DISSERTATION

SELECTED FACTORS THAT INFLUENCE PROFITABILITY OF FEEDLOT CATTLE

Submitted by

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY GARY KEITH TIBBETTS ENTITLED "SELECTED FACTORS THAT INFLUENCE PROFITABILITY OF FEEDLOT CATTLE" BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

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ABSTRACT OF DISSERTATION

SELECTED FACTORS THAT INFLUENCE PROFITABILITY OF FEEDLOT CATTLE

For the primary emphasis of this dissertation, twenty-three ranches were selected from ranch cooperators in a large scale Nebraska-based cattle system to establish baseline measurements for liver concentrations of trace minerals, disease titers, parasite load, percent morbidity and gain performance. Upon arrival at the feedlot blood, liver, and fecal samples were collected from approximately 10% of each ranch group. After all yr 1 cattle were harvested an 11 ranch subset of the original 23 ranches was selected based on ranch weaning practice for a second yr survey. In yr 2 all ranches shipped calves to the feedlot on the day of weaning and all fed a standardized free choice mineral containing organic trace mineral complexes (OTM) to cow calf pairs 45 d prior to weaning. Comparing yr 1 and 2 for the 1 ranches, percent 1st pulls decreased from yr 1 to yr 2. Carcass quality was decreased from yr 1 to yr 2. Liver Cu concentrations of calves at weaning increased from yr 1 to a yr 2 and Zn and Mn liver concentrations were similar across years. Across both years, higher liver Cu concentration was correlated with decreasing total pulls and increasing ADG and mortality tended to decrease as Cu concentration increased. Higher liver Mn concentrations tended to be correlated with lower total pulls.

There was no correlation between liver Zn concentration and animal and health performance. In conclusion, allowing cow-calf pairs access to free-choice mineral containing OTM prior to weaning improved some aspects of feedlot health and performance.

For a second paper feedlot performance records from the U.S. Meat Animal Research Center feedlot for 1993 through 2000, were analyzed to evaluate the impact of footrot on ADG and total days on feed. Records from the original pool of 36,755 bull, steer and heifer calves were sorted so that only steers that had a single footrot incidence and those with no other morbidities were included in the data set (7,100 steers). To roughly pattern these data to industry production practices, time of footrot insult during feeding was divided into three production periods; starting (0-60 d), growing (61-120 d) and finishing (121d - harvest). Records were evaluated to determine which limb was more likely to be affected with footrot. A total of 459 (6.5%) steers were treated for a single footrot incident. ADG for cattle experiencing a single footrot incident was decreased compared to non effected cattle. The production period of footrot onset impacted both ADG and total days on feed. Mean days on feed for the non-affected cattle was 262 d while mean days on feed for footrot affected cattle was 267 d (P<0.01). The impact of footrot on days on feed for the starting, growing and finishing periods was –9.9 d, +2.2 d and +14.3 d.

Key Words: Trace mineral, beef cattle, trace mineral complex, weaning, feedlot health, footrot, beef calf, feedlot performance

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Pursuing the Ph.D. degree has been a 25 year dream. The actual motivation to get started came from friend and Nebraska cattle feeder Jerry Adams. Jerry suggested I read a book called Halftime by Bob Buford. The basic premise of the book is now that you are at midlife, it is past time to prepare for what you really want to do with the rest of your life. I knew I really liked a lot about the cattle industry and the specific work I do. What I really wanted to do in the second half of my life was be better at what I already do.

My heartfelt thanks go to Jack Whittier for first hearing the idea and then encouraging me to go for it. I am grateful for both Jack's and Terry Engle's patience as I worked toward this degree, and especially while trying to get my arms around the dissertation.

I am especially grateful to Michael Anderson, Joe Carrica, Russ Wyllie and Connie Larson, all members of Zinpro Corporation management or technical support groups. Without Zinpro's support (emotionally, financially and by allowing me to make scheduling adjustments) pursuing the degree would not have been possible.

DEDICATION

This dissertation is dedicated to my wife Joyce Tibbetts. Without her understanding, gentle nudging to GET IT DONE and willingness to give up many evenings and weekend outings the course work and this dissertation would never have been completed.

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Objectives of Dissertation

It is the primary objective of this dissertation to review the impact of changing management practices at the ranch of origin on the subsequent feeding, health and carcass performance of calves being shipped to the feedyard at the time of weaning. Many papers have reviewed the impact of morbidity in the feedyard on animal and carcass performance and on profitability. It is the purpose of this dissertation to discuss morbidity in a cattle system and to review some of the causative factors that may be contributing to that morbidity.

The study used as the basis for this dissertation was first motivated by the need for more consistently healthy calves entering partner feedyards in the Nebraska based Power Genetics beef supply chain system. Power Genetics recognized that there were large differences in feedyard health status among calves that received a similar preconditioning protocol (vaccination, deworming, etc.) while on the ranch of origin. For this study a group of ranches in New Mexico, Utah, Colorado and Nebraska were selected from ranch cooperators in the Power Genetics system. There were two primary questions to be addressed by this survey. First: "Was the initial immune status and trace mineral status of the herds adequate to ensure low morbidity in the feedyard?" And, second: "Could the immune status and trace mineral status of the calves be improved with better management of the vaccination protocol and with more bioavailable and consistently delivered trace minerals?" Differences in heath status, feeding performance and carcass quality from year one to year two were measured.

It is recognized that there are many confounding factors and conflicting interests in this type of study. Improvements in health status once the calves arrive at the feedyard are most likely a result of several factors, intentional interventions and factors out of anyone's control (unfavorable weather, unplanned shipping delays, unexpected co-mingling, etc.), not just specifically planned interventions. All participants in this beef supply chain have the goal of providing a constantly higher quality and more predictable product to the next segment of the supply chain with the ultimate goal of providing the best product possible to the beef consumer.

The second objective of this dissertation is to evaluate the impact of feedyard cattle lameness on animal gain performance. Lameness diagnoses are common in feedyard production. Though it is generally accepted that common lameness diagnoses impact animal performance this paper quantifies the gain impact of footrot on cattle on feed for greater than 200 days. In coming years cattle lameness issues may become a bellweather issue in animal welfare discussions.

REVIEW OF LITERATURE:

Section 1: The Increasing Importance of Supply Chain Management in the Beef Industry

The beef industry is an industry in transition. It is changing from a commodity-oriented industry, dominated by small, independent producers, to an vertically coordinated industry made up of consumer-driven beef production systems in which large food companies and affiliated groups of producers are managing product attributes, from farm-to-table and producing value-added "brands" of beef (Smith et al., NBQA 2005). Types of brands are described in this audit were 1) USDA Certified Brands (e.g., Certified Angus Beef, Certified Hereford Beef, Chef's Exclusive), 2) USDA Process Verified Brands (e.g., PM Beef Group Ranch to Rail, Red Angus Association of America) and 3) Industry Brands (Laura's Lean Beef, Meyer Natural Angus, Coleman Natural Beef) (Smith et al., NBQA 2005). Ken Bull, Vice President of Cattle Procurement, Cargill Meat Solutions, stated that the growth of retail brands has been explosive (Bull 2006). He further listed brand options available to beef producers as Premium Brands, Everyday Brands, Enhanced Product Brands, Niche Brands and Age/Source Verified Brands for export.

Blach (2008) estimates that 40 to 50% of all beef is branded with national or store (house) brands. He suggests that as the desire of the consumer to shop by brand continues to grow, the potential exists for branding to reach 75% of beef sales. Cattle-Fax (2006) suggests that as a higher percentage of beef is sold with a brand, a more coordinated supply system will likely develop. Blach (2008) also suggests that the amount of beef consumed through food service will continue to increase, from 47% in 1995, to 52% currently, to 55 to 58% in coming years. In many cases food service establishments feature branded beef products.

A primary driver of the development of supply chains is the need to supply brand owners with a consistent supply of qualifying cattle or beef. Cattle alliances market their ability to supply the processor, or brand owner, with a "rateable supply", or a supply consistent with the year round needs of the brand. Supply chains are being initiated at every level of the beef industry. They range from as informal as the same cattle buyer purchasing a ranchers cattle each year to as formal as the Harris Ranch Beef Company Partnership For Quality (PFQ) (Smith et al., NBQA, 2005) The Harris Ranch program is described as a program involving 72 ranches and 40,000 beef cows where all producers focus on producing "consistent, high-quality, consumer-driven product, with the strictest standards for food safety, environmental stewardship, economic sustainability and animal welfare. As Vice President of Supply Chain Fulfillment with Swift and Company, Mike Self stated that committed cattle supplies are essential to enabling delivery of beef brands (personal communication). Without a committed supply, the brand is susceptible to the market conditions of feeding break-evens, feeder cattle availability and grain price fluctuations. Self emphasized that producers should look at developing partnerships in the industry to share the costs of pulling a system together.

A second driver of the growth in supply chains is the rapid consolidation of all phases of the cattle industry. Cattle-Fax (Cattle-Fax, 2006a) recently reported that over the past 30 years the number of beef cow operations has declined by more than 500,000 and currently 50% of the cows are in operations of 100 head or more. Further, the number of operations that have between 200 and 500 head has increased by 20%. Cattle-Fax expects the average cow herd size to continue to increase.

The feeding segment of the business is also consolidating. Cattle-Fax (2008) reported that 262 feedlots control 60% of all fed cattle and the top 26 cattle feeding companies feed 47% of all fed cattle. This consolidation exists even in the ranks of the very largest cattle feeding operations. For example, the formation of Five Rivers Ranch Cattle Feeding LLC is the largest merger to date. Five Rivers Cattle Feeding was formed in 2005 as an independently operated joint venture between the cattle feeding businesses of ContiGroup Companies, Inc. (formerly Continental Grain Company) and Smithfield Foods, Inc. Five Rivers Cattle Feeding was purchased by Brazilian beef processor JBS S.A. in 2008 as part of their acquisition of beef packing operations of Smithfield (Anderson and Hudson, 2008). Five Rivers has a combined feeding capacity of more than 800,000 head of cattle with locations in Colorado, Idaho, Kansas, Oklahoma, and Texas (JBS Five Rivers, 2009). Several other cattle feeding operations ranked in the top 25 in National Cattlemen Magazine's annual size ranking of cattle feeding operations have consolidated or added significant capacity to existing feedlots over the past several years (National Cattlemen, Summer, 2005).

Whether the increased emphasis on supply chains is due to the growth of branded products or the increase in consolidation at all levels of the beef industry, there is no doubt that producers in all areas are seeing need to become linked in some way to other like-minded producers. Supply chains may be as simple as ranchers developing a reputation for healthy and high quality cattle and then seeking buyers looking for this type cattle. More complex supply chains are being developed where producers and processors link in a formal production system with production procedures and inputs being mandated and verified at all levels of the chain. Tom Brink, Senior Vice President and Chief Risk Officer, Five Rivers Ranch Cattle Feeding, LLC suggested (Brink, 2006a) that ranching producers who will be successful in the coming years will have strong industry relationships. Brink further suggested those relationships should include relationships with bankers, packers, cow-calf and stocker producers, grain farmers, grain trading companies and other feed ingredient suppliers, pork and poultry producers, trade association personnel, brokers on the floor of the Chicago Mercantile Exchange, market analysts, nutritionists, veterinarians and other consultants, animal health manufacturers, and university faculty and students.

The need for third party verification and certification as part of supply chain management needs further discussion. In current feeder cattle marketing systems it is difficult for buyers to assess the relative quality of cattle, and sellers have incentive to overstate cattle condition and inputs. Third party verification and certification will become increasing important. In an evaluation of 20,051 sale lots at Iowa cattle auction markets, it was fond that cattle receiving third party certification of preconditioning claims returned $2.75/cwt more than those calves without third party verification (Bulut 2009).

Section 2: Impact of Non-Specific Morbidity and Mortality on Animal Performance, Carcass Quality and Overall Profitability

Economics of morbidity

For the purposes of this manuscript, morbidity is defined as the incidence of treatable clinical disease in the feedlot. The top ten specific disease entities that are treated at the feedlot are give in Table 1 (Frank 1988). Regardless of specific disease problem they all contribute to morbidity.

Table 1. Total clinical cases, total deaths, and total animals culled for the ten diagnoses most frequently made in a Colorado beef feedlot operation (May 1984 – April 1985).

Diagnosis	New cases	No. of animals died	No. of animals culled
Lower respiratory	4,837	196	41
Lame, unspecified	1,128	6	93
Buller	1,058	8	11
Footrot	980	4	20
Upper respiratory	290	8	15
Poor doer, unspecified	261	5	10
Bloat	235	41	10
Coccidiosis	195	8	2
Abscesses	121	2	5
Diarrhea, unspecified	110	0	0

In a personal communication in 2005, Jason Anderson, President and Director of Cattle Procurement for Power Genetics, a significant cattle supply chain company, stated that feeder cattle health status is the largest un-hedgeable risk in the cattle finishing business. Many of the other risks that can result in poor profitability can be mitigated with different commodity hedges or pre-payments, or with direct insurance. There are limited ways to assure low morbidity in in-coming cattle. Irsik (2006) noted that some variables are more easily managed than others. Purchase weight, origin of cattle, type or genetic makeup of cattle and background are more easily managed than the health liabilities cattle may experience.

