EVALUATION OF HIGH-INTENSITY AND LOW-INTENSITY PRECONDITIONING SYSTEMS

A Thesis

by

ANDREW NATHAN ORSAK

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

MASTER OF SCIENCE

December 2010

Major Subject: Animal Science

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Approved by:

Chair of Committee,	Jason E. Sawyer
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ABSTRACT

Evaluation of High-intensity and Low-intensity Preconditioning

Systems. (December 2010)

Andrew Nathan Orsak, B.S., Texas A&M University

Chair of Committee: Dr. Jason E. Sawyer

Steer calves n = 345 (year 1 n = 183; 253 ± 35 kg, year 2 n = 162; 241 ± 36 kg initial BW) were used to evaluate 56-d preconditioning systems in each of two years. Angus- and Charolais-sired calves out of crossbred dams were assigned to systems within breed and BW strata. The systems consisted of ad libitum access to a self-fed milo-based diet in drylot (**DL**); ad libitum access to the same self-fed diet while grazing dormant warm season pasture (**SF**); and hand-fed 20% CP pellets (2.1 kg 3 times/wk; equivalent to 0.89 kg/steer per d) while grazing dormant warm season pasture (**HF**). Steers were weighed after overnight shrink on d 0, 28, and 56. The economic analysis was based on current local prices for cattle and inputs. Morbidity and mortality rates were similar among treatments. In year 1, one steer was removed from SF (mechanical) and one from DL (chronic bloat). In year 2, two steers were treated for respiratory disease (DL and HF) and mortalities occurred in DL (1 steer, digestive), HF (1 steer, unknown) and SF (1 steer, mechanical). Shrink from weaning to d 0 averaged 4.45% across years and was similar (P = 0.70) among treatments. Across years, ADG was lower in HF vs. SF or DL-fed steers (P < 0.01), which had similar rates of gain (P =

0.29; 0.13, 0.98, and 0.96 ± 0.03 kg/d yr 1; $P = 0.13$; 0.14, 0.73, 0.79 ± 0.06 kg/d for HF, SF, and DL, respectively). In year 1, daily feed intake was similar (9.03 vs. 10.0 ± 0.96 kg/steer; $P = 0.17$) among SF and, DL systems. In year 2, intake was greater for DL than SF (10.1 vs. 8.3 ± 0.25; $P < 0.01$). Feed efficiency (G:F) was greater for HF steers vs. SF or DL steers in year 1 ($P < 0.01$). (P=0.91; 0.04, 0.11, 0.09, ± 0.04 for year 1 HF, SF, and DL respectively). In year 2, G:F did not differ among treatments (P= 0.50; 0.16, 0.09, 0.08 HF, SF, DL respectively). Forage utilization was not quantified; these values represent gain per unit of purchased feed delivered, a metric favoring groups fed at lower rates. Preconditioning costs were 73.50, 175.12 and 167.20 $/steer (year 1) and 53.58, 152.72, and 141.68 $/steer (year 2; HF, SF, and DL respectively). These systems resulted in losses of -57.89, -67.59, and -58.80 $/steer (SE = 4.99; P= 0.38) in year 1, and -28.35,-80.00, and -64.55 $/steer (SE = 17.39; P = 0.18) in year 2 for HF, SF, and DL. Price premiums of 10.61, 10.51, and 9.18 $/45.4 kg (SE = 0.85; P=0.46) in year 1 and 5.79, 14.01, and 11.31 $/45.4 kg (SE = 3.25; P=0.27) in year 2 would be required for HF, SF, and DL to be par with sale at weaning. Overall preconditioning was unprofitable for both years and would require substantial price premiums. Although a lower intensity pasture system reduced overall input cost, it did not result in profitability. Providing ad libitum access to a diet while on pasture did not result in any advantages over drylot based systems.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Introduction

Morbidity and mortality related to the Bovine Respiratory Disease complex (**BRD**) continues to be a leading concern in the management of newly received feeder calves. Efforts and advancements in knowledge regarding vaccine technology such as the adoption of modified live vaccines and protocols, and receiving practices such as the levels of concentrate and roughage included in the diet, has reduced the occurrence of BRD (Galyean et al., 1999; Snowder, 2009). During the mid 1970's BRD accounted for 27% of morbidity and 5% of mortality in feedlot placements (Snowder, 2009). In 2001, an estimated 14.4% of all feedlot placements developed BRD while at the feedlot (USDA APHIS, 2001). Despite this reduction in BRD industry wide, the direct economic losses due to respiratory disease are estimated at $692 million annually not including the indirect losses in production (USDA-NASS, 2006). The total cost of BRD includes the cost of prevention, treatment, mortality, feed costs, loss of performance, loss of carcass grid premiums, and discounts.[1] Because of the economic impacts of BRD and trends in the industry towards value based marketing, source verification, health and nutritional management practices have become even more important to consider and will

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

likely become increasingly important. The production processes of weaning, marketing, commingling, and transportation are often the most stressful elements of the production cycle of beef calves. The management practice of preconditioning calves prior to their entry to the feedlot to enhance immunity and overall health and to reduce the effects of these stressors is not a new concept. Preconditioning programs were introduced over 40 years ago in the mid-western USA (Thornsbury, 1991). Today preconditioning is often accepted theoretically as a sound concept for improving the health of calves entering the feedlot, but the application of this practice by producers has not been widespread (Cole, 1985). The popularity of the practice has gone up and down throughout the years. Perhaps some of the most obvious reasons why the practice has not been widely adopted is the structure of the beef cattle production and marketing chain, the wide variation of cattle operations across the U.S. in terms of the type of cattle produced and management systems used, the availability of economically feasible resources, and a lack of communication between buyers and sellers of preconditioned calves (Miksch, 1989; Thornsbury, 1991). Another important consideration is that the overall effectiveness of the practice to significantly reduce morbidity has shown to be variable (Pritchard and Mendez, 1990). Research has also indicated that the practice is often not economically feasible. The added benefits to cattle feeders have historically not offset the costs incurred by the cow-calf producer (Cole, 1985; Peterson et al., 1989). Preconditioning has been loosely defined throughout the industry and has not been standardized. Numerous preconditioning protocols have been developed which often vary in length, vaccination protocols, and nutritional inputs (Miksch, 1989). Limited research has been conducted evaluating the effects of different types of preconditioning programs on overall health throughout the overall production phase. Preconditioning in general is regarded to improve health, but data from previous research on receiving diets indicate that higher nutritional inputs (energy and protein) are possibly correlated to increased incidence of morbidity (Mathis et al., 2008; Mathis et al., 2009) The objective of this research was to evaluate the effects of high input dry-lot preconditioning methods and lower input pasture preconditioning methods on overall health, performance, and profitability of beef calves both during the preconditioning period and in the subsequent feedlot phase.

Stress and Health

*Stress***.** Stress in general has many definitions, but it can be defined as a non-specific response by the body to any demand from the environment (Selye, 1976). Newly weaned calves are often subject to high levels of stress throughout the process of weaning and marketing. Stressors can include social disruption, abrupt changes in diet and plane of nutrition, exposure to pathogens, transportation, and periods of feed and water deprivation. These stressors often result in transient endocrine responses, altered products of energy and protein metabolism, change in appetite and growth rate, compromised rumen function and digestion, and challenges in health and immunity (Loerch and Fluharty, 1999). Stress can negatively affect immune function leading to increased potential for morbidity (Squires, 2003). It is generally accepted that BRD results from the interaction of stress, immunity, and infectious pathogens (USDA-APHIS, 2001). Stressors encountered during weaning, commingling, and transport often result in reduced DMI and are associated with an increased incidence of respiratory disease in cattle (Cole and McCollumn, 2007; Mitchell et al., 2008). The Bovine Respiratory Disease complex (**BRD**) consists of both viral and bacterial elements. Preventative programs often vaccinate against include the viral pathogens bovine rhinotracheitis (**IBR**, caused by bovine herpes virus-1), bovine viral diarrhea (**BVD**) virus, bovine respiratory syncytial virus (**BRSV**), and parainfluenza-3 (**PI3**) virus and the bacteria *Mannheimia haemolytica, Histophillus somni, and Pasteurella multocida* (Apley, 2006; Cole and McCollum, 2007).

Immune function. The immune system can be separated into two general components, innate immunity and acquired immunity, which function together to prevent infection (Squires, 2003; Carrol and Foresberg, 2007). The innate immune system consists of the animal's natural defense against pathogens and consists of cellular components such as neutrophils, monocytes, macrophages, dendric cells, as well as NK cells which secrete cytokines, and cells such as basophils, mast cells, and eosinophils which also release inflammatory mediators (Carrol and Forsberg, 2007). Acquired immunity consists of both humoral and cell mediated immunity. Vaccination enhances immunity through specific response induced antibody production, production of lymphocytes, and production of cytokines such as interlukin-2 and interlukin-4 (Galyean et al., 1999; Carrol and Forsberg, 2007).

Increased incidence of morbidity and mortality associated with weaning, transportation, commingling, and other stressors encountered during marketing is often attributed to stress-induced alterations in immune function. Crookshank et al. (1979)

found that weaning increased serum cortisol levels and that trucking resulted in an additional increase in cortisol, with hormone levels returning to baseline within 2 d for weaned calves and 4-7 d in weaned and transported calves. Increased circulating concentrations of cortisol has been identified as a primary cause of immune suppression (Fike and Spire, 2006; Carroll and Forsberg, 2007). Blecha et al. (1984), in a study to evaluate the influence of shipping on cellular immune activity, measured total and differential leukocyte counts, lymphocyte blastogenic responses, monocyte function, Packed cell volume (**PCV**), and concentrations of plasma cortisol before, immediately after, and 1 wk after shipment. Shipped steers had increased levels of neutrophils and a decreased lymphocyte blastogenic response, but cortisol level and monocyte function was not affected.

Acute-phase proteins have been shown to increase in cattle in response to stress, injury, infection, or inflammation (Horadagoda et al., 1999; Arthington et al., 2003). Arthington et al. (2008) evaluated the effects of 4 pre-weaning management systems on plasma acute phase protein concentrations and the performance of weaned, transported steers during a 30 d feedlot receiving period. Management groups consisted of control (calves weaned on the day of shipping), creep-fed, early weaned and pre-weaned steers. Overall performance was found to be highest in early weaned steers. No calves within the entire study were classified as morbid even though acute phase protein response was evident. The authors concluded that healthy calves still undergo the acute phase protein reaction and produce acute phase protein as a result of normal management procedures. Mackenzie et al. (1997), in a study to measure the effects of transport and weaning on humoral immune function, found that calves weaned while still on pasture 9-13 days prior to transport had a significantly greater antibody response after vaccination than calves that were weaned and housed in pens and/or transported. Their results indicate that stressors such as weaning and transportation affect humoral immune responses and concluded that different management and environmental conditions may affect immune function through actions of glucocortcoids especially after weaning. Mitchell et al. (2008) reported that stressors associated with typical production practices such as weaning, transport, and commingling resulted in significant protein changes in the pulmonary epithial lining fluid (**ELF**) of the lungs which altered proteins involved with microorganism defense including those for bacterial and viral pneumonia. Overall, these data suggest that different management protocols used during weaning may affect immune response and function

Generally, the process of transportation and shipping is considered more stressful than commingling, in that commingling does not seem to increase acute phase proteins to the same extent that transportation does (Arthington et al., 2003). In studies measuring the physiological response to transport, the length of transportation was not the most critical factor. Sartorelli et al. (1992) found that most physiological changes occurring due to transport occur within the first 30 to 60 min of transport. Transport stress is likely to have greater impact in young calves (Fike and Spire, 2006). One of the most critical factors regarding transport related morbidity and mortality is calf age (Swanson and Marrow-Tesch, 2001, Fike and Spire, 2006). One explanation for this is that younger animals do not undergo a typical stress response observed in older cattle making them more susceptible to disease (Swanson and Marrow-Tesch, 2001). Young calves especially those less than 6 months of age are more susceptible to infection because of an incomplete, but developing hypothalmo-pituitary-adrenal axis (Fike and Spire, 2006). Pre-weaning and weaning vaccination management may provide use of the best methods to reduce morbidity and mortality.

Overall based on previous reported data regarding stress and its effect on health and performance it is important to consider any management practice which reduces the level of stress or enhances immunity.

Proper nutrition is required for optimum immune function and productivity. Nutrition is especially important during the first few weeks after weaning and transport to the feedlot. It is important to consider that nutrition and stress are interrelated in that stress can produce and aggravate nutritional deficiencies and nutritional deficiencies can impose a stress response (NRC, 2000). Inadequate nutrition especially during this critical phase of production often exacerbates the effects of stress. Nutritional status such as protein, energy, vitamin, and mineral malnutrition can severely depress immune function increasing susceptibility to viral and bacterial diseases especially those involved with the BRD complex (Hutcheson and Cole, 1986; Nockels 1988; Nagaraja et al., 1998).

Digestive Function in Newly Received Stressed Calves

Intake. One factor influencing the levels of stress are periods of feed and water deprivation which often result in low DMI during the first 2 wk after receiving (Cole and Hutcheson, 1981; 1985; Fluharty et al., 1994; Loerch and Fluharty, 1999). Fluharty et al. (1996) reported that longer durations of feed and water depravation resulted in greater reductions in DMI, ruminal volume and weight of ruminal contents. Newly arrived feeder calves typically consume 0.5-1.5% of BW per d during the first wk of receiving, 1.5-2.5% of BW per d during the second wk of receiving, and intake is usually normal (2.5-3.5% of BW per d) by wk 2 to4 after arrival (Hutcheson and Cole, 1986; Loerch and Fluharty, 1999). However, Buhman et al. (2000) found that eating and drinking behaviors of newly weaned/ received highly stressed feedlot calves are highly variable in both eating frequency and rate of feed intake. On average calf eating behavior changes during the first 57 d in the feed yard (Buhman et al, 2000). , Their data indicates that adaptation to feed and feed bunks prior to entering the feedlot may increase intake during the receiving period. Fluharty et al. (1994) determined that fistulated steers that were weaned, transported by truck, and held in an auction barn before their arrival to the feedlot, consumed 62% of the amount of feed on their first d of arrival compared to d 7 after arrival. Low DMI is a major factor effecting the performance and health during receiving. Cole and Hutcheson (1985) concluded that the low DMI for 7-14 d after a period of feed and water depravation seemed to be the result of reduced ruminal fermentative capacity. However, Fluharty et al. (1996) reported that DMI after feed and water deprivation, is likely not the result of reduced ruminal fermentative and digestive capacity. It is probable that such factors as previous plane of nutrition and management, quality of feed available, time since last feeding, passage rate, ruminal fill, and the absence of satiety all affect DMI. (Buhman et al., 2000).

Digestion and rumen function. Weaning, overall marketing, and transport stress could affect rumen function thus affecting DMI and the ability of calves to adapt to a new diet. Research measuring rumen function (digestive capabilities) in newly received feedlot calves has resulted in mixed results across numerous studies. Cole and Hutcheson (1981) conducted three trials in which the influence of feed and water depravation on rumen function, blood variables and feed intake in beef steers was evaluated. In each trial different diets were fed, and steers were fasted for 24 h, fed and watered for 24 h, deprived for 48 h, and then re-fed and watered. In two of the trials the fermentative activity (**RFA**) and fermentative capacity (**RFC**) were significantly reduced by deprivation of feed and water. Rumen fermentative activity is an indirect measure of microbial activity by in vitro gas production without added substrate, and RFC is the capacity of rumen microbes to ferment added substrate. Rumen fermentative capacity was reduced as much as 75% and remained low after d 5 of feeding. Both RFC and RFA remained significantly below pre-fast levels throughout the study (Cole and Hutcheson, 1981).In addition to the change in fermentative capabilities, Cole and Hutcheson (1981) also indicated a shift in the molar proportions of VFA and a change in pH after fasting. Ruminal proportions of propionate and butyrate tended to decline and acetate increased. Rumen pH increased significantly during deprivation, but after re-feeding pH returned to its pre-fast levels within 24 hours. Cole and Hutcheson (1981) also reported that rumen ammonia nitrogen (**N**) levels declined significantly during depravation and increased after 24 h, but levels remained significantly below pre-fast levels at 168 h after re-feeding. Pre-fast rumen ammonia N levels ranged from 4.9 to 6.5 mg/100 ml in both trials and during re-feeding levels ranged from 6.2 to 0.5 mg/100 ml. The authors concluded that the low rumen ammonia N levels could affect rumen activity, in that 2.2 mg/100 ml is required for maximum microbial growth in vivo (Slyter et al., 1979). However, these results could indicate a more efficient use of ammonia N. In a later study on the influence of realimentation diet on the recovery of rumen activity and feed intake Cole and Hutcheson (1985) reported rumen fluid N concentration was not significantly affected by feed and water depravation nor were total rumen VFA concentrations. However, rumen pH was increased in feed and water deprived steers, and returned to normal by d-3(Cole and Hutcheson, 1985). Fermentative capacity was also shown to have decreased. Overall, the RFC (ml gas produced/2h) of feed deprived steers was decreased 74% and 3-7 d were required for fermentative capacity to return to relatively stable levels (Cole and Hutcheson, 1985; Hutcheson and Cole, 1986).

