EFFECT OF FEEDING DIFFERENT PROTEIN AND ENERGY SUPPLEMENTS ON PERFORMANCE AND HEALTH OF BEEF CALVES DURING THE BACKGROUNDING PERIOD

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(ABSTRACT)

Newly received or weaned calves are highly susceptible to the incidence of bovine respiratory disease. In addition to high levels of stress, decreased feed intake and exposure to foreign antigens result in increased morbidity and possibly death losses. Four backgrounding trials were conducted to examine the effects of protein and energy supplements to stressed calves consuming different forages. Body weights, rectal temperatures and blood samples were taken on d 0, 7, 14, 28 and 42. Supplements consisted of corn or mixtures of corn and soybean meal. In trial 1, 48 heifers (average BW = 219 kg) fed fescue hay in drylot, were allotted to four treatments: no supplement, 15% CP supplement (0.5% BW), 15% CP supplement (1.0% BW) and 30% CP supplement (0.5% BW). Supplemented heifers had higher (P<0.05) ADG than unsupplemented heifers by 42 d. Heifers fed the 30% CP supplement had higher (P<0.05) plasma urea-N by d 42. In trial 2 (pasture study 1), 36 steers (average BW = 217 kg) grazed stockpiled tall fescue and were allotted to three treatments: no supplement, a 15% CP supplement (0.5% BW), and a 15% CP supplement (1.0% BW). After wk 1, ADG was lower (P<0.05) for supplemented calves. At the end of the trial, steers supplemented at 0.5% BW had higher (P<0.05) ADG than steers supplemented at 1.0% BW. Glutathione peroxidase levels were lower (P<0.05) for supplemented steers on d 28. For trial 3 (pasture study 2), 48 steers (average BW = 202 kg) grazed stockpiled tall fescue and were allotted to three treatments: no supplement, corn (1% BW), and 15% CP supplement (1% BW). After wk 1, ADG was higher ($P<0.05$) for steers supplemented with corn. Steers supplemented with 15% CP supplement had the lowest ($P<0.05$) ADG after 7 d. At d 42, supplemented steers gained faster ($P<0.05$) than unsupplemented steers. For trial 4 (pasture study 3), 48 steers (average BW = 202 kg) grazed stockpiled tall fescue or fescue-alfalfa and were allotted to two treatments: no supplement and a 15% CP supplement (0.5% BW). During wk 1, steers grazing fescue had higher ($P<0.05$) ADG than steers grazing fescue-alfalfa. During wk 1, supplemented steers had a higher ($P<0.05$) morbidity scores. At d 42, ADG was higher ($P<0.05$) for supplemented steers. No consistent differences were detected in forage and blood serum mineral concentrations in all trials. Glutathione peroxidase activity increased ($P<0.05$) for all trials on d 14, regardless of supplementation. Supplementation improved ADG by d 42 but did not affect overall health status of calves in all trials.

Key Words: Backgrounding, Cattle, Energy, Health, Protein, Supplements

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Introduction

Production of finished cattle consists of three phases: birth to weaning, weaning to finishing, and finishing. Backgrounding is a nutritional program imposed on newly weaned calves for a short period of time prior to entering a subsequent stocker or finishing phase of production. Although usually implemented with calves produced on the farm, backgrounding programs may also be used as a receiving program for purchased calves.

Backgrounding programs immediately follow weaning or shipping associated with weaning. Stresses of newly weaned or lightweight feeder calves include separation from dam, destruction of social hierarchy, mixing with strange animals, feed and water deprivation and exposure to infectious organisms. Cattle exposed to these stresses present health, management, and nutritional problems to the feeder, as the cattle are vulnerable to foreign antigens and bovine respiratory diseases encountered during the marketing process. Change in diet alone may result in metabolic changes due to depressed feed intake, dehydration and weight loss. The effects and extent of stress are functions of weaning program, shipping distance, weather, cattle weights, age and sex. Therefore, effects vary between groups of cattle.

Newly weaned calves face numerous physiological stresses, environmental factors that elicit nonspecific effects that may adversely affect health and performance. Backgrounding allows newly weaned calves an opportunity to overcome the negative effects of weaning stress and decreases the extent of marketing stresses. The backgrounding period eases the adjustment from nursing to eating out of feedbunks in pastures or drylot. During backgrounding, calves are allowed a period of time to become acclimated with feed bunks and waterers. During this phase, the cattle also become more familiar with regular handling and the producer can observe and treat morbid calves more effectively. The length of backgrounding programs may vary from approximately 30 to 90 d, usually 30 to 60 d.

Backgrounding programs may result in increased long-term health, performance, profitability of cow-calf enterprises, and allow a period of time after weaning for vaccinations to increase disease resistance. Therefore, backgrounded and preconditioned calves may have lower treatment costs and higher feed efficiency during the subsequent phase.

In addition to the obvious performance and health advantages of backgrounding, cow-calf producers may use backgrounding as a value-added program. Bovine respiratory disease (BRD) is a major problem within the industry costing approximately $500 million annually. Feedyards may pay more for calves with documented health backgrounds to reduce health problems during the feedlot phase. To obtain premium feeder calf prices, it may be beneficial that the producer capitalize on backgrounding programs to increase the value of the calves. A producer that sells backgrounded calves with health and backgrounding history, will repeatedly entice buyers to his enterprise while producers selling non-backgrounded calves may face a lack of buyers or encounter price discounts.

The overall objective of this project was to develop nutritional regimens for backgrounding weaned beef calves. The specific objectives were to evaluate the effects of various protein and energy supplements to stressed calves consuming different forages during the backgrounding period.

Review of Literature

Weaning stress

Loerch and Fluharty (1999) identified possible consequences of stress in feedlot cattle. Transient endocrine responses, altered products of energy and protein metabolism, decreased appetite and growth rate, compromised rumen function and digestion, anorexia, exhaustion, nutrient losses, dehydration, hormonal changes, behavioral changes, and challenged immune system may result from stresses incurred during marketing processes. Stress can be divided into a three-phase process called the general adaptive syndrome. The primary phase, labeled the alarm reaction, is characterized by vocalization, adrenal, pituitary and hypothalamic response, and breakdown of tissue. The second phase of the stress response is labeled the resistance phase. Usually beginning about 2 wk after arrival into the feedlot, this phase is characterized by increased feed intake. The final stage, exhaustion, may result from unsuccessfully adapting to the feedlot.

Susceptibility to disease during this period can be caused by decreased feed intake or increased systemic cortisol levels (Nockels, 1988). Stressed animals experience increased production and release of numerous hormones, neurotransmitters, and eicosanoids which further result in elevated lymphocyte cyclic AMP levels. More specifically, glucocorticoids, epinephrine and prostaglandins inhibit lymphocyte function, making stressed feeder calves more receptive to disease. Furthermore, as feed intake is depressed in the receiving period, calves may not receive adequate nutrition to combat an immune challenge (Lofgreen, 1988). Stressed feeder calves required 3 wk from the time of transport to return to normal feed intake. Because feed intake is depressed during the receiving period, concentration of protein, energy, vitamins, and minerals in the diet should be higher than normal requirements for maintenance and growth.

While providing adequate nutrition will not decrease the incidence of stress or infection, proper nutritional management can reduce the adverse effects of stress and accelerate the acclimation period (Cole, 1991).

Energy

In a feedlot receiving trial, feeder calves (165.9 kg) were fed 20, 55 or 72% concentrate receiving diets and performance of the cattle was monitored for 28 d (Lofgreen et al., 1975). Cattle on the 55 and 72% concentrate diets consumed more feed and gained faster during the first week after receiving. Average daily gains increased linearly with increasing protein content for the 29 d receiving period. Cattle fed the 72% concentrate diet consumed more feed for the entire trial than the other treatments.

In a second trial, performance and health status were measured on calves consuming 55, 72 or 90% concentrate receiving diets for 28 d. Feed intake was greater for calves consuming the 72% concentrate receiving diet. No differences were detected between the 55 and 90% concentrate treatments. Because feed intakes were higher for steers consuming the 72% concentrate diet, total energy intakes were similar for cattle fed the 72 and 90% concentrate treatments. Daily gains were higher for steers fed the 72 and 90% concentrate diets for the entire 28 d receiving period. Steers fed the high-energy receiving diet also had the highest percentage of morbidity, number of treatments and the highest rate of sick days. Energy level of the 28 d receiving diet did not significantly affect subsequent feedlot performance or carcass composition when all cattle were finished on the same diet.

A third study was conducted to determine response to newly received calves receiving a 72% concentrate receiving diet with or without free choice alfalfa hay. Fifty-nine calves (95 kg) were fed the two diets immediately upon receiving. No difference was detected in feed intake or total trial weight gains due to diet at the end of the 28 d trial. The authors suggested that sick calves will more readily consume hay rather than a total mixed ration.

According to Lofgreen (1988), when fed diets differing in energy concentration, unstressed feeder cattle consume adequate quantities to meet their energy requirement. He further indicated that stressed calves will not consume sufficient amounts of low-energy diets to meet energy requirements and have shown better preference if fed high concentrate diets than unstressed feeder calves.

Stressed calves, shipped from Texas to California, were given access to 20, 55, or 90% concentrate diets (Lofgreen, 1983). For the first 4 wk after shipping, calves consumed more of the 90% diet and selected diets with an average concentrate percentage of 78, 81, and 85% for wk 1, 2 and 3, respectively. In a second study, calves were fasted for 36 h and shipped for 24 h to simulate marketing stresses. Given access to 20, 55, and 90% concentrate diets, the stressed calves selected an average diet of 72% concentrate. Unstressed control calves selected an average diet of 63% concentrate. Although the increased consumption of high concentrate resulted in more efficient gains and lower cost per unit of gain, concentrate levels over 55% increased morbidity of feeder calves. In a third study, newly received calves (163 kg) were fed for 29 d. Comparing 20, 55, 72 and 90% concentrate diets, he found that feeding a 90% concentrate diet resulted in increased morbidity, compared to the 72% concentrate diet. Furthermore, calves fed the 72% concentrate diet had greater feed intakes and required fewer days to regain shrink weight than the other three treatments.

The effect of supplementing alfalfa hay to newly received, stressed calves (160 kg) was studied by Lofgreen et al. (1980). In a 3 x 2 x 2 factorial design, calves were randomly allotted to 22, 55 or 75% concentrate receiving diets, oxytetracycline injection or no injection upon receiving and free choice or no alfalfa hay. Daily weight gains were higher for steers fed the 50 and 75% concentrate receiving diet. No differences were detected in morbidity due to concentrate level. Steers fed alfalfa hay ad libitum had significantly lower death loss, number treated and number of retreated calves. Steers receiving alfalfa hay also had higher daily gains and feed efficiency and required fewer days to regain transportation shrink losses. Oxytetracycline injections decreased death loss and number of steers treated in this trial.

Consumption of alfalfa hay ad libitum may increase death losses due to bloat (Lofgreen et al., 1981). Millet hay was compared with alfalfa hay with and without a 75% receiving diet. Seven hundred and forty steers were used in this study. Steers fed the 75% concentrate diet had higher feed intakes and daily gains than steers fed alfalfa or millet hay alone. Of the steers fed the 75% concentrate diet, those allowed access to alfalfa hay had numerically lower feed intakes and daily gains than those fed millet hay or the 75% concentrate diet alone.

The physiological mechanism for the energy/morbidity relationship is unclear as there has been no research conducted on the effects of energy level on cell-mediated or humoral immunity of feeder calves (Galyean et al., 1999). The increased metabolism related to higher energy intake may place additional stress on the body and lower disease resistance (Lofgreen et al., 1981). Research at the cellular level could indicate if the increase in morbidity at high concentrate levels is due to increased susceptibility of the cattle or due to inaccurate diagnosis by the feeder.

Protein

Cattle experiencing severe feed intake depression may also have a lower potential for protein deposition (NRC, 1996). According to the NRC (1996) metabolizable protein system, protein requirements are a function of body weight and feed intake. When feed intake is depressed during periods of stress, net energy intake is low and the stressed animal will have a low protein deposition capacity. Therefore, feed intake during the backgrounding period will determine the concentration of protein required in the receiving diet (Galyean et al., 1999).

Eck et al. (1988) studied the protein source and level for incoming feedlot cattle with 230 heifers (255 kg) fed a 10.5 or 12.5% CP diet for 28 d. Protein sources were urea, cottonseed meal and a bloodmeal-corn gluten meal mixture. Performance was increased by feeding higher levels of dietary protein, as heifers fed the 12.5% CP diet had significantly higher feed intakes, gains and feed efficiency than those fed the 10.5% CP diet. However, no interaction was detected between protein source and level on daily gains or feed efficiency. In a second trial, 360 steers (200 kg) were fed the same diets as the cattle in the previous trial for 28 d. Steers fed the 12.5% CP diet had higher feed intakes and weight gains and required less feed per unit of gain. At both protein levels, the more slowly degradable protein sources, cottonseed meal and bloodmeal/corn gluten meal, resulted in greater weight gains and increase efficiency. The authors suggested that bypass protein sources result in a greater amino acid flow to the small intestine.

In a third trial, 370 steers (260 kg) were fed one of the following four protein sources for 28 d after receiving: urea; 67% urea-33% bloodmeal/corn gluten meal (50:50 combination); 33% urea-67% bloodmeal/corn gluten meal; or blood meal/corn gluten meal (Eck et al., 1988). All diets were fed at 12.5% CP, DM basis. Daily gains and feed efficiency increased with increasing proportion of bloodmeal/corn gluten meal in the diet. Feed intake tended to increase with increasing bloodmeal/corn gluten meal concentration. Based on the results from this trial, the authors suggested that receiving diets should have at least 60% of total diet CP as bypass protein.

Response to increased protein levels in the receiving diet may depend on the protein level fed prior to transport (Cole and Hutcheson, 1988). In a 3 x 2 factorial design of treatments, 70 steers (250 kg) were fed 8, 12 or 16% CP diets for 14 d prior to marketing, then were fed a 10 or 15% CP diet ad libitum upon receiving. The preshipment protein levels were chosen to represent below, at, and above the NRC (1996) protein requirements for dietary protein, respectively. Steers were fasted for 24 h, fed the assigned diet, and fasted again for 48 h to simulate marketing conditions. During the 14 d deprivation period, weight loss increased linearly with increasing dietary protein level. By d 4 of the realimentation period, weight gains were higher for steers fed the 8% CP prefast diet than for the other prefast diets. Of the steers fed the 8% CP prefast diet, weight gains were higher for steers consuming the 15% CP realimentation diet. Feed intake during the first 4 d were negatively correlated with prefast protein level. During realimentation, feed intakes were greater for steers fed the 15% CP diet. By day 11 of the realimentation period, weight gains decreased linearly with increasing prefast CP level. Daily gains were higher for steers fed the 15% CP diet compared to the 10% CP diet during realimentation. Of the steers that were fed the 16% CP prefast diet, feed intakes were greater if fed the 15% CP diet upon receiving. The authors suggested that this may indicate that steers switched from a high protein prefast diet to a low protein receiving diet may experience more severe feed intake depressions than steers fed a high protein diet upon receiving. Feeding at CP levels above prefast dietary protein levels did not increase feed intake or weight gains. However, receiving diets having lower protein concentrations than the receiving diet did result in decreased dry matter intakes.

Packed cell volume (PCV), an indicator of hydration status, was lower for fasted animals than control animals and was not affected by diet. At the end of the fasting period, fasted steers had higher total plasma protein. After adjustments were made for PCV, no differences existed. Plasma albumin was not affected by treatment. Due to differences in N intake, plasma urea-N during the 14 d deprivation period was related to prefast protein level. Steers fed the 8% CP diet had the lowest PUN followed by the 12 and 16%, respectively. Cole and Hutcheson (1988) suggested that the difference in PUN levels between fasted and control steers was likely due to hemoconcentration and increased packed cell volume. After fasting, steers fed the 10% CP diet had lower PUN levels than steers fed the 15% CP diet. Plasma cholesterol also increased during feed and water deprivation. In the prefast and realimentation phases, plasma cholesterol was inversely related with dietary protein levels, decreasing with increasing CP concentration. Steers fed the 15% CP diet had lower cholesterol levels if they had previously been fed the 12 or 16% CP diet. Steers fed the 8% CP prefast diet had lower plasma cholesterol levels if fed the 10% CP realimentation diet than the 15% CP diet. The reason for these relationships between cholesterol and protein concentration is unclear.

Three experiments were conducted at the Bushland (TX) Agricultural Experiment Station to determine the effects of increased protein levels in the receiving diet (Cole and Hutcheson, 1990). In the first trial, 84 calves (184 kg) were purchased in TN and shipped to Bushland, TX where they were fed 12 or 16% CP diets. During the first 14 d, calves fed the 16% CP receiving diet had higher daily gains, feed intake and feed efficiency than calves fed the 12% CP diet. No differences in performance were detected by d 56. Calves fed the 16% protein diet had fewer morbidity relapses and required fewer days of treatment. Mortality was 14.3% for both treatments.

In a second trial, 256 calves were used in a 2 x 2 factorial design to determine the effects of protein and K level in the receiving diet. Diets were 12 and 16% protein levels and .8 and 1.3% K. No significant differences were detected in performance between treatments. Mortality was lower for calves on the 16% CP diet. However, more of these calves became sick again. Similarly, calves fed the 1.3% K diet had a lower incidence of mortality but had a higher relapse rate. Effects of increased levels of protein and K may be summative as calves fed the 16% protein/1.3% K diet had the lowest mortality rate of all treatments. Calves fed the 12% protein/.8% K diet had the lowest incidence of relapse, required the fewest days of treatment, and had the lowest morbidity rate. For the two previous trials combined, 80% of shrink occurred during transportation and 42 calves died of respiratory disease during the two experiments. The authors suggested that performance differences due to protein level were likely due to feed intake.

In a third trial, a metabolism experiment was conducted with four steers (253 kg) in a 4 x 4 Latin square design (Cole and Hutcheson, 1990). Steers were given a 2 wk adjustment period, 7 d stall adjustment period, and 5 d prefast collection period during which steers were all fed a diet having 120% of the NRC crude protein requirement. Steers were fasted for 3 d. After fasting, the steers were fed diets of 100, 120, 140, and 160% of the NRC protein requirement. During realimentation, N digestibility, N excretion, and N balance increased with increasing protein level. As N intake increased, time to prefast plasma urea-N levels was reduced. Daily N intake over 82 g, provided only by the 140 and 160% diets, did not result in a significant improvement in N balance. Serum free fatty acids (FFA), which increased during the fasting period for all treatments, were not affected by diet in the realimentation period. Serum glucose and urea N increased linearly with increasing protein level. Serum P, Ca, Mg, and Cl were not different between treatments.