Northcut et. al. (1996), surveyed 10 small (<35,000 hd capacity) and 9 large (>35,000 hd capacity) feedlots. Feed efficiency and health were ranked equally as the two most important of 14 traits when considering which feeder cattle to purchase. Records from 1560 steers fed in the Oklahoma Steer Feedout were used by Gardner et.al. (1996) to develop a model for predicting the profitability of cattle in the feedlot. The best model for predicting profitability of all steers in order of importance was medical cost, marbling score, dressing percentage, feed intake, rib eye area, daily gain, days on feed, fat thickness, sale weight and hot carcass weight. Several summaries of industry data have substantiated the impact of morbidity on finishing performance and cattle profitability. Brink (2006b) summarized feedlot closeout reports of 75,206 yearling steers harvested in February 2006 to evaluate the impact of feedlot mortality on profit per head (Table 2).

Table 2. Impact of mortality on feedlot profitability. Summary of feedlot closeout data for February 2006.

Death Loss Group	Average Death Loss	Pre-interest Profit Per Head
0%	0%	$87.16
0-1%	0.43%	$81.82
1-2%	1.39%	$62.10
2-5%	2.46%	$47.54

In an earlier summary of industry data Brink (2000) found that cattle feeders paid and average $19.00 premium/hd for feeder cattle considered "low health risk" verses those that were considered "high health risk cattle". Reduced medicine costs and better performance actually made the "low-risk cattle" worth $22.00/hd more than "high risk cattle". Brink further pointed out the premiums paid were justified even before the potential for better carcass traits and related grid premiums are considered.

One of the earliest surveys and likely the most referenced data evaluating the total cost of feedlot morbidity is the Texas A&M Ranch to Rail Program. McNeill (1999) summarized five years of these data. Average return was $37.54/hd for 12,595 head from 1197 ranches over a five year period. Return on individual cattle ranged from $307.03/hd profit to $310.01/hd loss. Over five years, the average value spread between steers never treated for respiratory disease and those treated at least one time was $93.20/hd. Medicine costs averaged $31.97/hd for treated calves. The remaining loss of $61.87/hd was due to reduced performance, increased feed cost of gain, higher interest expense and lower quality carcasses. To recoup the difference in net return seen in this data set, cattle treated in the feedlot would have to be priced $16.32/cwt less when they were placed on feed. McNeill (1999) cited the impact of cattle health on the ability of steers to express their genetic potential and the costs associated with sick cattle beyond the cost of medicine as the 2 most important findings in the Ranch to Rail reports.

Reporting the results of a wide reaching survery of the US cattle feeding industry, Woolums (2005) reported that Bovine Respiratory Disease (BRD) was the leading cause of morbidity and mortality. Feedlots representing approximately 10% of the cattle placed on feed in 2000 reported that 12.8 of placements were treated for BRD and 0.8% died of BRD.

Decreasing health status of feedlot cattle was evaluated by Loneragan (2004). Citing data from the USDA Centers for Epidemiology and Animal Health, he reported mortalities in feedlots have increased by approximately 6% per year from 1994 through 2003. The greatest proportion of the increase in feedlot mortalities is a result of increasing proportion of placements that died from respiratory tract diseases. In 1994 deaths from respiratory tract diseases represented 52% of total mortalities. In 2003 that number had increased to 67% of total mortalities. The mortality percentage of all cattle placed on feed had increased from approximately 1% to approximately 1.6%.

Loneragan (2004) considered decreasing feedlot arrival weights as a cause for increasing morbidity from respiratory disease. Though arrival weight is a predictor of increasing mortality, it was less of a factor than was originally thought. Other factors that may be affecting the increase in morbidity in feedlots include a possible decrease in number and skill level of feedlot employees, possibly different or more virulent pathogens and potentially fewer cattle being shipped early as railers or chronics. He questioned what has and hasn't changed over time in the beef cattle business, postulating that antibiotics, vaccines, finishing systems and cattle growth efficiency have all improved. He suggests one thing that has not changed is the cattle procurement system. It was suggested that procurement methods may need to be modified to catch up with some of the other changes that have been made in the beef business.

Similar results were reported by Babcock (2006). Over the period 1992 0-2004 annual morbidity increased by 0.0467% for steers and 0.067% for heifers in 8 cooperating KS feedlots. Authors suggested possible explanations as cattle being pushed harder in the feedyard, slippage in the ability to identify and manage sick cattle or perhaps the cattle industry is better able to keep cattle alive in pre-feedlot pases resulting in higher death loss when cattle arrive in the feedlot.

Impact of animal origin and management practices on morbidity

Marketing. Recently Step et al. (2008) contrasted animal gain and health performance in the feedlot of calves purchased directly from the ranch of origin with calves purchased through conventional auction systems. He also compared unweaned calves with those weaned 45 days on the ranch of origin. Overall health treatments totaled 9.6% for ranch direct calves, either unweaned or weaned, and 19.3% for auction market calves. Ranch direct but unweaned calves had more health treatments (13.0% vs. 5.7%) and higher health cost per calf ($13.55 vs. $8.53) than ranch weaned calves.

The impact of morbidity on stocker cattle or on reproductive performance of replacement heifers has only had limited examination. Pinchak et al. (2004) evaluated the impact of respiratory disease on gain and profitability of cattle being grazed. In their first experiment (655 male calves, average BW = 231 kg), there was no difference in ADG of healthy or morbid cattle in a group of cattle that was marketed in July. Peer cattle marketed in August had a reduction in ADG of .06, .08 and .15 kg per d for cattle morbid 1 to 7, 8 to 14 and >14 d, respectively. In a second grazing experiment (279 male calves, average BW = 216 kg), any morbidity duration decreased gain by .05 kg per d ($P < .05$). In experiment three, 633 heifers (average BW = 251 kg) were used to test the effects of morbidity on weight gain and reproduction. Heifers requiring two or more antibiotic treatments gained 0.03 kg/d less ($P < 0.05$) than healthy heifers and had lower ($P < 0.05$) conception rates (66 vs. 81%). Morbid heifers conceived 0.6 mo later ($P < 0.05$) than healthy heifers.

Preconditioning. Over the past few years there has been a lot of discussion in the cattle industry about the value of ranch-level preconditioning programs. Cattle.Fax (2006a) reported in an annual summary of member ranches that the percentage of respondents saying they precondition calves has increased from 62% in 2002 to 84% in 2005. They report that nearly 8 out of 10 sold in preconditioned sales were 0.22 times as likely to receive treatment for BRD.

One of the common frustrations expressed by feedlot buyers of feeder cattle is whether or not producers believe preconditioning yields a return for their labor and financial. Marcartney et al. (2003) compared the health performance during the first 28 d in the feedlot for calves termed vaccinated or preconditioned and sold in special auctions focused on those type calves with calves sold through conventional auctions in Ontario. Calves sold as vaccinated were 0.68 times as likely to receive treatment for BRD as calves sold at conventional auctions.

Another frustration among feeder cattle buyers is the lack of common definitions of terms like “preconditioned” and “weaned”. Fennewald et al. (2001) attempted to compare a standardized ranch level weaning program to a non-standardized control group on MT ranches. A total of 2,898 calves were sent to feedlots in Colorado and Nebraska from 12 ranches. Standard specifications included minimum 45 d weaning period and specific vaccination protocols and nutrition specifications. Control calves may or may not have received pre weaning vaccinations and were weaned on the ranch for something less than 45 days. Calves that were weaned using the standardized protocol had a total post weaning morbidity (weaning and finishing period) of 6.3% compared to 19.5% in calves managed in traditional programs.

Cravey (1996) defined preconditioning to include at least weaning 45 d on the ranch in 2 comparisons of feedlot profitability of preconditioned and non-preconditioned calves. In the first comparison of 550 non-preconditioned and 640 preconditioned calves from the same ranch, the preconditioned calves had $60.72/hd more value through the finishing period than the non-preconditioned group. In the second comparison, 1685 preconditioned calves were compared to 1492 similar but non-preconditioned calves. In this comparison, the preconditioned calves had $55.93/hd more value at the end of the finishing period. When calculated as increased amount that a calf buyer could have paid for the preconditioned calves, the added amounts were $11.04 and $9.67 per cwt, respectively for the first and second observations. Neither of these amounts considered any added value that the calves may have realized as result of potentially higher quality carcasses.

Waggoner et al. (2005) made a compelling case for ranch weaning in a comparison of ranch weaning durations of 834 calves enrolled in the New Mexico Ranch to Rail program from 2001 to 2004. Weaning periods were 0 to 20 d, 21-40 d, 41 to 60 d and 61 d or more. Net income per head increased as weaning period increased. (-$41.66, -$20.02, $2.23 and $4.00). Marbling score increased as weaning duration increased ($P < 0.05$).

Though ranchers often suggest that the premiums being offered for weaning on the ranch are not adequate to cover the added production costs and risks of holding calves prior to shipping, increasing numbers of weaned and vaccinated calves are being offered for sale from their ranch of origin. Lalman and Ward (2005) summarized Pfizer Animal Health annual reports of value added health program cattle sold through Superior Livestock video auction service. Between 1994 and 2004 the number of sale lots that have been vaccination-certified (Pfizer Vac 34 program) increased from 8.3% to 49.2% of total lots. The value premium over non vaccination-certified increased from $0.77/cwt in 1994 to $3.47/cwt in 2004. The number of weaned and vaccination-certified sale lots (Pfizer Vac 45 program) increased from 1.8% to 25.2% of total lots. The added value received for these calves increased from $0.25/cwt in 1994 to $7.91/cwt in 2004.

Encinias (2009) pointed out that the best way for cow calf producers to add value to their calves is to focus on minimizing risk and increasing profit potential for stocker or feedlot operators that may be buying those calves. He suggested producers who have realized premiums in the value-added area have done so by adding multiple, additive factors, rather than by focusing on one single factor.

In his presentation to the 2006 Colorado State University Robert Taylor Symposium, Tom Brink suggested that cattle health is now a "social problem", not a "technological issue" (Brink 2006a). Brink explained that methods are now available to cow-calf producers to dramatically improve the health performance of cattle once they reach the feedlot. He suggested that cow-calf producers should shift their mindset toward more cooperative integration within the overall production chain.

Impact of treatment costs on profitability

Though numerous papers have shown there are many contributors to lower profitability in morbid cattle, as in the Ranch to Rail data, initial treatment costs are the first cost to be realized by the producer. In the National Animal Heath Monitoring System (Feedlot, 1999) survey, the cost to treat acute interstitial pneumonia and shipping fever ranged from $11.09 to $16.49 per hd, excluding labor or facility costs.

Gadberry et.al. (2006) looked at the costs of morbidity in a slightly different way. , He used stepwise regression analysis to evaluate the factors contributing to value of 1917 calves over a 9 year period. Healthy calves returned $65.74/hd more than calves treated during the finishing period. The authors noted that producers were losing a minimum $10 per average animal placed in the feedlot as a result of lost performance and carcass value from cattle becoming sick during the finishing period. The impact of calf mortality and those animals removed from the data prior to conventional harvest dates was not considered in this data set.

In a retained ownership demonstration project, Fulton et. al. (2006) demonstrated relationships between health status in the feedlot and performance parameters. Net value to the owner (carcass value less total costs in the feedlot) varied from \$365 to \$677 per hd over the 417 hd representing 24 cooperating herds. Compared with the calves that were not treated, the calves receiving 1 treatment returned \$40.64/hd less, those receiving 2 treatments returned \$58.35/hd less and those treated 3 or more treatments returned \$291.93/hd less ($P < 0.05$). Calves treated 2 or more times had poorer carcass grades than those not treated or treated only once ($P < 0.05$).

Roeber et al. (2001) evaluated the impact of morbidity and number of treatments in the feedlot on feedlot performance. There was no impact on ADG, final weight or actual carcass value of a single feedlot treatment for respiratory disease. Two or more treatments decreased dressing percentage by 0.71% and actual carcass value by \$29.18.

Schneider et al. (2009) evaluated the performance and harvest records from 5,976 cattle fed in midwest feedlots. Incidence of BRD was observed at a rate of 8.17%.

A total of 488 cattle were treated for BRD, of which 53% were treated once, 34% were treated twice, and 13% were treated three times or more. When untreated cattle were compared with BRD treatment classifications of 1, 2, and 3+, there was a difference of \$23.23, \$30.15, and \$54.01, respectively, from untreated cattle. These values underestimate total economic losses associated with BRD in this study as they do not account for the extra cost of animal treatments associated with medicine cost, labor, veterinarian fees, and death loss. When chronically ill cattle that were treated at least 3 times are compared with untreated cattle, the frequency of cattle that fell within the Standard grade was 5 times greater.

Impact of morbidity on carcass performance

One issue that has increased the focus on the importance of morbidities and mortalities is the trend toward poorer carcass quality in fed cattle. Corah (2006) cited Certified Angus Beef® (CAB®) data where percentage of cattle accepted into the Certified Angus Beef program has decreased from 20% to 14.1% from CAB® fiscal year 1999 to 2005. He further emphasized the drop in available high quality beef citing the 2005 National Beef Quality Audit (Smith et al. 2006). In these data there is a 1 percentage-point decline in Prime and a 6.2 percentage-point decline in Choice, comparing 1975 to 2005. The data were standardized to account for changes in marbling evaluation criteria over those years. In a brainstorming session with participants from several universities, an industry pharmaceutical company and two independent cattle nutritionists, increasing health problems in the cattle industry was identified as the most important contributor to poorer quality grades (Corah 2006)

A number of trials have demonstrated the impact of morbidity on animal and carcass performance measures. Stovall et al. (2006) followed 406 heifer calves from receiving though finishing evaluating the impact of morbidity occurring during the 42 d receiving period on total post weaning performance and carcass quality. One or 2-or-more morbidity incidents during the first 42 d did not impact ADG but did impact carcass traits and value. Cattle not treated, treated once or treated 2-or-more times during the first 42 d graded 66.19, 59.19 and 41.11 percent choice or prime. Using a $7.50/cwt spread between USDA Choice and Select carcasses, any morbidity event decreased carcass value by an average of $2.31/cwt of carcass. Treatment costs combined with lower carcass values equated to lower net value of $11.48 and $37.34 per hd for cattle treated once or 2-or-more times, respectively.