Galyean et al. (1981) studied the influence of fasting and transit on ruminal and blood metabolites in beef steers. Three treatments were used in the study. Control steers received free access to long-stem alfalfa hay, fasted steers (**F**) were deprived of feed and water for 32 h and fasted and transported steers (**FT**) were deprived of feed and water and hauled on a trailer for 32 h. After fasting both F and FT groups were placed in a pen with the control steers and allowed access to water and hay. Rumen pH of F and FT steers was increased compared to that of control steers. Upon re-feeding pH declined, but it declined more rapidly in F steers then in FT steers although the patterns were similar. The total VFA concentrations were in agreement with Cole and Hutcheson (1981), but in contrast to Cole and Hutcheson (1985), in that F steers had lower total VFA concentrations then control steers (39.5 mm vs.94.0 mm). Surprisingly, FT steers had total VFA concentrations of 202.2 mm. The authors concluded that the higher VFA in FT compared to F steers could be explained by the fact that transit imposed some additional influence on fermentation abilities total VFA concentration tended to be higher in FT steers throughout the re-feeding period which may be explained as a result of reduced rumen motility and poor absorption and passage rate, and not increased production. Reduced rumen volume and differential absorption of VFA and water could also explain the difference between the groups. Galyean et al. (1981) also measured rumen DM which was lower in F steers than FT steers indicating longer retention time and slower passage rate. One other possible mechanism could be that the FT calves consumed more feed upon re-feeding, but the authors indicated that weight patterns and bacterial numbers did not support this (Galyean et al., 1981). Blood glucose levels were higher in FT than in F steers, and rumen ammonia N concentrations were lower in F steers than in the control or FT steers, but returned to pre-fast levels in 46 h.

Fluharty et al. (1996) determined that steers weaned, trucked, and fasted for 48 or 72 h have similar ruminal volumes and percentage ruminal DM to those steers undergoing no feed and water deprivation. As with the previously reviewed studies, ruminal pH increased during deprivation, declined after feeding, and then rose to pre-feeding values. There were no differences in rumen fluid turnover between control and fasted steers, indicating no differences in ability of microbes to degrade substrate. Rumen fluid turnover is important because it is widely accepted that the change in the flow of the rumen liquid phase affects the rumen microbes and their abilities in degradation of feed constituents, and thus the metabolic and nutritional status of the animals (Chalupa, 1977).

Galyean et al. (1981) reported during a 32 h fasting and transit period, total counts of rumen protozoa were lower in F and FT steers than in control steers. Total numbers declined rapidly during fasting, but increased steadily during re-feeding. Rumen bacteria numbers also decreased rapidly during fasting and transit periods and returned to pre-fast levels after 104 h. Reduced rumen microbial population was consistent with observed reductions in fermentative capacity of F and FT steers. Hutcheson and Cole (1986) indicated that rumen protozoa and bacteria numbers were sharply reduced during fasting. Fluharty et al. (1994; 1996) reported that periods of feed and water deprivation decreased total number of ruminal protozoa, but indicated no difference in total rumen bacteria or celluloytic bacteria due to length of feed and water deprivation. Loerch and Fluharty (1999) reported no changes in rumen bacteria during a 72 h feed and water deprivation period along with 8 h of trucking. Based on the results of Fluharty et al. (1994; 1996); and Loerch and Fluharty (1999), the lower performance and decreased DMI of newly received/weaned, highly stressed calves may not be the result of reduced ruminal bacterial numbers and digestive capacity alone. If ruminal fermentation is compromised by feed and water deprivation and a cause of low DMI, then modification of the ruminal environment could potentially improve fermentative capabilities and increase DMI. Cole (1991) studied the effects of exchanging ruminal contents between fed and fasted lambs on ruminal characteristics and feed intake to determine the impact of ruminal function in the control of DMI in fasted ruminants. Approximately 50% of ruminal contents between fasted and non-fasted lambs were exchanged in the study. The exchange in ruminal contents had no effect on total microbial numbers. VFA concentrations were reduced 79% during fasting, but were not affected by ruminal exchange. Ruminal fermentative capacity was reduced 51% by feed and water deprivation and remained lower 4 d into the realimentation period, similar to that of steers in previous studies (Cole and Hutcheson, 1981; 1985). Exchange of rumen fluid had no significant affect on DMI or RFC, indicating that reduced ruminal fermentation is not the sole factor involved in low DMI of fasted ruminants. These conflicting results suggest that feed and water deprivation along with the stress of marketing, transportation, and commingling may induce a response in cattle which effects rumen function and fermentative capacity to some degree, but there are other factors such as the severity of stress and previous management, which could also affect DMI.

High Energy Diets as a Nutritional Strategy

Effects on ruminal characteristics, performance, and health. A large amount of research has been conducted evaluating the effects of receiving diets on the performance and health of newly received stressed cattle. Data from this research can also be applied to diet decisions involving preconditioning management. The on-ranch preconditioning period can be considered equivalent to feedlot receiving without the effects of transportation and commingling.

Because DMI is often decreased following weaning, one strategy to maintain total nutrient consumption is to increase the nutrient density of the receiving diet to offset low feed intake and supply calves with adequate nutrients to return to a positive energy balance (Loerch and Fluharty, 1999; Berry et al., 2004). The diet fed to newly weaned calves subjected to feed and water deprivation can influence both DMI and rumen activity (Cole and Hutcheson, 1981; 1985).

Cole and Hutcheson (1981) adapted steers to either an alfalfa hay diet or a 40%concentrate diet for 3 wk, deprived feed and water for two sequential periods, and then re-fed these diets. Steers fed the alfalfa hay diet tended to maintain a higher RFA and RFC value than those steers fed a 40% concentrate diet, indicating steers fed alfalfa hay tend to maintain greater rumen activity during and after deprivation periods. Calves fed alfalfa hay also consumed more than calves fed the 40% concentrate diet.

Cole and Hutcheson (1985) conducted 2 trials evaluating RFC and DMI. In trial 1, 18 ruminal fistulated steers were fasted and were limit fed 4.5 kg/d one of five diets based on varying amounts of roughage and energy. A high roughage diet consisted of 60% cottonseed hulls and 40% alfalfa (1.79 Mcal ME/kg). Three medium roughage diets were used (2.50 Mcal ME/kg) each with varying levels of crude protein, low, medium, or high. Diets consisted of 31, 29, 27% cottonseed hulls, 48, 43.6, 39.3% corn, and 3.5, 10.0, and 16.5% cottonseed meal each, respectively. Control steers in the study were not fasted and were fed prairie hay (1.63 Mcal ME/kg). In trial 2, 60 steers were subjected to the same treatment and given ad libitum access to the same 5 dietary treatments in order to measure DMI. In trial 1, RFC was reduced 74% in fasted steers and 3 to 7d were required for RFC to reach levels that were equal or greater than that of control steers. In trial 2, fasted calves fed the high roughage diet required more than 8 d to obtain DMI and ME intake equal to that of the control steers. Calves fed medium roughage diets had a DMI similar to or greater to that of those fed the control diet between d 4- 8, and ME intake was similar to or greater to those fed the control diet beginning on the first day of realimentation. When comparing the RFC data from trial 1 and the intake data from trial 2 realizing that the dry matter intake was different between the trials, the time in which optimum RFC and dry matter intake was achieved seem to correspond, indicating that a relationship between RFC and dry matter intake in fasted steers may exist. This relationship seemed to be the greatest with the high roughage diet and no relationship between RFC and medium fiber diets was observed (Cole and Hutcheson, 1985).Based upon this comparison of the trials it is also possible that the level of energy included in a diet fed to fasted calves could influence RFC. The medium roughage diets could affect RFC and feed intake by altering the synthesis of metabolites causing some type of chemostatic response. In the same sense, a high roughage diet could affect RFC and feed intake by its effect on the rate of fermentation, passage, and gut fill (Cole and Hutcheson, 1985). Feeding medium roughage diets will result in greater energy intakes while feeding high roughage diets may optimize RFC in fasted stressed calves.

Lofgreen et al. (1975) studied the effects of energy level in diets for newly received calves subjected to 30 h of feed and water deprivation. Steers were fed their respective diets for 63 d. Diets contained 0.84, 1.01, 1.10 and 1.19 Mcal NEg /kg and 20, 55, 72, and 90% concentrate, respectively. For the first 24 h following receiving, DMI was directly proportional to the energy level in the diet. However, during the first 2 wk of the receiving period steers fed the 55% concentrate diet had higher DMI than steers fed the 72% concentrate diet. Although steers receiving the 72% diet had lower

DMI, the diet contained more energy, and weight gains were a reflection of energy intake. After the first 2 wk no significant difference in intake existed between the 55% and 72% concentrate diets. Steers fed higher energy (72% or 90% concentrate) diets gained more weight and regained their initial purchase weight 2-5 d sooner than those steers fed the 20 or 55% diets. Feed required per unit of gain also favored high energy diets. Lower feed consumption was noted throughout the study for the steers started on the 90% concentrate diet. During the 2-wk period after receiving steers ate less of the 90% diet compared to the 72% diet. Percentage of morbid calves was lower on the 72% diet than that of those on the 55% diet. Medication costs per animal increased as the level of concentrate increased, but per unit of production (kg of weight gain) medication costs decreased with increasing concentrate level. Based on the low DMI and increased medicine costs, diets containing 90% concentrate or greater should be avoided because of potential risk of increased health problems. In a later study, Lofgreen et al. (1981), weaned steers subjected to similar stress ate more feed, gained more wt and gained more efficiently when fed a 75% concentrate receiving diet alone or with free choice hay compared with free choice hay alone. Lofgreen et al. (1981) reported that diets with greater bulk or lower energy densities did not promote higher feed intake based on the fact that during the first week after receiving steers fed a hay diet did not eat more than those on the concentrate diet. There was a tendency for calves fed hay diets to have fewer total sick days than steers fed the 75% diet. Reasons for increased respiratory disease among steers fed higher energy diets was not clear, but the authors suggested it may be due to subclinical acidosis which may place additional stress on the animals and lower disease resistance (Lofgreen et al., 1981).

Fluharty and Loerch (1996) conducted a series of experiments in which the effects of receiving diet energy concentrations on calf performance were evaluated. In one experiment, sixty steers were fed 16% CP diets of varying concentrate level (70, 75, 80 or 85% and 1.15, 1.21, 1.25, 1.30 Mcal NEg/kg respectively). During wk 1 after receiving, no differences in DMI, ADG, or feed efficiency due to dietary concentrate level were observed, but a significant increase in DMI with increasing dietary concentrate level was observed during wk 3 and 4 and therefore for the total trial. Throughout the trial no significant differences in health status based on level of concentrate were observed and no death loss occurred. Based on the authors' results, diets containing at least 16% CP and 70% to 85% concentrate may be beneficial (Fluharty and Loerch 1996).

Berry et al. (2004) used auction barn calves from Texas, Arkansas, and Oklahoma to study the effects of energy and diets differing in starch concentration on performance and health of newly received feedlot calves during a 42 d period. Upon arrival 1 kg of prairie hay was fed per calf and free access to water was given. Calves were assigned to one of four dietary treatments and were fed diets containing one of the two energy levels, 0.85 or 1.07 Mcal NEg/kg and 34 and 48% dietary starch for each energy level. Calves fed the lower energy diet consumed 3.7% more DM during the overall feeding period. Weight gain and gain efficiency were not affected by the diet energy or starch concentration, which is in agreement with Fluharty and Loerch (1996), but in contrast to Lofgreen et al. (1975, 1981). Berry et al. (2004) noted a gain and intake advantage for calves fed the lower energy diet over calves fed the high energy diet due to the form of added roughage, cottonseed hulls in low energy diet. Increased roughage might have resulted in positive associative effect by slowing the passage rate of fermentable carbohydrates and increasing digestible energy, increasing NE value of the diet. Calves fed the diets higher in starch had a numerically greater percentage receiving an antimicrobial treatment, and the first antimicrobial treatment tended to be 1 d later than calves fed the low starch diet (Berry et al., 2004). Overall, lower morbidity was associated with high energy- low starch diets, which suggests starch content in high energy diets might influence morbidity rate.

Dietary roughage concentration and the health of newly received calves was reviewed by Rivera et al. (2005) in which data from six studies were compiled and analyzed in order to determine the relationship between roughage concentration and morbidity, ADG, and DMI. Regression analysis of trial adjusted morbidity ($\text{Morbidity}\ \% = 49.59 - 0.067\ \text{x roughage}(\%); \text{r}^2 = 0.356$) indicated a weak relationship and a minor decrease in BRD morbidity by increasing roughage in the diet. Regression analysis of ADG($ADG\left(\frac{kg}{d}\right) = 1.16 - 0089\ x\ roughage(\%); r^2 = .632$) indicated that cattle fed higher roughage diets gain less (Rivera et al., 2005). Therefore, increasing roughage (decreasing energy) concentration as a strategy to decrease morbidity would not offset the lost gains and performance. Regression analysis of DMI ($DMI\left(\frac{kg}{d}\right) = 5.34 - 0.0135\ x\ roughage(\%); r^2 = 0.59$) indicated that increasing roughage in diets decreases DMI. Overall Rivera et al. (2005) concluded the optimum dietary strategy for highly stressed, newly received cattle should be 50-75% concentrate in the diet, which is in agreement with several of the previous studies reviewed.

Results from these studies can be applied to make nutritional decisions during preconditioning. Based on these results it is clear that higher concentrate diets would likely be the most feasible to use during dry lot preconditioning based on costs and performance. However, the data supporting lower morbidity with increasing level of roughage indicate the potential that providing pasture as a source of roughage may be a viable option which could have a significant impact on animal health.

Crude Protein Concentration in Diets

*Crude protein requirements***.** It is often recommended that newly weaned calves and incoming feedlot steers should receive a diet that contains at least 12.5% CP DM basis to improve ADG and DMI (Eck et al., 1988). However, CP levels at 12.5% in receiving diets may not meet requirements because of low DMI (Fluharty and Loerch, 1995). According to NRC (1996) diets for newly weaned calves should contain 13.5 to 14.5% CP. Galyean et al. (1993b) modeled the protein requirements of newly received calves and reported that in order to meet requirements during the first 2 wk period after receiving with a 12.5% CP diet an intake of 1.45% of BW of this diet would be required. Protein requirements are not different in stressed calves, but the concentration of protein required depend heavily on feed intake (NRC, 1996).

In addition to the concentration of protein required, it is also important to consider the type of protein included in the diet. Stressed calves have a lower tolerance for non-protein nitrogen (**NPN**) than non-stressed calves, it is suggested that 30 g/d or less can be included in diets for newly weaned calves to avoid negative effects on performance and intake (NRC, 1996). Rumen escape protein in the diets of stressed calves should also be considered. Eck et al. (1988) fed a 12.5% CP diet containing a minimum of 60% high- quality rumen escape protein to newly received calves and noted an advantage in performance, but this advantage diminished during the subsequent month on feed. Ruminal escape protein reduces the loss of N during rumen fermentation and increases the quality of protein available for absorption, thereby reducing the total amount of crude protein required in the diet (Eck et al., 1988). Need for ruminal escape protein is the greatest in lightweight cattle (< 205 kg) and escape protein needs decrease as bacterial crude protein synthesis increases with increasing intake of a high concentrate diet (Galyean et al, 1995). Therefore including a source of ruminal escape protein in diets of newly weaned calves might be advantageous to performance and health because of low DMI and possible reduced digestive function and capacity.

Effects of crude protein on performance and health. Cole and Hutcheson (1990) studied the effect of CP concentration on health and performance of market-transport stressed feeder calves. In the study 340, steers were fed receiving diets of 12 or 16% CP. Throughout the study there was a high overall death loss (42 of 340) due to BRD. This was likely due to the previous background and market stress. Calves in this group that were fed the higher (16%) CP diet tended to have fewer relapses and fewer treatment days per calf compared to 12% CP diets. However, in a second trial, calves fed the higher (16%) CP diet had a lower mortality rate, but a greater incidence of relapses. Although these trends were observed the differences in morbidity and mortality rates were not significant. Steers receiving the 16% CP diet had greater DMI, higher ADG, and improved G:F than calves fed the 12% CP 14 d after receiving, but by d 56 performance and efficiency were similar for both diets. The authors suggested the differences in response to the increased dietary CP involving the observed trends in morbidity and mortality may be due to the fact that cattle with lower DMI were affected greater than those with higher DMI since the CP requirement (g/d) of market stressed feeder calves is similar to non-stressed calves (Cole and Hutcheson, 1990).

Fluharty and Loerch (1995) evaluated the effects of concentration and source of CP in receiving diets on 240 crossbred steers. Steers received diets with 12, 14, 16, or 18% CP from either spray-dried blood meal (**SDBM)** or soybean meal (**SBM**). Feed efficiency and ADG increased with increasing CP concentration and with SDBM vs. SBM as the protein source. Steers fed 16% and 18% CP levels consumed more feed than those fed 12 or 14% CP (1.32 vs. 1.15 % BW). No death loss occurred, but morbidity rate increased with increasing CP concentration, (38, 50, 45, 68% respectively for 12, 14, 16, and 18% CP). In a second trial, 240 steers were fed a diet containing CP concentrations of 11, 14, 17, 20, 23, 26% from a combination of SDBM and SBM. As with the first trial, performance (feed efficiency, ADG) increased with increasing CP concentrations, but there were no effects of CP concentration on total antibiotic treatments required. These results between the two trials are inconsistent. One might expect a decrease in morbidity with increasing CP, especially when considering the higher CP (20, 23, and 26%) compared in the second trial which did not exhibit a linear increase in morbidity. The results of the first trial are also inconsistent to Cole and

Hutcheson (1990), which indicated that increasing dietary CP in the diet improved N balance of feed and water deprived steers which should improve health status.

McCoy et al. (1998), evaluated energy source and escape protein supplement, fed a diet of either dry rolled corn or wet corn gluten feed with or without supplementation of escape protein to newly received steer calves G:F was improved with escape protein supplementation, however total crude protein was a confounding factor in that diets containing escape protein contained more total crude protein. McCoy et al. (1998) results were similar to the second trial of Fluharty and Loerch (1995), and observed a negative correlation ($r = -0.61$ $P < 0.01$) between MP supply and morbidity, indicating that increased MP supply may improve health. In contrast to McCoy et al. (1998) but consistent with the first trial reported by Fluharty and Loerch (1995), Galyean et al. (1999) reported increased morbidity rates may occur as CP level in the receiving diet increases. Nissen et al. (1989) found that increasing MP level in the diet (5.2, 6.4, 7.4, and 9.5%) resulted in a linear increase in ADG and improved G:F, but the percentage of calves treated for morbidity significantly increased linearly with increasing MP level. Nissen et al. (1989) also found that as MP level increased the number of calves responding to an infectious bovine rhinotraceitis vaccine significantly decreased. Nissen et al. (1989) also noted increased cortisol with increasing MP might be responsible for some of the changes in health responses because serum cortisol concentrations were found to increase linearly with increasing MP. However, the increased cortisol levels could be explained by handling, shipping, and marketing stressors as well as temperament. (Crookshank et al., 1979).