In a more recent study, the effects of protein concentration of the diet on performance of stressed feedlot steers (243 kg) were investigated (Fluharty and Loerch, 1995). Diets with 12, 14, 16, and 18% CP with two protein sources, blood meal and soybean meal, were fed to 240 feeder steers in a 2 x 4 factorial experiment for 42 d. Following shipping, the steers were given access to water and hay to regain some shrink loss. During the first week in the feedlot, steers fed the 16 and 18% CP diets had higher DM intakes, feed efficiency, and average daily gains than steers on the 12 and 14% protein diets. No differences were detected due to protein source. The authors suggested that the 12 and 14% CP diets should meet protein requirements for these calves. However, if intake is depressed the requirement may not be met. Therefore, the 16 and 18% protein diets in this study would come closer to meeting the protein requirement of a stressed feeder calf.

During wk 2, DM intakes increased for all treatments. For the total 6 wk trial, there were no differences in DM intake due to CP concentration. After 3 wk, no differences in feed efficiency were detected between treatments. However, a linear increase in feed efficiency was present with increasing CP levels for the total trial. Morbidity was 38, 50, 45, and 68% for 12, 14, 16, and 18% protein diets, respectively. Although higher protein concentrations should increase the N-balance and health of stressed animals, increased cortisol levels may decrease immune function (Nissen et al., 1989).

In a second trial, 240 steers (246 kg) were fed 11, 14, 17, 20, 23, or 26% crude protein diets for 28 d (Fluharty and Loerch, 1995). Blood meal and soybean meal were used as the protein sources. The steers were provided supplemental urea to allow adequate ruminal microbial synthesis for the 4 wk trial. Protein level did not affect DM intake. Consequently, increasing protein levels resulted in higher protein intakes. According to the authors, only the 23 and 26% CP diets provided enough protein for steers to gain 1 kg/d. Therefore, these two treatments resulted in higher average daily gains. Feed efficiency was also increased with increasing protein levels during the first week. By wk 2, feed intakes had increased and all diet, except the 11% CP diet, met requirements for steers to gain 1 kg/d. During wk 2, steers fed the

17% CP diet had the highest feed efficiency and daily gains of all treatments. Feeding excessive levels of protein, 23 and 26% CP, did not improve steer performance. For the total trial, performance was the poorest for steers on the 11% protein diet. Steers fed the 20% diet had the highest average daily gains, final weights, and feed efficiency for the total trial. No clear pattern was apparent between morbidity rates and protein levels.

In a third trial, 216 steers (238 kg) were used to determine the effects of decreasing protein concentration on feed intake during the receiving period. Blood meal, corn gluten meal, fish meal and soybean meal were the protein sources for the diets. Diets containing 23, 17 and 12.5% CP were fed during wk 1, 2 and 3, respectively. Soybean meal provided at least 50% of supplemental protein to ensure adequate microbial protein synthesis. A control group was fed a 12.5% CP diet throughout the trial. During wk 1, protein intake and daily gains were higher for steers fed the 23% CP diet. By wk 2, no differences were detected in daily gains or feed intake due to protein level or source. No differences were detected in morbidity or mortality between treatments.

McCoy et al. (1998) studied the effect of protein and energy sources on health and performance of newly received calves. Steer calves (257 kg) were used in a 2 x 2 factorial design in which factors were energy source and escape protein supplementation. Dry rolled corn and wet corn gluten feed were the energy sources and urea and feathermeal/blood meal were the protein sources. Calves consuming the wet corn gluten feed had lower feed intakes than those fed the dry rolled corn for the 21 d trial. An 18% increase in feed intake was observed in calves fed the wet corn gluten feed diets when supplemental bypass protein was provided. Metabolizable protein was higher for the more slowly degraded energy and protein sources, dry rolled corn and feathermeal/blood meal. Calves fed the dry rolled corn diet had lower morbidity than those fed the wet corn gluten feed. Therefore, a negative relationship was detected between metabolizable protein and percent morbidity.

In a second trial, 315 steers (252 kg) were fed the same treatments as the previous trial. During wk 1, dry rolled corn was included in the diet of steers on the wet corn gluten feed treatment to increase intake. Intakes were lower for steers fed the wet corn gluten feed. However, no differences were detected in daily gains due to energy source. A negative relationship was detected between metabolizable protein and morbidity.

Vitamins

The role of vitamins in feeder calf stress is primarily through disease resistance and a properly functioning immune system (Nockels, 1988). Increased levels of vitamins in the receiving diet of stressed feeder cattle have been researched. Experiments with B-vitamin and vitamin E supplementation in weaned or received cattle have produced variable results. Appropriate conditions for B-vitamin supplementation and exact vitamin E levels are unclear and need to be defined (Galyean et al., 1999). Vitamins A, C and D have also been studied in the stress response (Nockels, 1988).

Rumen microorganisms are capable of synthesizing all of the B-complex vitamins. When intake is depressed during shipping, production of B-vitamins by ruminal microflora may be reduced. Fluharty and Loerch (1999) stated that during a 48 h period of feed and water deprivation, numbers of rumen bacteria were reduced 10 to 25%. This decrease in rumen bacteria population may cause a decrease in microbial activity and B-vitamin synthesis. Therefore, response of stressed feeder cattle to B-vitamin supplementation may depend on severity of feed deprivation and feed intake.

The effects of posttransit B-vitamin supplementation on stressed feeder steers were studied in a 2 x 2 x 2 factorial design with 275 steers from 17 TN farms (Cole et al., 1979). The treatments were backgrounding or no backgrounding, feeding hay or a high-concentrate diet with antibiotics upon receiving, and supplementation with B-vitamins or no B-vitamins. One third of the calves were backgrounded and fed a 50% concentrate diet for 30 d prior to shipping. The remaining calves were weaned on the day of shipping. All calves were shipped on the same day and fasted for 24 h. After the 24 h period of feed and water deprivation, the backgrounded calves and one half of the newly weaned calves were given access to water and grass hay. The remaining calves were fed on a 50% concentrate diet containing supplemental antibiotic. All calves were fed for 3 d before shipping to Bushland, TX. Upon arrival, all calves were fed a 50% concentrate diet. Half of the pens received B vitamins and half were fed a diet without B vitamins. Supplemental B-vitamins included thiamin, riboflavin, pyridoxine, pantothenic acid, niacin, choline and B_{12}. On d 15 after arrival, all calves were placed on a 75% concentrate diet.

Backgrounded calves gained more during the 30 d prior to shipment than calves left with their dams. Transport shrink was the same for both treatments. Calves fed the 50% concentrate diet at the auction barn had a greater percentage of total shrink during transit than backgrounded and newly weaned calves fed only grass hay. Backgrounded calves had higher DM and H_20 intakes during wk 1, wk 2, and the first month on feed. During the first week after arrival, calves supplemented with B vitamins had significantly higher DM intakes than unsupplemented calves. Inversely, during the second week, intakes were significantly lower for B vitamin supplemented calves. B-vitamin supplementation decreased morbidity in newly weaned calves that were fed hay at the auction market and increased morbidity in backgrounded steers. The effect of B-vitamin supplementation on morbidity of newly weaned steers that were fed a high-energy diet at the auction market was intermediate to backgrounded and newly received steers fed hay at the market. The authors suggested that the intermediate response by the steers fed the high-energy diet at the market is likely because the ruminal microflora had adjusted to the concentrate diet and ruminal B-vitamin synthesis was sufficient. Without B-vitamin supplementation, fewer treatments were required and fewer relapses occurred for backgrounded calves than for newly weaned calves. When B vitamins were supplemented in the starter diet, backgrounded calves had a higher morbidity and relapse rate and required more treatments than control calves.

Newly weaned calves given the 50% concentrate diet at the auction market had retreatment rates intermediate between backgrounded and control calves. Supplementation with B vitamins tended to increase the retreatments required by the backgrounded steers and steers fed at the market, but decreased retreatments in newly weaned, hay-fed calves. Without supplementation, backgrounded calves were overall healthier as they had lower morbidity and retreatment rates. When B-vitamins were supplemented, morbidity and retreatment rates were lowest for newly weaned calves. This is likely due to the decreased ruminal B-vitamin synthesis when intake declines, when energy increases, or when dietary B vitamin concentration increases (Cole et al., 1979). Because newly weaned calves had lower *in vitro* gas production, intakes, and ruminal activity than the other treatments, B-vitamin supplementation was beneficial. The authors offered no explanation for the adverse effects of B-vitamin supplementation on backgrounded calves. Days on feed, daily gains, and feed efficiency were not affected by weaning status or supplementation. Backgrounded calves had lower feed conversions for the entire trial, compared to the control and high energy fed calves. Calves that had respiratory disease had significantly lower feed and water intakes and lower daily gains.

Cole et al. (1982) studied the influence of B-vitamin supplementation in the receiving diet of stressed feeder calves. One half of the calves from each of seven farms were weaned 30 d prior to shipping and fed a 50% concentrate diet. The remaining calves remained with their dams until all calves were shipped to a commercial auction barn. The calves were fasted for 24 h. At the end of the 24 h fasting period, calves were allowed access to fescue hay and water. The calves were then shipped 1600 km to a feedlot where they were all placed on the same 50% concentrate diet. B-vitamins (thiamin, riboflavin, pyridoxine, pantothenic acid, niacin, choline and B_{12}) were supplemented at three levels: no supplement, medium (NRC, 1996 requirement), and high. Supplemental B-vitamin was topdressed on diets. On d 30, the feedlot diet was changed to 75% concentrate and to 90% concentrate on d 44.

Backgrounded calves gained more prior to shipping than calves that remained with their dams until shipping. The results were highly variable between farms. The authors suggested the these results are likely the result of variations in milk production and/or grazing conditions. Total weight loss and hay consumption were similar for backgrounded and newly weaned calves during the marketing process. During the first month in the feedlot, DM intake was higher for backgrounded calves and was not affected by B-vitamin supplementation. Despite higher DMI, backgrounded calves did not have higher daily gains, resulting in lower feed efficiency. Calves supplemented with B-vitamins at the medium level gained slower than calves that were not supplemented or were supplemented at a high level. After 2 mo in the feedlot, gains were similar for all treatments. Feed conversion after 2 mo was lower for steers supplemented at the medium level.

Morbidity and mortality were not affected by treatments before or after shipping. Backgrounded steers required more days of treatment. No supplementation level x preshipment treatment interaction was seen in this study. Packed cell volume was lower for backgrounded calves upon arrival to the auction barn and through the first 7 d in the feedlot. B-vitamin supplementation did not affect packed cell volume. Plasma glucose levels decreased during the marketing process, increased during the first 7 d in the feedlot, and declined again for all treatments. Backgrounded calves had higher blood glucose levels on d 14 in the feedlot. Plasma urea-N concentrations were lower for control calves than for backgrounded calves. B-vitamin supplementation at a medium level resulted in higher PUN levels than unsupplemented calves. Steers supplemented at a high rate had greater feed conversions.

The antioxidant properties of vitamin E have been shown to increase humoral antibody production and to decrease the level of blood glucocorticoids, which inhibit the function of lymphocytes in the immune response (Nockels, 1988). The most important form of vitamin E, α-tocopherol, is destroyed by the ruminal microflora and is not stored to a great extent in the ruminant (Gill et al., 1999). The response to supplemental vitamin E is influenced by the level stored in the animal and in the receiving diet ingredients.

Carter et al. (2000) studied the effects of vitamin E supplementation on 130 newly received feedlot heifers. Cattle were fed a diet containing 2000 I.U. for 0, 7, 14, or 28 d. The NRC (1996) requirement is between 75 and 100 I.U., DM basis. Daily gains did not differ between cattle supplemented for 0, 7, or 28 d. However, daily gains were higher for cattle supplemented for 28 d as compared to those supplemented for 14 d. Dry matter intake and feed efficiency did not differ between treatments and there was no economic advantage of supplementing steers based on an antibiotic treatment cost.

The health and performance of newly received stocker cattle supplemented with vitamin E for 28 d was studied (Gill et al., 1999). The calves were fed prairie hay and a supplement with or without vitamin E for 21 d after receiving. At d 22, cattle were fed one half of the supplement they had been receiving. Average daily gains were higher for cattle fed the vitamin E supplement. The average daily gains of cattle that were never sick for the 4 wk period was also higher for vitamin E supplemented steers. Morbidity, mortality, and sick days were also lower for vitamin E supplemented steers. Among the sick cattle, those supplemented with vitamin E also had greater daily gains than unsupplemented cattle. Although the number of sick days was lower for vitamin E supplemented cattle, these cattle had a higher relapse rate, 17.8% compared to 13.3% for the unsupplemented stocker calves. Feed intakes were similar for both treatments, resulting in increased feed efficiency for vitamin E supplemented steers.

The performance, health, and humoral immune response of stressed steers injected with vitamin E and Se were studied (Droke and Loerch, 1989). No differences were detected in performance or morbidity due to treatment. However, based on antibody titer level, supplemented steers were better able to resist pathogens. All steers were vaccinated with *P. haemolytica*. In the first trial, steers were given no injection or injections of Se and vitamin E. Average daily gains, feed intakes, and feed efficiency did not differ between treatments. Average sick days were not affected by treatment. The authors suggested that these results may be due to the fact that the steers were not shipped and consequently not exposed to stresses and pathogens typically encountered during the marketing process. At 0 d, serum Se levels did not differ between treatments. By 7 d, supplemented steers had a higher IgG antibody titer than unsupplemented steers. At d 14, serum Se concentrations were greater for supplemented steers. By d 21, no differences in antibody titer existed between treatments.

In a second trial, the additive effects of Se and vitamin E were studied as steers were given no injection, a Se injection, a vitamin E injection, or both a Se and vitamin E injection.

Daily gains, intakes, feed efficiency and morbidity were not significantly affected by treatment. In comparison with the earlier trial, calves used in this study were exposed to typical marketing procedures and therefore more pathogens and stresses. By d 6, serum antibody production was significantly higher for steers receiving both Se and vitamin E than for steers receiving only one treatment. On d 7, there were no differences in serum α-tocopherol levels between treatment. No differences existed between treatments by d 13.

In a third trial, it was shown that steers that received Se and vitamin E injections 2 wk prior to shipping and again at receiving had increased serum Se, but showed no advantage in any performance parameter and did not have an increase in antibody titers. Administering twice the dosage of Se and vitamin E at receiving also had no effect on morbidity or performance in the feedlot.

Little research has been conducted on the effects of vitamins A, C, and D on stressed feeder calves. Supplemental vitamin C should increase immunocompetence of stressed calves as stress decreases vitamin C stored in the body (Nockels, 1988). Vitamin C has been shown to enhance neutrophil function, reduce circulating corticoid levels, and reduce their effects on neutrophil. Stress has also been mentioned as a factor affecting redistribution of vitamin A, which is responsible for maintaining epithelial keratinization, preventing pathogen entry.

Minerals

The decreased intake associated with shipping and weaning stress can result in mineral deficiencies which can impair and alter immune function (Petersen, 1995). Because of decreased appetite and feed intake, concentration of trace minerals in receiving diets may need to be increased to meet the requirement. Not only are dietary mineral levels decreased, but mineral metabolism in feeder calves is altered by stress and by infection with IBRV (Infectious Bovine

Rhinotracheitis Virus) (Galyean et al., 1981; Galyean et al, 1999). Copper, Cr, Fe, K, Zn, Ca, P and Se play crucial roles in proper immune function (Cole 1991). Shipping stress has been shown to decrease serum Fe concentrations (Galyean et al., 1981). A 24 h fast can also cause a decrease in serum Ca, Mg and alkaline phosphatase and an increase in serum P levels (Galyean et al., 1981). Infection with IBRV has been shown to increase fecal P excretion and increased urinary Zn and Cu excretion (Orr et al., 1990). Increased levels of these minerals in the receiving diet may combat the detrimental effects of altered mineral metabolism (Galyean et al., 1999).

Orr et al. (1990) studied the effects of Bovine Respiratory Disease and Infectious Bovine Rhinotracheitis on serum Cu, Zn, Ca, and P concentrations. In an observational trial, peak morbidity of shipping stressed calves occurred at approximately 7 d after arrival to the feedlot. Serum Zn levels of morbid calves were lower than healthy calves, possibly due to decreased feed intake. Morbid calves also consumed less feed than healthy calves. Serum Cu levels were higher for morbid calves on d 9. By d 10, serum levels were higher for healthy calves. In a second trial, calves from seven different farms were shipped to a buying station where they were mixed for 3 d and shipped to the feedlot. At the buying station, morbid calves displayed lower serum Zn levels. After 52 d in the feedlot, serum Zn levels still had not reached the level prior to shipping. Serum levels increased for healthy and morbid animals from the time they left farm of origin until peak morbidity, about 7 d after arrival to the feedlot. Calves that had been morbid in the receiving phase had higher serum Cu on d 28 and d 52.

Steers averaging 255 kg were given an intranasal inoculation of IBRV 8 d after arrival to the feedlot (Orr et al., 1990). Serum samples were taken on d 20. Peak morbidity was reached 4 d after inoculation. While serum Zn levels decreased, urinary Zn excretion increased. Due to the catabolic effects of stress, the breakdown of proteins may yield amino acids that bind to plasma Zn and increase filtration rate in the kidney. The day after inoculation, serum Cu levels and urinary copper excretion were increased. Increased cortisol levels of stressed animals likely result in increased urinary Cu excretion. Serum Ca increased 4 d after inoculation with IBRV. Increased levels of corticoid in the stressed animal may cause release of parathyroid hormone (PTH) increasing serum Ca levels. Serum P decreased following infection. This could be a result of reduced P absorption, reduced resorption from tissues, increased P utilization, or simply reduced feed intake (Orr et al., 1990).