In data from 6,616 calves consigned to the Iowa Tri-County Steer Carcass Futurity, calf morbidity was classified as no treatment (NT), single treatment (ST) or two-or-more (2T) treatments (Busby et al., 2004). Certified Angus Beef® qualifications were 27.1, 24.2 and 18.7 percent for the NT, ST and 2T groups, respectively. Feedlot ADG was 1.39, 1.33 and 1.30 kg per day for the NT, ST and 2T groups, respectively.

Impact of morbidity on feeding performance

In a survey of records from two large western Kansas feedlots Irsik et al. (2006) attempted to quantify the impact of several variables, including morbidity and mortality, on FE and ADG. Other variables considered were average in-weight, average out-weight, sex, calendar quarter of feedlot placement, origin and background. The comparison period was August 2000 through January 2001. The total number of pens was 673 and the total number of head was 53,890. The average in-weight was 343.07 kg and the average out-weight was 570.16 kg. For each percentage increase in mortality in a pen of cattle the pen's feed conversion was poorer by a factor of 0.12 kg per kg gain, ADG decreased 0.036 kg/d and added total costs increased $1.00/d. For each percentage increase in morbidity treatments for a pen of cattle, death loss increased by 0.143%. In this dataset, a 10% morbidity treatment rate equated to a 1.7% death loss.

In a paper examining the impact of respiratory disease during a 150 d feedlot finishing period on daily gain and carcass traits including tenderness Gardner et al. (1999) used 222 spring born calves from a single South Dakota herd placed on feed in a southwest Kansas feedlot at weaning. Steers treated only once gained .14 kg/d (10%) faster than those treated more than once ($P = 0.04$). For the entire trial, weight gain was 21 kg less for steers treated more than once than for those treated only once. Cattle without respiratory tract lesions at harvest had the heaviest final live weights ($P < 0.01$) as a result of 11% greater ADG (1.58 vs. 1.4 kg, $P < 0.01$) than cattle with either active or inactive respiratory tract lesions. Steers with active bronchial lymph nodes had 18% lower ADG ($P < 0.01$) than steers with inactive bronchial lymph nodes. Carcasses from untreated steers were fatter both externally ($P < 0.01$), based on subcutaneous fat measurement, and internally, ($P < 0.05$), based on percentage of kidney, pelvic and heart fat, and tended to have larger ribeye ($P = 0.12$) areas than those carcasses from treated steers. Gardner et al. (1999) is often referenced to support the hypothesis that respiratory disease impacts meat tenderness. A difference ($P = 0.051$) in shear force for steaks aged 7 d was detected when steers were classified by absence or presence of respiratory tract lesions. Steaks from steers without lung lesions were more tender than steaks from steers with lung lesions.

Impact of subclinical morbidity

Clinically observed morbidity accounts for only a portion of the production losses attributable to respiratory disease. There may be a significant number of animals with unapparent, or subclinical respiratory disease, and evaluating only clinically affected cattle may be inadequate to assess the total costs and production losses attributable to respiratory disease. Wittum et al. (1996) found no significant association between cattle treatment for clinically diagnosed respiratory disease and weight gain. There was, however, a significant association between pulmonary lesions found at harvest and weight gain. Cattle with pulmonary lesions had 0.076 kg lower ADG ($P < 0.01$) than cattle with no pulmonary lesions. Pulmonary lesions were found in 68% of untreated animals at harvest.

Bryant et al. (1999) followed 439 steer and heifer calves born during the spring of 1995 at USDA MARC from birth through harvest to evaluate the impact of different types of lung lesions on ADG. Seventeen percent of the calves in this population suffered from clinically diagnosed respiratory disease between birth and harvest, with 1% of the treatments occurring before weaning and 16% occurring during the finishing period. Forty-two percent of all calves had pulmonary lesions at harvest. Forty percent of those diagnosed with respiratory disease had lesions, whereas 42% of calves never diagnosed with clinical disease also had pulmonary lesions. The presence of any pulmonary lesion observed at harvest was associated ($P < 0.01$) with a decrease of 0.026 kg in ADG for the finishing period.

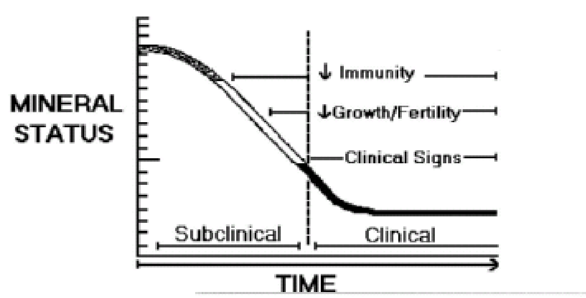
Thompson et al. (2006) found closer correlation between the impact of clinical and subclinical diagnosis of Bovine Respiratory Disease (BRD) on growth of 2,036 calves during the finishing period in two South African feedlots. Subclinical diagnosis of BRD was defined as an animal having pulmonary lesions at harvest but no clinical diagnosis. Subclinical BRD occurred in 29.7% of calves and clinical BRD occurred in 22.6% of calves. Pulmonary lesions were present in 43% of calves at harvest. Using a combined cased definition (treated for BRD and/or pulmonary lesions present at harvest) the incidence of BRD was 52.5%. During the first 35 d of the average 137 d finishing period, clinical BRD reduced ADG by 0.216 kg ($P < 0.001$), subclinical BRD reduced ADG by 0.091 kg ($P < 0.001$). The combined effect of BRD was a 0.142 kg reduction in ADG ($P < 0.001$). The overall effect of either clinical or subclinical BRD diagnosis was a 0.024 kg reduction in ADG ($P < 0.02$) and a 5.1 d increase in days on feed ($P < 0.001$).

In data reported by Schneider et.al. (2009) lung lesions were found in 60.6% of cattle that were never treated for BRD and in 74% of cattle that had been treated at least once. Presence of lung lesions did not influence animal or carcass quality in the data reported. The authors suggested the inconsistency of this data with earlier reports may point to a need to determine the extent to which lung lesions observed at harvest could be from infection before entering the feedlot. It was also suggested that researchers must be cognizant of limitations to physically manipulating lungs imposed when evaluating lung tissue in modern harvest facilities and the consequence that these limitations may have on possible misclassification of lungs.

Impact of trace mineral nutrition on immune response and animal morbidity

Preweaning nutritional management strategies offer the opportunity for producers to improve the immune status of calves prior to their movement into the next cattle production phases. Considerable industry attention has been focused on the mineral and trace mineral status of calves and high stressed feeder cattle as they arrive in feedlots. Arthington (2005) categorized the two types of trace mineral deficiencies seen as primary and secondary. A primary deficiency is defined as a deficiency resulting from the consumption of an essential trace mineral at levels inadequate to support the physiological functions associated with that element. Secondary deficiencies are those resulting from the consumption of an element which antagonizes the pre- or post-absorption of an essential trace element rendering the element incapable of supporting the physiological functions associated with that element. With an often referenced figure, Wikse (1992) postulated that deficient trace mineral status may impact economically important animal performance attributes well prior to clinical deficiency signs being seen in the animal (Figure 1).

Figure 1. Effects of trace mineral deficiencies on immune function in cows and calves.



Potentially low Zn and Cu concentrations in forages were noted by Corah (1996) who surveyed forage samples from 327 cooperators in 18 states (Table 3). Only 2.5% and 36% of samples were adequate in Zn and Cu content, respectively, relative to NRC (1996) requirements for beef cattle. Antagonists such as iron and molybdenum were in the marginal or high classification for 28.7% and 57.8% of samples, respectively, indicating that both of these elements are often present in levels that can cause a reduction in copper availability.

Table 3. Trace Mineral Classification for 352 Forage Samples.

					Antagonist Levels	
Trace Element	Adequate	Deficient	Marginal	High	Marginal	Very High
Copper	36%	14.2%	49.7%	----		
Manganese	76%	4.7%	19.3%	----		
Zinc	2.5%	63.4%	34.1%	----		
Cobalt	34.1%	48.6%	17.3%	----		
Selenium (n=305)	19.7%	44.3%	19.3%	16.7%		
Iron	62.8%	8.4%	----	----	17%	11.7%
Molybdenum	42.2%	----	----	----	48.6%	9.2%

Klasing (1992) suggested the interactions between nutrition and infectious disease can take two forms. First, nutrient requirements may be altered by the presence of clinical or non-clinical disease. Second, nutritional status may affect immunocompetence of the animal and consequently its resistance of infectious agents. Though supplemental Zn, Cu, Se and Cr have been seen to alter immune function of newly received calves, individual experiments measuring specific performance or health responses have been variable (Galyean, 1999). The lack of response seen in some trials may be explained by Klasing (1992) where it was suggested that the immune system is relatively resistant to marginal nutrient deficiencies given the capacity of the stimulated immune system to mobilize large quantities of nutrients from other tissues. Additionally, the binding affinities of transport proteins on the cell membranes of leukocytes suggest the immune system has a high priority for circulating nutrients and is able to compete favorably with many other tissues when nutrient levels are low. Beneficial effects of supplemental nutrients on immunity and the incidence of BRD in beef cattle would be most likely in animals with a marginal or deficient status of the nutrient. However, it is highly unusual to know the nutrient status of cattle used in most applied receiving studies (Duff, 2007)

Impact of zinc on health and immunity

Zinc supplementation may be needed for stressed calves with a propensity to succumb to bovine respiratory disease (BRD), and source of Zn has been important in some studies but not in others. Chirase (1991) reported that 3 d after an IBRV challenge, DMI was decreased 50% in steers fed a control diet with 31 mg of Zn/kg, compared with a 15% decrease in steers supplemented with 90 mg of Zn/kg from zinc methionine. Return to prechallenge DMI occurred 5 d sooner for steers fed zinc methionine than for control steers and mean rectal temperature was lower for zinc methionine supplemented steers than for controls on d 7 and 12.

Engle et al. (1995) fed one calf from each of five pairs of crossbred heifer calves (initial BW = 202 kg) a Zn-deficient diet (17 mg/kg), and the other calf was fed a Zn-adequate diet (40 mg/kg) diet for 28 d. Plasma Zn, feed efficiency, and phytohemagglutinin (PHA) skin-swelling response were less ($P < .05$) in Zn-deficient calves. In a second experiment, 208-kg crossbred heifers were fed a Zn-adequate diet for 30 d (40 mg of Zn/kg) and then allotted to either control (40 mg of Zn/kg) or Zn-deficient groups (17mg/kg). After 21 d of depletion, the 17 mg/kg diets were supplemented with zinc lysine, zinc methionine, or $ZnSO_4$ to bring the total Zn concentration up to 40 mg/kg. Zinc depletion decreased gain ($P < .05$) by an average of 45.6% and increased ($P < .05$) feed:gain by 97.5%. The cell-mediated skin swelling response to PHA was decreased ($P < .05$) by Zn depletion, but no differences were noted in plasma and liver Zn with Zn depletion. No differences in gain, intake, and feed:gain were evident after 22 d of Zn repletion.

Galyean et al. (1995) fed newly weaned steers a receiving diet with one of four Zn treatments: 1) 30 mg of Zn/kg from ZnO; 2) basal + 35 mg of Zn/kg from zinc methionine; 3) basal + 70 mg of Zn/kg from ZnSO4; and 4) basal + 70 mg of Zn/kg from zinc methionine. Morbidity from BRD during a 42-d receiving and subsequent concentrate adaptation period was decreased by approximately 52% (average of 22.9 vs 11.1%) for the two 70 mg/kg diets vs the basal and 35 mg/kg diets.

Gunter et al. (2001) supplemented steers with 103 mg of Zn/d from $ZnSO_4$, Zn-amino acid complex, or Zn-polysaccharide during a 116-d grazing period on Bermudagrass pastures, after which the steers were shipped (14 h) to a research feedlot, where they continued on the same Zn sources that were fed during grazing. Neither grazing nor feedlot performance or serum Zn concentrations were affected by Zn source, nor was the number of steers treated for BRD. Spears and Kegley (2002) fed Angus steers growing with no added Zn or 25 mg of supplemental Zn/kg of DM from ZnO and 2 different zinc proteinates. Lymphocyte blastogenesis and humoral antibody titers after IBR vaccination during the growing period did not differ among treatments.

Impact of copper on health and immunity

Engle (2005) suggested that factors affecting an animal's response to Cu supplementation could include; duration and concentration of Cu supplementation, the absence or presence of dietary Cu antagonists (S and Mo), environmental factors and breed differences in Cu metabolism.

Few BRD challenge or field studies have been conducted with supplemental Cu without the presence on Cu antagonists Fe or Mo. Galyean et al. (1995) reported that supplemental copper lysine (5 mg of added Cu/kg) fed during the receiving period had a negative effect on daily gain ($P < .02$) and DMI ($P < .09$) during the subsequent growing and finishing period. However, adding copper lysine to the receiving diet tended ($P < .17$) to decrease the percentage of morbid steers (13.9%) compared with the control diet (20.1%) that was formulated to supply 3.25 mg of supplemental Cu/kg from CuO.