Galyean et al. (1993a) fed newly- weaned, highly stressed calves (transported for 19.5 h, 6.8% shrink) receiving diets varying in CP concentration for a 42-d period. The diets contained 12, 14, and 16% CP from SBM. Average daily gain and DMI increased linearly with increasing CP concentration. Overall 35.8% of the calves were treated for BRD morbidity and more calves required treatment on the 16% CP diet (47.5%). The morbidity rate for the 14% CP diet was 22.5% which was slightly lower than the 12% CP diet which had a morbidity rate of 37.5%. It is obvious that transportation stress likely played a role in morbidity, but there was a trend of higher morbidity with the higher CP diet. This study indicates that increased CP in the diet does not have a direct effect on morbidity rate.

Galyean et al. (1999) pooled the data from Galyean et al. (1993a) and Fluharty and Loerch (1995) and used the data to perform a regression analysis. In this analysis dietary CP level ranged from 11 to 26 % and morbidity ranged between 15-68%. Morbidity rate was indexed by dividing the morbidity rate for each CP level by the trial mean morbidity. This allowed for the elimination of all variables except CP. The model accounted for approximately 52% of the trial-indexed morbidity. This model $Y = 866.27 - 149.05 * CP^2 - .17 * CP^3$ describes how BRD morbidity rates tended to increase with increasing CP. This model demonstrates how BRD morbidity rates tended to increase with increasing CP. These results seem paradoxical in that higher CP levels fed to calves result in equal or superior performance to those fed lower CP levels, but also appear to increase morbidity rates. These differences could be a reflection of inaccurate diagnosis (Galyean et al., 1999; Duff and Galyean 2007). An alternative explanation is that morbid calves fed higher CP levels have increased performance and that healthy calves fed higher CP may have superior performance that compensated for higher morbidity.

Overall, increasing CP concentration in receiving diets seems to improve performance and efficiency of production. However, no clear conclusion can be made on the role increasing CP in diets plays on overall morbidity, indicating a need for further research. Formulating diets to contain higher proportions of ruminal escape protein is likely the most critical for the first 2 wk after weaning/ starting on feed. Data from these studies involving receiving diets are important to consider when formulating preconditioning diets. In order to minimize weight loss and maximize performance, efficiency, and therefore manage cost of gain during preconditioning, diets need to contain adequate protein levels to meet requirements based on expected DMI.

Effect of diet after immune challenge. The effects of level of concentrate, CP, and roughage level on performance and animals visually identified as morbid in large feeding trials have been studied extensively. Several studies exist evaluating the metabolic profiles and immune response on a cellular level based on levels of concentrate and protein in the diet after an induced challenge by an infectious pathogen.

Whitney et al. (2006) evaluated the effects of two levels of protein supplementation (SBM 0.175 and 0.35% of BW) with a basal forage diet of bermudagrass hay compared to a 70% concentrate diet on metabolic profiles and febrile response to an infectious bovine herpes virus 1 (**BHV-1)** challenge during a 27-d receiving phase. Greater rectal temperatures were observed for steers receiving the 70%

concentrate and the SBM supplemented diet compared to the bermudagrass hay diet. However, IgG levels were higher in steers fed bermudagrass hay than the concentrate steers after the BHV-1 challenge, but no visual signs of morbidity were observed in the bermudagrass treatment. Because of the lack of any signs of clinical morbidity the authors concluded that steers fed the 70% concentrate may have been more effective than forage fed steers in neutralizing BHV-1 at the site of injection before it could elicit a strong immune response. After the 27 d receiving phase, all steers were fed the concentrate diet. Steers previously receiving the concentrate diet had greater ADG, DMI, and G: F compared to those previously fed forage, indicating no compensatory gain effects due to lower plane of nutrition. Reuter et al. (2008) evaluated the effects of energy source and level with or without antibiotic administration on immune function. Steers were fed one of three dietary treatments: 70% concentrate ad libitum, 30% concentrate ad libitum, or 70% concentrate restricted to offer the same amount of energy as the 30% ad libitum diet. Steers were challenged with an *Escherichia coli* lipopolysaccharide. Steers fed the 70% ad libitum diet had increased rectal temperatures after the challenge. Pro-inflammatory cytokine (**PIC)** response in the 70% restricted diet was intermediate in response to the 70% ad libitum and 30% ad libitum diets, indicating that an increased cytokine response may result from a combination of decreased energy intake and from direct effects of roughage. The authors noted that this observation may explain the mode of action for the decrease in morbidity that has been observed in newly received stressed calves fed roughage based receiving diets. Decreasing the diet concentrate to roughage ratio increased production of PIC in response to a LPS challenge, which in part may be due to dietary energy intake and the ingredients (grain vs. roughage) (Rueter et al., 2008).

Waggoner et al. (2009) studied the effects of dietary protein concentration on N balance, serum hormones and plasma amino acids in growing beef steers exposed to gram-negative bacterial LPS. Diet treatments included a control containing 14.5% CP, (14.5CON) three treatments with varying CP levels containing different proportions of rumen degradable protein (**RDP**) and rumen undegradable protein (**RUP**) (14.5% CP, 11.6% RDP, 2.9% RUP, 16% CP RDP (16.3% CP, 13.4% RDP, 2.9% RUP), and CP 16 RUP (16.1% CP, 11.2% RDP, 4.9% RUP) and the amount of RDP/RUP was altered with casein, fish meal, and corn gluten meal. Intake was limited to 1.8% of BW to minimize intake differences and to mimic the intake of newly received stressed calves. After the LPS infusion steers fed the 16% CP diets had higher rectal temperatures compared to steers fed the CP 14.5CON diet. This observation is similar to that of Whitney et al. (2006) and may indicate that an increased nutritional status results in greater febrile response and a higher probability of being diagnosed for clinical morbidity. Challenge also caused a decline in serum glucose in response to an increase in insulin concentration, indicating an increased metabolic energy demand. Challenge also caused changes in essential and non-essential amino acid concentrations in plasma, indicating altered N metabolism due to an increased amino acid demand after immune system activation (Waggoner et al., 2009). Contrary to previous studies, Waggoner et al. (2009) indicated that additional protein may alleviate the negative effects of infection on N balance. Steers fed the 16% CP diet utilized N more efficiently regardless of source.

Diets containing greater than 16% CP may be needed to meet increased metabolic demands (Waggoner et al., 2009). Orr et al (1988), in a similar study noted that IBR stressed calves reflected a need for higher quality and or quantity of dietary protein during stress and infection states.

Preconditioning Management

Definition. One of the main goals of preconditioning management is to reduce morbidity and mortality in the subsequent feedlot phase. Preconditioning is designed to both manage and reduce the stressors feeder calves encounter throughout the supply chain as a means of enhancing immunity to BRD. Preconditioning programs vary widely across the industry and have many definitions (Cole, 1985). The concept of preconditioning first originated in Iowa in the mid 1960's and was defined as a presale management program to reduce stress and disease in weaned calves by castrating and dehorning calves at an early age, vaccinating 3 to 4 wk before weaning and feeding calves for at least 30-d before marketing (Thornsbury, 1991). Later, preconditioning was defined by the American Academy of Bovine Practitioners (1968) and said to consist of the following elements: calves weaned at minimum 3 wk before sale, calves trained to eat from a bunk and drink from a trough, treatment of parasites, vaccination for clostridials, *parainfluenza -3 virus* (PI-3), *infectious bovine rhinotracheitis* (IBR), *Manhemmia haemolytica*, *bovine viral diarrhea virus* (BVD), and *haemophis somnus*, calves castrated and dehorned, calves identified with an ear tag and sold through special auctions.

Although criteria for preconditioning management was established decades ago, "preconditioning" is a term that has been applied without a strict definition. Many variations of preconditioning programs were created throughout the 1970's and 1980's across the country. In many cases manufactures of cattle feed, anthelmintics, insecticides, and other products used preconditioning to increase demand for their products (Miksch, 1989). Preconditioning was never fully accepted nor rejected during this time. One possible reason for the lack of application of the practice is uniformity in procedures and costs. The term preconditioning came to have a different meaning to different people because of lack of communication between buyers and sellers (Miksch, 1989). An overall lack of standardization along with a lack of profitability was often attributed to why preconditioning has not been widely adopted (Lofgreen, 1988; Miksch, 1989).

In the mid 1980's and throughout the 1990's more research regarding preconditioning, vaccination, and health management was conducted. Also more types of vaccination protocols were established. Due to research regarding the effects and cost of BRD and pre and post-weaning management, and projects such as the Texas A&M Ranch to Rail Program, the beef industry has become more aware of the value of preconditioning management and costs of feedlot morbidity (Mathis et al., 2007). Observations made from the Texas A&M Ranch to Rail program were used to develop several protocols of varying intensity (VAC-45, VAC-34), and since their introduction in the mid-1990's these have been employed across the United States (Anonymous, 2005a; 2005b; Mathis et al., 2007).

Vaccination. In order for preconditioning programs to enhance and boost immunity, and ultimately be successful in reducing disease incidence, vaccination must be implemented properly. Vaccination programs vary based on state or region, logistics of management practices, and marketing objectives. Of these differences, most of the options are related to the weaning and timing of vaccination. Texas A&M University developed a set of s health management protocols based upon performance in the Texas Ranch to Rail program. Vaccination protocols were designed for both operations that ship cattle at weaning or separate weaning and shipping for a minimum of 45 d (Mathis et al., 2007). Based on the Texas A&M VAC guidelines programs that ship at weaning require that calves be administered a modified live virus **(MLV**) and a 7 way clostridial vaccine either at 2-4 months old (VAC-Pre-Wean) or 4-6 weeks prior to weaning (VAC-Pre-Wean Plus). For the programs that separate weaning from shipping two options exist, a pre-weaning and a weaning option. The pre-weaning option consists of either an initial administration of MLV at branding or 4-6 wk pre-weaning and at weaning. With the weaning option vaccination occurs at weaning and again 2-3 wk post weaning. All calves in the VAC-45 program are not shipped until they have been weaned a minimum of 45d (Anonymous, 2005a). The 45 d requirement was established based upon records from the Texas A&M Ranch to Rail program which indicated that calves entering the feedlot within 14 d after weaning had higher medicine costs than calves entering the feedlot 41 d or more after weaning. This data corresponds with data from the New Mexico Ranch to Rail Program which also indicated that steers weaned 41 d or more before entering the feedlot generated greater net income per head than steers weaned 21 to 40 d or less than 20 days prior to shipping (Mathis et al., 2007). However, White et al. (2008), in a study evaluating the timing of vaccination and the number of days weaned prior to commingling noted no significant difference in morbidity between groups of calves weaned less than 45 d (11.7%) when compared to morbidity in a group of calves weaned more than 45 d (7.6%). However, overall observed morbidity in this study was low as one might expect given that calves that were weaned less than 45 d were weaned at least a minimum of 30 d.

A great deal of emphasis has been placed on management and convenience of vaccination timing, but there is not a large amount of data on the efficacy of different protocols. Overall, little is known about what type of vaccination schedule is most effective during preconditioning. Pre-weaning immunization 2-4 wk prior to weaning occurs is often considered optimal because it occurs when the calf is under minimal stress. White et al. (2008) noted that the timing of specific procedures such as vaccination relative to disease challenge may play a role in overall effectiveness of the preconditioning program to reduce disease risk. These authors found that morbidity was significantly higher when the time between initial and booster vaccination was less than 14-d, 28.8% morbidity with 14-d or less between initial booster vs. 10.6% morbidity for vaccination at 14-28 d. However, no significant difference in morbidity existed between weaning time or proximity of time between last vaccination and backgrounding (Less than 14-d, 13.9% and greater than 14-d 12.2 % morbidity).

Grooms and Coe (2002) compared the immune response of calves during a preconditioning program using different vaccination protocols. Calves receiving vaccine protocols that included at least one dose of MLV vaccine exhibited higher virus neutralizing antibody titers against BVDV than calves receiving only killed vaccines. Vaccine protocols combining both MLV and killed virus vaccines exhibited higher virus neutralizing antibody titers than calves receiving only one classification of vaccines. Snowder et al. (2006) noted similar results in that higher morbidity was observed in consecutive studies when using only killed virus compared to MLV in later years, demonstrating the importance of MLV vaccines.

Calves vaccinated later in the preconditioning program (d-21 and 42) also tended to have higher antibody titers than those vaccinated early (d-0 and 21), indicating that stress of weaning may play a role in effecting immune response to vaccination protocols or it could be an indicator that immunity as measured by antibody titers begin to decline in calves vaccinated early (Grooms and Coe, 2002).

These observations may be important because calves vaccinated early may be at greater risk of respiratory disease than those calves subject to another protocol in which calves are given a booster vaccination later in the preconditioning period.

Fulton et al. (2002) evaluated the animal health status of 24 herds represented by 417 calves in a retained ownership program that included guidelines for vaccination and anthelminitic treatment before entry into the feedlot. Vaccination protocols used by the 24 different ranches varied in the number of vaccinations and the timing of vaccine administration. Overall, 114 calves (23.7%) were treated for respiratory illness, and 4 (1.0 %) died. The three herds with the highest morbidity rates received only killed virus vaccine, of which the second dose was either lacking or given at or 2 d prior to delivery.

Antibody titers against BVDV-1 in these herds were significantly lower than in the three herds with the lowest morbidity rates. In the herds with the lowest morbidity rates calves received MLV vaccine approximately 7 wk and 3 wk prior to delivery (Fulton et al. 2002). One of the important implications of this study is that a great deal of variation may exist between vaccination protocols and their effectiveness in preventing respiratory disease.

Richeson et al. (2008) evaluated the effects of vaccination timing of a MLV BRD vaccine on health, performance, and IBR antibody titers in newly received stocker cattle. It is often thought that stress associated with management and shipment can cause immunosuppression, so that a vaccination given during this time may result in a reduction of vaccine efficacy and animal performance. In the study calves were vaccinated on arrival (d 0) or received a delayed vaccination (d 14). Average daily gains were significantly greater from d 0 to d 14 throughout the entire 42 d receiving period for calves receiving the delayed vaccination. Seroconversion of IBR titers were also significantly higher in delayed vaccination calves. However it is important to consider that morbidity rates were high 71.5% and 63.5% for on arrival and delayed vaccination calves respectively (Richeson et al., 2008). In a later study, Richeson et al., (2009) evaluated the effect of delaying respiratory and clostridial vaccination on d-0 (on arrival) vs. d-14 (delayed) on health and performance, and serum antibody titers for (BVDV). Stress associated with management and shipment can cause immunosuppression, so that a vaccination given during this time may result in a reduction of vaccine efficacy and calf growth. Although this particular study involved cattle being received to the feedlot it could be compared to the protocol of vaccinating at weaning and administering a booster vaccine 14-28 d later. Overall there were no differences due to timing of vaccination on ADG or health in newly received calves. However, antibody titer to BVDV type I developed earlier when cattle were administered respiratory vaccine on d-0 vs. d- 14 (Richeson et al., 2009). However, the results by Richeson et al. (2009) are contrary to the earlier results by Richeson et al. (2008) which noted that daily gains were greater over a 56 d period in calves which received delayed BVD MLV vaccine treatment compared to those that received vaccination on arrival as well as greater serum IBR titer when MLV was delayed (Richeson et al., 2008).

Overall the results of these studies have been variable, but they do indicate that vaccination timing based on the protocol used may be important to consider along with convenience and implementation of management strategies. There could be different effects on immunity based on timing of vaccination used in the defined and commonly accepted protocols but no clear conclusions can be drawn.

Effects of Preconditioning on Health and Performance

Preconditioning trials. The overall effect of preconditioning on health and performance both on ranch and in the feedlot has been evaluated numerous times, often with conflicting results. Prichard and Mendez (1990) evaluated effects of preconditioning on pre- and post- shipment performance of feeder calves. In two experiments involving several ranches, calves were weaned and preconditioned (**PC**) on ranch with ad libitum access to a pelleted diet and grass hay. Non-preconditioned (**NC**) calves remained with their dams. Overall, preconditioning had no effect on health or performance in the feedlot. No carcass effects resulting from preconditioning management, diet, or days on feed were observed. Preconditioning had no overall effect on shrink. Preconditioned calves had reduced shrink compared to NC calves in yr 1, but higher shrink in yr 2. These differences indicate that possibly ranch handling of the calves may affect transit shrink more than preconditioning. Preconditioning also did not increase ranch gains in all situations and a significant preconditioning management by year interaction indicates the variability of this practice (Prichard and Mendez, 1990).

Pate and Crockett (1978) evaluated the effect of on ranch preconditioning. Calves were either shipped to the feedlot at weaning or preconditioned on ranch for 21 to 27 d. During the first few days after weaning calves lost 4.5-9.0 kg and it required 7 to 14 d to regain this loss. Mortality during the preconditioning period was, 1% for the 3 on-ranch preconditioning trials, indicating an added risk to cow-calf producers. Initial weight loss at weaning, and time required to recover weight or gain additional BW may be a critical factor involving preconditioning. Several recommended protocols (give citations that reference these recommendations here) utilize separation of weaning and transport by 30-45 d, but due to expected initial weight loss, this duration may not allow for sufficient additional weight gain and value accumulation to offset the costs of this practice. Pate and Crockett (1978) indicated that preconditioning resulted in greater shrink 11 vs. 8.5% after transit to the feedlot. During the subsequent feedlot period preconditioning resulted in a 6% and 11% higher rate of gain in two trials with no differences in feed efficiency Health status measured by the number of calves treated was significantly different, 15.0 vs. 30.7% for preconditioned and non-preconditioned calves respectively. Death loss for preconditioned calves across 2 trials during the feeding trial was 0 vs. 2.3% for non preconditioned calves.

