccination of the herd to raise the resistance to IBR is the best way to control IBR. Once clinical signs of IBR are exhibited, antibiotic treatment must be administered to reduce the challenge of other infections.

Haemophilus somnus

Haemophilus somnus is a common disease-causing bacterium that usually creates a major problem before the disease is detected (Richey, 1990). In most cases, the minute blood vessels (capillaries) are blocked and blood flow is interrupted to the organs or parts of the organ. This results in tissue death and clinical symptoms of the disease. *Haemophilus somnus* can attack both the upper and lower respiratory tract. The result of attacking the upper respiratory tract in calves is calf diphtheria. The calf exhibits difficulty in swallowing, bawling and breathing. If the *H. somnus* organism reaches and attacks the lungs, severe pneumonia can result. This pneumonia can result in rapid death before any clinical signs have been detected. Although *H. somnus* is the primary cause of the pneumonia, Pasteurella quickly becomes the main problem.

In case of an outbreak of *H. somnus*, chlortetracycline and /or sulfamethazine is supplied in the feed for an extended period (30 d). However, relapse will usually occur without a simultaneous vaccination and booster given 14-21 d apart.

The Importance of Initial Vaccinations and Booster Vaccinations

Maternal antibodies passed to the calf via colostrurm are expected to be present in effective amounts as long as four to five months after birth (Richey, 1996). Perino (2001) found that achieving an immune response requires time. The first vaccination will produce an appreciable level of protection in seven to ten days but is not considered a strong immune response. The booster vaccination will produce a faster and more intense immune response and is required to reach an acceptable level of resistance. Perino (2001) recommended prebreeding vaccinations against BVD to protect the fetus from infection. Vaccinations 30 d before calving would help cows make high-quality colostrum, which is a one-time event just before calving. Calves that do not consume adequate colostrum are 3.2 to 9.5 times more likely to get sick and 5.4 times more likely to die than calves that do consume adequate amounts of colostrum.

Wankel et al. (2001) reported the effect of vaccinating cows and heifers precalving and calves preweaning for *Pasteurella haemolytica* to determine if serum antibody titers in dams could be elevated and the health and performance of the calves was improved. Vaccinations increased serum antibody titers in multiparous cows but not first-calf heifers. Precalving vaccination had no effect on mortality and morbidity of calves before or after weaning, which could be attributed to the low level of illness observed throughout the study.

Killed vs. Modified Live Vaccines

Faber et al. (1999) analyzed data from 496 steers and heifers in nine feedlot tests to determine the effects of age, weaning, and use of MLV or killed vaccines before the feeding period to predict BRD. Younger calves, non-weaned calves, and calves vaccinated with killed vaccines before the feeding period had higher BRD morbidity than those that were older, weaned, or vaccinated with MVL vaccines, respectively. Non-weaned calves were 3.4 times more likely to experience BRD than weaned calves. Calves vaccinated with killed vaccines were 2.2 times more likely to experience BRD than calves vaccinated with MLV vaccines. Calves vaccinated with killed vaccines had a 32% treatment rate for

BRD and 10% were treated 3 or more times vs. 18% treatment rate for calves vaccinated with MLV and 3% were treated 3 or more times. This treatment rate resulted in calves that were treated three or more times earning $174 less net profits than those that were not treated. However, these data do not agree with results by Kreikemeier et al. (1997) who compared Kentucky ranch calves (252 kg) assigned to one of three treatments. In the first treatment, calves were vaccinated with a killed viral vaccine 2 to 4 wk before weaning and revaccination with a killed vaccine at the time of commingling at a sale barn. The second treatment, calves were vaccinated with a MLV at the sale barn before shipment to a feedlot in western Kansas and boostered with MLV 21 d after arrival. For the third treatment, calves were vaccinated with MLV on d 1 and d 21 in the feedlot. Morbidity rates decreased for those vaccinated before weaning compared to calves vaccinated on arrival at the feedlot or vaccinated at the sale barn (27% vs. 37% and 33%, respectively). Treatments per morbid calf decreased for calves vaccinated before weaning (1 treatment) compared to calves vaccinated on arrival at the feedlot (1.14 treatments) and for those vaccinated at the sale barn (1.36 treatments).

Nutritional Stressors affecting Weaned Calves

Publications by the National Research Council (NRC) and Agricultural Research Council (ARC) provide the nutrient requirements for beef cattle. However, recommendations typically represent the minimum dietary levels for disease free animals, serving low production roles (Graham, 1991) and do not reflect requirements due to growth, pregnancy, sickness, etc.

