SUPPLEMENTAL PROTEIN: ENERGY INTERACTIONS FOR FALL CALVING BEEF COWS GRAZING DORMANT NATIVE RANGE

By

TODD AARON THRIFT

Bachelor of Science

University of Kentucky

Lexington, Kentucky

1991

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1994

OKLAHOMA STATE UNIVERSITY

SUPPLEMENTAL PROTEIN: ENERGY INTERACTIONS

FOR FALL CALVING BEEF COWS GRAZING

DORMANT NATIVE RANGE

Thesis Approved:

Charles A. Hibberd

Thesis Advisor

F. T. McCollum III

David S. Buchanan

Thomas C. Collins

Dean of the Graduate College

ACKNOWLEDGMENTS

I sincerely wish to thank my advisor, Dr. Charles Hibberd, for his assistance in conducting and analyzing my research. Many thanks also go to Dr. David Buchanan and Dr. Ted McCollum for serving on my graduate committee. Their assistance in statistics and nutrition have been helpful in the development of this thesis.

There are a number of graduate students who have made my graduate career more bearable and my deepest appreciation is extended to them. I am especially indebted to Twig Marston (Scientist), Jeff Hill (Spunky), Joel Yelich, Mark King, Troy Miller, and Gary Zeihe who spent may hours helping milk wild cows and collect fecal samples by the truckload. Additionally the assistance of Carolyn Bowen, Donna Perry, Marie Mottola and of course my lignin lady, Kathy Swenson has been greatly appreciated.

I would like to thank my parents and grandparents for their continued support of my educational endeavors. I would also like to thank a very special friend, Gwynne Overtoom, for her patience and encouragement during my stay at Oklahoma State University. Finally, I would like to dedicate this thesis to Nanny and Papa, who have always been an inspiration to me.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

Chapter III
Figure   Page

Chapter IV
Figure   Page

Figure Page

FORMAT OF THESIS

This Thesis is presented in the Journal of Animal Science style and format, as outlined by the Oklahoma State University graduate college style manual. The use of this format allows for the independent chapters to be suitable for submission to scientific journals. Three papers have been prepared from the data collected for research to partly fulfill the requirements for the M.S. degree. Each paper is complete in itself with an abstract, introduction, materials and methods, results and discussion, implications and literature cited section.

CHAPTER I

INTRODUCTION

Approximately one third of the beef cows in the state of Oklahoma calve in the fall. A fall calving system can help to increase cash flow, makes better use of available bulls, and allows older calves to utilize spring forage when quality is at its peak. However, nutritional management of the fall calving cow on native range presents a unique challenge to cow-calf producers. Tall grass prairie in Oklahoma is dominated by the warm season grass species, big bluestem, little bluestem, indiangrass and switchgrass (Waller et al., 1972). Essentially all of the growth of native grass occurs from the months of April to August. When cows calve in the fall these grasses are in abundance but are generally low in quality. Crude protein content drops rapidly in the fall and may reach a level of 2 % in the winter months when the grass is dormant (Waller et al., 1972). It is during this time period that the nutritional requirements of fall calving cows are at their highest. Lactation as well as environmental stress place large energy demands on the beef female. These increased nutrient requirements can rarely be met by forage alone and thus supplementation must be provided to maintain an acceptable level of performance.

Commercial range supplements are formulated on the basis of total protein and are typically available in 12, 20, 32, or 40% crude protein range cubes. These supplements are formulated from soybean meal or cottonseed meal blended with cereal grains or grain byproduct feeds. Production responses to these supplemental feedstuffs can vary widely depending on their effects on forage intake and digestibility. Since purchased feed is often the major cost associated with cow/calf production, it is important to utilize supplemental feed efficiently.

Current practices for formulating supplements are based on estimates of nutrient requirements, forage quantity and quality as well as forage intake. These estimates are based on research and previous experience. Variables such as environment and animal health as well as deficiencies in our knowledge of supplementation responses limit the accuracy of the system. Additionally, the current system does not consider the nutrient needs of the ruminal microflora. To optimize forage utilization, the ruminal microbes should also be provided with the proper level and ratio of nutrients.

Previous nutritional studies have compared protein and energy supplementation or have compared several protein sources at a single energy level. Although this information is very useful for making producer recommendations, the accuracy of extrapolation to other energy levels is unknown. Very few studies are available that compare a wide range of protein:energy ratios in supplements. In addition, the studies that utilized a wide range of supplemental protein:energy ratios also utilized cereal grains as a energy source (Clanton and Zimmerman, 1970; Rittenhouse et al., 1970). Cereal grains have well-documented negative associative effects on forage utilization (Chase and Hibberd, 1987). However, digestible fiber feeds such as wheat middlings and soybean hulls have been shown to be acceptable energy sources that do not adversely affect forage utilization (Martin and Hibberd, 1990; Ovenell et al., 1990). These digestible fiber feeds may offer potential for improving the performance of beef cows on native range.