Roeber et al. (2001) evaluated the effects of source of feeder steer calves on feedlot morbidity, mortality, and carcass attributes. Feeder steers from three different sources were evaluated. Two groups of steers originated from two different certified value-added calf programs, while the other group was of unknown origin originating from an auction market (**AM**). The certified value-added calf programs included the Certified Preconditioned for Health (**CPH**) and Gold Tag Program (**GT**). Differences in the CPH and GT programs included requirements for CPH calves to be bunk and water trough broke, de-wormed a max of 50 d with a pasturella vaccine booster optional. Other vaccine requirements included IBR, PI3, BVD, BRSV, and *H. somnus* vaccines administered 14-90 d presale. Gold tag calves were not required to be bunk or water trough broke, but did require a Pasturella vaccine and all other vaccines except BVD to be administered 21 to 60 d prior to sale. Morbidity was defined as hospital visits and was lower for the 2 preconditioned groups (34.7 CPH and 36.7% GT) compared to the AM calves (77.3 %). Mortality rates were 1.1% for both CPH and GT calves vs. 11.4% for AM calves. However, it may be important to note that the mortality rate in this study was high. Kelly and Janzen (1986) reported that mortality rates of feedlot cattle can range from 0-15%, but most often averages 1-5 %. Average daily gain during the first 67 d in the feedlot was highest for CPH calves 1.82 kg/d, but GT and AM calves were not different 1.63 and 1.67 kg/d, respectively. This difference may be partially explained by the fact that CPH calves were required to be accustomed to a bunk as part of the certified programs and the other treatments were not. Overall ADG in the feedlot was highest for AM cattle; however there were no significant differences in live weight of the cattle at time of harvest (Roeber et al., 2001).

To determine the effects of vaccination and preconditioning of cattle sold through special auctions versus conventional auction on performance and health in the first 28 d in the feedlot, Macartney et al., (2003) collected data on 211 lots bought by 112 individual owners. Calves were tracked from the auction to their respective destination feedlots and followed for the first 28 d after entering the feedlot. Analysis indicated that sale type was significantly associated with the incidence of BRD. Calves that receive only vaccination were 0.68 times as likely to be treated for BRD as the control groups and conditioned calves were 0.22 times as likely to be treated. Although some variation in receiving practices likely occurred in this study because cattle were fed at various feedlots, it is a good indicator of what is actually occurring in the industry.

Seeger et al., (2008) conducted an experiment in a commercial feedlot comparing health and performance of newly weaned calves of unknown origin compared to calves administered a health program. Calves of known origin were either enrolled in Pfizer Animal Health's Wean Vac program (**WV**) or in another 45 d weaning health program in which calves were marketed as weaned and vaccinated, but little documentation was available (**UWV**). Overall, mortality rates were low for all groups (0.84 %) and were similar among treatment groups. Steers of unknown origin had higher morbidity, lower ADG, and feed intake early in the feeding phase. During the first 28-d in the feedlot morbidity rates were 32.77, 6.85, and 6.9% for steers of unknown origin and WV and

UWV respectively. Morbidity rates during the first 85- d on feed were 41.43, 13.64, and 14.04% for steers of unknown health and WC and UWV protocols respectively. Steers of unknown health were more likely to receive treatments for respiratory disease during the entire feeding period. No effect on ADG was observed across treatments in steers that had no clinical sign of disease. Feed efficiency was not affected by treatment, but steers of unknown health required an additional 16-d on feed to reach the desired back fat thickness (Seeger et al., 2008).

Boyles et al. (2007) studied the effects of weaning management strategies on performance and health during a 28-d feedlot receiving period. Steers in the study remained on ranch and the weaning management employed included truck weaned (shipped on weaning) (**TRK)**, drylot weaned calves (separate from their dams and held 30 d) (**DL**), and calves weaned on pasture for 30 d with fence line contact to their dams (**PAST**). PAST and DL calves received a corn based supplement, and DL calves were also provided ad libitum access to round baled orchardgrass hay (10.3% CP and 67% NDF).. Both PAST and DL steers were vaccinated according to the requirements of the Five State Beef Initiative. All calves were vaccinated against IBR, BVD, PI3, BRSV, *Leptospira servars*, and administered a 7 way clostridial 30 d before weaning. Calves in the TRK treatment received a killed vaccine booster, and were vaccinated against Pasturella. Calves in the DL and PAST treatment received a MLV booster before trucking. Morbidity for pasture weaned calves was 15%, 28% for truck weaned, and 38% for drylot calves, but drylot and truck weaned calves were not significantly different. On the day of trucking all calves were weighed and shipped to a feedyard, where upon their arrival were a weighed. There was no significant difference in weight between treatments prior to shipment. Shrink averaged 3.2% across treatments. Steers were assigned to feedlot pens based on location of origin and treatment. During the 28-d receiving period ADG was greater (1.4 and 1.3 kg) for truck weaned and pasture steers vs. 0.9 kg for the drylot steers. Throughout a 4 wk receiving period DMI was greater for pasture and drylot steers; G:F was highest for truck weaned steers, intermediate for pasture steers and lowest for drylot steers. The lower than anticipated preconditioning gains in this study indicate that preconditioning programs may not produce sufficient additional weight gain to offset the cost of the preconditioning (Boyles et al., 2007). It may also be important to consider length of the preconditioning period and estimated ADG when considering additional weight gains among the treatments. The lower incidence of morbidity for pasture steers indicates that providing newly weaned calves pasture and fence line contact to their dams may be a superior alternative to drylot preconditioning methods with complete segregation of cows and calves.

Step et al. (2008) studied the health and performance of ranch calves from different preconditioning strategies during a 42-d receiving period when commingled with calves of unknown health histories from multiple sources. Treatments in this study consisted of single-source ranch calves that were either weaned on–ranch without receiving any vaccinations and held for 45 d then shipped (**W45**), weaned on ranch, vaccinated, and held for 45 d (**WVAC45)**, weaned and immediately shipped (**W**), and multisource steers which were purchased through auction markets (**MKT)**. During the 42-d receiving period ADG was similar between treatments. Intake was lower in W steers compared to W45 and WVAC45 treatments. Differences in DMI suggest that previously weaned calves are less influenced by transport and other stressors during shipment to the feed yard. Gain efficiency was not affected by treatment over the entire feeding period. Morbidity rates were 41.9% for MARKET, 35.1% for WEAN, 5.9% for WEAN45, and 9.5% for WEANVAC 45. Morbidity rates for MARKET and WEAN groups were not different, nor were morbidity rates for WEAN 45 and WEANVAC 45 treatments. Morbidity rates from the ranch WEAN 45 and WEANVAC 45 groups indicate that for one source calves, allowing time to recover from weaning before shipping may be of greater importance than vaccination alone. Calves from the market treatments were also pulled and treated earlier after arrival that calves from ranch-based treatments.

Cole (1985) summarized effects of preconditioning for both on-farm and feedlot performance, and observed that calves in a preconditioning program would require 12-d to recover their initial weight loss after weaning. This is similar to the findings of Pate and Crockett (1978). Cole (1985) also indicated that shrink was similar between preconditioned and un-weaned control calves when subjected to the same marketing channels. During the first 30 to 45 d in the feedlot preconditioned calves consumed more feed and had higher ADG but no differences in ADG were detectable after 100 d on feed. Preconditioning decreased feedlot morbidity from 26 to 20% and mortality from 1.4 to 0.74%.

Based on the research reviewed, preconditioning reduced the incidence of feedlot morbidity on average 22.8 percentage units and mortality 4.1 percentage units. However, it is important to consider that many differences exist between the studies evaluated such as genetics of the calves preconditioning systems employed. When comparing the effects of preconditioning, especially in single source ranch calves, it is also important to consider marketing and transit procedures and how stress during this time impacts morbidity and mortality. This could explain the differences between the findings of Pritchard and Mendez (1990) and Pate and Crockett (1978), on the effects of preconditioning one source ranch calves. Effects on shrink are likely to be variable based upon differences in weighing conditions across studies and because shrink varies with type of diet and level of forage (Owens et al., 1993). Other considerations also involve preconditioning weight gain compared to leaving calves on their dams. Environmental conditions such as available forage and factors such as dam milking ability should be considered in interpreting the results for studies using these comparisons. Overall, preconditioning likely can have some effect on ADG and DMI during the receiving phase at the feedlot, but this likely diminishes later in the feeding period.

Effects of Preconditioning Methods

Pasture methods. Preconditioning methods can vary widely based upon resources available to producers. Preconditioning often occurs in a drylot setting; feeding a TMR or allowing free choice access to hay while feeding a concentrate diet. Producers may also utilize pasture forage resources along with some type of supplemental feeding program. Research has been conducted comparing the effects of different preconditioning strategies on overall health and performance both on the ranch and in the feedlot.

As previously reviewed, Boyles et al. (2007) determined that calves weaned, placed on pasture with supplementation, and with fence line contact to their dams the first 7-d after weaning exhibited lower morbidity rates in the feedlot compared to drylot preconditioned calves fed the same concentrate ration. Price et al. (2003) also found that providing fence line contact between calves and their dams after weaning on pasture reduced behavioral indices of distress compared to totally separated calves. Fence line contact at weaning minimized weight loss following weaning compared to calves weaned on pasture without fence line contact with their dams, or weaned in a drylot with or without hay. Pasture weaned calves with fence line contact to their dams gained 95% more weight, 21.4 vs. 11.0 kg, respectively than calves in other weaning protocols. The difference in weight gain during the weaning phase was also reflected in BW gain over a 10 wk period following weaning (Price et al., 2003). Based upon the results of Price et al. (2003) and Boyles et al. (2007), utilizing preconditioning programs on pasture with fence line contact between calves and their dams may provide a way to help reduce behavioral distress at weaning This method could be considered in helping reduce the initial weight loss at weaning and increase ADG especially early in the preconditioning period.

Mathis et al. (2008) compared low-input pasture to high-input drylot preconditioning on performance and profitability through harvest. Drylot calves were fed corn-wheat middling pellets plus alfalfa hay; pasture calves were supplemented with

32% CP range cubes at a rate of 0.57 kg/d prorated to 3 times/wk delivery. During the 42 d trial pasture calves gained more wt (1.27 vs. 1.08 kg) from initiation to the interim BW (d 0-21), but drylot calves gained more BW over the entire preconditioning period (d 0-42) (28 vs. 22 kg). In the feedlot, morbidity rates were 47.6% for drylot steers and 34.3 % for pasture calves, but they were not significantly different. However, death loss was significantly higher for drylot (7.6%) compared to pasture (0 %). This death loss occurred between 28 and 128 days on feed, and the authors concluded that drylot steers may have experienced additional stress during the backgrounding phase compared to pasture steers. Overall, there were no differences in interim (d 0-21) BW, ADG, estimated final BW, DOF, YG, or quality grade based on treatments (Mathis et al., 2008). Mathis et al. (2009) in a follow up study compared the same low-input pasture preconditioning system to a higher input pasture system which allowed ad libitum access to self-fed corn-wheat middling based pellets. High input steers gained more weight and were heavier at the end of the preconditioning period. During finishing there were no differences in ADG, final BW, or carcass value due to treatment. Morbidity was greater for low input steers, 24.7% low input vs. 7.9% for high input steers. Also, a numerically higher death loss was observed for low input pasture steers 4.4% vs. high input pasture steers 1.6% (Mathis et al., 2009). Based upon the results of Mathis et al. (2009), preconditioning which provides a higher plane of nutrition to steers in a pasture environment may better prepare calves for the immune challenges associated with transport and commingling.

Data exists both disputing and supporting the claims of preconditioning as an effective management practice to reduce morbidity and mortality in the feedlot. It is likely that preconditioning has the potential to be an effective management practice in some management scenarios. Different methods of preconditioning exist which often utilize available feed resources. Pasture methods which can often provide the most similar environment to that of the calf before weaning may be an effective method to reduce potential stress compared to that drylot preconditioning programs in which mud, dust, social disruption, and close proximity of the animal may be potential stressors. However, many factors should be considered such as differences in diet, rate of gain, and overall management procedures

Effects of BRD

Feedlot and carcass aspects. Preconditioning and other management practices are primarily designed to reduce the incidence of morbidity and mortality associated with BRD in the feedlot. Respiratory disease in newly weaned/ received cattle continues to be one of the most significant problems facing the beef industry (Duff and Galyean, 2007). Gardner et al. (1999) found that steers treated for BRD in the feedlot had lower final live weights, ADG, hot carcass weights, less external and internal fat, and more desirable yield grades. A higher percentage of carcass yielded standard than steers not receiving treatment. Larson (2005) identified negative effects of disease on carcass traits, including carcass weight, logissimus muscle area, and marbling. Montgomery et al. (2009) found that heifers treated for BRD during an initial 36 d receiving period had decreased ADG during the finishing period. Hot carcass weights, fat thickness, and LM area were decreased linearly and marbling scores decreased quadratically with the number of BRD treatments. Roeber and Umberger (2002) found that cattle visiting the hospital two or more times had 12% lower ADG in the feedlot and that the number of hospital visits also affected hot carcass weight, dressing percentage, and yield grade. Waggoner et al. (2007) found that steers not treated for respiratory disease had greater ADG and required fewer days on feed than treated steers. Steers treated only once during the feeding period also tended to require fewer days on feed than steers treated twice when fed to a common compositional endpoint Morbidity in the finishing phase negatively impacted ADG, cost of production, and unit carcass price, and reduced net return per steer (Waggoner et al., 2007). In general BRD has negative impact on production and carcass traits and thus can result in decreased profitability.

*Economic considerations***.** The overall estimated cost of BRD to the industry includes the cost of prevention, treatment, morbidity and mortality rates, feed costs, loss of performance, sale price, and carcass grid premiums and discounts (Speer et al., 2001). Of all these costs the most noticeable and easiest to measure are medicine and death loss. Costs associated with respiratory disease therapy can vary widely and range from $0.30 to greater than $3.00/45.4 kg depending upon the antimicrobial regime (Apley, 2006). The Texas A&M Ranch to Rail program reported that medical expenses associated with morbid calves ranged from $20.76 to $37.90 per animal from 1992-2000 (Smith, 2000). Research has also shown differences in treatment costs based upon source of calves. Seeger et al (2008) reported that treatment costs were $7/animal higher for unknown health history calves compared to that of calves that went through some type of weaning protocol. The cost of cattle sold as realizers (railed cattle; railers) due to chronic disease and poor performance can often approach $240-307/ animal (Seeger et al., 2008). The incidence of railed cattle often approaches that of death loss during fall feedlot placements and thus can result in significant losses (Smith, 2000).

Although some losses associated with respiratory illness in the feedlot are quite obvious, other losses are not quite as apparent and can often be overlooked. Losses in performance and decreased carcass quality are very important, especially with value-based or grid marketing. Seeger et al. (2008) found that unknown health history calves were less profitable than calves originating from known health protocols. Calves of unknown health history were purchased at a lower cost, ($26.60 per animal) than those of known origin. Unknown calves resulted in $15.80 profit vs. $27.16, and $49.51/ animal profit for calves originating from known health protocols. This analysis also did not include the costs associated with labor and management involved with pulling and treating sick calves, indicating a greater economic advantage of calves with known origin.

Data from the Texas A&M Ranch to Rail program indicated that cattle treated for respiratory disease gained less, were less efficient, and had reduced carcass quality grades compared to those never requiring a treatment. In that program, morbid cattle gained 3% less than healthy cattle and had 18% higher total cost of gain. Morbid cattle also received a 4% discount based on quality grade. The total cost of morbid cattle in the Texas Ranch to Rail program ranged between $49.55-123.86 per morbid animal (Griffin et al., 1995; Smith, 2000). Van Donkersgoed et al. (1993) found that calves which were never treated for BRD gained 1.25 kg/d, while calves treated once gained 1.0 kg/d and those treated twice or more gained 0.7 kg/d. Morck et al. (1993), indicated calves treated once for BRD gained 0.18 kg/d less and those treated 2 or more times gained 0.33 kg/d less than cattle never treated for BRD. Morbidity reduces ADG in feedlot calves, and these differences can persist throughout the finishing period although differences in ADG tend to narrow as days on feed increase (Smith, 2000).

Economic Considerations for Cattle Feeders

Benefits of preconditioning. With increasing costs of production and trends for value based grid marketing it will be likely considerably more important to consider the costs of BRD in the feedlot. Based upon the research regarding performance, carcass traits, and economic aspects it will be important to identify preconditioning programs which add the most value.

Avent et al. (2004) surveyed a group of TCFA feed yard managers and these managers estimated that preconditioned calves had reduced morbidity and mortality, increased ADG, GF, higher percentage choice and fewer discounted or non-conforming carcasses. Dhuyvetter et al. (2005) also reported from a survey of feedlot operators, that preconditioned calves were expected to have 27.2% lower morbidity and 2.7 % mortality. Dhuyvetter et al. (2005) estimated feedlots could expect anywhere from a \$40-60/animal return in preconditioned calves compared to non-preconditioned calves. This would equate to a \$0.154 to \$0.243/kg advantage, indicating a potential for price premiums. However, premiums often do not reach these levels. The true value of preconditioning premiums that is what a feedlot is willing to pay will include the cost of potential risk involved.

Economic Aspects for Cow-calf Producers

Costs and economic viability. Regardless of the potential benefits that might accrue to the practice, preconditioning must be profitable in order for producers to implement this management strategy. When cow-calf producers decide to adopt a preconditioning program it is important to realize that it will require an investment of time and money. Producers will have to spend money vaccinating the calves, it may require added labor, and of course there will be a cost for feed. Preconditioning can require producers to take on more risk, such as volatility in market price and risks of death loss. An example of this added risk is that of Pate and Crockett (1978) in which a 1% death loss occurred during the preconditioning phase. Cow calf producers should consider if the added costs will yield a price premium sufficient to make this practice profitable. There has been much debate over the economic viability of preconditioning and some studies have reported conflicting results.