Feedlot calves undergo numerous nutritional stressors that result in 1) transient endocrine responses, 2) altered products of energy and protein metabolism, 3) changes in appetite and growth rate, 4) possible limited compromise of digestive and rumen function, and 5) a challenged immune system. Cortisol and epinephrine levels change in response to marketing, transportation and feedlot adaptation (Loerch and Fluharty, 1999). Cortisol was not affected when weaning was the only stressor (Lefcourt and Elsasser 1995). Others (Locatelli et al. 1989; Agnes et al. 1990) reported increased cortisol associated with transport but Galyean et al. (1981) did not see a change in cortisol levels associated with transport.

Cole (1993) suggested that actual mineral requirements of stressed calves were not greater than those of unstressed calves, except for potassium. However, because of reduced dry matter consumption, concentrations of most minerals need to be increased in receiving diets to compensate for reduced appetite. Blood levels of Ca, P, K, Mg, Cu, Zn and Na have not been seen to change due to marketing stressors (Cole and Hutcheson, 1979; Galyean et al., 1981; Cole and Hutcheson, 1985b, 1987).

Most cattle have been without feed for 24 to 48 h when they arrive at the feedlot. Calves are susceptible to digestive upsets due to a reduction and shift in rumen bacterial population. California studies indicated that after 48 h of food deprivation, rumen bacterial numbers were reduced to 10 to 15 percent of normal (Moseley and Sewell, 1993). Similarly, Galyean et al, (1981) reported steers deprived of feed for 32 h and transported had reduced total counts of ruminal bacteria, which returned to pre-experiment levels by 72 h after feeding resumed. Newly arrived feeder calves typically consume 0.5 to 1.5% of their BW during the 1st wk and 1.5 to 2.5% of the their BW the 2nd wk (Hutcheson and Cole, 1986). Normal intakes were achieved between 2 and 4 wk after arrival.

Strategies to Increase Nutrient Intake and Balance Nutrient Antagonists

Strategies have been suggested to achieve greater intakes by calves upon arrival at the feedlot. Preconditioning calves before marketing will result in increased intakes during the receiving period (Loerch and Fluharty, 1999). Increasing nutrient intake by increasing nutrient density of the receiving diet would help offset low feed intake (Cole, 1993). Increased CP concentrations are needed to meet a calf's protein requirement early in the receiving period when DMI is low (Loerch and Fluharty, 1999). Increased feed intake before sending calves to the feedlot resulted in greater reserves of energy, water, and electrolytes and shortened the realimentation adaptation period (Cole and Hutcheson, 1985a). This may be more critical for small calves although not all studies show a difference in initial weights for morbid and healthy calves (Gardner et al., 1999).

It has been hypothesized that newly weaned calves penned with older animals would adapt to the new surroundings faster. Newly weaned calves penned with trainer cows may have greater ADG than calves penned without trainer cows for the first week but no differences in ADG were evident at 28 d (Fluharty et al., 1996c). Morbidity was 16.7, 28.3, and 8.3% for control calves, calves with trainer steers and calves with trainer cows, respectively. From a health standpoint, trainer steers may not be advisable. Hays et al. (1988) reported use of feedlot-adapted lead steers did not enhance performance of stressed calves and resulted in increased morbidity. Loerch and Fluharty (1999) conducted a second trial with 12 pens of control calves and 12 pens of calves each with a trainer cow. Morbidity was 78% for control calves and 54% for calves penned with a trainer cow. Calves with a trainer cow had ADG of 1.42 and 1.33 kg/d for wk 1 and 2, respectively. Control calves had ADG of 1.26 and 1.06 kg/d for wk 1 and 2, respectively.

Nutrients Suspected of impacting Calf Health

Copper (Cu)

The primary role of the trace mineral Cu is as an enzymatic cofactor, activator and constituent (McDowell, 1992a). A Cu deficiency in ruminants results in decreases in enzymatic activity, which result in less than optimal productivity and metabolic health (Bailey et al. 2001). Copper deficiency among grazing ruminants is widespread and supplementation is usually provided. However, as is common in the western USA, high levels of molybdenum (> 7ppm) may cause Cu deficiencies (Church, 1988). Spears (2000) reported that Cu deficiency could also result from the presence of high levels of other minerals (S, Mo or Fe; Suttle, 1991) in the forage that interfered with Cu utilization rather than just a simple deficiency of Cu in the diet.

The earliest visual sign of Cu deficiency is depigmentation or bleaching of hair. This is manifested as a russet or pale color in black-haired cattle and a dull, dead-like appearance in red cattle (Spears, 2000). Neutrophils isolated from Cu-deficient cattle had a reduced ability to kill yeast organisms (Boyne and Arthur, 1981). Copper functions in the immune system through energy production, neutrophil activity and antioxidant enzyme production. Copper also aids in the development of antibodies and lymphocyte replication

(Nockels, 1994). Molybdenum (5 ppm) or Fe (500 ppm) fed to induce Cu deficiency in feeder cattle also impaired neutrophil function (Boyne and Arthur, 1986).