The objective of the research in this thesis was to improve the efficiency of predicting supplemental feed requirements for lactating beef cows grazing tallgrass prairie in the winter. In addition, information to assist in the refinement of nutritional requirements of gestating and lactating beef cows will be gathered. The endpoint of this research should be a more effective system to enhance the predictability and success of supplementation recommendations for beef cows.

Supplements with varying blends of soybean meal and soybean hulls were fed to fall-calving beef cows to study the effect of supplemental protein:energy ratio on cow/calf productivity and forage utilization. In addition, four levels of soybean hulls were fed to gestating beef cows to determine the responsiveness of cow body condition to supplemental energy.

CHAPTER II

LITERATURE REVIEW

Nutritional Status of Fall Calving Beef Cows

Nutritional Demands of Fall Calving Beef Cows

A good knowledge of the nutritional demands of the beef cow is essential to properly formulate supplements The major deficiencies of beef cows grazing dormant tallgrass prairie forage are crude protein, energy, calcium, phosphorus and salt. Calcium, phosphorus and salt deficiencies are corrected easily and economically by supplementing cows with a salt/dicalcium phosphate mineral mix Protein and energy deficiencies, however, are harder to alleviate.

The goal of every cow/calf producer should be to produce a weaned calf every 12 months from an optimal number of cows in the herd so as to maximize economic returns. This optimal number will differ with every operation depending on the available resources. The nutritional program should provide enough nutrients for each cow to give birth, milk at an adequate level and rebreed within a given period of time. Inadequate nutrition will result in poor rebreeding performance and reduced calf gains (Wettemann et al., 1987). Excessive feeding, however, adds unnecessary cost and may decrease cow longevity (Pope, 1965). Numerous factors affect the nutritional demands of beef cows including: stage of production, milking ability, age of cow, cow size and condition, and weather.

Factors Affecting Nutritional Demands for Maintenance. The feed required to maintain the cow herd constitutes a major portion (65-75%) of the total feed resources required for beef production (Gregory, 1972; Ferrell and Jenkins, 1985; DiCostanzo et al., 1991). Very little emphasis has been placed on the production efficiency of the cow herd when in reality two thirds to three fourths of the feed resources are utilized by the cow herd (Ferrell and Jenkins, 1985). The lack of research may be explained by the fact that the beef cow herd utilizes roughages as the main source of energy. These roughages are highly variable in quality and quantity making it difficult to characterize the efficiency of all cow types in all environments. This is in contrast to the predictable environment of the feedlot where conditions are more standardized and cattle are typically fed a high energy diet composed primarily of cereal grains.

The amount of dietary energy required by an animal to maintain constant body energy is known as the maintenance energy requirement (NRC, 1984). The net energy required for maintenance is the amount of energy equivalent to the fasting heat production of an animal (NRC, 1984) Several factors are known to affect the maintenance requirements of the beef female including: breed (Ferrell and Jenkins, 1984a), milk production potential (Ferrell and Jenkins, 1984a), hide thickness, hair coat (Fox et al., 1988), activity (NRC, 1984), weather or season (Laurenz et al., 1991), body condition (Lemenager et al., 1980), and mass of vital organs (Ferrell and Jenkins, 1985).

Cow size and milk production potential are two major factors associated with the nutrient demands of a beef animal. Ferrell and Jenkins (1984) evaluated energy utilization of non pregnant, non lactating cows that differed in biological type. They concluded that larger cows had similar maintenance requirements per kg of body weight as small cows. Differences in maintenance requirements between the biological types were attributed to differences in milk production potential. However, large heavy milking cows are often at a disadvantage in a restrictive nutritional environment. They can not consume enough low quality forage to meet their requirements for maintenance and production. In fact, Ferrell and Jenkins (1985) concluded that animals with high genetic potential for production may be at a disadvantage in restrictive environments.

Maintenance requirements are dependent on more than just cow size and milk production potential. Lemenager et al. (1980) concluded that visual body condition score, combined with weight, more accurately predicted the maintenance energy requirements of pregnant cows than did weight alone. This conclusion is the basis for development of a net energy system (NE_A) that can be utilized for adult beef cows (Buskirk et al., 1992). Wagner et al. (1990) established that fat and thin cows were more energetically efficient than cows in moderate condition. Other researchers have demonstrated similar results showing that fat cows have lower energy requirements for maintenance than lean cows (Klosterman et al., 1968; Russel and Wright, 1983a; Thompson et al., 1983). Researchers at Minnesota found that more energy is required to maintain a kg of protein than to maintain a kg of fat. Of the energy required for maintenance, 88.6% was utilized to maintain protein and 11.4% to maintain fat (DiCostanzo et al., 1990) The relationship between body condition and maintenance is not totally clear-cut. If cows are genetically fat then the assumption that fatter cows have lower maintenance requirements is assumed to be true (DiCostanzo et al., 1990). However, if cows are fat due to increases in their nutritional plane, then they may actually have higher nutrient requirements (Ferrell and Jenkins, 1984). Cows on a high nutritional plane show increases in the size of their metabolically active organs, especially the liver and gastrointestinal tract (Ferrell and Jenkins, 1985). A large percentage of the energy expenditures for maintenance is thought to be associated with lean protein turnover in the metabolically active internal organs.