Dorton (2003) compared steers individually fed 10 and 20 mg of copper sulfate ($CuSO_4$) or Cu-amino acid complex (AvailaCu) to control (no supplemental Cu) during growing and finishing periods. Liver Cu concentrations in supplemented steers were higher on d 56 and 112. Cell mediated immune response to PHA was higher ($P < 0.01$) in steers supplemented with 20 mg Cu/kg compared to steers supplemented with 10 mg Cu/kg. Total immunoglobulin and immunoglobulin G concentrations specific to pig red blood cells were higher ($P < 0.01$) in steers supplemented with Cu from $CuSO_4$ (P <

0.01). Steers supplemented with Cu from AvailaCu had higher (P < 0.01) antibody titers specific to ovalbumin than steers supplemented with Cu from $CuSO_4$.

Section 3: Performance Impact of Lameness in Feedlot Cattle

Economic impact of feedlot lameness.

Specific and non-specific lameness issues are generally considered one of the most costly animal health issues affecting feedlot cattle. Griffin et al. (1993) collected survey data from five Oklahoma and Kansas feedlots, and reported that lameness accounted for 16% of all feedlot health problems. Authors concluded that when costs for actual treatment, costs associated with chronically affected cattle, and overhead expenses were totaled, the average footrot incident total cost was $59.94 per effected animal. Frank et al. (1988) listed 72 diseases or abnormal conditions that occurred in a large Colorado feedlot during a 12 mo period. When ranked in terms of total disease occurrences, the top 4 morbidity causes were lower respiratory tract disease, unspecified lameness, footrot and bullers.

Footrot (necrotic pododermatitis, interdigital necrobacillosis) is generally considered the most prevalent cause of animal lameness in feedlot cattle. The causative bacteria, Fusobacterium *necrophorum or Bacteroides melaninogenicus*, are common in the environment and *F. necrophorum* is present in the rumen and feces of normal cattle (Greenough, 1997). Though the occurrence of footrot in feedlots is highly variable, it is often seasonal, occurring during periods of extreme moisture, frozen or muddy pens, or severe drought (Stokka et al., 2001).

Bartle and Preston (1991) reported the effect on ADG of cattle treated for footrot during the first 28 d in two pens of 400 steers each. Approximately 25% of the cattle in each pen were treated for footrot. In pen 1, treated cattle gained 45% less (P<0.01) than non-treated steers, 0.83 and 1.28 kg/d, respectively. The BW gain of the treated cattle improved but was still less than the gain of non-treated steers at the conclusion of the 140 day feeding period (1.19 kg/d vs. 1.27 kg/d, P<0.01). In pen 2, the ADG of steers treated for footrot through d 28 gained 8% less than non-treated steers (1.47 kg/d vs. 1.60 kg/d, P<0.06). At the end of the 170 d feeding period there were no differences in BW gain between treated and non-treated steers. Data documenting the impact of animal lameness on performance in non confined cattle is limited. Brazle (1994) reported a 3 year summary in which steers without footrot grazing native grass pastures gained more than those diagnosed with footrot (1.25 vs. 1.05 kg/d).

The increasing value of incoming and finished cattle coupled with increasing ration costs and total cost per lb of gain in feedlots has increased scrutiny of all morbidity costs. Several papers have measured the impact of lameness on gain in cattle (Bartle and Preston, 1991, Brazle 1994, Tibbetts et al., 2006). Very little has been done to evaluate the total costs of lameness in the cattle feeding industry. Total costs included: increased feedlot cost of gain due to decreased per day gain and decreased feed efficiency, medicine and handling costs for affected cattle, and lose do to the necessity of selling some lame cattle as railers prior to their pen mates optimal finish dates.

Griffin (1993) found that lame cattle accounted for 70 percent of all sales of non-performing cattle (railers). The price received for these salvaged lame animals was only

53 percent of the original purchase price. Non-performing cattle were sold 85 days after their arrival and weighed only 10 pounds more than their in-weight. The total loss per lame animal was $121 per head ($101.76 loss in value, $4.96 for medication and $14.28 for feed cost for salvaged animals). When averaged over all cattle purchased, the loss per head purchased attributable to lameness impacted salvage animals was $2.54 or an increase of $.50/cwt cost of gain for all animals.

Performance impact of lameness in dairy cattle.

Warnick et al. (2001) examined the milk production records of 2520 dairy cows on two New York dairies and found that general lameness caused a substantial (3.3 lb./day and 1.76 lb/day for dairy 1 and 2, respectively) reduction in milk production. Rajala-Schultz et al. (1999) found in a study of 23,416 cows in Finland that foot and leg disorders caused a loss in milk production ranging from 1.5 to 2.8 kg/day during the first two weeks after the diagnosis. In a French review paper, Fourichon et al. (1999) reported in 6 studies locomotion disorders were shown to decrease milk production (0.3 – 3.3 kg/d across the lactation).

Though there are numerous studies examining the impact of general lameness in dairy cattle, only a few examine the impact on milk production of footrot specifically. Hernandez et al. (2002) examined the impact of specific lameness diagnosis on milk yield. Any interdigital phelegmon (footrot) diagnosis was shown to decrease milk production over a 305 day lactation (19,007 lb vs. 17,122 lb). Reductions in milk production were seen beginning two weeks prior to the actual lameness diagnosis. Green et al. (2002) made several observations on the impact of lameness on dairy cattle. First, lameness decreased milk production by 360 kg over a 305 day lactation. Second, milk yield is reduced up to four months prior to the clinical lameness diagnosis. Third, high producing cows are the most likely to become lame. Comparing production differences of lame cows to herd averages may be underestimating the yield impact of lameness on the highest potential individuals. Relating these data to feedlot cattle, it may be that those individual feedlot cattle affected with footrot or other lameness causes would have been the highest performing individuals in the pen.

The reduction in milk production prior to lameness diagnosis seen in Green et al. (2002) and in Hernandez et al. (2002) may be a result of lingering sub clinical lameness issues and the animal's ability to conceal lameness from caretakers. Researchers (and dairy producers) may not recognize the high incidence of cows that are mildly or moderately lame within their herds (score 2 or 3 using the Locomotion Scoring Index) (Tomlinson and Socha, 2005). Bicalho et al. (2006) suggested that most dairy producers do not identify cows as lame until they are severely clinically lame (score 4 or 5). In these data, painful claw lesions were seen in 21.4 and 54.9% of cows with locomotion scores of 2 and 3 respectively. No data is available to correlate these dairy cow data with beef feedlot cattle.

Ramifications of animal lameness on animal welfare issues.

The scrutiny of animal production methods by non-farm special interest and consumer groups will very likely intensify in coming years. Cattle with any degree of lameness and certainly non-ambulatory cattle are readily identified by non-trained observers. Animal welfare activists recently used a video produced in cooperation with the Humane Society of the United States to make sweeping allegations about the handling of livestock destined for harvest at commercial abattoirs. The investigative findings of downed cattle mistreatment and allegations of non-ambulatory animals being slaughtered for human consumption also prompted congressional reaction, led school districts to pull beef from their menus, and purportedly led to questioning of the reliability of the USDA inspection process (HSUS, 2008).

Von Keyserlingk et al. (2009) suggested concerns about the welfare of animals typically include 3 questions: is the animal functioning well, is the animal feeling well and is the animal able to live according to its nature? Animals with any degree of clinical lameness will not meet the criteria for all of these questions. Increasing size of cattle feeding operations may have a detrimental effect on cattle lameness. The National Animal Health Monitoring Service survey, Feedlot 1999 (2000), reports a higher rate of lameness in larger beef cattle feeding operations when measured as percentage of incoming cattle (< 8000 hd, 1.3% vs. > 8000 hd, 2.0%). Stafford and Gregory (2008) suggested more intensive animal agricultural practices could lead to increasing lameness and other illness. They listed reduced opportunities for shade and shelter, longer walking distances and the likely reduction in the human:animal ratio as contributors to increasing incidence of lameness in beef and dairy cattle.

Though no corresponding data is available for feedlot producers, dairy producers feel lameness incidence has increased. The National Animal Health Monitoring Service survey, Dairy 2007 (2009) reports the percentage of operations reporting cases of lameness in bred heifers increased from 36.5 percent in 2002 to 58.7 percent in 2007.

Additionally, it is thought that producers generally underestimate the prevalence of lameness in the animals under their care. Although again no corresponding surveys of beef producers are available, consistently dairy producers underestimate the actual prevalence of lameness in their herds. In an investigation of 17 dairy herds in Minnesota and Wisconsin trained observers detected lameness in 13.7% of cattle (117/853) during the summer and 16.7% of cattle (134/801) during the spring. These prevalence rates were 2.5 times higher than those estimated by herd managers (Wells et al., 1993). In a similar UK study, Wray et al, (2002) data were collected from 53 dairy herds. Results indicated that the mean prevalence of lameness as identified by trained observers was 22.11% (range 0-50%). The mean prevalence of lameness as estimated by the dairymen was 5.73% (range 0-35%). These observations point out that lameness is not only a very prevalent animal health issue, but also, quite often goes undetected and therefore, untreated by dairymen. Failure to detect lameness leads to treatment delays, prolonged animal suffering and overall reduced animal welfare (Shearer, 2009).

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Effects of a Single Footrot Incident on Weight Performance of Feedlot Steers

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Abstract

Feedlot performance records from the U.S. Meat Animal Research Center feedlot for 1993 through 2000, were analyzed to evaluate the impact of footrot on ADG and total days on feed. Records from the original pool of 36,755 bull, steer and heifer calves were sorted so that only steers that had a single footrot incidence and no other morbidities were included in the data set (7,100 steers). To roughly pattern these data to industry production practices, time of footrot insult during feeding was divided into three production periods; starting (0-60 d), growing (61-120 d) and finishing (121d - harvest). Records were evaluated to determine which limb was more likely to be affected with footrot. A total of 459 (6.5%) steers were treated for a single footrot incident. ADG for cattle not affected by footrot was 1.30 kg. For cattle experiencing a single footrot incident, the ADG was 1.27 kg (*P*=0.03). The production period of footrot onset impacted both ADG and total days on feed. Steers diagnosed with footrot during the starting period gained 0.032 kg/d more than non-affected steers (*P*=0.083). Steers diagnosed in the growing and finishing periods gained 0.009 and 0.049 kg/d less than non-affected cattle (*P*=0.438 and *P*<0.01). Mean days on feed for the non-affected cattle was 262 d while mean days on feed for footrot affected cattle was 267 d (*P*<0.01). The impact of footrot on days on feed for periods 1 through 3 was –9.9 d, +2.2 d and +14.3 d (*P*<0.01, *P*=0.26, *P*<0.01). Footrot diagnosed in either front limb reduced BW gain by 0.031 kg (*P*=0.014).

(Key words: Footrot, Beef Cattle, Feedlot Performance)

Introduction

Footrot (necrotic pododermatitis, interdigital necrobacillosis) is a common disease in feedlot cattle. The causative bacteria, *Fusobacterium necrophorum or Bacteroides melaninogenicus*, are common in the environment and *F. necrophorum* is present in the rumen and feces of normal cattle. Though the occurrence of footrot in feedlots is highly variable, it is often seasonal, occurring during periods of extreme moisture, frozen or muddy pens, or severe drought. (Stokka et al., 2001). Frank et al. (1988) listed 72 diseases or abnormal conditions that occurred in a large Colorado feedyard during a 12 m period. When ranked in terms of total disease occurrences, footrot ranked fourth behind lower respiratory disease, unspecified lameness and bullers. Griffin et al. (1993) collected survey data from five Oklahoma and Kansas feedlots, and reported that lameness accounted for 16% of all feedlot health problems. Authors concluded that when costs for actual treatment, costs associated with chronically affected cattle, and overhead expenses were totaled, the average footrot incident total was $59.94 per effected animal.

Bartle and Preston (1991) reported the effect on ADG of cattle treated for footrot during the first 28 d in two pens of 400 steers each. Approximately 25% of the cattle in each pen were treated for footrot. In pen 1, treated cattle gained 45% less (P<0.01) than non-treated steers, 0.83 and 1.28 kg/d, respectively. The BW gain of the treated cattle, 1.19 kg/d, improved over the remainder of the 140 d feeding period, but were still less (P<0.01) than the gain of non-treated steers, 1.27 kg/d. In pen 2, the ADG of steers treated for footrot, 1.47 kg/d, was 8% less (P<0.06) than gain of non-treated steers 1.60 kg/d through d 28. At the end of feeding period, 170+ d, there were no differences in BW gain between treated and non-treated steers. Brazle (1994) reported a 3 year summary in which steers without footrot grazing native grass pastures gained more than those diagnosed with footrot (1.25 and 1.05 kg/d respectively).

The objective of this study was to evaluate the effects of a single footrot incident and time of occurrence during the feeding period on BW gain performance of steers fed 200 d or more.

Materials and Methods

Each fall approximately 4,700 spring-born calves of various breeds are weaned and placed into the 5,000 head capacity feedlot at Roman L. Hruska U.S. Meat Animal Research Center. All cattle are individually weighed when received and again within 14 d of harvest. Cattle are observed daily and those considered morbid for any reason are removed from their pens to a treatment area for diagnosis.