Nockels et al. (1993) studied the the effects of supplemental Cu and Zn levels on Cu and Zn levels of stressed cattle. Calves were acclimated to pens and fitted with urine and fecal bags. Steers were treated with adrenocorticotropic hormone (ACTH) to attain cortisol levels of stressed calves. After 12 d, the steers were fasted for 36 h to simulate feed deprivation during shipping. When supplemental Cu and Zn were removed from the diet, calves had a negative Cu balance. Fecal and urinary Cu excretion increased during stress. Zinc balance remained positive when mineral supplements were removed. Urinary Zn levels were reduced during stress. Possibly due to the degrading of muscle proteins during fasting, serum Zn levels were higher on the second day of fasting.

With the exception of K, actual mineral requirements of stressed cattle are not different from those of unstressed cattle (Galyean, 1999). Potassium in important in maintaining a cellular osmotic equilibrium, integrity of the heart and kidney muscle, and normal heart function. Dehydration during shipping can cause increased concentration of K in the extracellular space. This increased concentration of K activates aldosterone, which causes excretion of excess potassium from the body and could possibly result in a K deficiency (Hutcheson et al., 1984).

Feeder calves exposed to the stresses of the marketing process may require 20% more dietary K than feeder calves that are not transported (Hutcheson et al., 1984). Steers (198.2 kg) were used in a 2 x 2 factorial design. The treatments were a 55% concentrate diet vs. grass hay for 3 d prior to shipping and post-receiving diets of .9 vs. 1.4% K fed for 2 wk. After 2 wk, all steers were fed a .7% K diet. Calves fed the 55% concentrate diet prior to shipping had a higher shrink rate than calves fed grass hay. No differences were detected in morbidity or mortality due to pre- or postshipping treatments. An interaction between pre- and postshipping diet was observed. Steers fed grass hay prior to shipping and receiving the .9% K receiving diet had significantly lower gains during the receiving period than the other treatments. Calves fed the 55% concentrate diet before shipping and receiving the 1.4% K receiving diet had higher feed intakes than the other treatments. No differences were detected in plasma glucose between treatments. Steers fed the 55% concentrate diet prior to shipping had higher plasma urea-N and Na concentration than steers fed grass hay. By d 7, serum Na levels were higher for steers fed the 1.4% K diet than steers fed the .9% diet. Serum K and osmolality were not affected by K level in the receiving diet.

In a second trial, steers were used in a 2 x 4 factorial design. Steers were fed a 55% concentrate diet or grass hay prior to shipping. Upon receiving, they were fed diets with .7, 1.3, 2.2, or 3.1% K for 2 wk. All steers were fed a .7% K diet after wk 2. Potassium level in the receiving diet did not significantly affect morbidity. Mortality was lower ($P<.05$) for steers fed 1.3 and 2.2% K diets. Of calves fed hay prior to shipping, those fed the .7% potassium receiving diet had the lowest daily gains. When calves were fed the 55% concentrate diet prior to shipping, a receiving diet with 2.2% K resulted in the poorest daily gains. Because of the K content in the preshipment concentrate diet, these steers may not respond to additional K.

Although serum Na concentration, K concentration and osmolality were not affected by receiving treatment, packed cell volume did increase as dietary K level increased. An increase in packed cell volume can indicate dehydration, increased red blood cell numbers, or an increase in corpuscular volume. The authors suggested that the increased K levels may have caused a rapid influx of water into the red blood cells, increasing mean corpuscular volume.

Effects of Cr supplementation on stressed feeder cattle have been studied (Moonsie-Shageer, 1993). Chromium is primarily important for mediating the action of insulin through its role with the glucose tolerance factor, a complex molecule with nicotinic acid, glycine, glutamic acid, and cysteine. Steers were fed a high Cr yeast supplement, antibiotic supplement, or a combination of both for 28 d before being fasted and vaccinated with infectious bovine rhinotracheitis and parainfluenza viruses (Chang and Mowat, 1992). After 2 wk on the same prefast diet, steers were rerandomized and fed isocaloric and isonitrogenous soybean meal or urea-corn based growing diets for 70 d. Feed intake tended to be lower for control calves receiving neither supplemental Cr nor antibiotics. Feed intake tended to be higher for steers fed only the Cr or antibiotic suppplement, but the not for calves fed the combination of Cr and antibiotic. Decreased performance of control steers indicates that bioavailability of Cr in the corn silage receiving diet may be limited. Intakes were similar for all treatments by wk 4. Steers fed Cr had 30% higher daily gains and were 27% more efficient than unsupplemented steers. Antibiotic supplementation also increased average daily gains, intakes, and feed efficiency. However, effects of both supplements were not additive. Chromium supplementation had no effect on morbidity. After feed and water deprivation and vaccinations, Cr had no effect on daily gains, intake, or feed efficiency. Chromium requirements may therefore be lower in the growing period than in the more stressful receiving period. Chromium supplementation increased serum protein, urea-N, and Mg levels. A lower level of serum cortisol was present in steers given supplemental Cr. No differences were detected in insulin, cholesterol, or fatty acid levels of Cr supplemented steers. Steers supplemented with Cr and fed the soybean meal grower diet had higher serum alkaline phosphatase levels. Similarly, when combined with the soybean meal grower diet, Cr supplementation increased serum antibody titers.

Steers were fed 0, .2, .5, and 1 ppm Cr in receiving diets for 30 d (Moosie-Shageer and Mowat, 1993). Daily gains were higher for steers on the .2 and 1 ppm diets. Feed intakes were higher for steers fed at .2 and .5 ppm supplemental Cr. Morbidity was lower for Cr supplemented steers, with steers fed the .2 ppm Cr diet having the lowest morbidity for the entire 30 d period. Benefits of supplemental Cr may be delayed as plasma cortisol levels decreased linearly as Cr level increased on d 28 ($P<.05$). Supplementation did affect metabolism of other minerals. On d 7, serum Ca was higher for supplemented steers. Magnesium levels increased linearly with supplementation level. Supplemented steers tended to have higher antibody titers.

Results of Cr supplementation have been inconsistent. Kegley et al. (1995) studied the effects of Cr on immune response and performance of stressed feeder cattle. Steers were fed .4 mg Cr/kg of dry matter intake for 56 d after shipping. Possibly due to minor stress level, no morbidity was observed in this trial. No differences were detected in steer performance, cortisol levels, antibody titers, or cell-mediated immunity (skin fold test).

Kegley et al. (1997) also studied the influence of pretransit Cr supplementation on performance, immunity, and health of stressed feeder cattle. Steers were fed a 0 or .4 ppm for 56 d before being shipped to an unfamiliar location to simulate the marketing process. Chromium supplementation prior to shipping had no effect on daily gains, intake, efficiency, or plasma cortisol levels. For the entire pre and post-shipping study, Cr supplementation improved daily gains.

Selenium has been implicated in cell-mediated and humoral immune systems. Swecker et al. (1989) studied the influence of supplemental Se on the humoral immune response to newly weaned beef calves. Sixty steer and heifer calves were fed a Se-deficient diet for 112 d feeding trial. Calves were fed 20 mg Se/kg mineral mixture with and without a single injection of 0.1 mg Se and 0.22 IU vitamin E; 80, 120, 160, or 200 mg Se/kg of mineral mixture supplement. No differences were detected in performance. However, higher levels of Se supplementation (120, 160 and 200 mg/kg) increased serum Se concentrations. Calves supplemented with only 20 mg/kg Se had lower IgG antibody responses than calves on the other treatments. Calves supplemented at 80 and 120 mg/kg Se had the highest antibody response during this time. Calves injected with additional Se and vitamin E had an increased antibody response to an antigen when compared with calves consuming similar dietary Se.

A study was conducted to evaluate the effect of Se status on health and immune response of stressed calves (Reffet-Stabel et al., 1989). Twenty weaning and transport stressed calves were fed Se adequate and Se deficient diets with and without *P. hemolytica* inoculation. At the end of the trial, inoculated calves had significantly higher daily gains. Selenium deficient calves also had higher daily gains than Se adequate calves. Whole blood and serum levels of glutathione peroxidase (GSH-Px) were significantly higher in Se adequate cattle. Glutathione peroxidase is an antioxidant enzyme that inactivates the free radicals hydrogen peroxide and lipid peroxide that can result during periods of oxidative stress. In this study, increases in GSH-Px coincided with increases in appearance of morbidity. The authors suggested that the increases observed may indicate oxidative tissue damage caused by stress. High levels of GSH-Px can also indicate adequate Se status of the animal.

Objectives

The overall objective of this project was to develop nutritional regimens for backgrounding weaned beef calves. The specific objectives were to evaluate the effects of various protein and energy supplements to stressed calves consuming different forages during the backgrounding period. The effects of these supplementation programs on health, performance, blood serum components and immune parameters were investigated.

Experimental Procedure

Animals and Diets

Drylot Study. Forty-eight crossbred heifer calves (219.1 kg), produced at the Shenandoah Valley Agricultural Research and Extension Center (SVAREC), Steeles Tavern, VA, were used in a 6 wk backgrounding trial beginning on October 24, 2000, at SVAREC. The calves were blocked by preweaning weight into six blocks of eight heifers. Calves within each block were allotted to eight drylots. Drylots were 10.2 x 4.8 m in a partially covered shed. The drylots were allotted at random to two replicates of the following four treatments: 1) fescue hay, 2) fescue hay and a 15% CP supplement fed at 0.5% body weight (BW), 3) fescue hay and a 15% CP supplement fed at 1.0 % BW, and 4) fescue hay and a 30% CP supplement fed at 0.5% BW. Supplements were composed of corn and soybean meal (SBM) and were mixed in 682 and 818 kg batches for 15 min in a Davis horizontal mixer (H.C. Davis Sons MFG, Co., Inc., Bonner Springs, Kansas). Before being bagged, each batch was sampled and samples were stored in plastic bags for chemical analysis. Mineral supplement was provided to cattle in all lots, which contained 11.8% Ca, 6.5% P, 1.2% K, 11.3% Mg, 139 ppm I, 2511 ppm Cu, 120 ppm Se, 5100 ppm Zn and 1101 I.U./kg vitamin E, as fed basis. Ingredient composition of the supplements is presented in Table 1.

Pasture Study 1 –Big Meadow. Thirty-six crossbred steer calves (217.3 kg), produced at SVAREC, were used in a 6 wk backgrounding trial beginning on October 24, 2000, at SVAREC. The calves were blocked by preweaning weight into six blocks of six steers each. The calves within each block were allotted to six pastures of stockpiled tall fescue. The pastures were allotted at random to two replicates of the following three treatments: 1) no supplement, 2) 15% CP supplement fed at 0.5% BW, or 3) 15% CP supplement fed at 1% BW. Supplements were composed of corn and SBM, and were mixed in 818 kg batches for 15 min in a Davis horizontal mixer (H.C. Davis Sons MFG, Co., Inc., Bonner Springs, Kansas). Before being bagged, each batch was sampled and samples were stored in plastic bags for chemical analysis. Mineral supplement, which contained 11.8% Ca, 6.5% P, 1.2% K, 11.3% Mg, 139 ppm I, 2511 ppm Cu, 120 ppm Se, 5100 ppm Zn and 1101 I.U./kg vitamin E, as fed basis, was provided to cattle in all pastures. Ingredient composition of supplements is presented in Table 1.

Pasture Study 2 - Nutrient Management. Forty-eight crossbred steers (202 kg) were used in a 4 x 3 factorial backgrounding trial for 6 wk. Steers were purchased at a feeder cattle auction in Winchester, VA, on October 25, 2000, and transported the following morning to SVAREC. Upon arrival, steers were randomly allotted to twelve paddocks of stockpiled tall fescue in the order in which they came through the working chute. Paddocks were blocked by prior fertilization method. Prior fertilization methods included: no fertilizer, poultry litter fed to grazing cattle, poultry litter applied directly to pastures or inorganic fertilizer applied. Paddocks within blocks were randomly allotted to the following three treatments: 1) no supplement, 2) ground corn supplemented at 1% BW, or 3) a 15% CP supplement fed at 1% BW. The 15% CP

Table 1. Ingredient composition of supplements.

	Crude protein, %[a]	
Ingredient	15	30
	------------------%[b]----------------	
Corn	83.42	44.41
Soybean meal[c]	16.58	55.59

[a] Calculated, DM basis
[b] As fed basis
[c] 44% CP, solvent extracted

supplement was composed of corn and SBM and was mixed in 818 kg batches for 15 min each in a Davis horizontal mixer (H.C. Davis Sons MFG, Co., Inc., Bonner Springs, Kansas). Before being bagged, each batch was sampled and samples were stored in plastic bags for chemical analysis. Mineral blocks (PM ag Products, Homewood, IL) were provided to cattle on all pastures. The supplement blocks contained 4% CP, 5% Ca, 4% P, 2% K, 1% Mg, 69 ppm I, 27 ppm Cu, 21.6 ppm Se, 540 ppm Zn and 220 I.U./kg vitamin E, as fed basis. Ingredient composition of the 15% CP supplement is presented in Table 1.

Pasture Study 3 - Kentland Farm. Forty-eight steers (202.4 kg) were used in a 2 x 2 factorial backgrounding trial at Kentland farm, Blacksburg, VA, for 6 wk. The steers were purchased at a feeder cattle auction in Dublin, VA, on November 1, 2000, and transported the following morning to the Kentland farm. The steers were blocked into six blocks of eight steers by the order in which they came through the working chute upon arrival. Steers within each block were randomly allotted to eight pastures. Four pastures consisted of stockpiled tall fescue and four pastures consisted of stockpiled tall fescue-alfalfa. Steers in four pastures of fescue and four pastures of fescue-alfalfa were allotted at random to two replicates of the following two treatments: 1) no supplement, or 2) 15% CP supplement fed at 0.5% BW. Supplements were composed of corn and SBM and were mixed in 682 kg batches for 15 min in a Davis horizontal mixer (H.C. Davis Sons MFG, Co., Inc., Bonner Springs, Kansas). Before being bagged, each batch was sampled and samples were stored in plastic bags for chemical analysis. Mineral blocks containing 65.95 g poloxalene per kilogram (PM Ag Products, Homewood, IL) were provided to cattle in tall fescue-alfalfa pastures to prevent bloat. These blocks contained 4% CP, 5% Ca, 4% P, 2% K, 1% Mg, 69 ppm I, 27 ppm Cu, 21.6 ppm Se, 540 ppm Zn and 220 I.U./kg vitamin E, as fed basis. Trace mineralized salt blocks (Cargill, Inc., Minneapolis, MN) containing 38% Na, .35% Zn, .2% Fe, .2% Mn, .03% Cu, .01% I and .01% Co, as fed basis, were provided to cattle in fescue pastures and in fescue-alfalfa pastures after the alfalfa had been grazed. Ingredient composition of the supplement is presented in Table 1.

Protocol for all Trials

For calves produced at SVAREC, d 0 of the present trials was the day the calves were weaned. For the remaining calves, d 0 was the day the calves arrived on location.

Upon arrival or weaning, cattle on all trials were treated for internal parasites with Cydectin® pour-on anthelmintic (Fort Dodge Animal Health, Fort Dodge, IA). Calves in the drylot study and pasture study 1 were vaccinated 5 wk prior to weaning for bovine respiratory (BRD), infectious bovine rhinotracheitis (IBR), parainfluenza (PI_3), and bovine viral diarrhea (BVD) with Pyramid 4® (Fort Dodge Animal Health, Fort Dodge, IA) and for clostridial disease with Vision 7® (Intervet, Boxeer, Netherlands). Calves in pasture study 2 were vaccinated with Pyramid 4® and Vison 7® upon receiving. Calves in pasture study 3 were vaccinated at the sale barn on the day of the sale for IBR, PI_3, BVD, *P. haemolytica*, and clostridial diseases. Calves on pasture study 3 were also implanted with 36 mg zeranol (Ralgro®, Schering-Plough Animal Health Corp., Madison, NJ) on d 0.

Cattle were weighed and rectal temperatures were taken on d 0, 7, 14, 28 and 42. Upon receiving and on all working dates, blood samples were collected via jugular venipucture. Samples were centrifuged at 600 x g for 15 minutes and serum was frozen until analysis. On d 0, 14 and 28, blood samples were collected for Se and GSH-Px analysis. One-half of the calves in each pen or pasture were randomly selected for GSH-Px analysis on all three dates.

Supplemented cattle were fed 0.23 kg supplement beginning on d 1 and increased by 0.23 kg per day until the appropriate supplementation level was reached. Supplementation levels were adjusted by pen average body weight on the day following each working date. Refusals were weighed and recorded.

In the drylot study, 22.73 kg grass hay were fed to each pen of heifers on d 0. Hay was increased if refusals were 2.27 kg or higher. Refusals in excess of 4.55 kg were weighed and recorded.

Morbidity scores were assigned to each animal at feeding each morning. Morbidity scores were based on a subjective scoring system described in Table 2 (Perino and Apley, 1998). Sick cattle were identified by depression, anorexia, nasal discharge, coughing and separation from contemporaries. Cattle were treated with the broad-spectrum antibiotics Micotil® (Elanco Animal Health, Indianapolis, IN) or Nuflor® (Schering-Plough Animal Health Corp., Madison, NJ) when a morbidity score of 3 or higher was assigned or when rectal temperature was increased.

Botanical composition of each paddock was estimated on d 0. Forage quality samples were collected on d 0, 7, 14, 28 and 42. Grab samples were taken with a set of hand-held forage shears at approximately 10 paces in a crisscross pattern throughout each pasture. Samples were collected at an estimated forage height of 2.5 cm. Samples were dried for 48 h in a forced draft oven and stored in cloth bags until further analysis. Forage mass samples were collected on d 0, 14, 28 and 42. Two 3.0 x 0.5 m strips were selected at random and mowed at approximately 2.5 cm height with a mower (American Honda Motor Co., Duluth, GA). Samples were dried for 72 h in a forced draft oven in cloth bags and weighed. Hay samples were collected using a core sampler. Throughout the duration of the drylot trial, every third bale was sampled. Hay samples were stored in plastic bags until further analysis.

Chemical Analyses

Table 2. Morbidity scoring system

Score	Description
1	Normal, no signs of disease.
2	Noticeable depression, signs of weakness are usually not apparent.
3	Marked depression, moderate signs of weakness may be apparent. but without significantly altered gait.
4	Severe depression accompanied by signs of weakness such as altered gait or lowered head.
5	Moribund, unable to rise.