The maintenance requirements of the beef animal are highly correlated with lean body mass (Ferrell and Jenkins, 1985). Genetically lean animals have a higher fasting heat production per kg of metabolic body size than genetically fat animals. Fasting heat production has been shown to be more highly correlated with weight of the protein in the viscera than weight of skeletal protein (Tess et al., 1984; Webster, 1980). Mass of visceral organs may thus be one of the most important factors affecting the maintenance energy requirements of animals. The mass of visceral organs has been shown to vary with breed or type, plane of nutrition, and physiological state. Larger cows have larger livers and gastrointestinal tracts. Lactating cows have increased liver and digestive tract weights (Crooker et al., 1991). Canas et al. (1982) estimated that at least 24% of the increase in the maintenance expenditures by lactating rats could be explained by increases in the weight of the liver, kidney and heart. Additionally, animals on a high plane of nutrition have a greater increases in the size of their internal organs. Therefore, the liver and gastrointestinal tract are thought to account for a major portion of energy expenditures for maintenance (Ferrell and Jenkins, 1985; DiCostanzo et al., 1991). The cause and effect relationships associated with maintenance are still not clear and further research is needed to evaluate differences in maintenance requirements.

Factors affecting nutritional demands for production. Stage of production has enormous consequences on the nutrient requirements of beef cattle. Nutrient intake by dry pregnant mature cows (450 kg middle third of gestation) grazing native range can supply energy requirements almost anytime of the year with minimal supplementation. A cow in the last third of gestation requires adequate nutrients to gain approximately .4 kg/day. This weight gain is primarily composed of fetal growth and accumulation of fetal fluids, two-thirds of which occurs in the last third of gestation This additional nutrient demand equates to 2.15 Mcal NEm/day to support fetal growth (NRC. 1984). Nutrient requirements of the beef cow peak between calving and the end of the breeding season. During this period the cow must have nutrients for involution and repair of the reproductive tract, milk production, resumption of cyclicity and subsequent rebreeding. Milk production is the most energetically costly of these processes (Ferrell and Jenkins, 1985).

A lactating beef cow (500 kg) with average milking ability (5 kg/d) requires 56.6% TDN and 9.7% CP in the diet (NRC, 1984). Absolute daily requirements for TDN and CP are 5.6 kg and 957 g, respectively From September through March the average CP content of native range is approximately 3.0% (Waller et al., 1972). A fall calving cow would have to consume forage at a rate 6.4% of body weight to meet her crude protein requirement. During the same time period the TDN content of native range averages 40% (Lusby et al., 1985). Likewise a fall calving cow would have to consume 2.8% of body weight to meet her energy requirements. Typical forage intake on native range is 1.5-2.0% of body weight. Thus the fall calving cow is confronted with large nutrient deficits when consuming only forage.

The effects of lactation are further exacerbated as the milking ability of the cow increases. Utilizing the same circumstances as above, a superior milking cow producing 10 kg milk/day would have to consume 8.3 and 3.4% of body weight to meet CP and TDN requirements, respectively. Meeting the nutritional demands of a heavy milking cow may be very inefficient in a restricted nutritional environment.

A cow reaches her mature size at four years of age. This means that a young cow must continue to gain weight through her second calf. A 400 kg lactating heifer (5.0 kg milk/day) gaining 0.2 kg/day has almost the same absolute nutrient requirements as the 500 kg lactating cow that was discussed previously (NRC, 1984). Heifers generally have a lower intake of the basal forage diet making it even harder to meet their nutrient requirements. Further problems arise as young cows shed and replace temporary incisors.

Weather is one of the most variable of the factors that affect cow requirements. Weather exerts its primary impact on the energy status of the animal. The influence of weather on maintenance requirements depends on the insulation provided by the tissues and haircoat as well as environmental factors such as wind speed, humidity and solar radiation (McDonald et al., 1988) Wagner et al. (1988) examined the effects of body condition and weather on the maintenance energy requirements of non pregnant, non lactating Hereford cows. They concluded that for each decrease in temperature of one degree Celsius, metabolizable energy (Mcal/kg $BW^{.75}$) required for maintenance increased .0053, .0039 and .0025 Mcal/kg $BW^{.75}$ for cows in condition score 3, 5 and 7 units, respectively. Similar results were reported by Thompson et al. (1983). The temperature below which heat production must be increased to maintain homeothermy is known as the lower critical temperature. An increase in heat production to maintain body temperature is a increase in the energy requirement for maintenance. Animals acclimated to temperatures between 15 and 25°C (thermoneutral zone) have a maintenance requirement (Mcal/d) of $NEm = .077W^{.75}$ (NRC., 1984). Within this range, energy requirements for maintenance are not affected by environment and the maximum amount of energy can be allocated for weight gain or lactation. For animals acclimated to the thermoneutral zone, .0007 should be subtracted or added to the NEm formula coefficient for each degree Celsius above or below 20°C (NRC., 1984). The heat increment produced from the digestion of feed partially offsets the increased energy required to maintain body temperature. Therefore the effective critical temperature is generally lower than the lower critical temperature and is a much more valuable measure of an increase in maintenance requirements.