Diagnosis, treatment and ADG data were available for 36,755 bulls, steers and heifers from spring calving herds that were weaned in the fall and placed on feed at the research center feedlot from 1993 through 2000. Feet of cattle suspected to have footrot were washed and a positive diagnosis for footrot or other cause of lameness was made at the treatment area. The standard footrot treatment protocol included antibiotic therapy and topical treatment with a tame iodine (Povidine 10% non-irritating iodine solution) and oil antiseptic (20% Copper Sulfate Pentahydrate and 80% mineral oil) on affected feet. Cattle were allowed to recover in hospital pens for three days before returning to their original pens.

In order to address the question of the effects of a single footrot incident on feedlot performance as measured by ADG and days on feed, the following groups of cattle were considered to have confounding indicators and were removed from the data set.

1. Cattle that had treatment for any other reason other than a single footrot incident during the feeding period (14,387 head).
2. All heifers were removed because there was no differentiation between heifers placed on high-energy finishing diets and those that were destined for replacements which were fed lesser energy growing diets (17,694 head).
3. Males that were not castrated prior to arrival at the feedlot were removed (6,918 head).

4. Steers that were feed less than 200 d were removed. This group include cattle removed for other research purposes and poor performing cattle (723 head).
5. Steers that received more than one footrot treatment were removed (32 head).

With the exclusions described above, 7,100 records were analyzed in the final data set. Footrot cases were identified by location: left front, right front, left rear, right rear, multiple limbs and unknown for purposes of evaluating distribution. For some gain analyses, left and right front limb, and left and right hind limb locations were combined into front and rear categories. Projected marketing BW for the genetic groups from which the cattle were bred are based on assigned ration energy density and interim weights every 56 d.

To roughly pattern these data to industry production practices, time of footrot insult during feeding was divided into three production periods; starting (0-60 d), growing (61-120 d) and finishing (121 d - harvest). Data were analyzed using the General Linear Models Procedure (SAS Inst. Inc., Cary, NC). Period in which onset of lameness occurred (starting; growing; finishing) ADG and days on feed were evaluated as dependent variables.

Results and Discussion

As commonly seen in the feedlot industry, footrot incidence was highly variable between years in this data. Over the eight yr of data analyzed, a total of 459 (6.5%) steers were treated for a single footrot incident (Table 1). Footrot occurrence by production period (1.06%, 3.03% and 2.38%; Table 2) was more prevalent in the growing and finishing phases. Though it is more commonly thought that footrot affects the hind digits more often than the fore digits (Greenough, 1997), the individual limbs affected by footrot were equally distributed in this dataset, both for individual limbs and for front verses hind limbs (Tables 3 and 4).

When combining all production phases, ADG for non-affected steers, 1.30 kg, was higher than that of footrot affected steers, 1.27 kg (P<0.01; Table 5a). The effect of feeding phase when the foot rot insult occurred on gain performance was of interest. It was expected that cattle diagnosed with footrot to have reduced gain, regardless of when the footrot incident occurred during the feeding period. However, in this data set, steers acquiring footrot in the starting phase appeared to recover any gain lost due to foot rot, and gained more than non-affected cattle (0.032 kg/d; P=0.0825) over the entire feeding period. Steers diagnosed with footrot in the growing phase tended to have gains similar to non-affected steers (-0.009 kg/d, *P*=0.438). Steers diagnosed with foot rot in the finishing phase gained 0.048 kg/d less than non-affected steers (*P*<0.01; Table 5b). The severity of gain losses for steers diagnosed in the finishing phase is of particular interest. Heavier cattle that have a footrot incident are potentially less mobile and have a lesser ability to approach and stand at the feed bunk or water tank. Additionally, cattle affected later in the feeding period have less time to compensate gain lost due to footrot.

Days on feed to harvest was affected by footrot incidence. Days on feed for the non-affected cattle was 262 d while days on feed for the footrot affected cattle increased to 267 d (*P*<0.01; Table 6a). The feeding phase of the onset of lameness influenced days on feed as well. Steers diagnosed with foot rot in the starting phase actually finished 9.94 d sooner (*P*=0.03) than non-affected cattle. Steers diagnosed with foot rot in the growing phase numerically required more days on feed to harvest (2.2 d, P=0.256). Steers diagnosed with foot rot in the finishing phase required 14.3 more d until harvest (*P*<0.0001; Table 6b). Performance differences between the no footrot/footrot ADG and days on feed (Table 5a and 6a) and the ADG and days on feed data by period of footrot onset (Table 5b and 6b) do not appear to be equal. This is because of the different number of days in the starting, growing and finishing periods (60 d, 60 d, and 142 d) and the weighted treatment of the LS means by the SAS program.

It should be noted that the U.S. Meat Animal Research Center feedlot footrot diagnosis, treatment and convalescence protocols for feedlot cattle may be more rigorous than those at most commercial feedyards. Thus animal performance depression seen in this study may be less than that occurring in commercial production. It should also be noted that this study did not look at the impact of footrot incidence on carcass value or on the impact of footrot on cattle harvested early as “realizers” or “chronics”.

Implications

Feedlot cattle diagnosed with footrot gained weight more slowly and required more days on feed to reach harvest BW weight and condition than cattle not affected with footrot. The earlier the onset of the footrot incident, the less effects the disease had on BW gain or days to harvest. It can be speculated that the average effect on BW gain and days to harvest would be greater when cattle are placed on feed at heavier BW since they would have fewer days to compensate for gain losses during a footrot incident. When calculating the actual cost of a footrot incident, treatment and handling costs, lost animal performance costs, and likely lost carcass performance costs should be considered. It should be noted that in this data steers fed less than 200 days were removed from consideration. In feedlot production, footrot and other lameness issues are a major cause of early cattle shipments. The impact of footrot on cattle classified as “realizers” or “chronics” should be considered in further studies.

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Table 1. Footrot incidence by year of birth.

Birth cohort	Total Footrot	Total Cattle at Risk	% Footrot
1993	22	754	2.92
1994	6	796	0.75
1995	29	695	4.17
1996	20	650	3.08
1997	136	1194	11.39
1998	16	952	1.68
1999	101	1089	9.27
2000	129	970	13.30
Totals	459	7100	6.46

Table 2. Footrot occurrence by feedlot production phase

Stage of footrot diagnosis	n	Percent
Footrot not diagnosed	6641	93.54
Starting (day 0 to day 60)	75	1.06
Growing (day 61 to day 120)	215	3.03
Finishing (day 121 or greater)	169	2.38
Totals	7100	100.00

Table 3. Anatomical location of foot rot by individual limb

Location	Total Footrot	Percent
Left front[a]	78	16.99
Right front[a]	94	20.48
Left rear[a]	78	16.99
Right rear[a]	85	18.52
Poly[b]	7	1.53
Unknown[c]	117	25.49
Totals	459	100.00

[a] No more than one limb was affected by footrot at time of diagnosis
[b] A steer that had more than one limb affected with footrot simultaneously

[c] No designation of affected limb was available

Table 4. Anatomical location of foot rot by front, rear or poly.

Location	Total Footrot	Percent
Front - left or right[a]	172	37.47
Rear - left or right[a]	163	35.51
Poly[b]	7	1.53
Unknown[c]	117	25.49
Totals	459	100.00

[a] No more than one limb was affected by footrot at time of diagnosis
[b] A steer that had more than one limb affected with footrot simultaneously

[c] No designation of affected limb was available

Table 5a. Effect of footrot diagnosed at any point during the feeding period on average daily gain of feedlot steers.

	ADG Change, kg	SE	p value	LS means
No footrot	0.0000			1.295
Footrot	0.0170	0.008	0.0302	1.281

Table 5b. Effect of footrot in one of three feedlot production phases on average daily gain of feedlot steers[a].

	ADG Change, kg	SE	p value	LS means
Footrot not diagnosed	0.0000			1.295
Footrot onset during starting	0.032	0.0186	0.0825	1.330
Footrot onset during growing	-0.009	0.0111	0.4375	1.289
Footrot onset during finishing	-0.049	0.0.125	<0.0001	1.249

[a]Starting phase, 1–60 d, growing phase, 61-120 d, finishing phase, 121 d-harvest.

Table 6a. Effect of footrot diagnosed at any point during the feeding period on days on feed of feedlot steers.

	DOF Change	SE	p value	LS means
No footrot	0.0000			262.422
Footrot	4.7510	1.3597	0.0005	267.173

Table 6b. Effect of footrot in one of three feedlot production phases on days on feed of feedlot steers[a].

	DOF Change	SE	p value	LS means
Footrot not diagnosed	0.0000			262.39
Footrot onset during Starting	-9.9403	3.2258	0.0021	252.50
Footrot onset during Growing	2.204	1.9409	0.2562	264.59
Footrot onset during Finishing	14.3116	2.1630	<0.0001	276.70

[a]Starting phase, 1–60 d, growing phase, 61-120 d, finishing phase, 121 d-harvest.

Case Study: Assessing Ranch Level Preventative Management Practices on Feedlot Morbidity, Gain Performance and Carcass Quality [1, 2]

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Case Study: Assessing Ranch Level Preventative Management Practices on Feedyard Immunity, Morbidity and Gain Performance

ABSTRACT

Twenty-three ranches were selected from ranch cooperators in a large scale Nebraska-based cattle system to establish baseline measurements for liver concentrations of trace minerals, disease titers, parasite load, percent morbidity and gain performance. Upon arrival at the feedyard blood, liver, and fecal samples were collected from approximately 10% of each ranch group. After all yr 1 cattle were harvested an 11 ranch subset of the original 23 ranches was selected based on ranch weaning practice for a second yr evaluation. In yr 2 all ranches shipped calves to the feedlot on the day of weaning and all were fed a standardized free choice mineral containing organic trace mineral complexes (OTM) to cow calf pairs 45 d prior to weaning. Comparing yr 1 and 2 for the 11 ranches, percent 1^{st} pulls decreased ($P=0.04$) from a yr 1 mean of 42.6% to a yr 2 mean of 23.0%. Carcass quality was decreased ($P >0.01$) from yr 1 to yr 2. Liver Cu concentrations of calves at weaning increased ($P=0.01$) from a mean of 94.59 ppm in yr 1 to a mean of 128.08 ppm in yr 2. Zinc and Mn liver concentrations were similar across years. Across both years, higher liver Cu concentration was correlated with decreasing total pulls ($P = 0.03$), and increasing ADG ($P < 0.01$). Mortality tended ($P = 0.11$) to decrease as Cu concentration increased. Higher liver Mn concentrations tended to be correlated with lower total pulls ($P = 0.07$). There was no correlation between liver Zn concentration and

animal and health performance. In conclusion, allowing cow-calf pairs access to free-choice mineral containing OTM prior to weaning improved some aspects of feedyard health and performance.

Key Words: Trace mineral, beef cattle, trace mineral complex, weaning, feedlot health, beef calf, feedlot performance

INTRODUCTION

Costs associated with morbidity may be the most important factor influencing feedyard cattle profitability (Gardner et al., 1996). In fact, cattle feeders are increasingly willing to pay a premium for cattle perceived to have lower morbidity risk in the feedyard. King and Seeger, (2005), suggested that regardless of market conditions, over a 10 year (yr) period a strong correlation existed between level of participation in value-added calf programs and the price received for calves sold. The premium received for VAC 45 certified calves (Pfizer Animal Health, New York, NY) increased from $2.47 per cwt. in 1995 to $7.91 per cwt. in 2004 compared to non-weaned calves with no vaccination certification.. Brink (2006 b), indicated methods are readily available to improve animal health performance and that cow calf producers should shift their mindset toward more cooperative integration within the overall production chain. This opinion is shared by many involved in the beef cattle industry. Some believe the care and handling cattle receive in the production segments prior to placement in the feedyard to be the most critical determinant of health performance in the feedyard (J. Anderson, President Power Genetics, personal communication, 2004). The primary objective of this 2 yr study was to identify prefeedlot variables influencing health performance and productivity of calves from several geographic regions in the Western United States. The second objective was to evaluate the effectiveness of a specified free choice loose mineral product on improving trace mineral status of preweaned calves entering the feedyard.

MATERIALS AND METHODS

Year 1. Twenty-two ranches were selected from ranch cooperators in a large scale Nebraska-based cattle system to establish baseline measurements for liver concentrations of trace minerals, titer levels to IBR, BVD I, BVDII and BRSV, parasite load, animal morbidity levels and gain performance. Ranch selection criteria included an assessment by system management as to the willingness and ability of cooperating ranches to make changes recommended by findings of this study. Cooperating ranches were located in New Mexico (n=7), Nebraska (n=7), Utah (n=3), Colorado (n=) and Kansas (n=2). All ranches managed spring calving herds and all used similar protocols for branding, pre-weaning, weaning and feedyard arrival vaccinations (Table 1). Weaning and mineral nutrition programs varied across ranches. Cattle were shipped to 1 of 5 feedyards located in Colorado (n=2), Nebraska (n=2) or Kansas (n=1). Feeding and animal health protocols were similar but not identical between feedyards. A total of 3357 calves were shipped to the cooperating feedyards in ranch groups ranging from 59 hd to 429 hd (mean 153 hd/ranch).