Forage and hay samples were ground to pass a 1 mm-mesh screen of a Wiley mill (Thomas Wiley, Laboratory Mill Model 4, Arthur H. Thomas Co. Philadelphia , PA). Hay samples were ground individually, subsampled, and composited by week for chemical analysis. Concentrate samples were ground in an Osterizer® blender (Sunbeam-Oster, Milwaukee, WI) to equalize ingredient particle size and allow uniform subsampling. Forage, hay and supplement samples were analyzed for DM and ash (AOAC, 1990), NDF (Van Soest and Wine, 1967), ADF (Van Soest, 1963), cellulose and lignin (Van Soest and Wine, 1968) and N, using the Kjeldahl method (AOAC, 1990). All forage and supplement samples were wet-ashed with 2:1 (V|V) HNO_3:$HClO_4$ for mineral analysis (Muchovej et al., 1986). The digested samples and serum were analyzed for Ca, Mg, Zn, Cu, K and Se using an atomic absorption spectrometer (PerkinElmer, Inc., Norwalk, CN). Selenium analysis was conducted on whole blood using the graphite furnace component of the spectrometer.

Forage P analysis was conducted using a colorimetric method (Fiske and Subbarow, 1925) on a Spectronic® 21D (Milton Roy, Rochester, NY) on the digested samples. Blood samples were analyzed for serum urea-N (SUN) and P concentrations using an autoanalyzer (Beckman SYNCHRON CX SYSTEMS®, Beckman Instruments, Inc., Brea, CA). The SUN concentration of samples involved a SUN enzymatic rate reagent. The reaction between the reagent and the sample produces a change in absorbance at 340 nanometers and the concentration of urea N in the serum is proportional to the change in the absorbance. The SYNCHRON CX® System then calculates the SUN concentration of the sample. The serum samples were analyzed for P by a colorimetric reaction with a molybdate reagent. On d 0, 14, and 28, blood samples were analyzed for white blood cell GSH-Px using an OxyScan Automated

Oxidative Stress Analyzer® (OXIS Health Products, Portland, OR). A colorimetric reaction was used to measure the reaction of GSH-Px and reagents.

Statistical Analysis

Data for all trials were analyzed using the GLM (SAS, 1999) procedure for analysis of variance of a completely randomized block design. In the drylot study, single degrees of freedom comparisons were used to contrast supplemented and unsupplemented treatments, supplementation of a 15% CP supplement at 0.5% and 1% BW, and supplementation of a 15% CP or 30% CP supplement at 0.5% BW. In pasture studies 1and 2, an orthogonal contrast of effects was used to compare supplemention of a 15% CP supplement at 0.5% and 1% BW and supplementation of a 15% CP supplement or corn at 1% BW, respectively. In pasture study 3, Tukey's one way analysis of variance test was used to compare treatment and forage type effects and forage type x treatment interactions. For all trials, Tukey's one way analysis of variance test was conducted for time effect on serum concentrations. Except for Se and GSH-Px data, all serum data collected on d 0 was excluded for time interactions. Animal was the experimental unit when individual measurements were taken. Pen was the experimental unit used for hay and supplement intake. All means are reported as least squares means (LSM).

Results

Chemical Composition of Feeds.

Chemical composition of supplements is presented in Table 3. Crude protein was higher than calculated values for the 15% CP and 30% CP supplements. Crude protein for corn was lower than values reported by NRC (1996). Neutral detergent fiber, ADF, and cellulose were higher for the 30% CP supplement compared to the corn and 15% CP supplements. This difference is due to the higher proportion of SBM in the supplement and the higher proportion of NDF, ADF and cellulose in SBM than corn (NRC, 1996). Similarly, mineral concentrations increased with increasing concentration of SBM in the supplement. According to NRC (1996), SBM generally has higher mineral concentrations than corn.

Chemical composition of hay fed during the drylot study is presented in Table 4. The average analyzed CP value was similar to values of grass hay reported by NRC (1996). This protein concentration was adequate for growing calves in drylot (NRC, 1996).

Drylot Study

Performance. On d 28, heifers fed the 15% CP supplement at 0.5% BW were heavier (P<0.05) than those fed the 30% CP supplement (Figure 1). On d 42, supplemented heifers were heavier (P<0.05) than unsupplemented heifers.

The performance data are presented in Table 5. No differences were detected in initial weights across blocks or treatments. No significant differences were detected in cumulative daily gains due to treatment on d 7 or 14. By d 28, heifers supplemented with the 15% CP supplement at 0.5% BW had higher (P<0.05) daily gains than heifers fed the 30% CP supplement at 0.5% BW. At d 28, among the heifers fed the 15% CP supplement, those supplemented at 0.5% BW had higher (P<0.05) daily gains than those supplemented at 1% BW.

Table 3. Chemical composition of supplements.

	Supplement		
		Crude protein, %[a]	
Item	Corn	15	30
DM, %	87.6	90.8	91.3
Ash, %[b]	8.2	5.9	6.4
CP, %[b]	8.86	16.13	31.93
NDF, %[b]	11.2	9.9	11.2
ADF, %[b]	2.8	2.9	4.7
Cellulose, %[b]	3.4	3.5	5.3
Ca, %[b]	0.065	0.074	0.305
Mg, %[b]	0.122	0.160	0.279
K, %[b]	0.661	0.997	1.684
P, %[b]	0.388	0.404	0.594
Cu, ppm[b]	2.03	5.04	12.35
Zn, ppm[b]	19.1	20.1	31.8
Se, ppm[b]	0.799	0.756	1.424

[a] Calculated, DM basis
[b] DM basis

Table 4. Chemical composition of hay fed in drylot

Item	Fescue hay
DM, %	93.87
Ash, %[a]	7.04
CP, %[a]	11.76
NDF, %[ab]	62.57
ADF, %[ac]	35.17
Cellulose, %[a]	31.90
Lignin, %[a]	3.69
Ca, %[a]	0.703
Mg, %[a]	0.270
K, %[a]	3.64
P, %[a]	0.343
Cu, ppm[a]	6.59
Zn, ppm[a]	16.12
Se, ppm[a]	0.048

[a] DM basis
[b] Neutral detergent fiber
[c] Acid detergent fiber

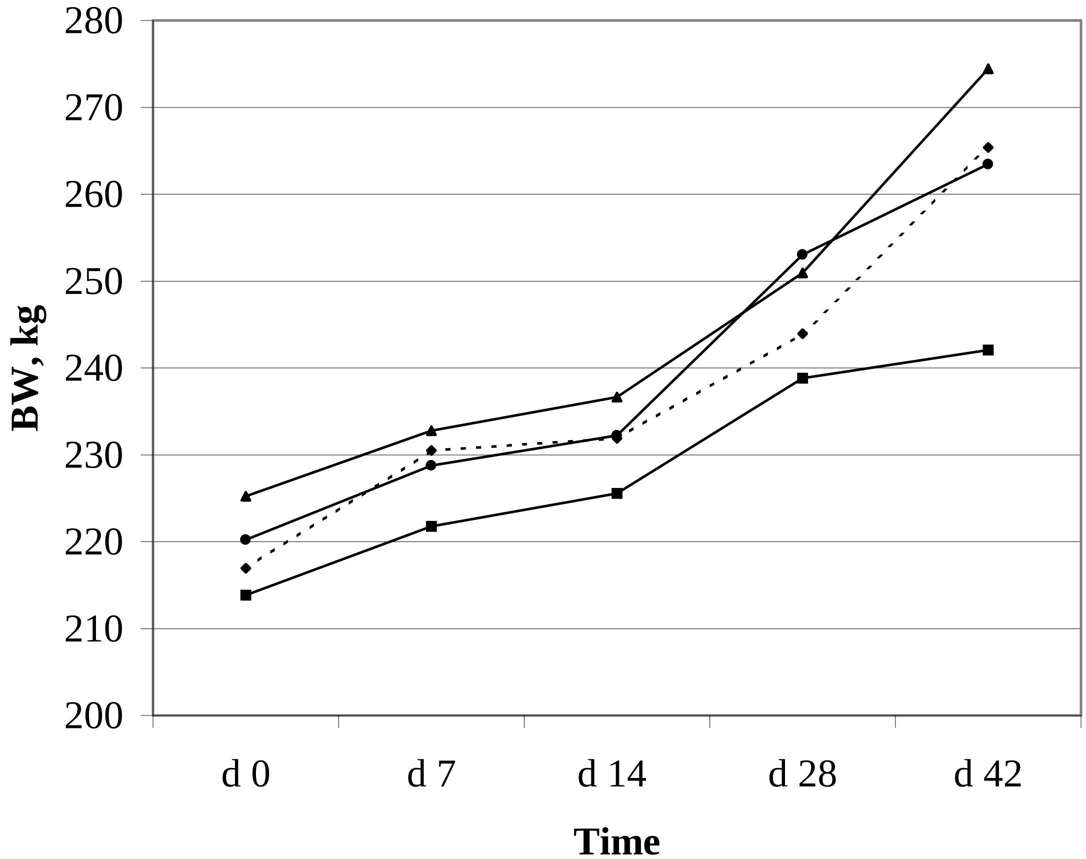

Figure 1. Body weights of heifers during the backgrounding period. Drylot study. Supplements: none (■), 15% CP, 0.5% BW(●), 15% CP, 1% BW(▲), 30% CP, 0.5% BW (♦). On d 28, 15% vs 30% CP supplement and 0.5% BW vs 1% BW of 15% CP supplement (*P*<0.05). On d 42, no supplement vs supplement (*P*<0.05).

Table 5. Effects of supplementation on performance of heifers fed grass hay. Drylot study.

		Supplement			
		Crude protein, %[a]			
		15		30	
Item	None	0.5% BW	1.0% BW	0.5% BW	SEM
Initial weight, kg	213.9	225.2	220.2	217.0	3.58
Average daily gain, kg/d[b]					
Day 7	1.13	1.08	1.22	1.93	0.40
Day 14	0.84	0.81	0.86	1.07	0.21
Day 28[cd]	0.89	1.17	0.92	0.96	0.10
Day 42[e]	0.67	1.17	1.03	1.15	0.07
DMI, kg/d					
Hay[d]	3.88	3.70	3.22	3.81	0.20
Supplement[d]	--	1.04	1.81	1.02	0.01
Total[e]	3.88	4.74	5.03	4.83	0.21
Feed:gain, kg					
Hay:gain[e]	5.79	3.16	3.13	3.31	0.51
Supplement:gain[d]	--	0.88	1.76	0.89	0.09
Total[e]	5.79	4.05	4.88	4.20	0.57

[a] Calculated, DM basis
[b] Cumulative daily gain
[c] 15% vs. 30% CP supplement at 0.5% BW (*P*<0.05)
[d] 0.5% vs. 1.0% BW of 15% CP supplement (*P*<0.05)
[e] No supplement vs. supplement (*P*<0.05)

By d 42, heifers on all supplement treatments had average daily gains that were higher (*P*<0.05) than unsupplemented heifers.

Hay intake was lower (*P*<0.05) for heifers fed the 15% CP supplement at 1% BW compared to heifers supplemented at 0.5% BW. Due to differences in supplementation level, heifers supplemented at 1% BW had higher supplement intake than heifers supplemented at 0.5% BW (*P*<0.05). Unsupplemented heifers had lower (*P*<0.05) total feed intake by the end of the trial.

Heifers supplemented the 15% CP supplement at 0.5% BW required less (*P*<0.05) supplement per unit of gain than heifers supplemented at 1.0% BW. Supplement efficiency was similar between heifers fed the 15 and 30% CP supplements at 0.5% BW. Hay efficiency and total feed efficiency was higher (*P*<0.05) for supplemented steers, compared to unsupplemented steers. However, no difference existed among supplemented treatments.

Rectal Temperatures, Morbidity Scores and Treatments. No differences in rectal temperatures were detected due to treatment throughout the present trial. The morbidity scores and health data are presented in Table 6. No significant differences were detected in morbidity scores assigned to heifers across all treatments throughout the trial, perhaps due to the low incidence of morbidity. For all treatments, morbidity scores were higher during wk 2 and 3.

Number of animals treated coincided with peak morbidity scores as the number of animals treated was highest during the second week. Twelve animals were treated during this trial, and no calves were treated more than once.

Blood Serum Mineral Concentrations. Serum mineral concentrations are presented in Table 7. At the beginning of the trial, serum concentrations of Ca, Mg, K, P, Cu and Zn were similar for all cattle. No differences were detected across treatment on d 7, 14, 28 and 42. A

Table 6. Effects of supplementation on morbidity and treatment of heifers fed grass hay. Drylot Study.

	Supplement				
		Crude protein, %[a]			
		15		30	
Item	None	0.5% BW	1.0% BW	0.5% BW	SEM
Morbidity[b]					
Week 1	1.01	1.07	1.08	1.02	0.22
Week 2	1.04	1.13	1.10	1.06	0.31
Week 3	1.03	1.07	1.08	1.01	0.29
Week 4	1.00	1.00	1.00	1.00	0.00
Week 5	1.00	1.08	1.00	1.00	0.04
Week 6	1.00	1.00	1.00	1.00	0.00
Treated[c]					
Week 1	--	--	2	--	
Week 2	1	2	3	2	
Week 3	--	1	1	--	
Week 4	--	--	--	--	
Week 5	--	--	--	--	
Week 6	--	--	--	--	

[a] Calculated, DM basis
[b] Based on a subjective morbidity scoring system (1= healthy, 5 = moribund)
[c] Number of animals treated

Table 7. Effects of supplementation on serum profiles of heifers fed grass hay. Drylot study

			Supplement			
			Crude protein, %[a]			
			15		30	
Day	Item	None	0.5% BW	1.0% BW	0.5% BW	SEM
0	Ca, mg/dl	11.41	11.42	11.40	11.37	0.18
	Mg, mg/dl	2.08	2.20	2.15	2.17	0.06
	K, mg/dl	22.59	21.88	22.10	22.06	0.71
	P, mg/dl	7.71	7.27	7.61	7.22	0.26
	Cu, ppm	0.50	0.48	0.50	0.51	0.05
	Zn, ppm	0.85	0.85	0.79	0.78	0.04
	Urea-N, mg/dl	13.42	12.36	13.59	13.41	0.69
7	Ca, mg/dl	11.09	11.06	11.06	11.13	0.13
	Mg, mg/dl	1.82	1.81	1.61	1.82	0.08
	K, mg/dl	20.28	19.21	19.15	20.74	0.65
	P, mg/dl	8.47	8.06	7.61	8.47	0.38
	Cu, ppm	0.42	0.40	0.43	0.40	0.02
	Zn, ppm	0.39	0.40	0.34	0.36	0.02
	Urea-N, mg/dl[bc]	9.45	8.97	7.01	12.69	0.60
14	Ca, mg/dl	10.96	10.97	11.01	11.21	0.11
	Mg, mg/dl	1.78	1.78	1.81	1.84	0.06
	K, mg/dl	20.09	18.68	19.36	20.68	0.48
	P, mg/dl	8.50	6.95	7.38	8.48	0.35
	Cu, ppm	0.45	0.40	0.48	0.41	0.05
	Zn, ppm	0.63	0.64	0.60	0.58	0.04
	Urea-N, mg/dl[bde]	12.03	8.07	8.12	13.67	0.58
28	Ca, mg/dl	10.43	10.29	10.31	10.26	0.10
	Mg, mg/dl	2.15	2.05	1.96	1.96	0.14
	K, mg/dl	22.69	21.24	21.57	21.84	0.69
	P, mg/dl	7.40	7.70	7.46	8.63	0.57
	Cu, ppm	0.45	0.43	0.49	0.45	0.03
	Zn, ppm	0.46	0.45	0.47	0.43	0.02
	Urea-N, mg/dl[bde]	7.51	8.82	10.01	12.97	0.75
42	Ca, mg/dl	11.18	10.97	11.08	10.99	0.14
	Mg, mg/dl	2.08	2.20	2.15	2.17	0.06
	K, mg/dl	27.23	26.91	25.78	25.52	0.89
	P, mg/dl	8.85	8.29	8.42	8.29	0.26
	Cu, ppm	0.88	0.88	0.86	0.83	0.04
	Zn, ppm	1.08	1.12	1.03	1.02	0.05
	Urea-N, mg/dl[b]	10.49	8.71	9.30	16.70	0.66

[a] Calculated, DM basis

[b] 15% CP supplement vs 30% CP supplement at 0.5% BW(*P*<0.05)

[c] 0.5% vs 1.0% BW supplementation of 15% CP(*P*<0.05)

[d] No supplement vs. supplement (*P*<0.05)

[e] Time x treatment interaction on d 14 and 28 with PUN levels of unsupplemented and 15% CP supplemented heifers (*P*<0.05)

block effect was detected on d 28. However, this effect was random as the cattle were blocked by preweaning weight.

Serum Urea-N. Serum urea-N (SUN) concentration data are presented in Table 7. No SUN differences were observed on d 0. By d 7, among heifers supplemented at 0.5% BW, those fed the 30% CP supplement had higher ($P<0.05$) SUN values than those fed the 15% CP supplement. Among the heifers fed the 15% CP supplement, those fed at 0.5% BW had higher ($P<0.05$) SUN values on d 7 than those fed at 1% BW.

On d 14, unsupplemented heifers had SUN concentrations that were higher ($P<0.05$) than supplemented heifers, but on d 28 the reverse was seen. A time by treatment interaction ($P<0.05$) was observed on d 14 and 28. On d 14, unsupplemented heifers had higher ($P<0.05$) SUN levels than supplemented heifers. By d 28, unsupplemented heifers had lower ($P<0.05$) SUN concentrations than supplemented heifers. On d 42, supplemented heifers did not differ in SUN concentration from unsupplemented heifers.

Blood Glutathione Peroxidase and Selenium Concentrations. Glutathione peroxidase activity and Se concentrations are presented in Table 8. No differences were detected in GSH-Px activity due to treatment on d 0, 14 or 28. On d 14 and 28, GSH-Px concentrations were higher ($P<0.05$) for all cattle than the initial values. Selenium concentrations did not differ across treatment on d 0, 14 or 28. Blood Se values were lower ($P<0.05$) on d 28 than values observed on d 0 and 14. No correlation was observed between GSH-Px and Se concentrations.

Pasture Study 1 – Big Meadow

Forage Mass and Composition. Forage chemical composition, mineral status and mass data are presented in Table 9. Data from all pastures were averaged and are presented by sampling date as no consistent differences in pasture composition were observed across

Table 8. Effects of supplementation on glutathione peroxidase activity and serum Se concentrations of heifers fed grass hay. Drylot study.