Hot and cold weather can influence the voluntary intake of feedstuffs. High temperature and humidity may decrease intake by as much as 30% (NRC, 1984). Cattle with a long winter hair coat may show some signs of heat stress on a warm winter day but, these effects are thought to be minimal. More importantly for the fall calving cow, low temperature combined with wet, muddy conditions may also decrease intake by as much as 30% (NRC., 1984). Snow cover can limit forage availability. Rittenhouse et al. (1970) reported decreased forage intake during periods of cold weather and snow cover. Depressions of up to 50% may be possible with heavy snow cover (NRC., 1984). There is little doubt that such harsh weather increases the requirements for maintenance, but it is difficult to assess the size of the requirement. During such periods of depressed nutrient intake, a beef cow must rely on body store or energy dense supplemental feeds to meet her energy needs.

Cold, wet weather is particularly detrimental to grazing livestock. The lower critical temperature for a dry pregnant cow in the middle third of gestation is -25°C when the air is dry and there is no wind. The lower critical temperature for the same cow in a wet snow storm with a 10 mph wind is -7.3 C (NRC, 1981). When the insulative effects of the haircoat are negated by wet weather the requirements for energy are increased at an alarming rate.

Short term cold stress causes the beef cow to compensate by increasing DM intake (Ansotegui, 1993). The increased level of intake increases the heat of fermentation which in tum helps to maintain homeothermy. Digestibility of forages may also be reduced during cold weather (Laurenz et al., 1991). Increased intake speeds rate of passage and reduces the digestibility of range forage. Reduced digestibility is offset by increased intake so that the total energy status of the animal remains unchanged. As cattle become acclimated to a cold, dry environment, resting metabolic rate may increase due to increased thyroid activity (Christopherson, 1985). The elevated thyroid hormone levels are thought to mediate appetite and stimulate intake (Ansotegui, 1993).

Factors Affecting Available Nutrients for Fall Calving Beef Cows

Oklahoma is approximately 44 million acres in size. About fifty percent of this area is rangeland which is not suitable for crop production (Waller et al., 1972). The majority of this land can be utilized by ruminants, beef cattle in particular. However, many variables affect the availability and utilization of native grass including, grass species, stage of growth, seasonal factors, and previous grazing.

The most common native grass species in central Oklahoma are big bluestem, little bluestem, switchgrass, and indiangrass. Virtually all of the forage production of tallgrass prairie occurs from April to August. The succession from immature to mature forage is accompanied by increases in the proportion of stem and decreases in the proportion of leaf tissue (Minson, 1990). It is a common practice to stockpile summer growth of forage and defer it from grazing until the winter months. This practice allows the grass to cure into a standing hay crop and avoids the cost associated with the traditional methods of harvesting and feeding hay. The reduction in harvest cost is not without expense because the nutritional value of the standing forage deteriorates. Most of the soluble nutrients are leached from the grass by rainfall and exposure to the elements. Likewise, crude protein content of native forage falls from a high of 10% in May to a low of 2-3% in the months of January, February, and March (Waller et al., 1972).

Cattle are typically selective grazers preferring larger portions of leaf as compared to stem. Previously grazed dormant pastures are typically lower in their ratio of leaf to stem as a result of selective grazing (Krysl and Hess, 1993). Since the leaf contains a large portion of the available nutrients (Minson, 1990) it is possible that previously grazed dormant pastures are severely limiting in available nutrients.

Climatic conditions also affect the amount of available nutrients. Heavy snow cover obviously limits the amount of forage available for grazing. The effects of snow cover can be most detrimental after the snow has melted. Heavy snow tends to reduce sward height and grazing accessibility by damaging the vertical structure of the grass plant. In addition, forages deteriorate at a quicker pace when in contact with the mulch layer.

Native range must be managed differently from introduced pastures. Introduced grasses such as bermudagrass will produce large quantities of forage with proper nitrogen fertilization. These forages can be grazed and regrazed throughout the growing season without hurting stand quality. In fact, plant vigor may be increased due to the challenge of grazing pressure. On the other hand, excessive utilization of native range may be detrimental to stand quality. The range management rule of thumb is to "take half and leave half" of the annual forage production. Of the 50% of native grass that is removed, it is assumed that half (25% of the total) is consumed and the other half (25% of the total) is lost due to trampling, bedding, or consumed by insects or other animals (McCollum and Bidwell, 1993). If these assumptions are true then only 25% of the available native grass forage is actually utilized by the grazing animal. This explains the lower relative stocking rates for native range compared to introduced pastures.