Upon arrival at the feedyard blood, liver, and fecal samples were collected from approximately 10% of each group, or a minimum of 14 randomly selected calves from each ranch group (number of cattle sampled was based primarily on financial resources available for sampling and sample analysis). Larger groups of calves from eight ranches were divided into 2 pens and calves from 1 ranch were divided into 3 pens. Smaller groups of calves were mixed with calves from other origins to fill pens at the discretion of feedyard management. Calves were vaccinated with modified live virus vaccines (Table 1) on the day of feedyard entry sampling (d 2 or d 3 post-arrival). In addition, ear notches were obtained from all calves in the study to identify individual animal's status as a persistently infected (PI) carrier for the bovine viral diarrhea virus (BVDV)(McClurkin et al, 1984).

Throughout the feeding period cattle were visually monitored daily by trained feedyard personnel to detect morbidity. Cattle displaying clinical morbidity symptoms were transported to a feedyard working facility and treated according to the feedlot's standard treatment protocol. It was also noted if an animal was being treated for the first time (1^{st} pull) or re-treated for signs of morbidity (re-pull). Total pulls were defined as the total number of treatments for an individual animal (1^{st} pull plus each time the animal was re-pulled). When the average finish condition of each ranch pen group was deemed to be optimal by feedyard management, the entire pen was transported approximately 220 - 360 km to a commercial abattoir, depending on feedlot location. All animals were harvested at the same abattoir both years. Pen closeout values were used to compare yr 1 to yr 2 ADG.

Year 2. After all yr 1 cattle were slaughtered and data collected, 11 ranches (New Mexico n=5; Nebraska n=1; Utah n=3; and Colorado n=2) were selected for the second year using the previously discussed criteria. The basis of this selection was on ranch weaning method. Only ranches who weaned directly to the feedlot were included. A total of 15 were eligible but due to marketing considerations 3 ranches within this pool could not be included. All selected ranches shipped calves to the feedlot on the day of weaning. Ranches agreed to use the same vaccination protocol as yr 1 (Table 1) and to feed a standardized mineral feed for a 45-60 day period prior to weaning (Table 2).

Table 1 . Vaccination protocol for calves in cooperating herds during yr 1 and yr 2.

Production period	Vaccination products
Branding Vaccination	Two 2 ml of a modified live virus respiratory vaccine containing bovine rhinotracheitis virus (IBR), bovine virus diarrhea virus, Type I and II (BVD), bovine parainfluenza3 virus (PI3) and bovine respiratory syncytial virus (BRSV) (Titanium 5). Two 2 ml of a inactivated bacterin and toxid vaccine containing **Clostridium chauvoei** (Blackleg), **septicum** (Malignant edema), **novyi** (Black disease), **sordellii** and **perfringens** Types C & D (Enterotoxemia) at branding (Vision 7).
Preweaning; 2-8 weeks prior to shipment	Two ml of a modified live virus and avirulent live culture vaccine containing bovine rhinotracheitis virus (IBR), bovine virus diarrhea virus, Type I and II (BVD), bovine parainfluenza3 virus (PI3), bovine respiratory syncytial virus (BRSV), Mannheimia hemolytica and Pasteurella multocida 2-8 weeks prior to shipment to the feedyard (Titanium 5 + P.H.M. Bac-1) Two 2 ml of a inactivated bacterin and toxid containing **Clostridium chauvoei** (Blackleg), **septicum** (Malignant edema), **novyi** (Black disease), **sordellii** and **perfringens** Types C & D (Enterotoxemia) 2-8 weeks prior to shipment to the feedyard. (Vision 7)
Feedyard Arrival	Two ml of a modified live virus respiratory vaccine containing bovine rhinotracheitis virus (IBR), bovine virus diarrhea virus, Type I and II (BVD), bovine parainfluenza3 virus (PI3) and bovine respiratory syncytial virus (BRSV) (Titanium 5).

Vision 7 are trademarks of Intervet Schering Plough Animal Health, Desoto, KS. Titanium 5 P.H.M. Bac-1 is a trademark of Agrilabs, St. Joseph, MO.

Table 2. Composition of free choice mineral product fed 45 days pre-weaning to yr 2 cow calf pairs on 11 cooperating ranches.[a,b]

Nutrient	Formulated Amount
Salt	23.0%
Ca	15.4%
P	7.0%
Mg	1.0%
Zn	3168 ppm
Mn	1780 ppm
Cu	1100 ppm
Co	106 ppm
I	115 ppm
Se	27ppm
Vit A	300,000 IU/lb
Vit D	30,000 IU/lb
Vit E	300 IU/lb

[a] Consumption targeted at 113.5 g per day (4 oz.).

[b] Zn, Mn, Cu and Co were supplied in metal amino acid complex trace mineral form (Zinpro Corporation, Eden Prairie, MN)

On site visits were made to each of the 11 ranches on branding day to help with vaccination and BVDV PI ear notching. One difference from year 1 was the sampling of all calves on the selected ranches for BVDV at the time of branding. At the same time, stockpiled ranch forages, fresh forages (5 ranches), and livestock water sources (6 ranches) were sampled when possible. Participating ranches used their best judgment when collecting samples. Forage and water samples were analyzed for trace mineral concentrations using methods described by Braselton (1997).

From these 11 ranches a total of 1934 calves were shipped directly to a single feedyard in Nebraska. Calves were in ranch groups ranging from 26 hd to 465 hd (mean 178 hd/ranch). As in year one, groups of calves coming from larger ranches were grouped separately while commingling of groups of calves from smaller ranches occurred according to feedlot preference. Just as in yr 1 vaccine response to vaccine components were determined by obtaining blood samples of approximately 10% of the group, or a minimum 14 randomly selected animals from each ranch group at the feedyard entry and again 21 to 28 d post feedyard arrival. Feedyard entry fecal samples were also obtained from these same cattle. Liver trace mineral status was determined by obtaining liver samples of approximately 14 different randomly selected animals per ranch at feedyard entry using methods described previously. Comparisons between like yr 1 (n=1803 calves) and yr 2 ranches were made in trace mineral status and serum neutralizing antibody titers. Morbidity and mortality, animal gain performance and carcass grade were compared.

Analytical procedures:

Parasite load: Approximately 100 g of fresh feces was placed in an individual plastic bag, labeled, and placed on ice. The samples were refrigerated and shipped to an independent laboratory (Animal Production Consulting, Lincoln, NE) for analysis of fecal egg numbers. The Modified Wisconsin Sugar Flotation Technique (Cox and Todd, 1962) was utilized to examine each individual fecal sample. A 3 gm base sample was used for analysis.

Blood samples**:** Blood samples were collected via jugular venipuncture in heparinized trace-mineral-free vacutainer tubes (Becton Dickienson Co., Franklin Lakes, NJ). Once collected, samples were placed on ice and transported to the laboratory. Serum neutralizing antibody titers to IBV, BVDV 1, BVDV 2 and BRSV were determined using a standardized microtiter format with bovine turbinate cells as indicator cells (Carbrey et al., 1971) for each serum sample and the geometric mean titers for each ranch were determined. These values were used within yr to measure serological response to vaccine components by comparing arrival to post arrival titer levels in those calves where both values were available. Titers were reported as the reciprocal of the greatest dilution of serum to provide complete protection of cells.

Liver biopsy: Liver biopsy samples were collected from 14 different randomly selected animals from ranch groups using the true-cut technique described by Pearson and Craig (1980), as modified by Engle and Spears (2000). A 10-cm x 10-cm area was clipped of hair on the right side of each animal between the 11^{th} and 12^{th} ribs and scrubbed 3 times with iodine and 70% alcohol. Approximately 5 ml. of 2% lidocaine hydrochloride (Abbot Laboratories, North Chicago, IL) was injected via a 20-ga x 2.5-cm needle between the 11^{th} and 12^{th} ribs on a line from the hip to the point of the shoulder. A small incision (approximately 1.0 cm) was made thru the skin with a 11 scalpel blade, and a core sample of liver tissue was collected using a modified Jan Shide bone marrow biopsy punch (0.5 cm x 14 cm; Sherwood Medical, St. Louis, MO). The biopsy probe was inserted into the liver and negative pressure applied with a 20 cc syringe to aspirate the sample. All biopsy instruments were cold sterilized in 50% Nolvasan/50% deionized water in a closed stainless steel instrument container prior to use on each animal, and a new pair of gloves was used for each biopsy. Banamine (Flunixin Meglumine; 1.1 mg/kg i.m.) was administered immediately post biopsy. Following collection, samples were immediately rinsed with 0.01 *M* PBS (pH = 7.4) and placed into acid washed polyethylene tubes, capped, placed on ice for approximately 8 h until stored at -20º C.

Liver samples were analyzed for trace mineral concentrations using the inductively-coupled plasma-atomic emission spectroscopy (ICP-AES) methods described by Brazelton (1997).

Ear notches*:* An effort was made to detect antigens to BVDV from individual ear notch samples according to the procedures of IDEXX Laboratories (HerdChek*)

Statistical analyses.

Year 1 was used to establish baseline measurements for feedyard entry fecal parasite levels, serum neutralizing antibody titer response, presence of BVDV persistently infected (PI) calves, liver tissue trace mineral concentration and health and gain performance for the entire feeding period. This data was combined into individual ranch averages.

Eleven ranches were included in the data set in both yr1 and yr2. Changes in values in the variables of interest (liver Zn, Cu and Mn concentrations) and animal gain and health performance (ADG, QG, 1st Pulls %, Repulls %, Total Pulls %, Mortality %, serum neutralizing antibody titers and parasite concentration) were analyzed using a logistic regression model with fixed effect for mineral concentration and a random effect for year by ranch combination to account for correlations among animals within the same ranch. Computations were performed using SAS Proc Mixed (SAS Inst. Inc, Cary, NC).

With the large amount of data from all ranches (yr1 n=22, yr2 n=11) liver mineral concentration (Zn, Cu, Mn)and animal gain and health performance measurements (1st Pulls %, Repulls %, Total Pulls %, Mortality%, ADG, QG,) were used to assess correlation between liver mineral concentrations and animal health and performance. The normal mixed model with fixed effect for variables of interest and a random effect for ranch, with degrees of freedom estimated using the Kenworth Roger method was used to assess correlation between those variable and animal gain and health performance. Computations were performed using SAS Proc Mixed (SAS Inst. Inc, Cary, NC).

RESULTS AND DISCUSSION

Individual ranch averages for yr 1 for feedyard entry fecal parasite levels, serum neutralizing antibody titer response, presence of BVDV persistently infected (PI) calves, liver tissue trace mineral concentration and health and gain performance for the entire feeding period are presented in Table 3 and 4. Weaning on the ranch resulted in less morbidity and mortality than not weaning on the ranch. The average total pulls for ranch weaned calves was 13.5% vs 81.6% for unweaned on the ranch calves. Death losses at the feedlot were .02% vs 3.03% for ranch weaned vs unweaned at the ranch calves, respectively. Feedlot performance as measured by ADG was 3.06 lbs per day vs 2.79 lbs per day for ranch weaned and unweaned on the ranch, respectively. From this information, few could argue that weaning at the ranch was advantageous to the feedlot from the standpoint of health and feedlot performance. Whether this was advantageous to the individual ranch owner cannot be determined from this information.

. There was no communication with ranches prior to the end of the yr 1 feeding period with the exception of notifying ranches of about the PI calf identification in the feedyard.

In yr 1, three BVDV PI calves were identified, 1 from each of 3 ranches. Calves from 1 of these 3 ranch groups experienced high morbidity in the feedlot (39%) while the other two ranch groups had relatively low morbidity rates (5.5% and 1.7%). The high morbidity in the feedlot ranch group was from a much larger ranch than the other 2 and it is likely that much less preweaning exposure occurred in those calves as a result. Upon identification, PI calves were removed from their feedlot pens (d 26 in the high morbidity group and d17 and 13 in the low morbidity groups). No BVDV PI calves were identified in yr 2 either on the ranch or in the feedyard.

Year 2 individual ranch averages health and gain performance for the entire feeding period are presented in Tables 5 and 6. In addition, individual ranch averages are given for feedyard entry fecal parasite levels, presence of BVDV persistently infected (PI) calves, and liver tissue trace mineral concentration. Water quality assays (23 samples) were available for 6 yr 2 ranches (Table7). Water high in total dissolved solids (Patterson, et al., 2003) or water with high sulfates (Loneragan, et al., 2001) has been shown to impact animal performance, however, water quality appeared not to influence animal health in this study. Only 1 sample exceeded maximum upper limits for Mn and 1 sample exceeded maximum upper limits for S (National Research Council, 1974).

Table 3. Year 1 ranch average feedlot performance, morbidity, mortality, and carcass characteristics by unweaned or ranch weaned.