		Supplement			
			Crude protein, %[a]		
		15		30	
Item	None	0.5% BW	1.0% BW	0.5% BW	SEM
Day 0					
GSH-Px, mU/mg	39.16	42.06	35.54	42.98	5.87
Se, ppm	0.177	0.174	0.170	0.174	0.012
Day 14					
Gsh-Px, mU/mg[b]	58.64	52.90	65.44	54.76	5.98
Se, ppm	0.176	0.187	0.161	0.178	0.010
Day 28					
Gsh-Px, mU/mg[b]	64.53	65.14	60.67	62.67	4.88
Se, ppm[c]	0.169	0.169	0.145	0.157	0.011

[a] Calculated, DM basis
[b] GSH-Px values on d 14 and 28 differ from values on d 0 (P<0.05)
[c] Values on d 28 are lower than values on d 0 and 14 (P<0.05)

Table 9. Chemical composition, mineral levels and forage mass of pastures grazed by steers[a]. Big Meadow

	Sampling day				
Item	0[b]	7	14	28	42
Ash, %	9.4	9.8	9.5	8.1	6.4
CP, %	18.10	18.15	17.66	15.34	15.16
NDF, %[c]	51.51	49.40	53.81	54.08	57.19
ADF, %[d]	25.77	25.10	27.26	27.82	28.8
Cellulose, %	24.26	24.57	25.22	25.70	26.7
Lignin, %	1.09	0.79	1.64	1.84	1.70
Ca, %	0.50	0.55	0.64	0.56	0.54
Mg, %	0.291	0.287	0.295	0.259	0.231
P, %	0.28	0.28	0.26	0.27	0.25
K, %	2.88	3.00	3.03	2.027	0.895
Cu, ppm	6.09	4.48	7.3	13.5	4.26
Zn, ppm	17.11	15.71	17.03	13.75	14.80
Se, ppm	0.029	0.036	0.018	0.021	0.026
Mass, kg/ha	3292.4	--	2978.9	2803.0	1673.1

[a] Dry matter basis
[b] Cattle supplemented at 0.5% BW grazed pastures higher in Zn than cattle supplemented at 1.0% BW on d 0.
[c] Neutral detergent fiber
[d] Acid detergent fiber

treatments. At the beginning of the trial, cattle placed on the 15% CP supplement at 0.5% BW treatment were grazing forage higher (*P*<0.05) in Zn concentration than unsupplemented steers and steers supplemented at 1.0% BW. No differences were detected in forage chemical composition across treatments for the remainder of the trial.

Fiber components (NDF, ADF, cellulose and lignin) generally increased in all pastures over the 6 wk period. Crude protein level in the forage generally decreased throughout the grazing period. No consistent trends were observed in mineral composition between pastures. Forages in all pastures were low in Se concentration. Forage mass decreased throughout the grazing period.

Performance. On d 7, supplemented steers were heavier (*P*<0.05) than unsupplemented steers (Figure 2). On d 14, 28 and 42, steers supplemented at 0.5% BW were heavier (*P*<0.05) than steers supplemented at 1% BW.

The performance data are presented in Table 10. As the calves were blocked by preweaning weight, no difference was detected at the beginning of the trial across treatments. During wk 1, unsupplemented steers had higher (*P*<0.05) daily gains than steers receiving either supplement. During the second week, performance of unsupplemented steers did not differ from unsupplemented steers. Among the supplemented treatments, at the end of wk 2, 4, and 6, steers supplemented at 0.5% BW had higher (*P*>0.05) daily gains than those supplemented at1.0% BW. Steers supplemented at 0.5% BW had higher (P<0.05) supplement efficiencies.

Rectal Temperatures, Morbidity Scores and Treatments. No differences in rectal temperatures were detected due to treatment throughout the present trial. Health and morbidity scoring data are presented in Table 11. Morbidity scores were averaged across treatment by week. No differences were detected in morbidity scores across treatment for any week or for the

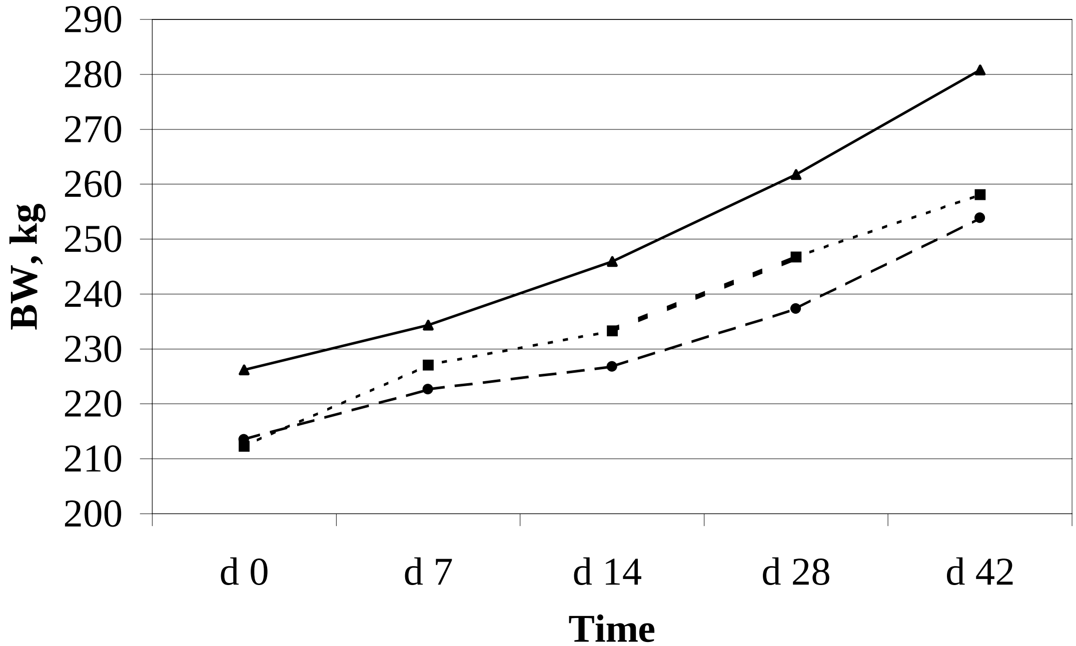

Figure 2. Body weights of steers during the backgrounding period. Pasture study 1. Supplements: none (▪), 15% CP, 0.5% BW (▲), 15% CP, 1% BW (•). On d 7, no supplement vs supplement (*P*<0.05). On d 14, 28 and 42, 0.5% BW vs 1% BW of 15% CP supplement (*P*<0.05).

Table 10. Effects of supplementation on performance of steers grazing stockpiled tall fescue. Big Meadow.

	Supplement			
		15% CP[a], %BW		
Item	None	0.5	1.0	SEM
Initial weight, kg	212.3	226.2	213.5	2.95
Average daily gain, kg[b]				
Day 7[c]	2.11	1.16	1.31	0.27
Day 14[d]	1.50	1.41	0.95	0.13
Day 28[d]	1.23	1.27	0.85	0.09
Day 42[d]	1.09	1.30	0.96	0.08
Supplement intake, kg/d[d]	--	1.03	1.87	0.02
Supplement:gain, kg[d]	--	0.79	1.94	0.15

[a] Calculated, DM basis
[b] Cumulative daily gain
[c] No supplement vs supplement (*P*<0.05)
[d] 0.5% supplement vs 1.0% supplement (*P*<0.05)

Table 11. Effects of supplementation on morbidity and treatment of steers grazing stockpiled tall fescue. Big Meadow.

		Supplement 15% CP[a], % BW		
Item	None	0.5	1.0	SEM
Morbidity[b]				
Week 1	1.00	1.03	1.00	0.21
Week 2	1.06	1.06	1.08	0.22
Week 3	1.01	1.03	1.07	0.23
Week 4	1.00	1.00	1.00	0.00
Week 5	1.00	1.00	1.00	0.00
Week 6	1.00	1.00	1.00	0.00
Treated[c]				
Week 1	--	--	--	
Week 2	1	2	--	
Week 3	--	--	--	
Week 4	--	--	--	
Week 5	--	--	--	
Week 6	--	-	--	

[a] Calculated, DM basis
[b] Based on a subjective morbidity scoring system (1 = healthy, 5 = moribund)
[c] Number of animals treated

entire trial. Peak morbidity scores were observed during wk 2.

Treatment of sick calves occurred during incidence of peak morbidity. During wk 2, three steers were treated for BRD. No calves were treated more than once during this trial. No differences were observed across treatment during any week or for the total trial in number of treated calves.

Blood Serum Mineral Concentrations. Serum mineral concentration data are presented in Table 12. On d 0 and d 7, no differences were detected in Ca, Mg, K, P, Cu or Zn due to treatment. From d 0 to d 7, a time effect was observed ($P<0.05$) as serum Mg, Cu and Zn concentrations were lower than initial values. On d 14, unsupplemented steers had higher ($P<0.05$) serum Ca concentrations than supplemented steers. Among the supplemented steers, supplementation at 0.5% BW resulted in higher serum Ca levels. On d 28, a block effect was detected on serum Ca concentration. By d 42, supplemented steers did not differ in serum Ca concentration from unsupplemented steers. Among the supplemented steers, those supplemented at 1% BW had lower ($P<0.05$) serum Ca concentrations. A random block effect was detected in serum K concentration on d 14. No difference was detected in P concentration between supplemented and unsupplemented steers throughout the trial. However, on d 14, steers supplemented at 0.5% BW had higher ($P<0.05$) serum P concentrations than those supplemented at 1.0% BW. Zinc status did not differ between supplemented and unsupplemented treatments throughout the trial. On d 14, steers supplemented at 0.5% BW had higher ($P<0.05$) serum Zn levels than those supplemented at 1.0% BW. Zinc levels were higher ($P<0.05$) on d 0 and 42 compared to the other days. Serum Cu levels were lower ($P<0.05$) for unsupplemented calves than for supplemented calves on d 28. However, this difference was not detected on d 42.

Serum Urea-N. Serum urea-N (SUN) concentration data are presented in Table 12. No

Table 12. Effects of supplementation on serum profiles of steers grazing stockpiled tall fescue. Big Meadow.

Day	Concentration	Supplement None	15% CP[a], % BW 0.5	15% CP[a], % BW 1.0	SEM
0	Ca, mg/dl	11.07	11.08	11.31	0.20
	Mg, mg/dl	2.10	2.12	2.23	0.06
	K, mg/dl	19.91	19.90	20.48	0.48
	P, mg/dl	7.37	7.56	7.74	0.17
	Cu, ppm	0.74	0.83	0.73	0.04
	Zn, ppm	0.57	0.71	0.69	0.04
	Urea-N, mg/dl	12.24	13.29	13.00	0.66
7	Ca, mg/dl	11.35	11.26	11.09	0.10
	Mg, mg/dl[b]	1.66	1.66	1.67	0.05
	K, mg/dl	19.60	19.58	20.30	0.36
	P, mg/dl	6.34	6.11	5.96	0.34
	Cu, ppm[b]	0.38	0.41	0.38	0.02
	Zn, ppm[b]	0.35	0.33	0.30	0.02
	Urea-N, mg/dl	12.63	11.12	11.64	0.70
14	Ca, mg/dl[cd]	11.32	11.25	10.93	0.07
	Mg, mg/dl	1.84	1.91	1.81	0.04
	K, mg/dl	18.76	18.87	18.54	0.46
	P, mg/dl[d]	6.27	7.11	5.50	0.33
	Cu, ppm	0.74	0.78	0.84	0.05
	Zn, ppm[bd]	0.37	0.42	0.35	0.02
	Urea-N, mg/dl[b]	10.53	9.30	8.05	0.77
28	Ca, mg/dl	10.77	10.89	10.69	0.10
	Mg, mg/dl	1.89	1.85	1.86	0.05
	K, mg/dl	21.96	22.80	24.03	0.73
	P, mg/dl	6.12	6.42	6.26	0.38
	Cu, ppm[bc]	0.36	0.44	0.46	0.02
	Zn, ppm[b]	0.37	0.41	0.39	0.02
	Urea-N, mg/dl[b]	10.35	9.47	9.47	0.65
42	Ca, mg/dl[d]	11.97	11.94	11.49	0.15
	Mg, mg/dl	2.16	2.08	1.98	0.06
	K, mg/dl	24.44	25.99	26.30	0.69
	P, mg/dl	7.48	7.33	6.85	0.32
	Cu, ppm	0.75	0.82	0.86	0.04
	Zn, ppm	0.80	0.89	0.91	0.05
	Urea-N, mg/dl[d]	11.40	13.21	10.78	0.65

[a] Calculated, DM basis
[b] Values are different from d 0 and 42 (P<0.05)
[c] No supplement vs. supplement (P<0.05)
[d] 0.5% BW vs. 1.0% BW (P<0.05)

differences were detected in SUN concentration on d 0 or 7. On d 14 and 28, SUN concentrations were lower (*P*<0.05) for cattle on all treatments than initial values. No differences were detected among treatments. At 42 d, steers supplemented at 0.5% BW had higher (*P*<0.05) SUN concentration than steers supplemented at 1.0% BW.

Blood Glutathione Peroxidase and Selenium Concentrations. Glutathione peroxidase activity and Se concentration data are presented in Table 13. No difference was detected in GSH-Px activity on d 0 and 14 across treatment. A block effect was present on d 0 (*P*<0.05). Cattle placed on the unsupplemented treatment showed a trend (*P*<0.10) towards higher GSH-Px concentration on d 0. However, this effect was random as cattle had not been exposed to treatments. On d 28, unsupplemented cattle had higher (*P*<0.05) GSH-Px activity than supplemented cattle. For all cattle, GSH-Px activity was higher (*P*<0.05) on d 14 and 28 than initial values. Selenium concentration did not differ among treatments on d 0 and 14. On d 28 supplemented steers had higher (*P*<0.05) blood Se concentration.

A positive correlation (r = 0.42, P<0.05) was observed between Se and GSH-Px concentrations (P<0.05) at d 28. Calves on the unsupplemented treatment also had higher (P<0.05) GSH-Px values on d 0 and 14.

Pasture Study 2 – Nutrient Management

Forage Mass and Composition. Forage mass and chemical composition data are presented in Table 14. At the beginning of the trial, unfertilized pastures had lower (*P*<0.05) herbage mass than pastures fertilized with the three fertilizer treatments.

On d 7, ash was lower for unfertilized pastures (*P*<0.05). On d 14, no differences were detected in forage composition or mass across fertilization method or supplementation level. On d 28, ash was higher (*P*<0.05) in forages that had litter applied compared to unfertilized pastures

Table 13. Effects of supplementation on glutathione peroxidase activity and Se concentrations of steers grazing stockpiled tall fescue. Big Meadow.

Item		Supplement		
		15% CP[a], % BW		
	None	0.5	1.0	SEM
Day 0				
Gsh-Px, mU/mg	48.59	34.40	38.81	4.25
Se, ppm	0.161	0.175	0.164	0.012
Day 14				
Gsh-Px, mU/mg[b]	62.15	58.87	59.03	7.28
Se, ppm	0.147	0.174	0.178	0.014
Day 28				
Gsh-Px, mU/mg[bc]	69.01	57.42	55.40	2.93
Se, ppm[c]	0.159	0.194	0.187	0.013

[a] Calculated, DM basis
[b] Values differ from d 0 (*P*<0.05)
[c] No supplement vs. supplement (*P*<0.05)

Table 14. Chemical composition and forage mass of pastures grazed by steers[a]. Nutrient management

Day	Item	Fertilization method: None	Litter fed	Litter applied	Inorganic fertilizer	SEM
0	Mass, kg/ha	1855.4[b]	3486.1[c]	3927.9[c]	3436.5[c]	203.3
	Ash, %	8.06	8.84	9.30	8.63	0.34
	Crude protein, %	16.81	17.61	16.71	17.71	0.47
	NDF, %	54.83	55.93	56.49	56.91	1.32
	ADF, %	27.85	28.48	28.83	28.82	0.52
	Cellulose, %	25.45	25.98	26.52	26.39	0.53
	Lignin, %	1.65	1.88	2.22	1.30	0.68
7	Ash, %	7.45[b]	8.38[c]	8.65[c]	8.97[c]	0.48
	Crude protein, %	15.30	16.66	17.26	16.51	0.39
	NDF, %	55.65	55.67	55.62	56.36	1.09
	ADF, %	26.19	26.64	26.36	26.71	0.32
	Cellulose, %	24.02	24.28	24.22	24.52	0.29
	Lignin, %	1.80	1.74	1.43	1.95	0.36
14	Mass, kg/ha	1248.8	1723.9	2392.7	2093.1	344.4
	Ash, %	7.33	8.26	8.65	7.95	0.35
	Crude protein, %	14.41	14.62	15.84	15.07	0.45
	NDF, %	59.70	59.66	61.17	58.68	1.25
	ADF, %	29.58	29.77	30.13	28.80	0.70
	Cellulose, %	26.23	26.49	27.25	26.08	0.52
	Lignin, %	2.02	2.80	2.19	2.26	0.44
28	Mass, kg/ha	1024.0	2189.4	2788.0	2478.2	451.4
	Ash, %	6.49[b]	6.93[b]	8.03[c]	7.06[bc]	0.23
	Crude protein, %	13.12	12.88	12.97	13.49	0.55
	NDF, %	53.82	54.09	54.86	53.15	0.84
	ADF, %	26.62	27.02	27.63	26.63	0.44
	Cellulose, %	24.81	25.43	25.50	25.04	0.31
	Lignin, %	1.38	1.39	1.30	1.23	0.15
42	Mass, kg/ha	663.7[b]	1431.1[c]	2579.9[c]	1897.4[c]	395.1
	Ash, %	5.97	6.25	6.60	6.33	0.30
	Crude protein, %	13.00	13.23	13.40	13.27	0.36
	NDF, %	58.5	57.03	57.35	55.70	0.83
	ADF, %	29.30	28.68	28.60	27.57	0.44
	Cellulose, %	27.27	26.80	26.60	25.83	0.34
	Lignin, %	1.70	1.28	1.60	1.03	0.38

[a] DM basis
[b, c] Means with different superscript differ (P<0.05)

or pastures previously grazed by litter fed cattle. On d 42, no differences were detected in chemical composition or forage mass. Generally, decreases in forage CP, mass and ash were observed with time in all pastures. In the present study, no consistent differences were detected in forage mass or chemical composition due to supplementation treatment. Therefore, the calves on all treatments likely selected similar forage components and had similar available forage during the trial.