Nutritional Deficiencies of Beef Cows Grazing Dormant Native Range

The nutrient requirements for a 450 kg lactating cow of average milking ability are .91 kg CP, 5.3 kg TDN, 26 g of Ca and 21 g of P (NRC, 1984). In order for this cow to meet her requirements for CP, TDN, Ca and P from dormant native range, she would have to consume 37 kg, 14.7 kg, 8.6 kg and 37 kg of dry matter for each nutrient, respectively. These intakes would have to be further exaggerated for a superior milking cow. Forage intake would typically range from 6.75 to 9 kg per day (1.5 to 2.0% of body weight for a 450 kg cow). Obviously some level of supplementation is required to sustain the productivity and profitability of cow calf production on native range.

Correcting Nutritional Deficiencies With Supplementation

Types of Supplementation. Many options are available for meeting the supplemental nutrient needs of grazing beef cows in Oklahoma. Among the more popular are hay, energy supplements and protein concentrate feeds. However, grain by-products, wheat pasture, and liquid feeds offer flexibility for economically meeting the nutrient requirements of the beef cow.

Protein concentrates, such as soybean meal and cottonseed meal, are the primary ingredients of protein supplements commonly referred to as cake or cubes. Because the protein content of dormant forage is low, feeding protein cake will alleviate a protein deficiency. Also, low to moderate levels of a high protein supplement simulates intake and digestibility of low quality forages (Kartchner, 1980). Low voluntary intake of forages is usually attributed to a ruminal ammonia deficiency. Ammonia is an essential nutrient for rumen microbes. Supplemental protein increases ruminal ammonia and stimulates microbial digestion of forage (McCollum and Hom, 1990) The faster rate and extent of digestion allows for a faster rate of passage from the rumen. Improvements in the voluntary intake of range forage are thus usually attributed to increased rate of forage digestion and passage or change in nutrient absorption from the small intestine (McCollum and Hom, 1990). The increase in intake and digestibility is often large enough to meet the energy demands of an average milking beef cow.

The use of urea in range supplements has generally been discouraged. The efficiency of urea utilization is estimated to be 25% on dormant range (NRC, 1976). Poor utilization has been attributed to the asynchrony between available nitrogen and readily fermentable carbohydrates (Johnson, 1976) and rapid loss of free ammonia. Simple sugars such as glucose must be available for ruminal microbes to utilize the available nitrogen from the breakdown of urea. Molasses/urea supplements are common in the southeast. Urea in molasses-based supplements are utilized more efficiently (50%) because molasses offers readily available source of fermentable sugars. Additionally, these liquid supplements offer the advantage of self feeding which can substantially reduce labor cost.

Other liquid supplements contain a variety of ingredients, many of which are by-products from the manufacture of food products, alcoholic beverages and other fermentation processes. Corn steep liquor and condensed molasses solubles are two of these byproducts that offer potential to help reduce the labor cost associated with supplemental feeding. These byproducts have amino acids as their source of nitrogen which may increase the utilization of supplemental feed. Studies indicated that corn steep liquor was equal to cottonseed meal for wintering pregnant cows on native range (Lusby et al., 1981). The relative cost and availability of these supplements will determine their usefulness for supplementing cows on native range.

Many convenience supplements are offered for sale in the form of large protein blocks. The majority of these blocks are formulated with urea and a large amount of molasses. Since they are formulated with molasses, the efficiency of urea utilization is approximately 50%. However if these supplement blocks are compared to typical supplements on a cost per pound of usable CP, they are extremely expensive. Moreover, the consumption of these supplements is often highly variable making them an ineffective supplement.

Many moderate protein (20% CP) supplements utilize a cereal grain as the major component. Cereal grains such as corn, milo, and wheat are available in Oklahoma but it is well documented that they have negative associative effects on forage utilization when fed at high levels (3 kg/d) (Chase and Hibberd, 1987). Forage utilization may be depressed to the extent that the total energy balance of the animal is unimproved or reduced.

Many byproducts of the food industry are utilized in the manufacture of livestock feeds. Food processing yields grain by-products and roughage products that are often utilized to formulate beef cattle supplements. Processed grain by-products can be highly variable in nutritive value. Many of these by-products are moderately good sources of nutrients, unfortunately, poor quality by-product feeds such as rice hulls (12% TDN) and rice mill feed (30% TDN) have caused producers to distrust several excellent by-product feeds such as soybean hulls and wheat midds.

Soybean hulls are an good source of digestible fiber and are low in soluble carbohydrates (Merrill and Klopfenstein, 1985). These properties make soybean hulls an effective and useful supplement for wintering beef cows on range. Soybean hulls were found to be an effective alternative to corn (Trautman, 1987). No depression in forage intake or digestibility was observed when hulls were fed at a low to moderate level (Martin and Hibberd, 1990).

Wheat midds are another digestible fiber feed that is useful for formulating supplements for cows grazing native range. Midds are a byproduct of the wheat milling industry and are readily available in the state of Oklahoma. Studies have demonstrated that wheat midds do not cause a depression in forage intake typically associated with the grain-based supplements when they were fed at a level to equalize daily CP intake. Digestibilities were increased over nonsupplemented controls and corn-based supplements so that total diet digestibilities were similar to supplementing cows with soybean meal (Ovenell et al., 1991). Researchers in Kansas found that wheat midds (3.2 kg/d) increased forage intake (Sunvold et al., 1991). This response was not be expected when wheat midds are fed at such a high level. However, the intake of forage by the controls was .86% of body weight which is abnormally low. Although wheat midds are considered a high fiber ingredient they do contain 25-30% starch. Therefore some caution should be used when feeding wheat midds at a high level or in a self feeder.