State	Ranch	Arriv	UN or RW[a]	PI[b]	Hd	Inwt	Dof	Adg	Outwt	% 1st pulls	% repulls	% tot pulls	% deads	Killday	Qual[2]	Yield	Hotwei	Dress
NM	101	8/30/04	UN	P	429	581	224	2.67	1180	38.46	24.01	62.47	1.86	4/10/05	2023.00	2.08	755.05	64.00
CO	103	10/22/04	UN	N	283	466	271	2.82	1229	37.46	11.31	48.76	2.47	7/19/05	2021.55	2.66	802.51	65.31
NM	104	10/4/04	UN	N	48	598	193	2.84	1151	64.58	47.92	112.50	4.17	4/15/05	2021.26	2.93	739.05	64.22
CO	106	11/11/04	UN	N	71	682	261	2.37	1302	64.79	42.25	107.04	0.00	7/29/05	2021.72	1.95	846.53	65.03
KS	107	10/27/04	UN	N	118	638	205	3.03	1263	39.83	33.90	73.73	3.39	5/19/05	2021.54	2.73	806.02	63.78
KS	109	12/8/04	UN	N	70	730	171	3.93	1402	12.86	1.43	14.29	0.00	5/28/05	2021.31	3.00	881.94	62.91
NM	111	10/20/04	UN	N	96	500	323	2.57	1327	45.83	19.79	65.63	2.08	9/7/05	2022.02	2.27	849.45	64.03
UT	112	10/28/04	UN	N	260	518	287	2.81	1325	58.46	23.46	81.92	8.46	8/11/05	2021.53	3.22	858.09	64.72
NM	113	10/5/04	UN	N	94	537	286	2.56	1258	65.96	24.47	90.43	6.38	7/18/05	2021.65	2.52	807.53	64.24
NE	114	10/27/04	UN	N	187	525	273	2.66	1204	50.80	19.25	70.05	3.21	7/26/05	2021.49	3.17	818.05	64.97
UT	115	12/7/04	UN	P	73	696	214	2.87	1312	5.48	1.37	6.85	2.74	7/8/05	2021.46	2.21	869.07	66.26
NM	117	10/14/04	UN	N	87	564	226	2.69	1171	1.15	0.00	1.15	0.00	5/28/05	2021.66	2.59	756.20	64.58
UT	119	10/11/04	UN	N	92	512	239	2.97	1223	34.78	19.57	54.35	0.00	6/7/05	2021.47	2.91	780.95	63.84
NM	120	10/18/04	UN	N	47	541	246	2.51	1166	46.81	21.27	68.00	.	6/21/05	2021.58	2.52	763.90	65.50
CO	121	9/12/04	UN	N	185	574	236	3.02	1288	3.78	1.62	5.41	1.08	5/5/05	2021.55	2.77	763.37	59.36
Average		10/20/04			2140	558.21	240.07	2.79	1257.67	37.84	26.46	81.60	3.03	6/21/05	2021.65	2.64	806.45	64.20
NE	102	1/17/05	RW	N	275	614	177	3.60	1254	0.73	0.36	1.09	0.36	7/13/05	2021.72	2.53	816.57	65.06
NE	105	12/20/04	RW	N	201	662	181	3.06	1231	4.98	0.50	5.47	0.00	6/19/05	2021.64	2.15	820.37	66.90
NM	108	11/20/04	RW	N	157	574	167	3.02	1078	12.10	1.91	14.01	0.00	5/5/05	2021.55	2.77	763.37	70.84
NE	118	12/3/04	RW	N	125	705	168	3.26	1251	3.20	2.40	5.60	0.00	5/19/05	2021.47	2.47	800.67	63.98
NE	122	10/8/04	RW	N	80	636	210	3.47	1363	13.75	5.00	18.75	0.00	5/5/05	2021.68	2.88	867.95	63.67
NE	123	10/8/04	RW	N	59	615	221	3.05	1288	11.86	1.69	13.56	0.00	5/17/05	2021.42	2.81	841.06	65.29
NE	110	12/14/04	RW	P	320	548	208	3.36	1249	1.56	0.00	1.56	0.63	7/10/05	2021.92	2.64	801.62	64.20
Average		11/25/04			1217	610.43	189.84	3.26	1247.62	6.89	2.54	13.49	0.02	6/3/05	2021.63	2.61	816.52	65.65

[a] Un = unweaned on ranch of origin, RW = weaned on ranch of origin
[b] Positive or negative persistently infected for bovine viral diarrhea virus
[c] Scale Prime=2020, Choice=2021, Select=2022, No Roll-2023

Table 4. Year 1 ranch average liver trace mineral concentrations and fecal egg counts by unweaned or ranch weaned.

State	Ranch	Arriv	UN or RW[a]	PI[b]	hd	Inwt	Dof	Adg	Outwt	EggCount	Feppm	Moppm	Znppm	Cuppm	Mnppm
NM	101	8/30/04	UN	P	429	581	224	2.67	1180	5.29	176.36	3.27	124.21	139.37	7.46
CO	103	10/22/04	UN	N	283	466	271	2.82	1229	28.61	286.00	3.07	117.41	24.86	8.29
NM	104	10/4/04	UN	N	48	598	193	2.84	1151	16.20	256.73	2.84	122.98	65.95	7.88
CO	106	11/11/04	UN	N	71	682	261	2.37	1302	0.33	.	.	.	.	.
KS	107	10/27/04	UN	N	118	638	205	3.03	1263	34.83	231.27	3.29	123.92	92.89	7.33
KS	109	12/8/04	UN	N	70	730	171	3.93	1402	0.86	226.56	3.67	152.02	406.11	8.62
NM	111	10/20/04	UN	N	96	500	323	2.57	1327	31.75	320.54	2.90	100.48	72.61	7.29
UT	112	10/28/04	UN	N	260	518	287	2.81	1325	47.00	409.15	2.57	100.23	24.89	8.46
NM	113	10/5/04	UN	N	94	537	286	2.56	1258	1.08	266.38	2.75	125.49	83.73	6.69
NE	114	10/27/04	UN	N	187	525	273	2.66	1204	7.07	262.29	3.14	122.10	104.29	7.68
UT	115	12/7/04	UN	P	73	696	214	2.87	1312	27.69	210.23	3.32	141.18	189.39	10.80
NM	117	10/14/04	UN	N	87	564	226	2.69	1171	30.89	279.93	2.84	97.71	154.44	7.62
UT	119	10/11/04	UN	N	92	512	239	2.97	1223	32.50	362.19	2.17	119.50	17.59	8.10
NM	120	10/18/04	UN	N	47	541	246	2.51	1166	3.43	299.00	2.83	97.64	125.81	6.72
CO	121	9/12/04	UN	N	185	574	236	3.02	1288	7.44	243.67	2.68	123.36	11.69	8.04
Average		10/20/04			2140	558.21	240.07	2.79	1257.67	23.53	298.76	2.90	120.26	115.26	8.16
NE	102	1/17/05	RW	N	275	614	177	3.60	1254	2.24	205.55	3.49	113.07	223.36	8.83
NE	105	12/20/04	RW	N	201	662	181	3.06	1231	14.44	344.15	3.13	107.76	114.25	11.61
NM	108	11/20/04	RW	N	157	574	167	3.02	1078	1.73	333.29	2.97	103.57	359.14	6.40
NE	118	12/3/04	RW	N	125	705	168	3.26	1251	4.82	198.77	3.35	104.63	430.62	9.95
NE	122	10/8/04	RW	N	80	636	210	3.47	1363	1.67	312.21	2.67	105.28	134.79	7.58
NE	123	10/8/04	RW	N	59	615	221	3.05	1288	0.00	251.77	2.73	123.97	206.54	9.23
NE	110	12/14/04	RW	P	320	548	208	3.36	1249	.	227.64	3.64	123.57	313.00	9.09
Average		11/25/04			1217	610.43	189.84	3.26	1247.62	0.82	300.66	3.09	111.89	253.62	8.79

[a] Un = unweaned on ranch of origin, RW = weaned on ranch of origin
[b] Positive or negative persistently infected for bovine viral diarrhea virus
[c] Parasite eggs per g

Table 5. Year 2 ranch average feedlot performance, morbidity, mortality and carcass characteristics. All cattle are unweaned.

State	Ranch	Arriv	UN or RW[a]	PI[b]	hd	Inwt	Dof	Adg	Outwt	% 1st pulls	% repulls	% tot pulls	% deads	Killday	Qual[2]	Yield	Hotwei	Dress
NM	101	9/21/05	UN	N	42	582	229	2.75	1207	33.33	42.86	76.19	7.14	5/7/06	2021.84	1.32	779.30	64.57
CO	103	11/11/05	UN	N	195	473	233	2.94	1158	14.87	8.72	23.59	2.56	7/2/06	2022.01	2.29	734.63	63.46
NM	104	10/3/05	UN	N	27	597	224	2.83	1233	0.00	0.00	0.00	0.00	5/14/06	2021.64	2.36	778.89	63.16
CO	106	11/4/05	UN	N	26	561	260	2.90	1313	0.00	0.00	0.00	0.00	7/21/06	2021.57	2.23	866.16	65.97
UT	112	10/31/05	UN	N	258	492	249	3.17	1282	4.26	3.49	7.75	0.78	7/7/06	2021.63	3.04	827.58	64.53
NM	113	10/17/05	UN	N	94	500	230	2.70	1117	64.89	86.17	151.06	29.79	6/4/06	2021.97	1.90	708.19	63.40
NE	114	10/28/05	UN	N	165	455	263	2.96	1232	33.94	14.55	48.48	4.85	7/17/06	2021.75	2.88	783.15	63.56
UT	115	10/22/05	UN	N	163	556	216	2.97	1198	14.11	7.98	22.09	1.23	5/26/06	2021.65	2.29	775.73	64.77
NM	117	10/19/05	UN	N	169	553	219	2.96	1200	29.59	5.33	34.91	1.78	5/25/06	2021.97	1.93	760.19	63.34
UT	119	10/24/05	UN	N	330	537	240	3.10	1280	38.48	22.42	60.91	2.42	6/21/06	2021.67	2.75	809.35	63.22
NM	120	10/17/05	UN	N	465	470	258	2.87	1212	20.43	9.89	30.32	2.37	7/2/06	2021.62	2.71	778.07	64.19
Average		10/20/05			1934	504.95	237.38	2.92	1222.56	22.61	35.42	95.57	12.42	6/16/06	2021.76	2.33	785.05	64.04

[a] Un = unweaned on ranch of origin, RW = weaned on ranch of origin
[b] Positive or negative persistently infected for bovine viral diarrhea virus
[c] Scale Prime=2020, Choice=2021, Select=2022, No Roll-2023

Table 6. Year 2 ranch average liver trace mineral concentrations and fecal egg counts. All cattle are unweaned.

State	Ranch	Arriv	UN or RW[a]	PI[b]	hd	Inwt	Dof	Adg	Outwt	EggCount	Feppm	Moppm	Znppm	Cuppm	Mnppm
NM	101	9/21/05	UN	N	42	582	229	2.75	1207	34.05	224.81	3.28	115.59	203.08	6.76
CO	103	11/11/05	UN	N	195	473	233	2.94	1158	16.73	324.08	2.86	145.87	97.48	8.02
NM	104	10/3/05	UN	N	27	597	224	2.83	1233	40.81	166.74	3.42	113.04	114.83	8.85
CO	106	11/4/05	UN	N	26	561	260	2.90	1313	0.36	219.99	3.16	138.64	147.24	7.99
UT	112	10/31/05	UN	N	258	492	249	3.17	1282	12.89	269.42	2.76	128.63	31.37	8.43
NM	113	10/17/05	UN	N	94	500	230	2.70	1117	20.86	263.55	2.58	123.84	114.29	7.42
NE	114	10/28/05	UN	N	165	455	263	2.96	1232	10.15	176.29	2.88	128.07	151.79	7.05
UT	115	10/22/05	UN	N	163	556	216	2.97	1198	31.00	372.39	3.07	100.71	141.39	7.72
NM	117	10/19/05	UN	N	169	553	219	2.96	1200	5.35	361.94	3.00	121.59	189.44	6.03
UT	119	10/24/05	UN	N	330	537	240	3.10	1280	23.77	208.96	3.00	114.89	32.67	8.09
NM	120	10/17/05	UN	N	465	470	258	2.87	1212	30.00	229.76	2.64	146.82	185.41	5.90
Average		10/20/05			1934	504.95	237.38	2.92	1222.56	21.60	248.09	2.95	124.67	128.45	7.18

[a] Un = unweaned on ranch of origin, RW = weaned on ranch of origin
[b] Positive or negative persistently infected for bovine viral diarrhea virus
[c] Parasite eggs per g

Table 7. Water assays from six yr 2 ranches, ppm.

	Fe	Mg	Zn	Na	Cu	Mn	Mo	S
Average	0.038	36.6	0.0687	65	0.009	0.008	0.023	50.6
SD	0.12	34.8	0.162	75	0.007	0.004	0.017	57.3
Minimum	0.01	3.2	0	7.6	0.005	0.005	0	3.24
Maximum	0.589	136	0.695	338	0.03	0.017	0.07	226
Desired Upper Limit[a]		50	25	50	0.2	0.05		50
Maximum Upper Limit[a]		100	50	300	0.5	0.05		300

[a] R. Puls. 1994. Minerals in Animal Nutrition. (2nd Ed.).

Year 2 forage assays were available from 5 of the 11 particpating ranches (14 samples; Table 8). Analyzed values are similar to those reported by other authors. Ahola et al. (2007) collected masticate samples of native Eastern Colorado range from fistulated beef cows over a 2 yr period. Overall mean (± SD) trace mineral concentrations (mg/kg DM) were: Se, 0.26 ± 0.097; Cu, 3.9 ± 1.84; Fe, 428.1 ± 530,06; Mn, 67,7 ± 24.05; and Zn,18.3 ± 6.43 in diet samples collected at 27 sampling periods. Relative to NRC (1996) recommendations for beef cows, all samples were adequate for Se and Fe, 26 out of 27 ranch samples were adequate for Mn and 25 out of 27 ranch samples were inadequate for Zn. Mean Cu forage concentration was not adequate at any of the collection times. Mathis and Sawyer (2004) reported results of a New Mexico state-wide forage mineral survey. Of 134 samples, the percentages of samples not meeting NRC (1996)requirement for beef cattle were Co, 8%, Cu, 40%, Fe 0%, Mn, 16, Se, 47 and Zn 77%. Mortimer et al. (1999) reported similar results in a large survey where 352 samples collected from 18 states were evaluated for trace mineral concentration. Zinc was adequate in only 2.5% of samples, Mn in 76%, Cu in 36% and Co in 34% of samples. Selenium was adequate in 19.7% of samples and high in 16.7% of samples. Similar results were reported by Ghrings et al. (1996), Sprikle et al. (2000) and Fisher et al., (2003).