Copper requirements tend to vary more than other trace minerals. High concentrations of Mo and S in forage greatly increase Cu requirements. High levels of S increased the negative action of Mo on Cu utilization. Copper deficiency or Mo toxicity can be prevented by maintaining a Cu to Mo ratio of 3:1 (Spears, 2000). Sulfur levels well within the normal range (0.2 to 0.4%) found in forages could reduce Cu absorption, even when Mo concentrations were low. In addition, growing cattle consuming Fe at levels as low as 500 ppm (typical of those often found in forages) could have reduced Cu levels (Spears, 2000).

Bailey et al. (1999) suggested supplementing trace minerals to incoming feedlot cattle which previously consumed dietary mineral antagonists, replenished lost mineral stores more effectively than cattle with no previous supplementation. In addition, a combination of inorganic and complexed Cu and Zn may be used strategically to limit hepatic accumulation on Mo while conserving hepatic Cu. Swenson et al. (1996a) reported consumption of the complexed form of Cu (copper lysine) increased liver Cu levels in the presence of antagonists and maintained a higher Cu level approximately 150 d after supplementation had ceased.

Breed may also affect copper levels. Simmental and Charolais cows and their calves had lower plasma Cu concentrations than Angus cattle when fed similar diets (Ward et al., 1995) and based on liver Cu, one-half of the Simmental cattle were classified as deficient (Underwood, 1981; Puls, 1994) whereas none of the Angus cattle were classified as deficient. Angus calves had fewer apparent clinical signs of copper deficiency than Simmental calves. Liver copper concentrations were twice as high in Angus steers compared to Simmental steers managed and fed together since birth (Spears, 2000).

Zinc (Zn)

Baker and Ammerman (1995b) found that chelating agents and ionic interactions were the most important dietary factors affecting the bioavailability of Zn. Zinc has been associated with synthesis of DNA, RNA and protein, i.e. expression of genetic potential, growth and tissue repair. Zinc also plays a role in the function of enzymes and hormones. Toxicities of Zn can be reduced with the addition of Cu and vise versa (McDowell, 1992b). Age, physiological state, environmental stress and health can affect the requirement for Zn (McDowell, 1992b).

A severe Zn deficiency results in reduced feed intake and growth, loss of hair, skin lesions, excessive salivation, and impaired reproduction. Severe Zn deficiency is rare but has been observed in ruminants grazing forages. Marginal or subclinical zinc deficiency is widespread (Spears, 2000). A genetic disorder of Zn metabolism has been reported in Holstein and Shorthorn calves. This disorder results in a deficiency due to the impaired ability to absorb Zn resulting in suppressed cell-mediated immune response (Spears, 2000).

Immune function in laboratory animals, such as the rat, is severely impaired by zinc deficiencies (Spears, 2000). Zinc supplementation enhanced recovery rate in IBR-virus-stressed cattle (Chirase et al., 1991) and zinc methionine has been shown to increase antibody titer against bovine herpesvirus-1 (Spears, 1991).

Swenson et al (1996) studied 60 first-calf gestating beef heifers to determine the effect of feeding zinc as an amino acid complexed mineral or inorganic sulfate compared to a control of no additional minerals. Heifers were injected with phytohemagglutinin (PHA-P) to illicit an immune response. The peak response to the swelling for the complex and inorganic minerals was 3 h while the control peaked at 6 h, suggesting Cu and Zn supplemented heifers were able to respond more rapidly. Zinc methionine appeared to be more bioavailable because of increased retention compared to supplementation with zinc sulfate. Heifers fed complexed Zn (zinc methionine) had increased liver Zn levels within 30 d of supplementation (Swenson et al, 1996a).

Molybdenum (Mo)

Abnormalities normally attributed to Cu deficiencies may actually be due to Mo toxicity. Molybdenum toxicity occurs when Mo intake is excessively high (20 ppm or higher) and toxicity can be overcome by providing additional dietary Cu. The addition of Mo (5 ppm) to a diet low in Mo reduced growth and feed efficiency and caused infertility in heifers (Phillippo et al., 1987). Supplementing Cu will generally prevent or correct adverse effects due to Mo (Spears, 2000).

Selenium (Se)

Selenium deficiency is a major problem in many areas of the U.S. despite the relatively small (0.1 to 0.3 ppm) amount required by cattle. Deficient animals may show lameness, stiffness or in extreme cases, cardiac failure. Other signs include unthriftiness, anemia, and increased incidence of retained placenta.