Alfalfa hay is a major cash crop in many parts of Oklahoma. One and one quarter to one and a half kg of alfalfa hay is equal to .5 kg of soybean meal in protein supply (Clanton et al., 1980). However, most producers overfeed alfalfa hay making it a expensive and wasteful supplement. Research in Kansas indicates that alfalfa hay is as beneficial as grain-based supplements for wintering cows on native range (DelCurto et al., 1990b). Researchers at Nebraska tested alfalfa hay against soybean meal for supplementing cows on native grass. The results indicated that cows performed better when supplemented with 1.4 kg of alfalfa/d than when fed .45 kg of soybean meal/d (Clanton et al., 1980). Subsequent studies indicated that cattle performance was similar between the two supplementation regimes. But, differences related to forage utilization are known to exist. Feeding low levels of protein concentrates has positive effects on forage intake and digestibility (McCollum and Horn, 1990). Feeding hay tends to substitute for forage rather than enhancing forage utilization. Vanzant and Cochran (1991) utilized cannulated steers to demonstrate that as the amount of supplemental alfalfa hay increased from .23 to .94 % of body weight, the intake of dormant native forage decreased from 1.44 to 1.12 % of body weight. Total DM intake, however, increased with increasing levels of supplemental alfalfa. Supplemental alfalfa may provide acceptable cow/calf performance, especially when forage supplies are limiting.

Wheat pasture is another potential supplement for beef cows on dormant range. It is common practice to place growing stocker cattle on wheat pasture for winter grazing. The crude protein content of wheat pasture can approach 30% (DM basis) under optimal growing conditions (Horn, 1983). The practice of limit-grazing cows for short periods daily or less frequently can help offset some of the supplementation cost for the cow calf producer. This is particularly true for fall calving cows because the periods of peak lactation coincide with peak forage production and quality. Studies indicate that wheat pasture is a very effective supplement for fall calving cows. Cows allowed access to wheat pasture on alternate days (approximately 5 hours at a time) outperformed cows that were wintered on native range with cottonseed meal (Apple et al., 1993). It should be remembered that wheat pasture growth is highly variable and animal performance may vary from year to year.

Method and Timing of Supplementation. Studies have shown that protein supplements can be fed every other day, every third day or even weekly without affecting cow/calf performance (McIlvain and Shoop, 1962; Melton and Riggs, 1964; Huston et al., 1986). Energy supplements based on cereal grains should be fed more often with every other day being the maximum and daily feeding being the preferred method especially when the feeding rate is fairly high (>3 kg/d). By altering the daily timing of supplementation, cattle should not develop a pattern of feeding where they wait for supplemental feed. Instead, the cattle spend more time grazing. Grazing distribution can also be affected by supplementing cattle in areas of the pasture that are underutilized.

Supplements can also be placed in a self feeder and intake can be limited with salt. The level of salt is adjusted until the desired intake of supplement is obtained. This type of supplement is often utilized with stocker cattle but it will work with cows as well. It allows for a reduction in labor cost associated with typical feeding regimes. Research data generally shows that performance is similar when the same level of protein or energy are supplemented either by hand feeding or self feeding (Brandyberry et al., 1990).

Protein vs. Energy Supplementation

The question is frequently asked by producers, "Should I feed a protein or an energy supplement?" Both protein and energy must be considered together. In reality the total energy content of high and medium quality protein cubes is not different even though the medium quality cubes are often referred to as energy cubes. A typical protein supplement is formulated from soybean meal or cottenseed meal which is 84% TDN. This level of TDN is not drastically different from energy supplements that are 20% crude protein. It is less costly to provide supplemental energy in a low protein supplement than in a high protein supplement. Likewise, it is less expensive to provide supplemental protein in a high protein supplement. The true value of either protein or energy will depend on the nutrient deficiencies of the cow. These deficiencies are difficult to quantify because the quantity and quality of the diet selected by grazing animals are difficult to assess. The answer to the producers question depends on several factors including forage quality and quantity as well as cow body condition, cow age and stage of production. In general, energy intake is the primary factor limiting performance, and protein intake is the primary factor affecting energy intake and utilization.

For cattle grazing rangeland, the fundamental goal should be to optimize utilization of the range forage resources. This is accomplished by feeding the kind and amount of supplement that will complement or enhance the utilization of the available forage, while meeting the cow's nutritional requirements All ranching operations do not have the same range conditions or access to the same feeds and equipment. It is therefore difficult to develop an ideal supplementation strategy to fit everyone's needs. Anticipated responses to supplementation must be thoroughly evaluated. Fortunately the fundamental principles of supplementation and forage utilization will apply in most production situations.