Table 8. Feed micro nutrient analysis from five yr 2 ranches, ppm

	Fe	Zn	Cu	Mn	Co	Mo
Average	181.72	23.23	5.90	52.64	0.53	1.30
SD	258.93	5.97	2.74	42.06	0.09	0.41
Minimum	53.90	15.00	2.49	9.25	0.50	1.00
Maximum	912.00	36.00	9.40	134.00	0.79	2.34
Growing Cattle[a]	50.00	30.00	10.00	40.00	0.10	
Stressed Cattle[a]	100 – 200	75 - 100	10 - 15	40 – 70	.1-.2	
Max Tolerable[b]	1000.00	500.00	100.00	1000.00	10.00	5.00

[a] NRC. 1996. Nutritional Requirements of Beef Cattle: Seventh Edition
[b] NRC. 2000. Nutritional Requirements of Beef Cattle: Seventh Edition: update 2000

Comparisons were made between yr 1 baseline measurements and yr 2 measurements for the 11 ranches sampled in both yr 1 and 2 (Table 9). Percent 1st pulls decreased from a yr1 mean of 42.6% to a yr 2 mean of 23% ($p < 0.05$) when the same 11 ranches were compared across years. Similar improvements in feedlot morbidity were seen by Grotelueschen et al. (2001).

Ranch 113 seemed to have a disproportionate impact on the morbidity and mortality summary. Total pull % was 66.0 and 151 and morbidity % was 6.4 and 29.8 for yr 1 and yr 2 respectively. Health and adg statistics for 2 yr with this ranch removed are presented in Table 10.

Reported USDA quality grades were converted to an index where Prime = 2020, Choice = 2021, Select = 2022 and No Roll = 2023. No Roll is defined as any cattle that would not qualify for the Select grade. Carcass quality grade was poorer ($P < 0.01$) in yr 2 (2021.56 vs. 2021.76). This decrease in carcass quality disagree with work by Roeber et al., (2001) and McNeill (1999) where an increase in feedlot cattle morbidity were associated with decreases in carcass quality. In this study, yr 2 carcass quality may have been negatively impacted by numerous factors, including ranch genetics that may have changed between yr 1 and yr 2, higher hot carcass weights in y1 (363.5 vs. 355.4 kg respectively) or different feedlot ration energy levels yr 1 vs. yr 2.

Table 9. Comparison of gain, health performance, carcass quality, liver mineral concentration and parasite concentration of 11 like yr 1 and yr 2 ranches [a, b].

	Year 1			Year 2				
Variable	Min	Max	Mean [c]	Min	Max	Mean	Diff	P <
1st Pulls, %	1.1	66.0	42.6	0	65.0	23.1	- 19.5	0.05
Repulls, %	0	47.9	21.4	0	86.2	18.3	- 3.1	0.80
Total Pulls, %	1.09	112.5	64.0	0	151.0	41.4	- 22.6	0.22
Mortality, %	0	8.5	2.9	0	29.8	4.8	+ 1.9	0.47
Egg Count, epg [d]	0	47.0	18.2	.4	40.8	20.5	+ 2.3	0.71
Zn ppm	97.6	141.2	116.8	100.7	146.8	125.2	+ 8.40	0.20
Cu ppm	17.59	189.39	94.6	31.37	203.08	128.1	+ 33.5	0.02
Mn ppm	6.69	10.8	8.0	5.9	8.85	7.5	- 0.5	0.19
ADG, kg	1.08	1.35	1.23	1.25	1.44	1.33	+ 0.10	0.02
QG [e]	2021.26	2021.84	2021.56	2021.57	2022.01	2021.76	- 0.20	0.01

[a] n=1803 yr 1 and 1934 yr 2 calves
[b] min and max values of each parameter are represented as ranch mean values.
[c] LS Means
[d] Egg per gram
[e] USDA Prime = 2020, Choice = 2021, Select = 2022, No Roll = 2023

Table 10. Comparison of gain and health performance of 10 like yr 1 and yr 2 ranches [a, b]. Ranch 113 excluded.

	Year 1			Year 2				
Variable	Min	Max	Mean [c]	Min	Max	Mean	Diff	P <
1st Pulls, %	1.1	64.6	40.3	0	34.0	23.1	-21.4	0.02
Repulls, %	0	47.9	21.0	0	43.9	11.5	- 9.5	0.15
Total Pulls, %	1.09	112.5	61.3	0	76.2	30.4	- 30.9	0.04
Mortality, %	0	8.5	2.5	0	7.2	2.3	+ 0.2	0.84
ADG, kg	1.08	1.35	1.23	1.25	1.44	1.33	+ 0.10	0.02

[a] n=1803 yr 1 and 1934 yr 2 calves
[b] min and max values of each parameter are represented as ranch mean values.
[c] LS Means

Though the most reliable method of diagnosing a mineral deficiency is to monitor an animal's response to the supplementation of a particular trace mineral, time and cost constraints dictate that the most ideal indicators of trace mineral status are animal tissue analysis (McDowell, 1992). However, Suttle, (1994), suggested that conventional indexes of trace mineral status (blood or liver concentrations) are only approximate measurements. A comparison of yr 1 and yr 2 liver trace mineral concentrations for the same ranches (n=11) is presented in Table 9. In this study liver Cu concentrations of calves at weaning increased ($P < 0.02$) from a mean of 94.6 ppm in yr 1 to a mean of 128.1 ppm in yr 2. The increase in liver Cu concentrations may be related to the standardized mineral supplementation program instituted in yr 2 operations. Zinc and Mn liver concentrations were similar across years (116.8 vs. 125.2 ppm, $P < 0.20$, 8.0 vs. 7.5 ppm, $P < 0.19$, respectively). For these 3 trace minerals, the liver Cu assay may be considered more reliable than using liver tissue as an indicator of Zn or Mn status. Corah and Arthington (1993) suggested that analysis of liver tissue obtained by biopsy is a good indicator of animal Cu status. Zinc and Mn tissue analysis may be misleading. Soft tissue Zn concentration varies little with Zn status. McDowell (1992) suggested that using a combination of plasma and forage Zn concentrations may be more acceptable than using either forage or plasma individually to ascertain Zn adequacy in an animal. Spire (2002) reported results of a study where serum Zn concentrations were analyzed in 80 randomly selected steers at feedlot arrival, at the time of first morbidity treatment and at time of re-pull for treatment. Serum Zn concentrations were deficient (< 0.60 ppm Zn) in 35%, 30% and 55% of cattle at respective samplings. Manganese liver concentration does not respond substantially to Mn supplementation, even at extreme dietary concentrations (Underwood and Suttle, 1999**).**

Engle et al. (1997) reported a greater skin swelling response in calves fed a Zn adequate diet (42 ppm Zn) when compared to calves fed a marginally Zn-deficient diet (17 ppm Zn). George et al. (1997) reported increased antibody titer response and a decrease in respiratory disease in feedlot steers supplemented with Zn, Mn, Cu and Co. There are many factors that could affect an animal's response to trace mineral supplementation such as the duration and concentration of trace mineral supplementation, physiological status of an animal, the absence or presence of dietary antagonists, environmental factors and the influence of stress on trace mineral metabolism (Baker et al., 2003). Spears (2000) suggested that despite the involvement of certain trace minerals in animal production and disease resistance, deficiencies of trace minerals have not always reduced performance or increased the susceptibility of livestock to natural or experimentally-induced infections. A summary of the yr1 and yr1 changes in serum neutralizing antibody titers to IBV, BVDV 1, BVDV 2 and BRSV from feedyard arrival to 21 – 28 d post arrival is presented in Table 11. Results of titer level comparisons suggest an improved vaccine y2 response for BVD 1 and BVD 2. There is no explanation for the decrease in IBR titers from feedyard arrival until day 21-28 in yr 2. It is important to note that natural exposure and subsequent host immune response may also contribute to increased antibody response.

Table 11. Feedlot arrival and 21-28 day post arrival serum neutralizing antibody titers to IBV, BVDV 1, BVDV 2 and BRSV. LS Mean differences for eleven like yr 1 and yr 2 ranches.

Year 1	Arrival	Post	SE	P <
IBR	79.48	84.23	29.38	0.88
BVDV 1	275.09	380.77	144.90	0.48
BVDV 2	832.82	1025.42	278.11	0.50
BRSV	83.86	137.41	53.75	0.33
Year 2				
IBR	5.01	9.68	27.17	0.88
BVDV 1	52.14	413.56	138.57	0.02
BVDV 2	54.44	650.58	265.94	0.04
BRSV	8.39	16.6	52.47	0.88

The relatively large number of calves in this trial and the number of liver trace mineral assays, parasite measurements, and titer measurements over yr 1 and yr 2 allowed for examination of correlations between these measurements and animal performance and morbidity indicators (Table 12). Liver biopsies were collected from 292 yr 1 calves and 193 yr 2 calves upon entry in the feedlot . Blood was drawn from 378 calves in yr 1 and 189 calves in yr2. Fecal samples were collected from the same cattle as blood sampling at feedyard entry (n = 332, yr 1, n = 168, yr 2).

Disagreeing with Snider (1986) and Smith (2000), numerically higher feedyard total pulls, lower ADG and higher mortality ($P < 0.07$) was observed as fecal egg counts decreased. Higher liver Cu concentration seemed to be strongly correlated with decreasing total pulls ($P < 0.03$), and increasing ADG ($P < 0.001$). Mortality tended to decrease ($P < 0.11$) as Cu concentration increased. These data agree with Groteleuschen et al., (2001) where weaned calves with higher liver Cu concentration had a lower total sick incident rate in the subsequent feeding period. Higher liver Mn concentrations seemed to be correlated with lower total pulls ($p < 0.03$). There appeared to be no correlation between Zn concentration and animal and health performance. However, as discussed previously, Zn and Mn liver tissue analysis may be misleading.

Table 12. Impact of liver copper, zinc and manganese concentration and parasite concentration on morbidity, mortality and ADG, 23 yr 1 and 11 yr 2 ranches [a].

		Min	Max[b]	Intercept	SE	Slope	SE	P <
Cu [d]		11.69	430.62					
	TPulls[c]			59.5	11.35	-0.14	0.06	0.03
	Dead			6.8	1.88	-0.02	0.01	0.11
	ADG			2.65	0.09	+0.002	0.0005	0.001
Zinc [d]		97.64	152.02					
	TPulls			68.6	55.70	-0.25	0.46	0.6
	Dead			1.63	10.23	+0.02	0.08	0.8
	ADG			2.47	0.24	+0.004	0.002	0.08
Mn [d]		5.90	11.61					
	TPulls			140.3	42.45	-12.65	5.23	0.03
	Dead			14.35	7.45	-1.25	0.91	0.2
	ADG			2.31	0.36	+0.078	0.04	0.09
Egg [e]		0	47					
	TPulls			36.32	11.02	+0.39	0.51	0.45
	Dead			1.59	1.77	+0.15	0.08	0.07
	ADG			3.05	0.11	-0.006	0.005	0.25

[a] 23 Ranches in yr 1 and 11 ranches yr 2. Total n=5311 calves.
[b] The minimum and maximum values of each parameter are represented as ranch mean values.
[c] TPulls represents the total medical treatments during the feeding period inclusive of 1st treatment and all subsequent treatments for individual animals.
[d] Parts per million
[e] Egg per gram

IMPLICATIONS

Loneragan (2004) illustrated that feedlot mortality rate increased from approximately 1.0% in 1994 to 1.6% in 2003. The author examined factors contributing to this increase and suggested over the 9 yr period there have been improvements in antibiotics and presumably better vaccines are available. One thing that had not changed appreciably is the way cattle are procured. Loneragan (2004), suggested that procurement systems may need to be modified to meet the demands of other changes and improvements that have been made in beef production. Management of cattle through conventional marketing systems results in many stressors on cattle. More recently Step (2008) contrasted the economic value of calves purchased directly from their ranch of origin to those marketed through conventional auction market systems. Total health treatments totaled 9.6% for ranch direct calves and 19.3% for auction market calves.

This report document the efforts by cooperators in one cattle production system to identify inputs easily adopted by participating ranchers in the cattle system's supply chain.The ultimate goal was to improve performance and profitability of individual ranches and of the system as a whole. We were not entirely successful. The primary change from yr 1 to yr 2 was the standardized free choice mineral program implemented 45 d prior to the stress of weaning, shipping and co-mingling on the feedlot.

The authors recognize the inherent risk of using correlation statistics to draw conclusions and weaknesses of year to year comparisons when analyzing data. Results suggest important responses in morbidity, mortality and ADG to specific and easily applied ranch level vaccination, parasite control and mineral nutrition interventions.

All participants in the beef supply chain involved in this study share the goal of constantly providing a higher quality and more predictable product to the next segment in the supply chain and ultimately providing the best product possible to the consumer. Changing consumer expectations together with shrinking profit margins in every beef production segment will encourage producers in separate segments to work together more in coming years than previously experienced.

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