Pate and Crockett (1978), indicated that preconditioning was found to improve performance and reduce morbidity which resulted in a savings in feedlot finishing costs of $26.81 per animal, but there was a preconditioning expense of $27.94, resulting in a net system performance loss of $1.13 per animal. When combined with a greater transit weight loss in preconditioned calves of $10.40, total losses were $11.53. In a similar study by Cole (1985), the cost of preconditioning was $38.76 per animal and this would require a $0.213/ kg premium to be paid by the feeder to breakeven. These authors reported that 50% of the costs of preconditioning were attributed to feed costs and an additional 20% were attributed to labor. Preconditioning may not be feasible for all producers or feeders because of higher costs imposed upon both. An economic analysis by Peterson et al. (1989) reported similar results, noting that because of the costs of preconditioning, price premiums high enough fort cow-calf producers to participate were too high to be profitable for cattle feeders. The breakeven premium required by cow-calf producers exceeded the breakeven purchase price of feeders by 0.11 $/kg.

Although several studies suggest that preconditioning may not be economically viable, data indicates that it can be economically viable. Pate and Crockett (1978), Cole (1985), and Peterson et al. (1989) are all dated studies in relation to economic aspects and changes in both market environment and input costs may have altered these relationships.

Nutritional input costs often make up the largest costs to preconditioning. Improving efficiency in resource utilization is important for profitability and thus sustainability of the preconditioning for cow-calf producers. Mathis et al. (2008) indicated that drylot preconditioned calves fed an ad libitum milled diet with hay had a fourfold greater feed and total cost than calves preconditioned on pasture receiving supplementation. Total feed costs for drylot steers was $66.77/ steer compared to $14.01 per steer for pasture preconditioned steers. Net income was $45 greater for pasture steers. Net income was $15.72/steer for pasture steers, while drylot steers lost $28.87/steer. Mathis et al., (2009) determined steers with ad libitum access to a milled diet on pasture had a 42 $/head greater feed cost than steers receiving only a pelleted supplement on pasture. Total costs for the low-input system was $19.66 compared to the high-input $102.80. The low- input system resulted in a net income advantage of $20.54/animal. However, comparing sale at weaning vs. after preconditioning for 49-d both systems resulted in a net loss, ($66.38) low-input and ($89.92) for the high input. This loss can be attributed to seasonal price decline and insufficient performance.

St. Louis et al. (2003) compared two drylot preconditioning systems and pasture based system to evaluate the costs of preconditioning calves. Calves preconditioned for 28 d on rye grass pasture had greater ADG than cattle receiving either of two drylot diets. Cost of feed was 11.00 $/calf for calves in the ryegrass system, $26.94, and 14.70/calf for the two drylot groups. Total cost of processing, including a metaphylaxis treatment for all groups was $17.92/hd. Ryegrass calves had the highest net return from preconditioning, $46.38/calf for ryegrass, $3.21/calf drylot, and $18.25/calf for drylot (St. Louis et al. 2003). In this study, drylot groups were limit fed and not allowed ad libitum access to the milled diet, which would have likely increased feed costs. Cattle in this study also were of mixed origin from several auction markets, not single source calves.

Because of the many costs and variables associated with preconditioning, Dhuyvetter (2003) recommends that cow-calf producers create budgets for particular preconditioning situations, including initial weaning value, production aspects such as ADG, death loss costs, and selling price. Feed costs can make up the largest expense in a preconditioning program and Davis (2007) suggests that producers often underestimate feed requirements when budgeting preconditioning programs. Davis (2007) estimates feed intake of 3 to 3.5 % of BW would be a reasonable estimator for calculating feed costs. Dhuyvetter et al., (2005) estimated costs for a 45-d preconditioning program to fall in-between $40-60 per animal, while St. Louis et al. (2003) reported that feed costs alone could exceed $40 per animal. Dhuyvetter, (2003) also estimated mortality rates of single-source weaned calves in a preconditioning program to be 0.25%. In Oklahoma over 10 yr, Johnson (2008) indicated average preconditioning costs were $49.94/animal, of which feed, hay, and pasture costs were estimated to be $27.56/animal. Cost will ultimately vary across regions and nutritional resources. Animal performance during the preconditioning period will be critical to the profitability of preconditioning programs. However, costs which are not as obvious such as facilities (fences and pens), additional equipment, opportunity costs of forage, and interest need to be considered (Johnson, 2008).

Donnel and Ward (2008) determined the key factors influencing preconditioning costs and returns and formulated a model for preconditioning. An average total cost of $53.40 was predicted by their model, and ADG had a significant impact on net margins. The results indicated that margins were -$48.61/animal when all other cost characteristics were at their calculated average. The model also indicated that if ADG was increased by 0.2 kg, one could expect a possible contribution of $7.60 to net margins. For every $ 1.00 increase in feed and mineral costs there was an estimated $1.77/animal decline in net returns. Overall analysis indicated that of all preconditioning costs, ADG, nutritional inputs, vaccination, and death loss were significant influences on net returns in preconditioning programs. (Donnel and Ward, 2008).

Price premiums. Preconditioned calves are expected to receive premiums due to the added value of reduced incidence of morbidity in the feedlot. Price premiums can vary across the industry, time of year, location, and weight of the cattle. Dhuyvetter et al. (2005) reported that feeders are willing to pay $0.044 to $ 0.110/ kg premiums for preconditioned calves. Premiums were found to be higher in the fall and lower when calves are sold in the winter, when cattle are heavier, and when cattle markets are strong. Preconditioning programs 45-d or more increase potential net returns to cow-calf producers by $14.00/animal (Dhuyvetter et al., 2005). However, premiums may often be insufficient to cover preconditioning costs (Avent et al, 2004). Preconditioning programs often increase weight, and as feeder cattle weight increases, unit prices decline (Dhuyvetter et al., 2005). Buyers discount cattle with greater body condition $0.60/45.4 kg on average (Avent et al., 2004; Dhuyvetter et al., 2005). Avent et al. (2004) surveyed a group of TCFA feed yard managers and these managers estimated that preconditioned calves are worth $5.25/45.4 kg on average more than non preconditioned calves. These authors also indicated that pooling calves and having truckload sized lots of cattle increased price received for preconditioned calves and that selling preconditioned calves through normal outlets (auction markets) did not increase price. Premiums for cattle in a typical VAC-45 program averaged $3.30/45.4 kg (Avent et al., 2004). Donnel and Ward (2008) determined that on average a $2.49/45.4 kg price premium existed for preconditioned calves and as the level of management integrity increased (records, documentation) the price premium increased to $4.36/45.4 kg. King et al, (2006), determined that preconditioned cattle marketed through six videotape auctions conducted by a livestock auction service had a significantly higher sale price compared to calves that were not in a certified health program. From 1995 through 2004 price premiums for preconditioned calves ranged from \$2.47 to \$7.91/45.4 kg, showing a substantial increase over the years. Similar to other research King et al. (2006) also found that premiums were higher for larger lot sizes. Interestingly, Dhuyvetter (2005) reported that as feeder cattle prices increased, price premiums decreased, which is somewhat unexpected since preconditioning programs should be valued the most when feeder cattle prices are high since there is more economic incentive to minimize death loss. Overall, price premiums have been shown to be variable and are often subject to many factors.

Forage and Response to Supplementation

Considerations regarding available forage. Animal performance is directly related to quality and quantity of forage available (Guerrero et al., 1984). Quantity of forage alone can have a limited value in estimating intake. Forage allowance is a more useful tool when evaluating how availability affects intake and performance (Lyons et al., 1995). One important consideration is that as digestibility of available forage decreases, more available forage is required to maximize animal performance. Thus, change in BW gain is relatively larger at lower forage availability than at higher forage availability (Guerreo et al., 1984).

Sollenberger et al. (2005) determined that when trying to predict animal performance both stocking rate and sward characteristics should be considered. Similar to that of Guerrero et al. (1984), Sollenberger et al. (2005) found that the relationship between ADG and forage allowance is linear up to a high allowance after which added gain levels off. Another consideration involves calculating and reporting forage allowance. The assumption of constant rate of decline in forage mass is often incorrect because canopy characteristics change over time leading to progressively lower intake throughout a grazing period (Sollenberger et al., 2005). Intake is often greater in the first days of grazing period and declines as forage nutritive value and mass declines (Sollenberger et al., 2005).

Wilkinson et al. (1970) determined that in bermudagrass forage crude protein concentration and digestibility declines with increased defoliation. Declining quality is often attributed to reduced leaf to stem ratio in the lower vertical profile of bermudagrass. This same relationship is likely to occur in other types of forages. Thus, ADG may be limited by DM digestibility (forage quality) when forage quantity appears to be adequate. Duble et al. (1971) studied the forage characteristics limiting animal performance on warm-season grass. They reported that ADG increases as available forage increases to a point where ADG shows no further increase. They indicated that ADG was maximized for 60% digestible forage with 500 kg forage/ha, 1000 kg forage/ha for a 50-60% digestibility, and 1250 kg forage/ha for forage that was less than 50% digestible. Above these levels of forage availability, quality largely drove animal performance; however, below these levels forage quantity was more important (Duble et al., 1971). According to the NRC (2000), forage standing crop levels above 2250 to 3000 kg/ha do not limit intake for most livestock. As standing crop levels decline from 2250 to 1000 kg/ha, a 15% decline in forage intake occurs, followed by a rapid decline when forage supplies drop below 1000 kg/ha (NRC, 2000). Thus comparing this on a basis of live BW, intake is not expected to increase above a forage allowance of 0.20 kg forage/kg BW. However, from 0.20 to 0.04 kg forage/kg BW a 15% decline is expected and below 0.04 kg forage/kg BW, a steep decline is expected (Lyons et al., 1995). Minson (1990) reported similar findings in that the intake of beef calves is depressed approximately 18% when forage allowance is reduced from 90 to 30 g DM/kg live weight, which is associated with a decline in forage height and OM digestibility. Minson (1990) also reported that the affects of forage allowance on intake is similar for steers 5 to 6 and 15 to 16 months of age. Generally, maximum ADG is achieved at forage allowances approximately 25% BW per animal per day.

Forage quality. Often forage can be stockpiled for utilization late into the grazing season and dormant season. Bermudagrass has a potential for use in stockpiling and fall and winter feeding programs. Fall bermudagrass accumulation is sensitive to many variables such as variety, climate, fertilization, and duration of the stocking period (Lalman et al., 2000). As plants mature nutrient values, CP and DM digestibility decline (Lalman et al., 2000). Holt and Conrad (1986) showed that in vitro dry matter digestibility (**IVDMD**) declines about 2g/kg with each advancing day of age. Lalman et al. (2000) noted that stage of maturity at the onset of dormancy is an important factor determining nutritive value in forage accumulated over time. Forage accumulated over a shorter time would have a higher nutritive value than that of forage accumulated over longer periods. Hart et al. (1969) studied the nutritive content of standing coastal bermudagrass during late autumn and winter. Dry matter digestibility (**DMD**) declined from November through February. The authors also noted that DMD decreased faster in warm, wet weather and the effect of weather was greater on younger, more digestible material. Scarborough et al. (2002) measured the DM yield, CP, and fiber constituents of bermudagrass from October to January. Neutral detergent fiber and ADF increased slightly and lignin increased significantly. Overall the ruminal availability of CP in stockpiled bermudagrass decreases as the forage ages. Evers et al. (2004) indicated that CP decreased with time, but the rate of decline was related to initial CP concentration and forage maturity at first frost. Acid detergent fiber also increased significantly after first frost. Hart et al (1969) indicated heifers weighing 320 kg gained 225 g/d on forage cut in October (8.6% CP and 54% TDN), but lost 50 g/d on forage cut in December (6.8% CP and 54% TDN). McCullough and Burton (1962) reported that dairy heifers weighing 170 kg consuming coastal hay containing 6.3% CP and 49% DMD gained 400 g/d on the coastal hay but did not gain on hay containing 5.3% CP and 45% DMD. Coblentz et al. (1999) reported that TDN of stockpiled bermudagrass declined from 63% in October to 57% in January. In contrast, CP concentration is often not significantly reduced, but protein degradability declines (Coblentz et al., 1999; Scarborough et al., 2002). Based upon the data from these studies and that of Hart et al. (1969) animals may select the best-quality forage and make small gains, but over time would likely lose weight without some form of supplementation. Environmental conditions such as precipitation and frost will accelerate the reduction in further quality and further reduce gains.

Supplementation considerations. Supplemental feeding is often utilized for grazing cattle to correct nutrient deficiencies, conserve or improve forage utilization, and improve animal performance in order to attempt to increase economic returns (Kunkle et al., 1999). When utilizing pasture, stockpiled forages can be utilized for fall and winter grazing, but with increased maturity and declining quality it is difficult to meet the requirements of growing cattle. Forage CP levels below 6 to 8% generally result in decreased forage intake, which is related to decreased ruminal microbial activity which reduces digestion (Lyons et al., 1995). When considering performance and growth of calves for example, a 250 kg steer would require a diet containing 8.9% CP in order to gain 0.70 kg/g.

Supplemental strategies can vary based on objectives. Providing supplemental protein to cattle consuming low quality forage (less than 7%) can improve forage utilization and performance (McCollumn and Horn, 1990). Intake and digestion of low-quality forages usually increase when supplemental degradable protein is fed (Olson et al., 1999). When cattle fed forages below the 7% CP level response to protein supplementation has been variable, and this variability could be due to animal, forage, and or supplement characteristics (Mathis et al., 2000).

DelCurto et al. (1990) indicated that feeding moderate levels of protein (26%) at 0.5% of BW increased intake and digestibility of low quality forage. Gadberry et al. (2009) supplemented steers grazing bermudagrass pasture during summer with cottonseed cake at 0, 0.3, or 0.6% BW and indicated that incremental gain at the 0.3% BW level was greater (0.2 kg/d) that that of the 0.6 % BW treatment. Similarly, Grigsby et al. (1989) indicated that cottonseed meal based supplements fed at 0.26% BW resulted in 0.22 kg/d gain above that of the non-supplemented calves and resulted in a feed conversion of 4:1. Bement (1970) indicated that steers grazing native shortgrass range in the fall when supplemented with cottonseed cake at 1.1 kg/d resulted in a 0.3 kg/d gain advantage. Woods et al. (2004) studied the effects of the level of protein supplementation on the performance of calves grazing Tifton 85 bermudagrass. Steers received 0, 0.2, 0.4, or 0.8% BW of a 2:1 SBM: corn supplement. Steers receiving the 0.8% BW treatment gained the most weight, 37 kg more than that of non-supplemented steers gain.

Starch based energy supplementation to cattle grazing low quality forage can result in negative associative effects often resulting in reduced forage intake and digestibility (Chase and Hibberd, 1987; Pordomingo et al., 1991). However, concentrate feeds have been fed from 0.25 to 0.5% of BW without causing large decreases in forage intake and digestibility (Canton and Dhuyvetter, 1997; Kunkle et al., 1999). Chase and Hibberd (1987) found that small quantities of grain (< 1kg/d) may not decrease forage utilization to the same extent as larger quantities do, but overall fiber digestibility decreased as the amount of corn increased. There was no significant effect of frequency of supplementation, but a decrease in digestible OM intake occurred when the supplement was fed on alternate days.

Grain based supplements with intermediate ranging protein levels (20% CP) have been fed infrequently with no reduction in performance (Kunkle et al., 1999). DelCurto et al (1990) indicated that steers supplemented with moderate CP levels (26%) improved intake and utilization of dormant forage. However, Beaty et al. (1994) fed cows a corn or sorghum grain based supplement with 20% CP either daily or 3 times per wk for 111 d. A greater amount of weight loss and BCS was reported with less frequent supplementation. Chase and Hibberd (1987) also indicated that corn supplements formulated with inadequate levels of DIP depresses forage digestibility and intake to the extent that the energetic advantages for grain supplementation may not be realized. Bodine et al. (2000) and Bodine et al. (2001) indicated that when feeding concentrate and fiber based energy supplements an adequate DIP: TDN balance decreased the negative effects on forage utilization. Jones et al. (1988) studied the effects of corn supplementation on intake and digestibility of warm-season grass hay and indicated that small quantities of supplemental grain (0.3% BW) did not significantly affect intake and digestion of forage and should improve performance. Corn supplementation at 0.5% of BW resulted in lower intake of forage, but did not significantly affect total fiber digestion. Pordomingo et al. (1991) indicated that supplemental corn grain fed a 0.2% of BW to steers grazing summer native range had no detrimental effects on intake and actually increased intake and digestibility over the non-supplemented control. The authors attributed this to the possible increase in protein flow resulting in stimulation of microbial growth without depression of ruminal fiber digestion, but supplemental corn fed at 0.4 and 0.6% of BW decreased forage intake and thus supplementation at these levels maintained a digestible OM similar of that of un-supplemented steers. Aiken (2002) studied the weight gain and cost effectiveness of corn supplementation to steers grazing bermudagrass during summer. The level of supplementation that resulted in the most gain and thus economic benefit was when corn was fed at rates between 0.16 and 0.5% of BW kg per day.