Forage mineral concentration data are presented in Table 15. At the beginning of the trial forage in unfertilized pastures had lower (P<0.05) K concentration than fertilized pastures. On d 14 and 28, unfertilized forages had lower (P<0.05) K concentrations than the litter fertilized and litter fed pastures. On d 28, Mg concentrations were lower (P<0.05) for both litter fed and litter applied pastures, compared to unfertilized pastures.

Performance. On d 0 and 7, corn supplemented steers were lighter (P<0.05) than those fed the 15% CP supplement (Figure 3). For d 0, this effect was random as calves had not been exposed to treatment. On d 7, unsupplemented steers were heavier (P<0.05) than supplemented steers. By d 14, corn supplemented steers were heavier than those fed the 15% CP supplement. On d 42, supplemented steers were heavier (P<0.05) than unsupplemented steers.

The performance data are presented in Table 16. After 7 d, steers supplemented with the 15% CP supplement had lower (P<0.05) daily gains than corn-supplemented steers. Steers supplemented with the 15% CP supplement had negative weight gains during wk 1. Unsupplemented steers had higher daily gains than supplemented steers (P<0.05).

After 14 d, cumulative daily gains for unsupplemented steers did not differ from supplemented steers. Corn supplemented steers had higher (P<0.0001) daily gains than steers supplemented with the 15% CP supplement. By d 28, no differences were detected in

Table 15. Mineral composition of pastures grazed by steers[a]. Nutrient management.

		Fertilization method				
Day	Item	None	Litter fed	Litter applied	Inorganic fertilizer	SEM
0	Ca, %	0.94	0.75	0.77	0.81	0.025
	Mg, %	0.41	0.36	0.35	0.37	0.014
	K, %	3.07[b]	3.72[c]	4.46[c]	3.97[c]	0.171
	P, %	0.33	0.38	0.34	0.39	0.032
	Cu, ppm	7.67	7.69	8.07	6.34	0.372
	Zn, ppm	17.53	15.98	15.94	16.22	1.50
	Se, ppm	0.037	0.032	0.026	0.030	0.003
7	Ca, %	0.88	0.72	0.75	0.79	0.043
	Mg, %	0.46	0.38	0.40	0.42	0.024
	K, %	3.35	4.00	3.83	4.33	0.303
	P, %	0.30	0.32	0.29	0.33	0.013
	Cu, ppm	6.87	6.93	7.40	5.93	0.368
	Zn, ppm	15.17	13.80	16.63	14.83	2.52
	Se, ppm	0.033	0.030	0.030	0.033	0.002
14	Ca, %	0.85	0.68	0.70	0.67	0.05
	Mg, %	0.40	0.35	0.35	0.34	0.018
	K, %	1.25[b]	2.00[c]	2.12[c]	1.80[c]	0.171
	P, %	0.31	0.34	0.33	0.37	0.02
	Cu, ppm	3.96	4.26	3.81	3.31	0.43
	Zn, ppm	17.13	18.88	15.65	14.79	2.52
	Se, ppm	0.036	0.021	0.021	0.024	0.007
28	Ca, %	0.67	0.55	0.55	0.60	0.04
	Mg, %	0.33[b]	0.29[c]	0.29[c]	0.30[bc]	0.012
	K, %	1.17[b]	1.61[c]	1.97[c]	1.67[c]	0.139
	P, %	0.29	0.32	0.31	0.33	0.014
	Cu, ppm	3.70	3.76	1.91	2.20	1.10
	Zn, ppm	14.8	12.43	12.37	12.97	1.77
	Se, ppm	0.019	0.023	0.023	0.017	0.003
42	Ca, %	0.70	0.60	0.60	0.63	0.05
	Mg, %	0.30	0.28	0.30	0.30	0.02
	K, %	1.00	1.35	1.35	1.40	0.17
	P, %	0.28	0.29	0.28	0.32	0.01
	Cu, ppm	6.77	5.38	5.80	5.50	0.76
	Zn, ppm	15.80	13.68	14.75	13.10	2.18
	Se, ppm	0.040	0.023	0.023	0.028	0.001

[a] DM basis

[b, c] Means with different superscript differ (P<0.05)

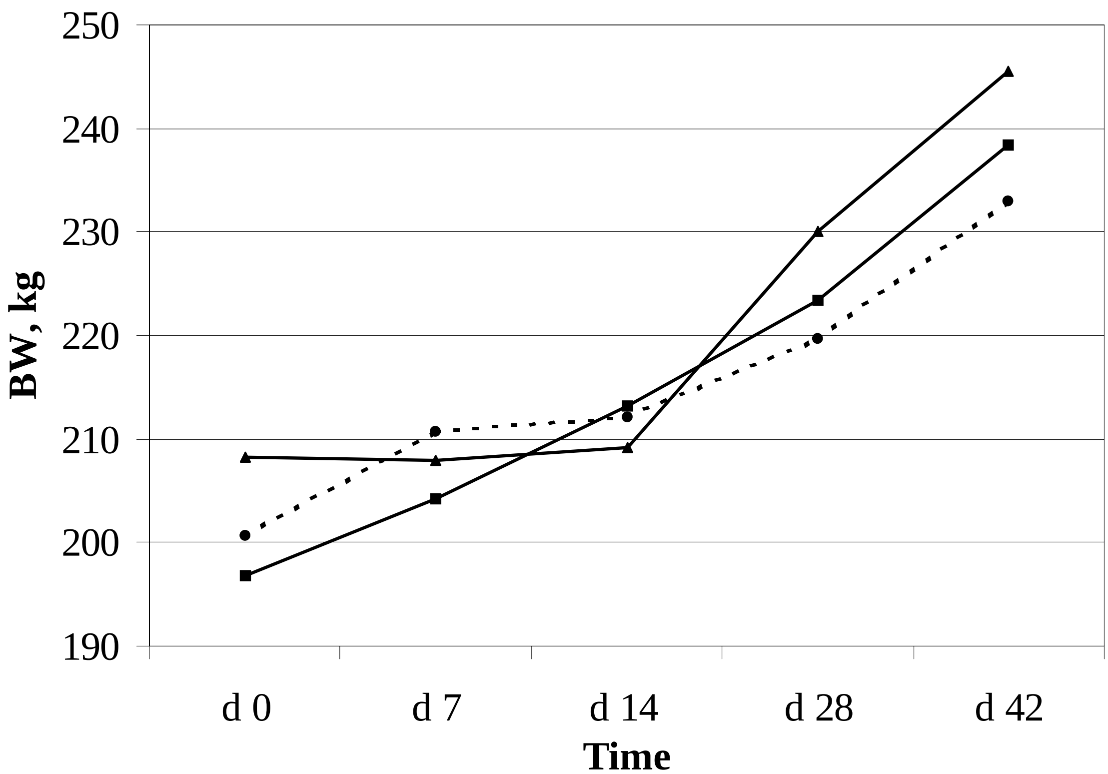

Figure 3. Body weights of steers during the backgrounding period. Pasture study 2. Supplements: none (•), corn, 1% BW (▪), and 15% CP, 1% BW (▲). On d 0, 7, and 14, corn vs 15% CP supplement (*P*<0.05). On d 7 and 42, no supplement vs supplement (*P*<0.05).

Table 16. Effects of supplementation on performance of steers grazing stockpiled tall fescue. Nutrient management.

Item	Supplement			
	None	Corn	15% CP[a]	SEM
Initial weight, kg[b]	200.6	196.8	208.2	3.85
Average daily gain, kg/d[c]				
Day 7[bd]	1.45	1.07	-0.04	0.53
Day 14[b]	0.82	1.17	0.07	0.22
Day 28	0.68	0.95	0.78	0.23
Day 42[d]	0.77	0.99	0.89	0.13
Supplement intake, kg/d	--	1.64	1.76	0.18
Supplement:gain, kg		1.66	1.98	0.35

[a] Calculated, DM basis
[b] Corn vs. 15% CP supplement (P<0.05)
[c] Cumulative daily gain
[d] No supplement vs. supplement (P<0.05)

cumulative daily gains between treatment. By the end of the trial, supplemented steers higher ($P<0.05$) daily gains than unsupplemented steers. No differences were detected in daily gains between the two supplemented groups. No differences were detected in supplement efficiency between the two supplemented treatments.

Rectal Temperatures, Morbidity Scores and Treatments. No differences in rectal temperatures were detected due to treatment throughout the present trial. Morbidity scores and health data are presented in Table 17. Morbidity scores were averaged across treatment within week. No difference was detected throughout the trial in morbidity scores across treatment. Morbidity scores were numerically higher during wk 2 and 3 of the trial.

Number of cattle treated did not significantly differ across treatment during any week or for the total trial. A higher number of unsupplemented cattle were treated compared to unsupplemented cattle. The highest number of animals treated occurred during wk 2. By the end of the trial, 11 calves had been treated. One calf was treated more than once. During wk 4, one steer died due to Bovine Viral Diarrhea (BVD). A second steer was diagnosed with BVD and removed from the study. Data from these animals were eliminated from statistical analysis to avoid any bias.

Blood Serum Mineral Concentrations. Serum mineral concentration data are presented in Table 18. No difference was detected in serum Ca concentration between treatment or pasture treatment on d 0. On d 7, corn supplemented steers had higher ($P<0.05$) serum Ca concentrations than steers supplemented with the 15% CP supplement. A time x treatment interaction was observed as this difference was reversed ($P<0.05$) on d 14. A block effect was detected on d 14, 28 and 42 ($P<0.05$). On d 42, supplemented cattle had higher ($P<0.05$) serum Ca concentrations than unsupplemented calves.

Table 17. Effects of supplementation on morbidity and treatments of steers grazing stockpiled tall fescue. Nutrient management.

Item	Supplement			SEM
	None	Corn	15% CP[a]	
Morbidity[b]				
Week 1	1.00	1.00	1.02	0.07
Week 2	1.13	1.02	1.00	0.35
Week 3	1.26	1.04	1.00	0.58
Week 4	1.10	1.02	1.00	0.31
Week 5	1.01	1.00	1.00	0.04
Week 6	1.00	1.00	1.00	0.00
Treatments[c]				
Week 1	--	--	1	
Week 2	6	2	1	
Week 3	--	1	--	
Week 4	--	--	--	
Week 5	--	--	--	
Week 6	--	--	--	

[a] Calculated, DM basis
[b] Weekly values based on a subjective morbidity scoring system (1 = healthy, 5 = moribund)
[c] Number of animals treated

Table 18. Effects of supplementation on serum profiles of steers grazing stockpiled tall fescue. Nutrient management.

Day	Concentration	Supplement None	Supplement Corn	Supplement 15% CP[a]	SEM
0	Ca, mg/dl	11.18	11.00	10.93	0.18
	Mg, mg/dl[b]	2.29	2.19	2.14	0.03
	K, mg/dl	26.33	26.69	24.70	0.93
	P, mg/dl	8.37	8.46	7.29	0.32
	Cu, ppm	0.71	0.62	0.68	0.03
	Zn, ppm	0.78	0.76	0.80	0.04
	Urea-N, mg/dl	10.49	12.13	10.95	0.99
7	Ca, mg/dl[c]	11.60	11.68	11.44	0.06
	Mg, mg/dl[c]	1.68	1.77	1.60	0.03
	K, mg/dl[c]	21.52	23.34	21.24	0.59
	P, mg/dl	6.79	7.65	7.03	0.25
	Cu, ppm	0.36	0.34	0.34	0.01
	Zn, ppm[c]	0.50	0.51	0.40	0.02
	Urea-N, mg/dl[d]	12.81	12.01	12.44	0.56
14	Ca, mg/dl[c]	11.30	11.28	11.46	0.06
	Mg, mg/dl[c]	1.76	1.90	1.74	0.06
	K, mg/dl	20.62	21.19	21.82	1.05
	P, mg/dl[c]	8.40	8.56	7.41	0.31
	Cu, ppm	0.58	0.61	0.63	0.04
	Zn, ppm[c]	0.43	0.42	0.34	0.03
	Urea-N, mg/dl[d]	11.08	10.91	9.53	1.18
28	Ca, mg/dl	10.99	10.13	10.75	0.26
	Mg, mg/dl	1.95	1.81	1.88	0.05
	K, mg/dl	20.18	19.92	20.10	1.00
	P, mg/dl[b]	6.22	7.69	7.71	0.19
	Cu, ppm[bc]	0.45	0.55	0.49	0.02
	Zn, ppm	0.41	0.37	0.43	0.03
	Urea-N, mg/dl[b]	11.27	9.18	8.97	0.29
42	Ca, mg/dl[b]	10.93	11.75	11.95	0.24
	Mg, mg/dl[be]	2.29	2.19	2.14	0.03
	K, mg/dl	22.76	24.31	23.28	0.74
	P, mg/dl[b]	7.05	8.76	8.29	0.18
	Cu, ppm	0.75	0.78	0.73	0.04
	Zn, ppm[bc]	0.91	0.98	1.14	0.05
	Urea-N, mg/dl[bc]	10.24	7.24	8.84	0.27

[a] Calculated, DM basis
[b] No supplement vs. supplement (P<0.05)
[c] Corn vs 15% CP supplement (P<0.05)
[d] Time x treatment interaction on d 7 and 14 between serum Ca levels of corn and 15% CP supplemented steers (P<0.05)
[e] Calves from litter fed pastures had serum Mg values were higher than other three fertilization methods (P<0.05)

At the beginning of the trial, unsupplemented steers had higher serum Mg conceentrations than unsupplemented steers ($P<0.05$). However, these effects were random as cattle had not been exposed to pastures or treatments at this time. On d 7, a block effect was detected ($P<0.05$). This effect was also random as cattle were allotted by order through the chute upon arrival. On d 7 and 14, corn supplemented steers had higher ($P<0.05$) serum Mg concentrations than steers supplemented with the 15% CP supplement. Treatment, fertilization method, and block effects were detected by the end of the trial. Unsupplemented steers had higher Mg concentrations than supplemented steers ($P<0.05$). Steers grazing litter fed pastures had higher ($P<0.05$) serum Mg concentrations than the other three treatments. On d 7, corn supplemented steers had higher ($P<0.05$) serum K than the cattle on the other two treatments.

Phosphorus concentration did not differ by treatment or fertilization method on d 7. By d 14, corn supplemented steers had higher ($P<0.05$) serum P concentrations than steerssupplemented with the 15% CP supplement. On d 28 and 42, supplemented steers had higher ($P<0.05$) serum P concentrations than unsupplemented steers.

On d 28, serum Cu concentrations were higher ($P<0.05$) for supplemented steers than for unsupplemented steers. Corn supplemented steers had higher ($P<0.05$) Cu concentrations than steers fed the 15% CP supplement. By the end of the trial, no differences were detected in Cu concentrations across treatments or fertilization methods.

Zinc concentrations were higher for corn supplemented steers than for steers supplemented with the 15% CP supplement on d 7 and 14 ($P<0.05$). On d 42, values were lower ($P<0.05$) for corn supplemented steers, compared to the steers fed the 15% CP supplement. At the end of the trial, supplemented steers also had higher serum Zn concentrations than unsupplemented steers ($P<0.05$).

Serum Urea-N. Serum urea-N data are presented in Table 18. No differences were detected at the beginning of the trial. On d 28 and 42, unsupplemented steers had higher (P<0.05) SUN levels than supplemented steers. On d 42, corn supplemented steers had lower (P<0.05) SUN concentrations than steers supplemented with the 15% CP supplement.

Blood Glutathione Peroxidase and Selenium Concentrations. Glutathione peroxidase and Se concentration data are presented in Table 19. On d 0, unsupplemented steers had higher GSH-Px concentrations than supplemented steers (P=0.05). This effect was random as cattle had not been exposed to treatments. On d 14 and 28, no difference was detected between treatments. No interactions between time, treatment or fertilization method were detected. A time effect for all calves was observed, as values on d 14 and 28 were higher (P<0.05) than initial values. Glutathione peroxidase activity for all calves tended to be lower (P<0.10) on d 28 than d 14.

Serum Se concentrations did not differ between supplemented and unsupplemented cattle at the beginning of the trial. On d 28, corn supplemented steers had higher (P<0.05) Se concentrations than the 15% CP supplemented steers. Serum Se was higher (P<0.05) on d 14 and d 28 compared to d 0. No correlation was detected between Se and GSH-Px concentrations on any date.

Initially and throughout the trial, steers on the corn supplement treatment had numerically higher Se concentrations than steers on the 15% CP supplement. However, this difference was not significant until d 28.

Pasture Study 3 – Kentland

Forage Mass and Composition. The forage chemical composition and forage mass data are presented in Table 20. At the beginning of the trial, no differences were detected in ash, CP, and lignin concentration between the fescue and fescue-alfalfa pastures. Neutral detergent fiber,

Table 19. Effects of supplementation on glutathione peroxidase activity and Se concentration of steers grazing stockpiled tall fescue. Nutrient management.

Item		Supplement			
		None	Corn	15% CP[a]	SEM
Day 0					
	Gsh-Px, mU/mg[b]	72.72	44.73	49.57	4.38
	Se, ppm	0.026	0.033	0.025	0.003
Day 14					
	Gsh-Px, mU/mg[c]	72.57	70.81	59.98	6.02
	Se, ppm[c]	0.035	0.044	0.033	0.003
Day 28					
	Gsh-Px, mU/mg[c]	59.61	59.24	64.98	2.94
	Se, ppm[cde]	0.039	0.059	0.034	0.003

[a] Calculated, DM basis
[b] No supplement vs. supplement (P<0.05)
[c] Values on d 14 and 28 are higher than values on d 0 (P<0.05)
[d] Values on d 28 tended to be higher than values on d 14 (P<0.10)
[e] Corn vs 15% CP supplement (P<0.05)

Table 20. Chemical composition and forage mass of pastures grazed by steers[a]. Kentland.