Protein Supplementation. Proteins are complex compounds that are composed of amino acids which contain nitrogen in addition to carbon, hydrogen and oxygen. Non ruminants require specific, preformed amino acids in the diet. Ruminants, on the other hand, only require a nonspecific source of protein or nitrogen. Ruminal microbes can utilize low quality protein or non protein nitrogen to synthesize essential amino acids which can then be utilized by the ruminant. Rumen bacteria degrade much of the dietary protein and amino acids to ammonia. They then utilize ammonia to form bacterial protein with an amino acid composition similar to soybean meal (Scott, 1992). Thus, protein quality is less important in feeding beef cattle provided they are old enough to be functional ruminants. In ruminants, rather, it is the total quantity of protein or nitrogen that is of primary importance.

Protein is generally the first limiting nutrient for beef cows grazing dormant forage. Protein is essential for maintenance, growth, reproduction and lactation. Consequently, many producers supplement beef cows grazing dormant forage with small quantities (1-2 kg/d) of a high protein (40% CP) supplement. Although protein is a rather expensive nutrient to supplement, protein supplements can be economically efficient if fed properly.

Numerous studies have demonstrated improvements in cow performance when protein supplements are fed to beef cows grazing poor quality forages. DelCurto et al. (1990) found that feeding high protein (39 % CP) supplements reduced pre- and post-calving cow weight and body condition loss compared to cows supplemented with a soybean meal/sorghum grain cube (25% CP). Akhtar and Stanton (1992) fed several levels and sources of protein supplements and concluded that the most beneficial level was .34 kg/d of cottonseed meal. This level provided equal reproductive performance to higher levels of cottonseed meal, even though it was formulated so that the cows would still be protein deficient (negative control).

Increased production appears to be attributable to increased forage intake and digestibility (McCollum and Galyean, 1985). The benefits of protein supplementation are actually two fold in nature. First, high protein supplements will eliminate the protein deficiency. Secondly, small quantities (.5-1.0 kg/d) of a high protein supplement increase intake and digestibility of low quality forages. The magnitude of this response may be large enough to eliminate the energy deficiency as well. Physiologically, the concentration of ruminal ammonia may be mediating the intake response. Ruminal ammonia stimulates the utilization of ingested fiber by cellulolytic bacteria (Van Soest, 1982) and many cellulolytic species require ruminal ammonia as their sole source of nitrogen (Orskov, 1982). Concentrations of ruminal ammonia are generally low (<2 mg/dl) in cattle consuming low quality forage diets (Guthrie and Wagner, 1988) Small quantities of protein supplements will increase ruminal ammonia concentrations (Guthrie and Wagner, 1988) and consequently increase the intake of the basal forage diet.

The studies mentioned previously primarily utilized a source of ruminally degradable protein such as cottonseed meal or soybean meal as the protein supplement. Some natural protein sources such as blood meal and corn gluten meal are resistant to degradation by microbes in the rumen. These protein supplements are sources of bypass or ruminally undegradable protein (RUP). They elicit a very different response in terms of forage utilization. A certain amount of ruminally degradable protein is necessary to maximize fermentation of forages. The quantity of supplemental ruminally degradable protein required to maximize microbial protein synthesis, forage utilization and intake of cows grazing dormant tallgrass prairie forage has been estimated to be 400 g/d (Scott, 1992). This level of ruminally degraded protein is equivalent to typical supplementation with soybean meal. If the level of bypass supplementation is too high, a ruminal ammonia deficiency may result causing a decline in forage utilization (Hibberd et al., 1988). Cow responses to supplemental bypass protein have been somewhat variable (Petersen et al., 1985; Hibberd et al., 1988). It appears that the effects of escape protein are much stronger as the cows energy balance becomes negative (McCollum and Horn, 1990)

Energy Supplementation. Energy requirements of the beef female are based upon body weight and stage of production (NRC, 1984). Until the energy requirements of the beef cow are satisfied, protein, minerals and vitamins may not be well utilized The amount of supplemental energy required will vary considerably for different stages of production. Lactating cows obviously have a higher energy requirement than dry cows Because the cow/calf segment of the beef cattle industry relies on the utilization of energy from forage as the major energy source the requirements for supplemental energy fluctuate depending on the basal forage quality and supply When energy is limiting, supplemental protein will be used for energy until the energy needs are meet (Clanton and Zimmerman, 1970) This process is extremely wasteful since high protein supplements are often very expensive

Energy status of the beef cow can be evaluated by visually estimating body condition score Aside from the weight lost at parturition, most of the weight change of a mature cow is reflected as changes in body condition (loss or gain of body fat). As a rule of thumb, cows should gain an amount of weight the last trimester equal to the weight lost at calving When mature cows lose condition from inadequate energy intake prior to calving, the interval from calving to first estrus will be lengthened (Wiltbank et al., 1962) Inadequate energy after calving can reduce conception rates (Wiltbank et al., 1962, 1964; Somerville, 1979, Rakestraw et al., 1986) Weight gain between calving and breeding is desirable and will improve conception rates (Whitman, 1975) However, it is costly and very difficult to feed cows to gain weight following calving because of the high energy requirements associated with lactation. The levels of supplemental energy required to accomplish weight gain after calving may cancel the benefits of improved conception rates If cows are in moderate to good condition (BCS=5) prior to calving, they can lose some weight and still maintain acceptable conception rates and days to conception

(Richards et al., 1986). This is particularly relevant for fall calving cows grazing dormant forage since their breeding season and peak lactation coincides with declining forage quality.