Rates of starch degradation may exert significant effects on the response to supplemental starch. Galloway et al. (1993) fed ground corn, whole corn, barley, sorghum grain, and wheat at a rate of 1% of BW once daily to calves grazing bermudagrass pasture for 84-d. Gain was greater in steers fed grain that degrades in the rumen slowly (whole corn, ground corn, and sorghum) compared to that which degrades rapidly (barley and wheat), indicating that differences in ruminal conditions such as pH and starch availability effect forage intake and digestion. Total NDF digestion declined with grain supplementation, except for sorghum which is slowly fermented (Galloway et al., 1993). Beaty et al. (1994) reported that reducing starch concentration or increasing the amount of protein relative to starch in supplements can limit or potentially decrease the negative effects of starch on digestion of fiber in low-quality forages. Because energy supplementation, especially starch is associated with reduced intake and digestibility it is important to consider possible options for the type of supplement to be used. Supplements predominantly consisting of fibrous byproduct feeds which contain low levels of non-structural carbohydrates have been shown to have a less negative impact on forage intake and digestion (Kunkle et al., 1999). Garces-Yepez et al. (1997) studied the effects of supplemented energy source and amount on forage intake and performance. Steers were fed corn-soybean meal based supplement, wheat middling, or soybean hulls at low (0.5% BW) and high (1.0% BW) rates while fed bermudagrass hay. At low levels of supplementation ADG did not differ between supplements. However, at the high level of supplementation ADG was lower for steers fed the corn-soybean based supplement 0.76 kg/d vs. 0.90 and 0.95 kg for wheat-middlings and soybean hull supplements. These differences were attributed to changes in intake and modification of the ruminal environment by starch. Garces-Yepez et al. (1997) demonstrated that performance response depends on the level of supplementation. At less than 0.5% of BW supplements did not reduce forage intake or digestibility, but at or near 1.0% of BW cattle supplemented with SBH or WM diets had greater performance than cattle supplemented with corn. Many different feed products by- products/ exist and vary based upon region. Based upon research many of these types of feedstuffs may be a viable option to incorporate into a supplemental feeding program.

Utilization of dormant forage. Numerous research studies have been conducted involving the utilization of accumulated forages such as bermudagrass during the dormant phase (Johnson et al., 2000; 2002; Coffey et al., 2006). Lalman et al. (2000) studied the economics of stockpiled bermudagrass as a grazing system in cow-calf enterprises. Nitrogen fertilization and accumulation of forage resulted in reduced costs compared to that of hay feeding systems. However, the costs associated with stockpiling bermudagrass was found to be very sensitive to climatic conditions, forage utilization rate, and the costs of hay (Lalman et al., 2000). Coffey et al (2006) studied the effects of supplementation and forage source on the performance of steers during fall backgrounding. Steers were allotted to late summer fertilized bermudagrass pastures and received either no supplemental feeding or 1.8 kg of a 14% CP supplement per day, or bermudagrass hay in a drylot. Calves were backgrounded from September through

December. Protein content decreased over time as well as the amount of available forage. Forage CP content started at 13.6 % and declined to 9% at 0.5% of BW by early December. Forage ADF increased over time. For the first 28 d, steers receiving pasture gained more than those receiving hay, but performance in the subsequent three periods was similar. Steers that received supplemental feeding outperformed those receiving no supplementation. Each additional kg of gain required 5.4 kg of supplement. Supplementation had the greatest benefit as forage quality decreased. Supplemented steers had an ADG of 0.65 kg/d compared to 0.48 kg/d for non-supplemented cattle. Johnson et al. (2000) utilized several supplementation strategies involving cows grazing stockpiled bermudagrass. Treatments included a non supplemented control, soyhulls and SBM, corn and SBM, and corn and SBM formulated to provide 2 times as much DIP than the other groups. The supplements were fed at a rate of 0.9 (.17% BW) per steer fed 4 times/wk. Weight change and forage intake were unaffected by treatment although supplementation did improve BCS. Supplementation of DIP beyond that of the requirement did not improve performance or affect forage intake (Johnson et al., 2000). Wheeler et al. (2002) studied the effects of supplementation on the intake, digestion, and performance of cattle grazing stockpiled bermudagrass. Cattle were supplemented with 0.2, 0.4, or 0.6 g of protein per kg of BW. In a 2 yr grazing trial yr had a significant impact on cow BW and BCS change. In yr 1 cattle lost more BW and BCS than in yr 2. Non-supplemented cattle lost the most BW in both yr while supplemented cattle gained or maintained BW in yr 2. Although differences in forage composition did not explain the reduced performance in yr 1, the authors concluded that environmental factors may have influenced standing forage characteristics or cow requirements resulting in the differences between years. In addition to the grazing trial, Wheeler et al (2002) conducted a digestibility trial with crossbred steers utilizing the same level of protein supplementation as the grazing trial. Supplementation at all levels increased intake and apparent digestibility. This experiment demonstrates that supplements may not need to contain high concentration of protein to improve performance and utilization of fertilized, stockpiled bermudagrass for cows, but requirements for growing cattle and level of desired performance should be considered. (Wheeler et al, 2002). Martson et al. (1995) evaluated the effects of different post weaning nutritional regimes in heifers grazing native tallgrass forage compared to a limit fed concentrate diet in a drylot. Heifers were supplemented with either 0.9 kg/d SBM (40% CP 0.4% BW), 1.8 kg/d of a soyhull based supplement (20% CP 0.84 % BW) or 2.7 kg/d (1.25% BW) of the same 20% CP supplement. From November to February heifers receiving higher rate of the 20% CP supplement gained more weight 0.51 kg/d compared to that of the SBM and the lower amount of CP supplement which were similar (0.23 and 0.29 kg/d respectively).

Based upon available resources, the utilization of pasture (dormant and stockpiled forage) resources for calves after weaning during the fall is often a strategy adopted by some producers. However, it will be important to consider environmental and production factors which may affect animal performance such as stocking rate, forage nutrient composition and availability. Forage during this time will likely be inadequate for growing calves to make adequate weight gain without some type of supplemental feed to correct nutrient deficiencies. Many supplement strategies exist and it will be important to consider the effects of supplementation on overall forage utilization and enhancement to performance. Research suggests that supplements containing moderate to high CP levels and low amounts of NSC are viable strategies.

Summary and Conclusions

Preconditioning practices can vary widely in their procedures. Research has indicated that no one strict definition of preconditioning exists. Differences in procedures include duration, nutrition, and vaccination protocol utilized, which may explain why results have been variable. The common aspect of all preconditioning programs is vaccination for the bacterial and viral diseases often associated with the BRD complex. Theoretically, preconditioning should increase productivity and health by decreasing the impact of stress incurred during weaning, marketing, and transport and thereby enhancing immune function. Based on empirical results, on average, preconditioning enhances calf health during subsequent production by reducing morbidity on average 22.8 percentage units and calf mortality by 4.1 percentage units. Performance and efficiency during subsequent production between preconditioned and non-preconditioned calves are usually not different. Preconditioned calves often consume more feed and may have higher ADG during the initial receiving phase in the feedlot, but these differences diminish as days on feed increase. The advantages and differences from preconditioning come from improved health status. This is especially true involving carcass quality and yield. Differences exist due to incidence of morbidity, thus preconditioned calves can exhibit fewer days on feed and greater carcass merit, but little differences exist when fed to the same compositional endpoint. The most apparent benefits of preconditioning are realized during the feeding period in the form of lower costs for respiratory disease treatment and improved performance such as fewer days on feed. The economic feasibility of preconditioning is debatable. Research has reported mixed results on profitability for cow-calf producers. Variation is likely to exist due to differences in methods, costs, and availability of resources. However, it is likely that cow-calf producers cannot rely solely on expected price premiums, but will have to consider costs and potential value of gain when utilizing this management practice. The advantages of preconditioning are realized by the cattle feeder through improved health. The costs associated with the incidence of BRD can range anywhere from $20 to $150 per animal. Price premiums for preconditioned calves are often variable, but the fact that premiums exist and feeders are willing to pay them indicates that preconditioning is advantageous to the cattle feeder.

However, preconditioning strategy may cause variation in these responses. Intensive management may be less advantageous than extensive management especially involving health in the subsequent feedlot phase. However performance levels such as efficiency based upon the level of inputs need to be considered in order to maximize profitability potential. In conclusion, while preconditioning may achieve some goals, an ideal solution has not been identified. Key questions regarding diet and housing/intensity remain unanswered, especially involving differences in health. It would be beneficial to identify potential advantages and disadvantages which may exist between different preconditioning strategies so that have the greatest profitability potential for both cow-calf producers and feedlots can be realized.

CHAPTER II

EVALUATION OF THE EFFECTS OF THREE ON RANCH PRECONDITIONING METHODS ON ANIMAL PERFORMANCE AND PROFITABILITY TO COW-CALF PRODUCERS

Introduction

The management practice of preconditioning calves prior to their entry into the feedlot is often employed by cow-calf producers. Many types of methods exist which often utilize a wide array of nutritional resources and management procedures. Although research has been conducted evaluating the effects of preconditioning on health, performance, and profitability, less research has been conducted evaluating the possible differences between types of preconditioning management protocols with varying levels of nutritional and management intensity. Previous studies (Pate and Crockett, 1978; Pritchard and Mendez, 1990) were conducted to evaluate preconditioning as opposed to traditional weaning. It is likely that based on the broad range of differences throughout different regions of the country that no one single preconditioning program is likely to fit all types of production systems.

In order to be cost effective, producers who precondition their calves are challenged to conceptualize practical approaches involving preconditioning management. Several studies (Boyles et al., 2007; Mathis et al., 2008) have observed that calves receiving lower input preconditioning may be superior to those calves preconditioned in a drylot receiving a total mixed ration, in that morbidity and mortality was increased during the subsequent feeding phase with higher quality rations. Mathis et al. (2009) observed lower morbidity and mortality in calves that were preconditioned on pasture receiving a higher plane of nutrition, but neither of the methods evaluated were profitable. No clear conclusion can be drawn based on the limited research conducted and conflicting factors which exist (Boyles et al., 2007). Additional research is required to determine both the economic and production benefits of different types of preconditioning management systems. The objectives of this research were to evaluate the performance and profitability of single-source, ranch-raised calves subjected to three different preconditioning management protocols with varying levels of intensity to determine if breakevens may be substantially lowered by adequately managing and reducing input costs.

Materials and Methods

All animal care and use procedures described in this protocol were approved by the Texas A&M University Institutional Animal Care and Use Committee (AUP 2007-12).

Animals. Over 2 years, 345 steer calves (yr 1 n = 183: 253 ± 35 kg, yr 2 n = 162; 241 ± 36 kg initial BW) were used to evaluate 56-d, on-ranch preconditioning systems at the Texas AgriLife Research Center in McGregor, TX. Angus- and Charolais-sired calves out of spring-calving *Bos taurus* X *Bos indicus* crossbred dams were castrated and vaccinated with an 8-way clostridial vaccine at branding (approximately 80-d of age). During pre-weaning (14 to 21 d before weaning) calves received a booster dose of the 8-way clostridial vaccine and were vaccinated against viral respiratory diseases (IBR, BVD, PI3 and BRSV; yr 1, BovaShield Gold5; Pfizer Animal Health, New York, NY, USA; yr 2, Virashield 6, Novartis Animal Health, US, Larchwood, IA, USA). Calves were weaned in mid-October during a 7-d period in both years. At weaning, calves were weighed and revaccinated against viral respiratory diseases with the same vaccine that they received pre-weaning. As calves were weaned, they were held in common holding pens with free access to hay and automatic water stations, and acclimated to electric fencing. In yr 1 steers were weaned beginning October 8, 2008 and were weaned on average 34-d before initiation of the study (November 18, 2008). In yr 2 steers were weaned beginning on October 1, 2009 and were weaned on average 11-d prior to the initiation of the study (October 15, 2009).

Treatments. Steers were randomly assigned to systems within breed type and BW strata. Systems consisted of ad libitum access to a self-fed milo-based diet (Table 1) in drylot (**DL**); ad libitum access to the same self-fed diet while grazing dormant warm season pasture (**SF**); or hand-fed 20% CP pellets (4-square Breeder Performance 20N, Purina Mills St.Louis MO) (Table 2) delivered at a rate 2.1 kg/steer per d 3 times/wk (equivalent to 0.8 kg/steer) while grazing dormant warm season pasture (**HF**). Free choice access to mineral (Purina Wind & Rain All Season 7 Complete; Purina Mills St. Louis, MO) was provided to HF steers. Each treatment consisted of three replicate groups with 20 or 21 steers per group for yr 1 and 18 steers per group in year 2.

Pastures utilized for the SF and HF treatments were approximately 8.09 ha each and stocking rates were 2.47 steers/ha and 2.2 steers/ha for yr 1 and yr 2, respectively. Pastures consisted of predominantly Coastal bermudagrass (*cyndon dactylon*) and kleingrass (*pancium coloratum*).

Table 1. Milled diet composition

Item	%
Ingredient[1]	
Ground milo	40.8
Cottonseed hulls	35.0
Cottonseed meal	11.0
Molasses	10.0
Trace Mineral Premix	2.0
R-1500	1.2
Composition	
DM, % afb	92.3
CP, % DM	12.3
NDF, % DM	43.4
ADF, % DM	27.0
OM, % DM	94.0

[1]As-fed formulation.

Limited forage availability in yr 1, resulted in the provision of free choice access to coastal bermudagrass hay (Table 3) provided on d-28 of the preconditioning period. As a result of improved forage conditions and reduced stocking rate, no hay was required during yr 2.

Table 2. Nutrient composition of 20% pelleted supplement

	2008	2009
Item		
DM	90.1%	88.0%
CP	20.2%	20.5%
NDF	24.3%	28.4%
ADF	12.7%	12.7%
OM	82.7%	88.1%
Ash	17.3%	11.9%

Table 3. Nutrient composition of coastal hay

Item	
DM	91.3%
CP	4.4%
ADF	35.4%
TDN	45.9%
NEm	0.18 Mcal/kg
NEg	0.08 Mcal/kg
Ca	0.58%
P	0.09%

Data collection. Shrunk BW was measured on all cattle on d 0, 28, and 56. On the preceding days, steers were gathered from pastures and drylot pens in the afternoon and held without access to feed or water overnight to obtain a shrunk weight the following morning. Blood samples were obtained prior to overnight shrink (d -1, d- 27, and d -55). Blood samples were collected by jugular venipuncture using 18 gauge needle and evacuated tubes. Blood samples were transported to a laboratory, centrifuged, and serum frozen at -20°C for later analysis.

Feeding and feed sample collection. Feeders for the DL and SF steers were inspected daily to insure adequate feed availability and to monitor rate of feed disappearance. Feed was milled and delivered to self feeders once weekly or as required in 909 kg batches. On data collection days (d 28 and d 56) any feed remaining in the feeders was removed and weighed in order to calculate total feed consumption for the period. A 1.1 kg sample was collected from each batch of feed manufactured during discharge from the mixer. Additional samples were collected from the bulk feeders twice weekly. Samples were composited by pen and type (mixer or bunk), ground to pass through a 1 mm screen of a Wiley mill (Thomas Wiley, Laboratory Mill Model 4, Thomas Scientific Co. Philadelphia, PA) and analyzed for CP, NDF, ADF, DM, and ash. Crude protein content was analyzed using Dumas combustion (Rapid-N-Cube, Elementar Americas Inc. Mt. Laurel, NJ).

Standing forage evaluation. Within each year, forage samples were obtained at approximately 2 wk intervals. Forage sampling occurred on d 0, 14, 28, 49, and 56 of the study. Forage sampling methods were based on the sampling procedures of White and Richardson (2005). During each sampling period, 36 plots (0.25 m^2) were randomly selected within each pasture, and a visual estimate of standing forage was recorded. In each pasture, 6 of the visually estimated plots were clipped to a height of approximately 2.5 cm. In each pasture sample plots were randomly chosen in a zigzag staggered type pattern to obtain a representative sample. Plot frames were randomly tossed in order to minimize any estimator bias. Clipped samples from each quadrat were placed into paper bags and oven dried at 60 °C for 72 h and weighed. The dried samples were then multiplied by a conversion factor of 35.64 grams to determine DM standing crop based from the clipped sample. The visual estimates were than compared to the six actual dry weight values to obtain a correction equation. This correction equation was developed by linear regression and the average of all 36 visual estimates was applied to the resulting equation and used to determine the corrected average forage supply. Clipped samples were ground to pass through a 1 mm-mesh screen of a Wiley mill (Thomas Wiley, Laboratory Mill Model 4, Author H. Thomas Co. Philadelphia PA) and composited by clip date and pasture. Samples were based upon the individual weight of the clipped samples and were composited based upon to the ratio of the individual clips. Composite forage samples were then analyzed for CP, NDF, ADF, DM, OM, and ash. Crude protein content was analyzed using Dumas combustion (Rapid N-cube, Elementar Americas Inc. Mt. Laurel, NJ.).

Subjective health status evaluation and antimicrobial protocol. All calves were monitored twice daily (a.m. and p.m.) for health status. Morbidity was determined subjectively by visual observation based on a 5-point scoring system and rectal temperature. Calves exhibiting signs of lethargy, anorexia, nasal and or ocular discharge, coughing / rapid breathing, that is those with a morbidity score of 3 or greater were removed from their pen or pasture and their rectal temperatures taken. Any calves exhibiting a temperature > 39.7 °C were treated with antimicrobial according to label instructions. For the first treatment steers clinically defined as morbid were administered oxytetracycline (Liquamycin LA-200 Pfizer Animal Health) at a rate of 9mg/lb of BW. Any steers requiring a second treatment were given entrofloxacin (Baytril 100, Bayer Corporation, Shawnee Michigan). These procedures were adapted from those of Apley (2006). Before antimicrobial administration a BW was obtained to calculate the appropriate dosage. The morbidity scoring system is shown in Table 4.

Table 4. Morbidity scoring system

Score	Description
1	Normal, no recognizable signs of illness.
2	Noticeable signs of depression.
3	Signs of depression, weakness, and or anorexia, altered breathing, mild coughing, minimal nasal/ocular discharge.
4	Severe depression, weakness, noticeably drawn in appearance, noticeably altered gait, heavy labored breathing, constant coughing, severe nasal and or ocular discharge.
5	Moribund – unable to travel.