Day	Item	Fescue	Fescue-alfalfa	SEM
0	Ash, %	8.66	8.84	0.31
	Crude Protein, %	13.79	14.38	0.58
	NDF, %	54.78[b]	49.77[c]	1.24
	ADF, %	28.41[b]	26.34[c]	0.61
	Cellulose, %	26.97[b]	24.50[c]	0.63
	Lignin, %	1.36	1.36	0.38
	Mass, kg/ha	5093.5[b]	3982.7[c]	331.2
7	Ash, %	7.57	8.58	0.30
	Crude Protein, %	15.23	15.34	0.18
	NDF, %	59.53[b]	54.68[c]	0.79
	ADF, %	31.52[b]	29.22[c]	0.38
	Cellulose%	28.03[b]	25.36[c]	0.48
	Lignin, %	2.26	2.08	0.48
14	Ash, %	6.10[b]	7.53[c]	0.25
	Crude Protein, %	13.46	12.99	0.56
	NDF, %	57.27[b]	53.70[c]	0.90
	ADF, %	29.58[b]	27.80[c]	0.45
	Cellulose%	26.94[b]	25.05[c]	0.38
	Lignin, %	1.10	1.63	0.34
	Mass, kg/ha	4970.9[b]	3930.2[c]	178.7
28	Ash, %	5.62[b]	6.68[c]	0.29
	Crude Protein, %	13.04	12.38	0.36
	NDF, %	60.16[b]	57.42[c]	1.44
	ADF, %	31.41	29.82	0.84
	Cellulose%	28.37	26.89	0.60
	Lignin, %	1.33	1.14	1.18
	Mass, kg/ha	4024.6[b]	3146.1[c]	431.8
42	Ash, %	5.92	6.25	0.38
	Crude Protein, %	13.24	13.13	0.49
	NDF, %	68.72	67.19	0.67
	ADF, %	36.87	36.04	0.24
	Cellulose, %	32.20	30.93	0.50
	Lignin, %	2.78	2.61	0.38
	Mass, kg/ha	4687.7[b]	3127.6[c]	324.6

[a] DM basis
[b, c] Means with different superscript differ (P<0.05)

ADF and cellulose were lower (*P*<0.05) for the fescue-alfalfa pastures. Forage mass of fescue pastures was higher (*P*<0.05) than fescue-alfalfa pastures throughout the trial.

On d 7 and 14, fescue pastures had higher (*P*<0.05) NDF, ADF and cellulose components compared to fescue-alfalfa pastures. On d 14 and 28, fescue pastures had lower (P<0.05) ash components than fescue-alfalfa pastures. On d 28, NDF was lower (P<0.05) for fescue-alfalfa pastures, compared to fescue pastures. By d 42, forages were similar in composition across forage types and supplementation treatments.

Forage mineral concentration data are presented in Table 21. On d 0, 7 and 14, Ca levels were higher (*P*<0.05) for fescue-alfalfa pastures than for fescue pastures. On d 14, fescue-alfalfa pastures had higher (*P*<0.05) K concentrations than fescue pastures. On d 28 and 42, Mg levels were lower (*P*<0.05) for fescue-alfalfa pastures than for fescue pastures.

Performance. On d 0, 7, 28 and 42, supplemented steers were heavier (*P*<0.05) than unsupplemented steers (Figure 4). The effect observed on d 0 was random as cattle were randomly allotted to treatement by order through the chute upon arrival.

The performance data are presented in Table 22. Treatment and block effects were detected on d 0. Daily gains for steers grazing tall fescue pastures were higher (P<0.02) after 7 d than for steers grazing fescue-alfalfa pastures. No differences were detected due to treatment or forage type on daily gains after d 14 and 28. By the end of the trial, supplemented steers had higher (P<0.05) cumulative daily gains than unsupplemented steers.

Rectal Temperatures, Morbidity Scores and Treatments. No differences in rectal temperatures were detected due to treatment throughout the present trial. Morbidity scores and health data are presented in Table 23. Morbidity scores were averaged across treatment by week. During wk 1, unsupplemented steers had lower (*P*<0.05) average morbidity scores than

Table 21. Mineral composition of pastures grazed by steers[a]. Kentland

Day	Item	Forage type: Fescue	Fescue-alfalfa	SEM
0	Ca, %	0.44[b]	0.68[c]	0.06
	Mg, %	0.44	0.39	0.02
	K, %	3.10	3.10	0.20
	P, %	0.26	0.27	0.01
	Cu, ppm	5.00	6.02	0.51
	Zn, ppm	15.81	13.19	1.80
	Se, pppm	0.024	0.035	0.012
7	Ca, %	0.44[b]	0.58[c]	0.03
	Mg, %	0.34	0.32	0.01
	K, %	2.33	2.58	0.18
	P, %	0.30	0.29	0.02
	Cu, ppm	4.48	5.27	0.76
	Zn, ppm	17.92	16.75	1.38
	Se, pppm	0.055	0.072	0.006
14	Ca, %	0.39[b]	0.45[c]	0.01
	Mg, %	0.30	0.29	0.01
	K, %	1.71[b]	2.31[c]	0.15
	P, %	0.25	0.26	0.01
	Cu, ppm	3.00	3.11	0.26
	Zn, ppm	13.63	11.00	1.20
	Se, pppm	0.047	0.050	0.011
28	Ca, %	0.38	0.40	0.02
	Mg, %	0.30[b]	0.25[c]	0.02
	K, %	1.48	2.02	0.17
	P, %	0.24	0.26	0.01
	Cu, ppm	2.43	2.36	0.21
	Zn, ppm	14.26	11.33	0.94
	Se, pppm	0.081	0.069	0.01
42	Ca, %	0.47	0.51	0.05
	Mg, %	0.37[b]	0.28[c]	0.02
	K, %	1.53	1.79	0.08
	P, %	0.24	0.24	0.01
	Cu, ppm	6.23	6.52	0.44
	Zn, ppm	16.98	16.51	0.88
	Se, ppm	0.032	0.027	0.01

[a] DM basis
[b, c] Means with different superscript differ ($P<0.05$)

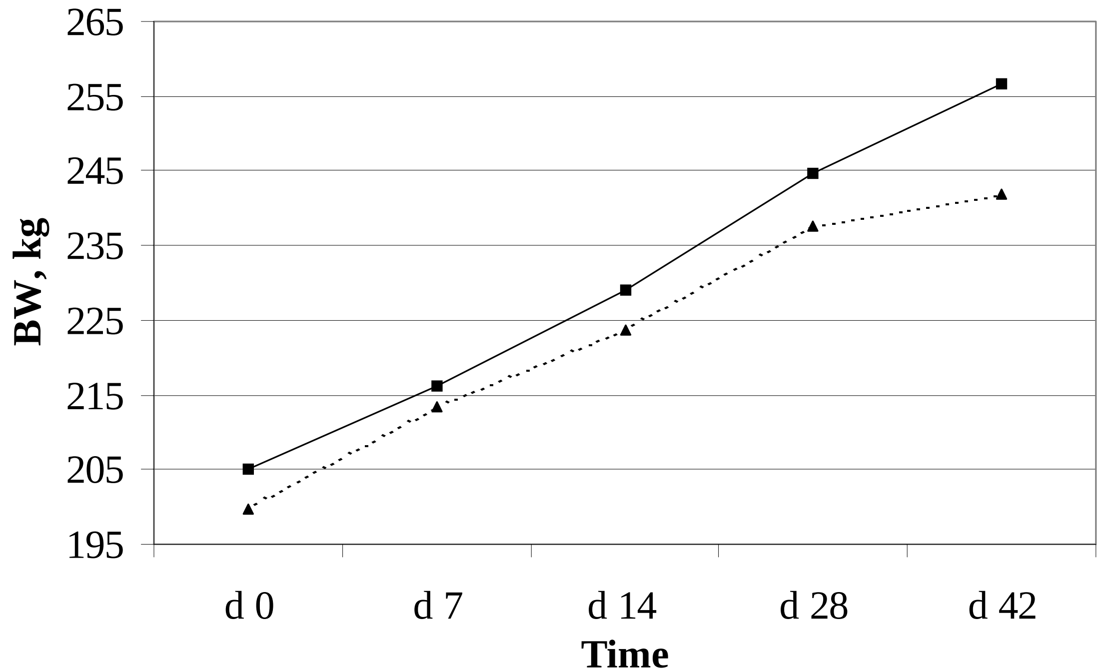

Figure 4. Body weights of steers during the backgrounding period. Pasture study 3. Supplements: none (▲), and 15% CP, 1% BW (▪). On d 0, 7, 28, and 42, unsupplemented vs supplemented (*P*<0.05).

Table 22. Effects of supplementation on performance of steers grazing stockpiled forages. Kentland.

Item	Supplement: None	Supplement: 15% CP[a]	SEM
Initial weight, kg[b]	199.8	205.0	1.96
Average daily gain, kg/d[c]			
Day 7[d]	1.93	1.59	0.22
Day 14	1.71	1.71	0.16
Day 28	1.35	1.42	0.18
Day 42[b]	1.00	1.23	0.15
Supplement intake, kg/d	--	0.96	--
Supplement:gain, kg	--	0.78	--

[a] Calculated, DM basis
[b] Unsupplemented vs. supplemented (P<0.05)
[c] Cumulative daily gain
[d] Steers grazing fescue pastures had higher daily gains during wk 1 compared to steers grazing fescue-alfalfa pastures (P<0.05)

Table 23. Effects of supplementation on morbidity of steers grazing stockpiled forages. Kentland.

Item	Supplement None	Supplement 15% CP[a]	SEM
Morbidity[b]			
Week 1	1.05[c]	1.14[d]	0.20
Week 2	1.05	1.12	0.26
Week 3	1.04	1.06	0.16
Week 4	1.04	1.04	0.23
Week 5	1.02	1.02	0.10
Week 6	1.01	1.00	0.06
Treatments[e]			
Week 1	--	17	
Week 2	10	7	
Week 3	--	--	
Week 4	--	--	
Week 5	--	--	
Week 6	--	--	

[a] Calculated, DM basis
[b] Based on a subjective morbidity scoring system (1=healthy, 5=moribund)
[c, d] Means with differing superscripts differ (P<0.05)
[e] Number of animals treated

supplemented steers. No differences were detected throughout the remainder of the trial due to treatment or forage type.

Number of cattle treated did not differ due to treatment. Treatment of sick cattle occurred during the first 2 wk of the trial, coinciding with peak morbidity. Thirty-two calves were treated during this trial. One supplemented steer grazing fescue-alfalfa died during this trial due to bloat. Data taken from that steer were not used in statistical analysis to avoid any bias.

Blood Serum Mineral Concentrations. Serum mineral data are presented in Table 24. No differences were detected on d 0 in serum Ca concentrations due to treatment or forage species. On d 7, supplemented steers had lower (P<0.05) serum Ca levels than steers on the unsupplemented treatment. On d 28, a forage type x treatment interaction was detected. Supplemented steers had higher (P<0.05) serum Ca concentrations than unsupplemented steers when they were grazing fescue pastures. Serum Ca concentrations were lower (P<0.05) for supplemented steers compared to unsupplemented steers when grazing the fescue-alfalfa pastures. By the end of the trial, a block effect was detected. At that time, no diffences were detected due to treatment or forage type. No forage type, treatment and time interactions were detected throughout the trial. At the beginning of the trial, no differences were observed in serum Mg concentrations. Supplemented steers had higher (P<0.05) serum Mg levels than unsupplemented steers on d 14 and 28. Potassium concentrations were higher (P<0.05) for unsupplemented steers on d 7. A block effect was detected on d 28 (P<0.02). No differences were detected in serum K levels due to treatment or forage type by the end of the trial.

A block effect was detected on serum P concentrations on d 0 (P<0.05). This effect was random as cattle were allotted by order through the chute upon arrival and had not been exposed to treatments. On d 14 and 28, supplemented steers had higher (P<0.05) serum P concentrations

Table 24. Effects of supplementation on serum profiles of steers grazing stockpiled tall Fescue. Kentland.

		Supplement		
Day	Item	None	15% CP[a]	SEM
0	Ca, mg/dl	11.36	11.29	0.10
	Mg, mg/dl	2.20	2.25	0.06
	K, mg/dl	21.68	21.57	0.71
	P, mg/dl	7.45	7.33	0.20
	Cu, ppm	0.64	0.63	0.02
	Zn, ppm	0.49	0.46	0.02
	Urea-N, mg/dl	13.28	12.72	0.46
7	Ca, mg/dl[b]	10.89	10.63	0.09
	Mg, mg/dl	1.49	1.54	0.05
	K, mg/dl[b]	21.91	19.96	0.35
	P, mg/dl[bc]	5.32	5.83	0.21
	Cu, ppm	0.32	0.33	0.01
	Zn, ppm[e]	0.43	0.43	0.02
	Urea-N, mg/dl	11.49	11.07	0.47
14	Ca, mg/dl	10.77	10.68	0.07
	Mg, mg/dl[b]	1.14	1.74	0.06
	K, mg/dl	17.45	17.62	0.36
	P, mg/dl[b]	5.71	6.24	0.23
	Cu, ppm	0.92	0.86	0.04
	Zn, ppm	0.36	0.40	0.02
	Plasma urea-N, mg/dl	9.30	9.16	0.34
28	Ca, mg/dl[d]	9.79	10.45	0.34
	Mg, mg/dl[b]	1.67	1.90	0.07
	K, mg/dl	19.33	20.10	0.41
	P, mg/dl[b]	6.04	6.87	0.18
	Cu, ppm	0.40	0.40	0.01
	Zn, ppm	0.41	0.43	0.02
	Urea-N, mg/dl[b]	9.71	8.59	0.36
42	Ca, mg/dl	11.19	10.91	0.18
	Mg, mg/dl	2.04	2.14	0.04
	K, mg/dl	17.61	17.55	0.36
	P, mg/dl[bc]	7.37	7.77	0.24
	Cu, ppm[b]	0.82	0.88	0.03
	Zn, ppm	0.85	0.82	0.04
	Urea-N, mg/dl	12.03	9.76	0.43

[a] Calculated, DM basis

[b] Unsupplemented vs. supplemented ($P<0.05$)

[c] Steers grazing fescue pastures had higher serum P than steers grazing fescue-alfalfa on d 7 and lower serum P on d 42 ($P<0.05$)

[d] Supplemented steers had higher serum Ca concentrations on fescue and lower serum Ca on fescue-alfalfa ($P<0.05$).

[e] Unsupplemented steers had higher serum Zn on fescue pastures and lower serum Zn on fescue-alfalfa pastures ($P<0.05$)

than unsupplemented steers. On d 7, steers grazing fescue pastures had higher (P<0.05) serum P levels than steers grazing fescue-alfalfa pastures (P<0.05). At the end of the trial, steers grazing fescue-alfalfa had higher (P<0.05) serum P concentrations than steers grazing fescue pastures.

No difference was detected in serum Cu concentration due to treatment until the end of the trial. On d 42, supplemented steers had higher (P<0.05) serum Cu concentrations than unsupplemented steers. Block effects were observed on d 7, 14 and 28 (P<0.002). These effects were random as cattle were blocked by order through the chute upon arrival. No time, treatment and forage type interactions were detected on serum Cu concentration.

On d 7, a forage type x treatment interaction (P<0.05) was detected in zinc concentration. Unsupplemented steers grazing fescue pastures had higher (P<0.05) serum Zn levels than supplemented steers. Among the steers grazing the fescue-alfalfa pastures, serum Zn concentrations were higher (P<0.05) for supplemented steers. No differences were detected throughout the remainder of the trial due to forage type or supplement. No time, treatment and forage type interactions were detected.

Serum Urea-N. Serum urea-N data are presented in Table 24. No difference was detected on d 0, 7 or 14 due to treatment or forage type. On d 28 and 42, unsupplemented steers had higher (P<0.05) SUN concentrations than supplemented steers.

Blood Glutathione Peroxidase and Selenium Concentrations. Glutathione peroxidase and Se concentration data are presented in Table 25. Glutathione peroxidase activity was not affected by supplementation treatment or forage type on d 0, 14 or 28. For all cattle, Gsh-Px activity was higher (P<0.05) on d 14 than on d 0. No other differences were detected for Gsh-Px activity.

Selenium concentrations did not differ between cattle at the beginning of the trial. On d

Table 25. Effects of supplementation on glutathione peroxidase activity and Selenium concentration of steers grazing stockpiled forages. Kentland.

Item		Supplement		
		None	15% CP[a]	SEM
Day 0				
	Gsh-Px, mU/mg[b]	46.15	50.44	3.67
	Se, ppm	0.046	0.047	0.006
Day 14				
	Gsh-Px, mU/mg[c]	54.12	63.57	5.38
	Se, ppm[de]	0.052	0.056	0.006
Day 28				
	Gsh-Px, mU/mg[bc]	52.22	53.63	3.44
	Se, ppm	0.042	0.036	0.006

[a] Calculated, DM basis

[b, c] GSH-Px values on d 14 were higher than d 0 (P<0.05)

[d] Se values on d 14 were higher than values on d 28 (P<0.05)

[e] Calves grazing fescue-alfalfa had higher serum Se concentration (P<0.05)

14, cattle grazing fescue-alfalfa pastures had higher (P<0.05) blood Se concentrations than cattle grazing fescue pastures. A block effect was detected on d 28. Lower (P<0.05) blood Se concentrations were observed on d 28 than on d 14. No correlation was detected between Se and Gsh-Px activity during the 4-wk period.

Discussion

The present trials were conducted to evaluate the effects of various supplements to stressed calves during the backgrounding period. It had been hypothesized, based on data from other studies (Elizalde et al., 1998; Horn et al., 1995; McKinnon et al., 1998), that supplementation during the backgrounding period would increase daily gains, compared to unsupplemented cattle. The effects of supplementation on health and morbidity were unclear, as previous work indicated that high levels of protein and energy in receiving diets may adversely affect health (Lofgreen et al., 1980; Cole and Hutcheson, 1988; Galyean et al., 1999).

Forage Mass and Composition.

In the grazing studies, forage mass, CP and ash decreased with time as the forage matured. Forage mass decreased throughout the grazing period, undoubtedly due to forage removal by the cattle, since the forage was not growing at the time. Forage mass values reported in the present trial are similar to tall fescue forage mass values reported by Allen et al. (1992) and Fritz and Collins (1991).

Data from the present trials agree with previous studies concerning CP concentration of tall fescue. Sheehan et al. (1985) observed a decreased in crude protein of autumn-accumulated, or stockpiled, tall fescue with increasing maturity of the forage. Increases in ADF, NDF and cellulose were also reported with increasing maturity in that study. Crude protein concentrations in the present trials were higher than values reported in that study at similar dates. Crude protein concentrations in the present study were also higher than values reported by Bagley et al. (1983) of stockpiled tall fescue at similar dates Fritz and Collins (1991) and Beconi et al. (1995) observed similar decreases in CP of stockpiled tall fescue. Sampling dates in that trial were similar to dates of the present trials.