Financial analysis. Prices for final and initial value were obtained from the USDA National Feeder & Stocker Cattle Summary, (SJ_LS850) for the Texas Auction weekly average (ams.usda.gov) for the corresponding weaning dates and end dates. Year 1 weaning price obtained for the week ending October 17, 2008 and final price for the week ending January 16, 2009. In yr 2 weaning and final price were obtained for the week ending October 9, 2009 and December 11, 2009. Weaning weights were unshrunk, a 3% pencil shrink was applied for the analysis. Pasture rates were based on USDA land value rates (ams.usda.gov) $14.50/animal/month, $27.07 throughout the trial. Labor was based on $12.00/h and prorated based on labor required per type of treatment. An additional 20 min three times per week was charged for HF treatments for delivery of the supplement. Equipment charges for bulk feeder were based on actual quoted rental rates, $90/month 30 animal capacity. Drylot calves were charged a yardage fee $0.10/steer/d. Processing charges included vaccination and parasitcide treatment. All expenses in financial calculations were calculated deads in.

Data analyses. Weight, ADG, G:F and economic data were analyzed using the mixed procedures of (SAS Inst Inc. Cary, N.C.) with pen or pasture as the experimental unit, feeding treatment as a fixed effect and pen replicate as a random effect. Forage (standing crop and forage allowance) and nutrient composition data were analyzed first by year. No differences existed between years, thus data was analyzed within yr using repeated measures with compound symmetry as covariance structure.

Results

Performance. Initial BW (d-0) did not differ between treatments for either year (P = 0.87 yr 1; P = 0.83 yr 2). From weaning through initiation of the trial shrink averaged 4.45% for both years and did not differ between treatments (P = 0.70). Performance data for yr 1 are shown in Table 5. In yr 1 ADG did not differ for SF or DL steers throughout the study, but was significantly different (P < 0.01) from HF steers. For the initial period (d 0 to 28) ADG was 0.31, 0.79, and 0.72 kg HF, SF, and DL respectively. From d 29 to 56 ADG for HF steers declined to 0.05 kg and SF and DL increased to 1.16 and 1.20 kg, respectively. Throughout the entire 56-d preconditioning period ADG averaged 0.13 HF, 0.98 SF, and 0.96 kg DL. From d 0 to 28 GF was significantly greater ($P < 0.01$) 0.36 for HF steers vs. SF 0.10 and DL 0.07 which were similar. G:F values for d 28 to 56 included hay and were significantly lower ($P < 0.01$) for HF 0.01 than SF and DL steers 0.11, which were similar.

Table 5. Performance summary 2008

Item	Hand-fed	Self-fed	Drylot	SE	P-value
ADG kg/d					
d 0-28	0.31^{a}	0.79^{b}	0.72^{b}	0.06	<0.01
d 29-56	0.05^{a}	1.16^{b}	1.20^{b}	0.05	<0.01
d 0-56	0.13^{a}	0.98^{b}	0.96^{b}	0.03	<0.01
G:F[1]					
d 0-28	0.36^{a}	0.10^{b}	0.07^{b}	0.05	<0.01
d 29-56	0.01^{a}	0.11^{b}	0.11^{b}	0.01	<0.01
d 0-56	0.04^{a}	0.11^{b}	0.09^{b}	0.01	<0.01
Weight kg					
wean wt	256.7	252.2	250.7	4.5	0.61
initial d 0	240.8	237.8	238.6	4.4	0.87
mid d 28	249.4	260.0	258.0	4.3	0.19
end d 56	248.1^{a}	292.5^{b}	291.6^{b}	4.5	<0.01

$^{a\text{-}c}$ means with different superscripts differ.
[1]G:F values include only feed provided and hay.

Average daily feed intake data for both years are shown in Table 6. In yr 1 feed intake was not different between SF 8.23 kg/d and DL steers 9.18kg/d. However from d 28 to 56 SF steers consumed less feed (supplement only) 9.82kg/d ($P < 0.01$) than DL steers 10.83 kg/d. HF steers consumed 1942 kg more hay than SF steers (*P* < 0.01; 2469, 526 ± 62 kg respectively). Total feed intake including hay is also represented in Table 6. When taking into account hay and supplemental feed, intake of SF and DL steers did not differ from d 28 to 56 but was different from HF steers (*P* < 0.01). Also when accounting for hay consumption throughout the trial (d 0 to 56) HF, SF, and DL intakes were all different (P < 0.01). Total BW from d 0 to 28 was not different (*P* = 0.19) across treatments, but by d- 56 SF and DL steers were heavier (*P* < 0.01) than HF steers. HF steers weighed 44.0 kg less at the end of the 56- d preconditioning period. HF steers failed to regain their initial weaning weight during the preconditioning period. During yr 1 no incidence of morbidity occurred, but 2 steers were removed from the study (SF- lameness, DL- chronic bloat).

In yr 2 (Table 7), ADG from d 0 to 28 was low for all treatments and did not differ (*P* = 0.22). Hand-feed steers lost 0.04 kg/d while SF and DL gained 0.15 and 0.09 kg respectively. However, from d 28 to 56 ADG was 0.32 kg for HF (*P* < 0.01) and 1.29 and 1.50 kg for HF and DL steers, which did not differ. Throughout the entire 56-d period ADG for SF and DL steers was similar, 0.73 and 0.79 kg/d, and greater than HF steers 0.14 kg/d (*P* < 0.01). During d 0 to 28 G:F did not differ (*P* = 0.80) between treatments and was low, -0.04 HF, 0.02 SF, and 0.01 for DL steers. Feed intake was greater for DL steers, 8.62 kg compared to SF steers 6.60 kg (*P* < 0.01). From d 29 to 56 G:F did not differ between SF and DL 0.13. However DL steers consumed more feed

Table 6. Average daily feed intake

Item	Treatment Hand-fed	Self-fed	Drylot	SE	P-value
Feed Intake kg/d 2008					
d 0-28[1]	0.86[a]	8.23[b]	9.18[b]	0.79	<0.01
d 28-56[1]	0.79[a]	9.82[b]	10.83[c]	0.23	< 0.01
d 0-56[1]	0.83[a]	9.03[b]	10.00[b]	0.44	< 0.01
d 28-56 hay[2]	5.20[a]	10.59[b]	10.83[b]	0.52	< 0.01
d 0-56 hay[3]	3.03[a]	9.26[b]	10.00[c]	0.46	< 0.01
Feed Intake kg/d 2009					
d 0-28[1]	0.89[a]	6.60[b]	8.62[c]	0.36	< 0.01
d 28-56[1]	0.88[a]	10.04[b]	11.58[c]	0.15	< 0.01
d 0-56[1]	0.85[a]	8.32[b]	10.01[c]	0.25	< 0.01

[a-c] means with different subscripts differ.
[1] Supplement only
[2] Includes hay for HF and SF treatments.
[3] Includes hay for HF and SF treatments and all feed consumed.

11.58 kg/d vs. 10.04 kg/d for SF steers ($P < 0.01$). Overall, G:F was not different between treatments throughout entire 56 - d period (P =0.50). At the end of the preconditioning period SF and DL steers BW were similar, but greater than HF steers ($P < 0.01$). HF steers weighed 33.39 kg less than SF or DL steers. HF steers regained their initial weaning weight and SF and DL steers gained 34.4 kg over their initial weaning weight. During yr 2 steers were treated for respiratory illness during the trial (DL and HF). Mortality rate was 1.85%. During the trial three steers died one from each treatment (DL-digestive, HF-unknown, SF- mechanical).

Table 7. Performance summary 2009

Item	Hand-Fed	Self-fed	Drylot	SE	P-value
ADG					
d 0-28	-0.04	0.15	0.09	0.07	0.22
d 29-56	0.32[a]	1.29[b]	1.50[b]	0.08	<0.01
d 0-56	0.14[a]	0.73[b]	0.79[b]	0.06	<0.01
G:F[1]					
d 0-28	-0.04	0.02	0.01	0.07	0.80
d 29-56	0.36[a]	0.13[b]	0.13[b]	0.05	0.02
d 0-56	0.16	0.09	0.08	0.05	0.50
Weight kg					
wean wt	227.21	227.70	226.17	4.25	0.97
initial (d 0)	219.85	220.22	216.95	4.06	0.83
mid (d 28)	218.87	225.31	219.67	4.14	0.52
end (d 56)	227.93[a]	260.99[b]	261.65[b]	4.95	<0.01

[a -c] means with different superscripts differ.
[1] G:F includes only feed provided
.

Financial analyses. During both years preconditioning programs resulted in a net loss. Financial analysis for 2008 is shown in Table 8. In yr 1, final price $/45.4 kg was $98.15 HF and $96.07 for SF and DL steers. Final value did not differ for SF $618.19 and DL $616.54 steers, but was greater than HF $535.73 steers ($P < 0.01$). Initial in price for the analysis was $92.07 /45.4 kg for all calves and in value did not differ ($P = 0.41$). Feed costs differed ($P < 0.01$) across all treatments. Feed costs were $15.40, $128.19, and $145.78 per steer for HF, SF, and DL treatments, respectively. Hay costs were $19.14 and $4.05 per steer for HF and SF treatments and were different ($P < 0.01$). Total expenses were greatest for SF \$175.12, but did not differ significantly from DL \$167.20, but were different (P < 0.01) from HF \$73.50. SF steers incurred the greatest loss, (\$67.59) followed by DL (\$58.80), and HF (\$57.89), but were not significantly different (P = 0.38). Calculated breakeven premium price for the protocols were not different (P = 0.46) but was greatest for HF \$10.61, followed by SF \$10.51 and DL \$ 9.181. Overall in yr 1 DL preconditioned steers would require the least price premium for adoption of this practice.

Financial analysis for 2009 is shown in Table 9. In yr 2, final price applied to steers was \$100.58/45.4 kg for HF steers, and \$96.33/45.4 kg for SF and DL steers. Final value did not differ for SF \$553.15 or DL \$554.31 steers, but was greater than HF \$504.65 steers (P = 0.03). Initial in price was determined as \$95.91/45.4 kg for all three treatments. In-value was not different across treatments (P = 0.90). Feed cost was highest for DL \$125.86, intermediate for SF \$109.84, although SF and DL were not significantly different, and lowest for HF \$14.62 (P < 0.01). Total expenses were highest for SF \$152.72, intermediate for DL \$141.68, and lowest for HF\$53.58 (P < 0.01). Net loss was the greatest for SF (\$80.00), DL (\$64.55), then HF (\$28.35) respectively (P = 0.18). The calculated breakeven premium price for the protocols was greatest for SF \$14.01, DL \$11.31, and least for HF \$5.79. However, these differences were not significant (P = 0.27). Thus, HF required the least breakeven premium.

Table 8. Preconditioning financial analysis 2008

Item	Hand-Fed	Self-Fed	Drylot	SE[1]	P-value
Revenues					
Final Wt kg	248.10[a]	292.50[b]	291.40[b]	4.47	<0.01
Final Price $/45.4 kg[2]	98.15	96.07	96.07	-	-
Final Value	535.73[a]	618.19[b]	616.54[b]	8.93	<0.01
Expenses					
In Wt kg[3]	253.74	252.15	250.73	4.47	0.61
In Price $/45.4 kg[4]	92.07	92.07	92.07	-	-
In Value	520.12	510.60	508.13	6.23	0.41
Feed Costs[5]	15.40[a]	128.19[b]	154.78[c]	2.92	<0.01
Hay[6]	19.14	4.05	-	0.70	<0.01
Grazing Fee[7]	27.06	27.06	-	-	-
Labor[8]	7.28	5.60	5.60	-	-
Yardage	-	-	5.60	-	-
Equipment[9]	-	5.60	5.60	-	-
Processing[10]	4.62	4.62	4.62	-	-
Total Expenses	73.50[a]	175.12[b]	167.20[b]	3.10	<0.01
Net Income	-57.89	- 67.59	- 58.80	4.99	0.38
Premium Required	10.61	10.51	9.18	0.85	0.46

[a-c] means with different superscripts differ.
[1] n=9
[2] Price based from USDA National Feeder & Stocker Cattle Summary; ams.usda.gov, accessed Jan.16, 2009.
[3] 3% pencil shrink applied to weaning BW
[4] Price based from USDA National Feeder & Stocker Cattle Summary; ams.usda.gov, accessed Oct. 17, 2008.
[5] TMR $233/ton; Range pellet $280/ton; $20/ton milling & delivery charge included for TMR
[6] Based on $42/ton
[7] Based on USDA Land Value $14.50/AUM; ams.usda.gov
[8] $0.10/steer/d drylot & self-fed, $0.13/steer/d hand-fed based on 12.00/h prorated
[9] Bulk feeder rental rate $90/month, 30 steer capacity per feeder
[10] Processing includes vaccinations and paracitide treatment

Table 9. Preconditioning financial analysis 2009

Item	Hand-Fed	Self-Fed	Drylot	SE[1]	P-value
Revenues					
Final Wt kg	227.93[a]	260.00[b]	261.65[b]	4.95	<0.01
Final Price $/45.4 kg[2]	100.58	96.33	96.33	-	-
Final Value	504.65[a]	553.15[b]	554.31[b]	10.82	0.03
Expenses[3]					
In Wt kg[4]	227.21	227.70	226.18	4.25	0.97
In Price $/45.4 kg[5]	95.91	95.91	95.91	-	-
In Value	479.42	480.43	477.18	5.01	0.90
Feed Costs[6]	14.62[a]	109.84[b]	125.86[b]	11.19	<0.01
Grazing Fee[7]	27.06	27.06	-	-	-
Labor[8]	7.28	5.60	5.60	-	-
Yardage	-	-	5.60	-	-
Equipment[9]	-	5.60	5.60	-	-
Processing[10]	4.62	4.62	4.62	-	-
Total Expenses	53.58[a]	152.72[b]	141.68[b]	11.19	<0.01
Net Income	- 28.35	- 80.00	-64.55	17.39	0.18
Premium Required	5.79	14.01	11.31	3.25	0.27

[a-c] means with different superscripts differ.
[1] n=9
[2] Price based from USDA National Feeder & Stocker Cattle Summary; ams.usda.gov, accessed Dec 11, 2009.
[3] Calculated deads in.
[4]3% pencil shrink applied to weaning BW
[5] Price based from USDA National Feeder & Stocker Cattle Summary; ams.usda.gov, accessed Oct. 9, 2009.
[6] TMR $190/ton; Range pellet $262/ton; $20/ton milling & delivery charge included for TMR
[7] Based on USDA Land Value $14.50/AUM; ams.usda.gov
[8] $0.10/steer/d drylot & self-fed, $0.13/steer/d hand-fed based on 12.00/h prorated
[9] Bulk feeder rental rate $90/month, 30 steer capacity per feeder
[10] Processing includes vaccinations and paracitide treatment

Forage standing crop. No treatment X day interactions were observed for any measures of forage availability or nutritive value ($P \geq 0.35$). Estimates of forage standing crop were higher in yr 2 than yr 1 (Figure 1). In both years standing crop differed by date ($P < 0.01$) and there was not a significant treatment X day interaction in either year (P ≥ 0.05). Forage standing crop was less than 1500 kg/ha throughout yr 1. In contrast, forage standing crop was greater than 2000 kg/ha for at least the first 28-d in yr 2 and declined mainly from d 28 to 49 to levels below 2000 kg/ha.

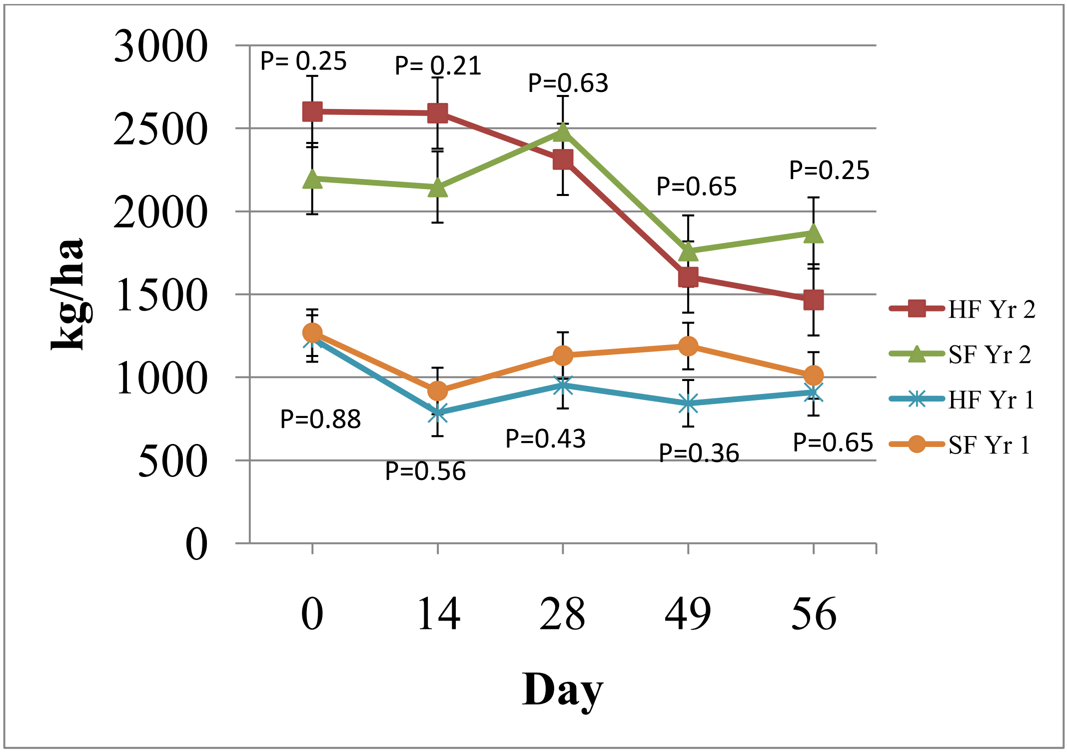

Figure 1. Estimated standing forage kg/ha

Forage allowance kg forage per kg BW. Forage allowance (Figure 2) as expected, follows a similar pattern to forage availability with date differing ($P < 0.01$) in both yr and no treatment X day interaction (P ≥ 0.32). In yr 1, forage allowance was below 0.11 kg/kg BW and declined slightly throughout the trial to 0.07 kg/kg BW. In contrast forage allowance was above 0.20 kg/kg BW in yr 2 for the first 28-d and declined from d 28 to 56 to 0.15 kg/kg BW.