Although differences were not detected between CP concentration of fescue and fescue-alfalfa pastures in pasture study 3, fescue-alfalfa pastures had lower fiber components (NDF, ADF, and cellulose). Seman et al. (1999) reported higher CP and lower fiber component values of fescue-alfalfa pastures, compared to fescue pastures. In that study, forage intake was higher for calves grazing the fescue-alfalfa mixed swards, compared to calves grazing monocultures of fescue or alfalfa. In pasture study 3 forage mass was lower for fescue-alfalfa pastures throughout the trial. This was due to the fact that the stockpiling of fescue-alfalfa pastures started approximately 1 mo after stockpiling of fescue pastures.

In addition to the increasing maturity of the forage, selective grazing likely contributed to the decrease in analyzed CP and the general increase in fiber components of forage samples throughout the grazing period. Decreases in forage protein concentrations result from selective grazing (Hardison et al., 1954; Howard et al., 1992; McCracken et al., 1993). Hardison et al. (1954) reported that cattle grazed herbage that was higher in CP and lower in crude fiber, compared to whole herbage. Fontentot and Blaser (1965) reported that cattle selectively graze more digestible plant parts that are higher in CP. Minson (1981) observed that, when available, cattle graze higher quantities of legumes, compared to grasses.

Several studies have been conducted to determine the effects of supplementation on forage intake (Kryls and Hess, 1993). Carey et al. (1993) and Hess et al. (1996) observed higher forage intake by unsupplemented steers compared to energy supplemented steers. No differences were detected in forage intake due to supplementation level or protein source. This indicates that supplementation may cause the disruption of normal grazing and result in decreased forage intake. Contradicting those studies, Caton et al. (1988) reported no difference in forage intake between protein supplemented and unsupplemented steers.

In agreement with results reported by Carey et al. (1993) and Hess et al. (1996), hay intake was lower for heifers supplemented at 1% BW, indicating that high levels of supplementation may lower hay intake.

Forage from unfertilized paddocks in pasture study 2 had lower forage yields and mineral concentrations than fertilized pastures. In an earlier experiment conducted at the same location, Frank et al. (1998) observed lower forage P and Cu concentrations of unfertilized pastures compared to pastures on which litter was fed to cattle or litter and inorganic fertilizer were applied to the soil. Similar to the present trial, no difference was detected in forage CP due to fertilization method in that study.

In the present trials, with the exception of forage mass in pasture study 3, no consistent differences were detected in forage composition and mass due to supplementation treatment or forage type. Therefore, the calves on all treatments likely selected similar forage components during the trial. Differences in mineral concentrations of forage across trials were inconsistent. Decreases in mineral concentration were usually observed at all sites as the grazing period progressed.

Performance.

In pasture studies 1 and 2, unsupplemented steers had higher ($P<0.05$) daily gains during wk 1 than unsupplemented steers. By the end of all four trials, supplemented calves had higher ($P<0.05$) daily gains than unsupplemented cattle. When different levels of supplementation were fed in pasture study 1, supplementation at 0.5% BW resulted in higher daily gains than supplementation at 1% BW. In the drylot study, supplementation at 0.5% BW resulted in higher numerical daily gains and higher hay intake compared to heifers supplemented at 1% BW. In pasture study 3, the higher performance by steers grazing fescue pastures, compared to fescue-alfalfa pastures, indicates that fescue may be used for backgrounding programs without negatively affecting performance.

Performance was similar for calves produced at SVAREC on drylot and pasture study 1. Daily gains were lowest for the purchased calves on pasture Study 2. Lower performance may be due to lower forage quality, more severe stress or may be due to the source of calves. In that trial, supplementation of a 15% CP supplement resulted in lower performance by steers compared to corn supplementation. Compared to the calves on pasture study 3, the lower performance on pasture study 2 may have been due to the higher supplementation level, implantation status, or source of calves.

Several studies have examined the effects of supplemental protein and energy to cattle grazing various forages. Supplementation has generally increased performance of grazing cattle (Adams, 1985; Bodine et al., 2001; Bowman and Sowell, 1997; Caton and Dhuyvetter, 1997; Goetsch et al., 1991; Hannah et al., 1989; Horn et al., 1995). Fewer studies have been conducted on backgrounding supplementation programs in drylot and on pasture. Supplementation studies conducted on lightweight calves grazing tall fescue generally agree with results in the present trials (Elizalde et al., 1998; McKinnon et al., 1998). Daily gains of supplemented calves in the drylot trial and pasture study 1 were higher than values in an earlier study conducted at the same location (McKinnon et al., 1998). In the earlier study, newly weaned steers, produced at the SVAREC station, were supplemented at 1% BW for 42 d with a 13% CP supplement. Cumulative daily gain for steers on that study were 0.96 kg/d. The lower performance by steers in that study may have been due to the lower protein content of the supplement.

Performance of heifers in the drylot study was similar to performance of heifers (203.6 kg) receiving an alfalfa hay based receiving diet for 28 d after purchase at a sale barn. (Blasi et al., 2001). Heifers on that study gained 1.15 kg/d compared to an average of 1.12 kg/d for supplemented heifers in the present trial.

Elizalde et al. (1998) reported increased performance due to supplementation. Steers (246.8 kg) were supplemented with corn or corn gluten feed at 0.5 or 1% BW for 85 d. However, an interaction was observed between supplementation level and kind of supplement. Supplementation of corn gluten feed at 1% BW resulted in higher daily gains than supplementation with corn, while an inverse relationship was reported when supplemented at 0.5% BW. In that study, no differences were detected in performance due to supplementation level. This is in agreement with results from the present drylot study in which no difference in daily gains due to supplementation level, energy level or protein level was detected by the end of the trials. Contradicting that study, calves supplemented at 1% BW on pasture study 1 had lower daily gains than calves supplemented at 0.5% BW. Steers on 1% BW treatment had lower daily gains from wk 2 through the end of the trial. The decreased performance could be due to decreased forage intake due to a substitution effect. Similar to the results from Pasture study 2, negative weight gains during wk 1 have been reported (Fluharty and Loerch, 1995; Lofgreen, 1988). This effect is likely due to decreased forage intake during this period.

Rectal Temperatures, Morbidity Scores and Treatments.

For all trials, peak morbidity, determined by the morbidity scoring system, was observed during wk 2 and 3. With the exception of the Kentland trial, no difference was detected on morbidity due to supplementation program.

Morbidity patterns in these trials are similar to those observed in several other studies (Lofgreen et al., 1975; Lofgreen et al., 1980; Lofgreen et al., 1981; McCoy et al., 1998). Lofgreen et al. (1975) observed morbidity patterns of newly received feeder calves (166 kg). In three separate trials, peak morbidity was observed during wk 1. The calves in that study were subjected to the marketing process whereas the calves in the drylot and pasture study 1 trials were placed immediately into a backgrounding study and were not subjected to the level of stress of marketed and shipped calves.

High levels of energy can increase morbidity in stressed calves (Lofgreen, 1983). Calves receiving 25, 50 or 75% concentrate receiving diets displayed a linear increase in morbidity with increasing concentrate level. The calves on the present trials were supplemented rather than fed a total mixed diet, hence they may not have received supplemental energy at levels high enough to have an adverse effect.

In agreement with results from pasture study 3, Fluharty and Loerch (1995) reported increased morbidity with increasing protein concentrations in the receiving diet. Supplemented calves on pasture study 3 received higher morbidity scores than unsupplemented calves. Contradicting this observation, McCoy et al. (1998) reported a decrease in morbidity of newly received calves with increased metabolizable protein (MP) levels in the receiving diet.

In the present trials, supplemented calves did not consistently have higher morbidity scores than unsupplemented calves. Supplementation did not affect subjective morbidity of the calves. Differences in number of calves treated at each site varied. These differences may be due to different sources of calves. The two groups of purchased calves came from different livestock markets where different receiving vaccination programs were used. Calves in pasture study 2 were vaccinated upon arrival. Calves on pasture study 3 were not vaccinated upon receiving as they had been vaccinated at the stockyard prior to shipping. Level of management and interpretation of morbidity scoring system may have contributed to different incidences of morbidity between trials.

Blood Serum Mineral Concentrations.

Results from previous research on serum mineral concentrations during stress are inconsistent. One possible explanation for inconsistent reports is that changes in mineral concentrations during the backgrounding or receiving period may be caused by infection with BRD or by feed deprivation associated with marketing and shipping (Cole, 1995). Depending on the protocol and method of stress, mineral concentrations may increase if the animal is stressed or decrease during infection. In a trial conducted on lightweight calves, Ca, Mg, K, Na and P did not decrease during periods of feed deprivation, similar to those encountered during the marketing process (Galyean et al., 1981). However, Ca and Cu have been shown to increase following inoculation with BRD (Orr et al., 1990).

Orr et al. (1990) observed several changes in serum mineral concentrations of calves stressed by bovine respiratory disease. Similar to values reported in the present trials, Zn concentrations decreased by d 12 and returned to initial levels by d 52. Contradicting results from the present trials, serum Cu and Ca concentrations were increased by d 10 and d 12, respectively. However, these mineral changes were due to infection and not exposure to stress. Because some calves in the present trials were not subjected to severe morbidity, increases in Cu and Ca during morbidity may have been avoided. Similar to the present trials, Orr et al. (1990) reported that P concentration did not change during the period of stress and infection. Contradicting those studies, a decrease in P concentration was reported by Hutcheson and Cole (1988). Nockels et al. (1993) induced stress in feeder calves be fasting and administering adrenocorticotropic hormone (ACTH). They observed a decrease in serum Zn concentrations by 4 d after receiving. In that study, an increase in Cu concentrations was observed by d 3.

Several studies have been conducted on the effects of mineral supplementation on stressed calf serum concentrations (Hutcheson et al., 1984; Chang and Mowat, 1992; Nockels et al., 1993). Limited data are available regarding serum concentrations of stressed calves consuming forage and high-roughage diets. In the present trials, supplementation did not affect serum mineral concentrations as no consistent differences were detected due to treatment throughout the backgrounging period. Any differences may have been negated due to mineral supplementation as all calves were allowed access to trace mineralized salt. The decrease in serum mineral concentrations during the trial for all calves may be due to the decreased feed intake during stress. Generally, mineral concentrations had returned to initial values by d 42.

Serum Urea-N.

Supplementation level did not affect SUN concentration in the drylot study by d 42. Due to higher protein concentration, supplementation with the 30% CP supplement resulted in higher SUN levels in the drylot study. In pasture study 1, supplementation at 0.5% BW resulted in higher SUN concentrations compared to supplementation at 1% BW. In pasture study 2, corn supplementation resulted in lower SUN concentrations by d 42. This was probably due to the higher protein concentration of the 15% CP concentration.

Cole and Hutcheson (1988) observed higher PUN concentrations in newly received calves fed higher levels of dietary protein. They also observed higher values at the end of a fasting period. Values reported in that study were similar to values reported in the present trials. Plasma urea-N concentrations were higher for calves fed an 8% CP diet, compared to a 16% CP diet prior to shipping when they were fed a common 15% CP receiving diet upon receiving.

In the present trials, higher SUN values on d 0 were likely a result of the higher nutritive content of the forage and milk of the dam consumed prior to the trial. This effect could also be due to the fasting period incurred during the marketing process. No consistent trend was observed in SUN over time. By the end of each trial, supplementing had not affected SUN concentrations, compared to unsupplemented calves. In pasture study 3, SUN concentrations were numerically higher for unsupplemented steers from wk 2 through the remainder of the trial. Variations in analyzed SUN values over time may be due to hemoconcentration, or water loading.

Blood Glutathione Peroxidase Activity and Se Concentrations.

Generally, no differences were detected due to supplementation treatment on GSH-Px concentrations. In pasture study 2, supplemented calves had higher GSH-Px concentrations by d 28. In all four trials, GSH-Px activity was higher on d 14 than initial values. This may indicate that all calves were subjected to oxidative stress during the backgrounding period regardless of sex, supplementation treatment, forage type, source or extent of stress. In pasture study 3, GSH-Px values by d 28 had returned to values similar to initial values. This may indicate that oxidative stress had decreased by 4 wk after receiving.

In pasture study 3, blood Se concentrations reflected the time effect observed in Gsh-Px activity. Blood Se concentrations on d 14 were numerically higher than initial values. Selenium concentrations of fescue-alfalfa pastures were numerically higher than values of fescue pastures. This difference would explain the difference in blood Se concentrations of steers grazing these paddocks. By d 28, when Gsh-Px values had decreased to initial levels, serum Se concentrations had also decreased. This effect could be due to decreased Se concentrations and availability in the forage.

Reffet-Stabel et al. (1989) fed calves (212 kg) a corn and peanut hull based diet for 21 d with and without Se supplementation during the receiving period. They found that increases in

GSH-Px activity increased with all calves regardless of treatment, indicating that the enzyme activity increases during periods of oxidative stress regardless of dietary treatment or Se status. In that trial, higher GSH-Px concentrations were observed in Se-supplemented calves indicating that GSH-Px values could be used as an indicator of Se status. Values in the present studies were higher than values reported in that trial. Gluthathione peroxidase activity in that study was analyzed on whole blood and plasma. This difference may have resulted from values in the present trial being obtained from white blood cell GSH-Px activity, which would be more reflective of short-term oxidative stress.

No consistent correlation was detected between GSH-Px and Se concentrations. This could be due to analysis of GSH-Px on white blood cells rather than on whole blood or red blood cells. Dargatz and Ross (1996) analyzed blood Se concentrations from cattle operations across the United States. Despite the low Se concentrations in the hay fed and forages grazed during the present trials, blood Se concentrations of calves were adequate for cattle in the Southeastern region. Swecker et al. (1989) supplemented newly weaned calves with Se and vitamin E. Blood Se concentrations of the present trials are similar to values reported in that study.

Although GSH-Px and Se concentrations were not compared across trials, general statements regarding differences may be made. Calves raised at the research station had lower GSH-Px values on d 0. According to Reffet Stabel (1989), GSH-Px values may indicate both Se status and incidence of oxidative stress. This would support the values of the current experiment. Purchased calves had higher initial GSH-Px values as they were exposed to a greater intensity and duration of stress. Calves on the station were weaned at the beginning of the trial, but were not exposed to foreign cattle or the shipping stress incurred on purchased calves.

In the two trials involving calves raised at the SVAREC, GSH-Px values were higher on d 14 and d 28 than initial values. This trend was not apparent in the trials involving purchased calves. In pasture study 2, GSH-Px values for calves on d 28 were still higher than initial values. However, the average GSH-Px activity value for all calves was numerically lower than the d 14 average. In the pasture study 3, GSH-Px activity was not greater than initial values. These differences may indicate that although purchased calves may be exposed to greater stress, the response is quicker and they return to initial values faster.

The low Se concentrations observed initially in purchased calves may indicate that these cattle had not been supplemented with Se prior to marketing. Enjalbert et al. (1999) reported higher serum Se values for calves born to Se supplemented beef cows compared to unsupplemented beef cows.

Reffet Stabel et al. (1989) also reported that Se supplementation to stressed calves increased Gsh-Px activity compared to unsupplemented calves. In the present studies, purchased calves had similar serum Se concentrations. Both groups of calves raised at the research station had similar Se concentrations as they were from the same herd. The cows were supplemented with high Se trace mineralized salt. According to the serum Se survey of cattle in different parts of the United States (Dargatz and Ross1996), the calves purchased in this experiment were severely deficient and the calves raised at the station were adequate in their serum Se concentrations (Figure 5). Mineral supplementation history of the purchased calves is unknown.

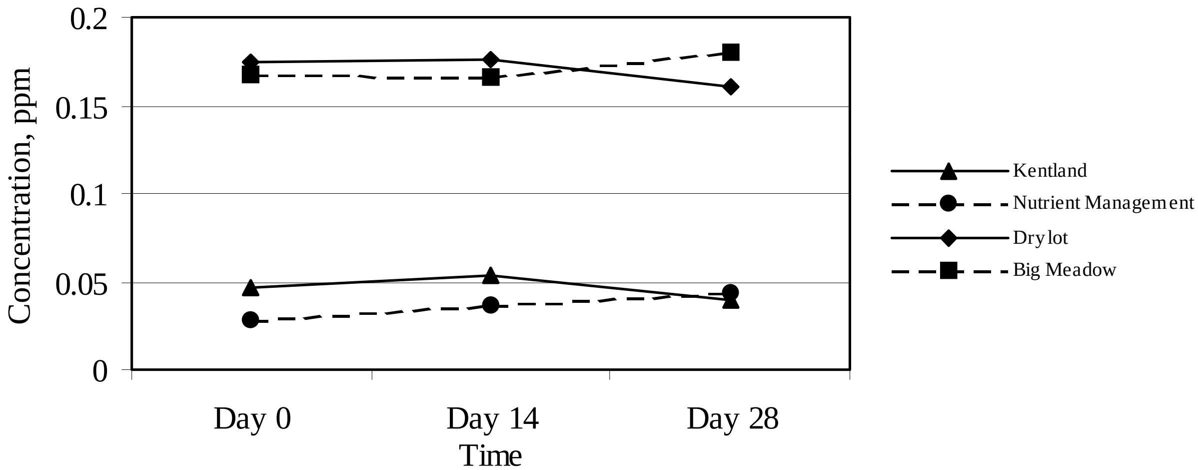

Figure 5. Serum selenium concentrations of calves on all trials.

Implications

Supplementation of energy and protein supplements improves performance by stressed calves when the backgrounding period is at least 42 d. Health status, apparent immune competence and mineral concentrations are similar between calves receiving different supplements and grazing different forages. High level of supplementation and high protein concentration do not improve performance during backgrounding. Most previous research on calf health and nutrition indicating that higher levels of protein and energy in the receiving diet may negatively affect health status of the calf has been conducted in feedlot environments. Little research of backgrounded cattle on pasture has been conducted. The limited number of backgrounding trials of this nature warrants further investigation in this area. The ability to improve health status of stressed beef calves during backgrounding through nutrition would be beneficial to cow-calf producers and cattle feeders.

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