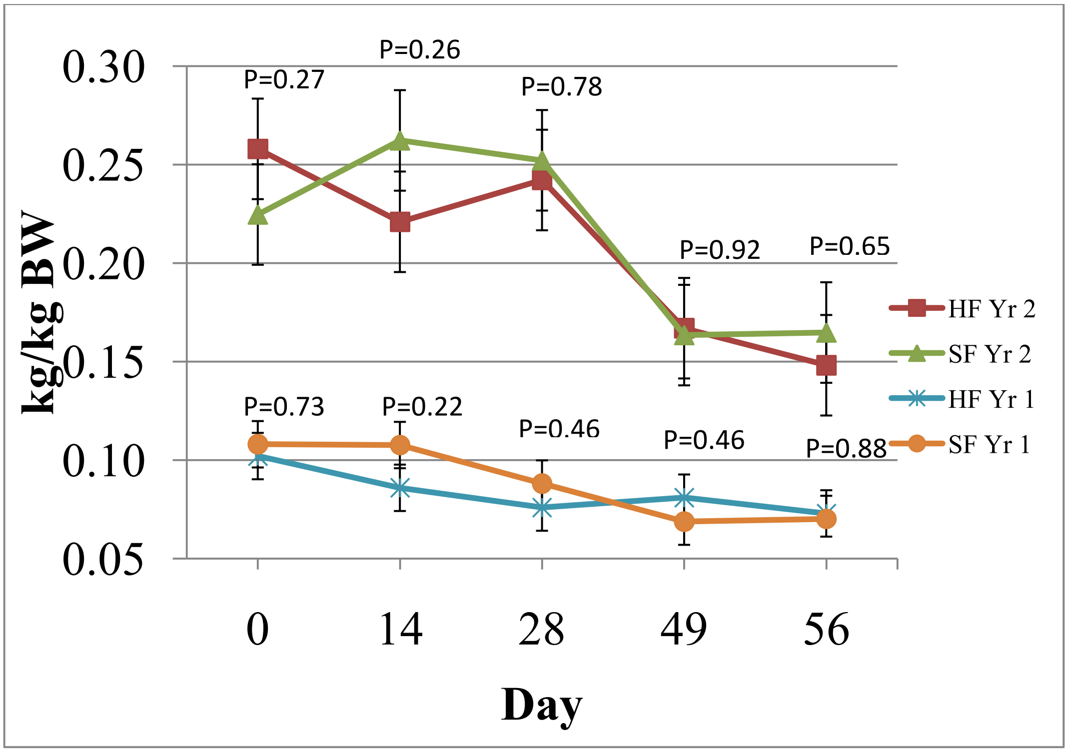

Figure 2. Forage allowance kg/kg BW

Forage nutrient composition. Day exerted a significant effect ($P < 0.01$) on crude protein content of the forage in both years (Figure 3). However the magnitude of the change across time was small and its biological significance is questionable. During yr 1 no significant treatment X date interaction occurred ($P = 0.42$) and initial crude protein concentration was 5.6 %. However, in yr 2 a weak treatment X day interaction occurred ($P = 0.03$) due to a rearrangement of the treatments, but the change in magnitude did not result in a significant difference ($P = 0.90$). In contrast, initial CP values were higher in yr 2, 9.2% HF and 7.94 % SF and declined to 6.29% HF and 6.85% SF by d-56. The greatest decline in CP appeared to occur from d 0 to 14 as the forage approached dormancy

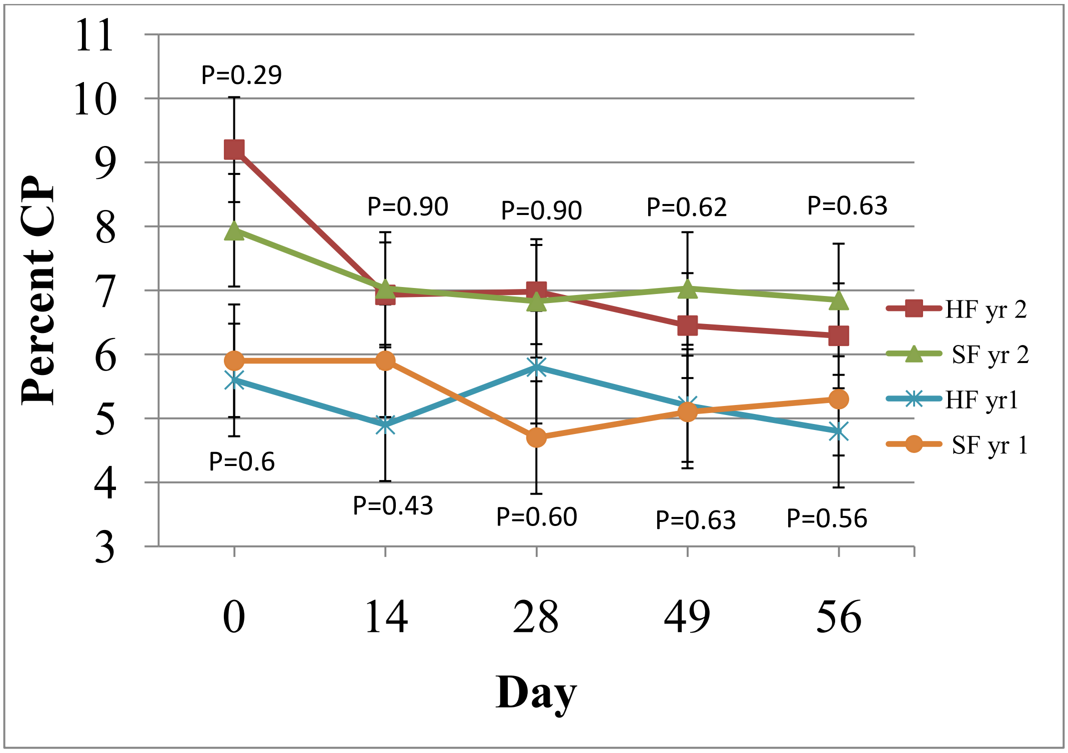

Figure 3. Forage crude protein

The fiber components (NDF and ADF) are shown in figures 4 and 5. Day was significant for NDF content ($P < 0.01$) in both yr and no treatment X date interaction occurred in either year ($P \geq 0.2$). Overall NDF content of the forage increased with time during the 56-d for both yr. In yr 1 initial NDF was 65.8% HF and 65.5% SF and this increased to 68.8% and 66.3% respectively. In yr 2 initial NDF was 63.5% HF and 64.4% SF and increased to 67.1% and 65.9% respectively. Differences by day were significant in yr 1 ($P < 0.01$) for ADF, but was not significant in yr 2 ($P = 0.68$). ADF generally increased in yr 1 but was constant in yr 2. No treatment X date interaction occurred in either yr ($P \geq 0.35$).

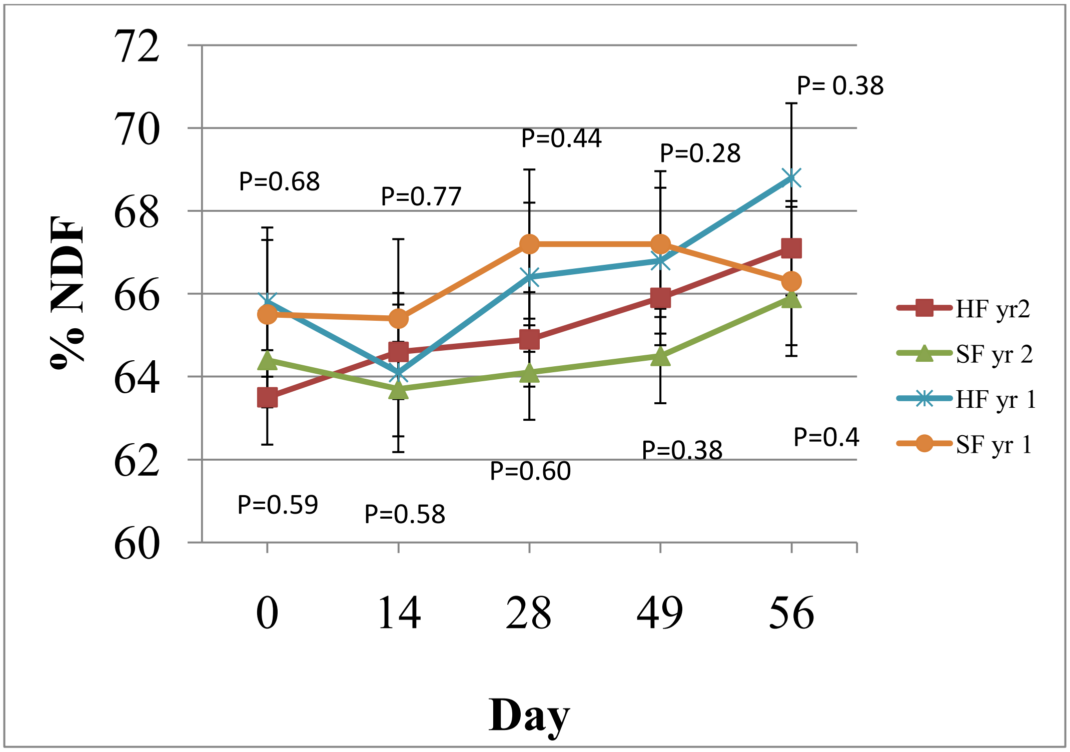

Figure 4. Forage NDF

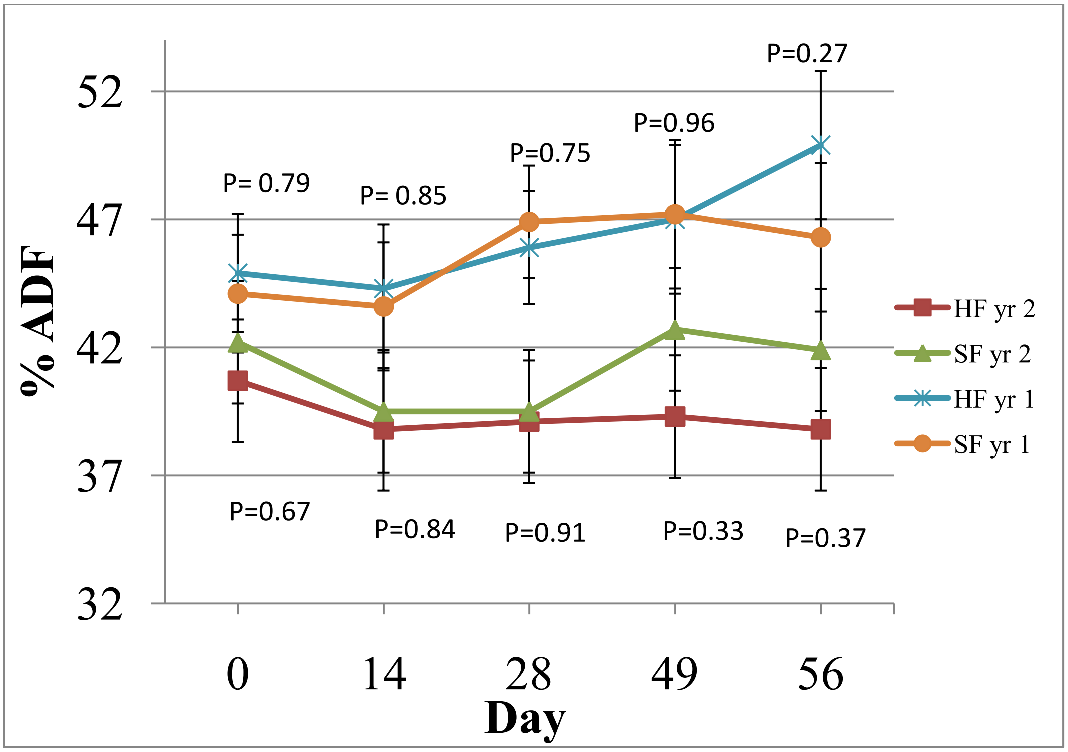

Figure 5.Forage ADF

Discussion

Performance. Steers were weaned an average 34 and 11-d before initiation of the treatments in yr 1 and 2 respectively. Between weaning and study initiation steers had ad libitum access to hay and were given the pelleted 20% supplement as an attractant. The shorter period between weaning and application of the treatments may explain a substantial portion of the performance differences observed from d 0 to 28. These differences could be due to inadequate nutrient intake which can occur when calves are subjected to the stress associated with weaning and gathering (Loffgreen, 1988). Low performance and erratic and low DMI affected by stress, environment, and previous management can occur after weaning, with the number of calves eating increasing during the first ten days (Hutcheson and Cole, 1986). Steers in yr 1 had more time to recover from stress and become accustomed to eating from a bunk. In yr 2, HF steers did not consume the entire supplement during the first 7-d period which could also explain the negative performance. Shrink and low performance during the first few days and weeks of preconditioning can be expected (Pate and Crockett, 1978; Cole, 1985). However, feed intake as a percentage of BW for SF and HF group did not correspond to the low intakes reported by Hutcheson and Cole (1986), as intakes were greater than 3% of BW. Perhaps the greater change in diet and digestion impacted gain and gain efficiency. In yr 2, DL steers were also subject to a high degree of mud, which may have affected nutrient requirements NRC (2000). In yr 1 no differences in feed intake were apparent between SF and DL groups from d-0 to 28. This likely is attributed to low forage availability for SF steers. However from d-28 to 56 after free choice hay was provided SF and DL group feed intakes were different. Forage allowance in yr 1 ranged from 0.11- 0.07 kg/kg BW which is likely limiting in that Gurerro et al., (1984) indicated that 0.14- 0.18 kg/kg BW of a medium to high-quality forage is required to maintain BW and as forage digestibility declines more available forage is required. Even after providing supplemental forage (hay), performance was low and may be explained by the low nutritive value of the hay in that CP was 4.4%. In yr 2, forage was not determined to be limiting and SF and HF feed intakes differed throughout the entire study. However, in yr 2 forage allowance did decline below 0.20 kg/kg BW which may have limited performance to some degree. One may expect lower feed intake in SF vs. DL since steers had access to a roughage source, although some substitution effects were likely in that greater amounts of starch have been shown to decrease forage intake (Chase and Hibberd, 1987). Overall forage quality declined over time as would be expected as the forage neared its dormant stage and these observations are consistent to that of Hart et al., (1969) in which CP and digestibility of autumn-saved bermudagrass declined over time.

Financial analyses. By design nutritional inputs were expected to be lower for HF and SF treatments. However in yr 1 the limiting forage availability resulted in the need for hay which also increased preconditioning costs. This in addition to the grazing costs resulted in the lower intensity HF steers and SF having greater cost of gain. Thus the high intensity drylot system resulted in the least loss and least price premium required ($9.18/45.4 kg) to breakeven. Another factor contributing to the differences in HF, SF, and DL treatments was the price slide for the final value. Although weights were greater for SF and DL steers only a $2.08/45.4 kg price differential occurred. This can be explained by the relatively higher corn prices experienced in yr 1. Price weight relationships vary based upon prevailing market environment and the price slide between heavier and lighter cattle generally narrows as corn prices increase (Dhuyvetter and Schroeder, 2000). In yr 2 HF steers had least total expenses and resulted in the least net loss -$28.35 and required the least premium. Most of this can be attributed to an increase in price $95.91 to $100.58 per 45.4 kg because weight gain from initial weaning weight was 0.72 kg. Cattle prices are seasonal and often exhibit low periods in fall with winter price peaks (Peel and Meyer, 2002). SF steers resulted in the greatest net loss -$80.00 per steer and can be attributed that feed costs were not significantly lower than that of the drylot group. Based upon price premium data, preconditioned calves can receive from a $2.47 to $7.91/45.4 kg premium (King et al, 2006). HF treatments for yr 2 could possibly breakeven or profit depending upon the amount of premium received.

Overall during both years preconditioning costs can be considered high. Feed cost was the greatest contributor to overall expenses. Avent et al., (2004) reported that normal preconditioning costs should range near $60 /calf. In a similar study Mathis et al. (2008) reported a total cost of $66.77/steer for a Drylot system and $ 14.01 for a hand-fed system. However in comparison to our findings DL steers were limit fed and differences in grazing fee applied may explain the differences. If intake values of the DL treatment from our research were applied to the feed costs of Mathis et al. (2008) total costs would be in excess of $100/steer. In a later study by Mathis et al. (2009) self-fed steers grazing pasture incurred a total cost of $102.80 which along with our data may indicate the limitations of self feeding systems. Perhaps recommendations and budgets involving feed costs such that of Avent et al. (2004) and Dhuyvetter (2003) are often based on limit feeding.

Retaining calves in a preconditioning program does involve a degree of added risk. Although no morbidity or mortality occurred during yr 1, two steers were removed from the study and sold early and likely received a discount. Troxel et al., (2006) reported lame or sick calves sold at auctions often receive discounts of $20-40/ 45.4 kg. In yr 2 three steers died and an overall mortality rate of 1.85% was observed. Similarly Pate and Crockett (1978) observed a 1.1% mortality rate during preconditioning. This loss was accounted for in the financial analysis but it is important for cow-calf producers to consider the added risk.

CHAPTER III

CONCLUSION

Overall, this research indicated that methods to decrease the nutritional inputs and thus total costs of preconditioning did not equate to profitability. A number of factors, especially year and availability of resources (forage) can have an effect on which preconditioning strategy should be considered. Our data indicates that supplying ad libitum feed to cattle on pasture vs. a drylot did not result in significant reductions in feed costs. It is likely preconditioning programs will not be economically viable for cow-calf producers unless significant price premiums are received and cost and value of gain are considered. Additional research and economic analysis may be needed to compare costs and benefits of limiting milled feed intake to calves grazing dormant warm season pastures as well as levels and types of supplements which could be used to decrease nutritional inputs.

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