In most range situations, lactating females will lose weight during part of the year. Weight may be regained during periods of abundant forage production. This type of cyclic loss and gain of weight may not be detrimental to overall calf production. On the other hand, if condition did not cycle calf production should be maximized, but preventing condition changes may not be economically feasible.

The economy of the cow/calf segment of the beef cattle industry is based upon the utilization of energy from forage. Because forage is the principle component of the beef cow's diet, supplementation practices that alter forage utilization should be a primary concern for the cow/calf producer. Supplements such as corn may decrease forage intake (Chase and Hibberd, 1987; DelCurto et al., 1990a; Kartchner, 1981; Lusby et al., 1976; Rittenhouse et al., 1970). Other supplements such as soybean/cottonseed meal may increase forage intake (Clanton and Zimmerman, 1970, DelCurto et al., 1990a; Hannah et al., 1991; Ovenell et al., 1991). The primary difference in the intake response appears to be associated with the protein content of the forage and the protein concentration and type of supplement fed. If forage quality is low (< 6% CP), forage intake will increase when a small amount of a high protein supplement is fed. When high levels of supplement are fed, forage intake could be reduced by displacement.

The simplest and most economical method of providing energy to beef cows is in the form of cereal grains. However, grain supplements have had variable effects on forage utilization. During a mild winter, Kartchner (1981) found that 1.4 kg barley-based supplements, fed every other day, had little effect on forage intake and digestibility. In a more severe winter barley-based supplements resulted in lower intake and digestibility of range forage than did no supplement. In contrast, protein supplementation increased the intake and digestibility of forage during the severe winter. Similar results were observed by Chase and Hibbberd (1987) when corn-based supplements were fed at a rate of 2 to 3 kg/d. When high levels (2 to 4 kg/d) of cereal grains are supplied there is a shift in the fermentation patterns in the rumen. Ruminal microbes digest starch preferentially to fiber causing a decline in ruminal pH that may inhibit the growth of cellulolytic bacteria (Orskov, 1982). Consequently, large quantities of grain-based supplements may decrease forage utilization to the extent that overall energy status of the cows is not improved. In contrast, researchers at Kansas State University have utilized sorghum grain-based supplements and observed improved cow performance (Davis et al., 1977). However, in this study 1.4 kg of supplemental alfalfa was fed per day. This level of alfalfa would offset much of the protein deficiency and a reasonable response to energy supplementation could be expected. In addition, this study, as well as many others, compared with low protein, high starch versus high protein, low starch supplements. Consequently, their interpretation is questionable because starch levels varied and no measure of forage intake was recorded.

Protein x Energy Interactions. Hay intake has been shown to increase (curvilinear, Guthrie and Wagner, 1988; Stokes et al., 1988) in response to increasing quantities of soybean meal. Supplemental energy consumption increased as level of soybean meal supplementation increased. Consequently, effects of supplemental protein could not be separated from the effects of supplemental energy because protein and energy were confounded. Graded levels of protein supplementation could be evaluated more appropriately if supplemental energy consumption was equalized (Scott, 1992).

Few studies have attempted to quantify the interaction between supplemental protein and energy. Supplementation studies are traditionally designed to compare different levels of supplementation or the efficiency of use of different sources of supplement (i.e. soybean meal vs. corn). As with the previously mentioned studies, the effects of supplemental protein and supplemental energy are hard to evaluate because protein and energy are often confounded. DelCurto and associates (1987) studied the effects of supplemental protein:energy ratios on the intake and digestibility of low quality native grass. Only three supplements were utilized to make conclusions on the proper ratio of supplemental protein to energy. Such a small number of supplemental protein:energy ratios limit the usefulness of the results. The few studies that have attempted to utilize a wide range of supplemental protein:energy treatments also utilized corn grain or cornstarch as the source of supplemental energy (Clanton and Zimmerman, 1970; Rittenhouse et al., 1970). Since cereal grains have a well documented negative associative effect on forage utilization, the results of these experiments may have been biased.

Clanton and Zimmerman (1970) found an significant interaction between supplemental protein and energy when two levels of protein and two levels of energy (4 treatment combinations) were studied. Increasing energy intake within the low level of protein decreased heifer weight gains. On the other hand, increasing energy intake within the high level of protein increased weight gains (Clanton and Zimmerman, 1970). This interaction was only observed during one year of the two year study. Rittenhouse et al. (1970) utilized a wide range of supplemental protein and energy combinations (3 levels of protein within 4 levels of energy) and concluded that there was no interaction between supplemental protein and energy. The influence of supplemental protein on forage intake and digestibility was small and the average of the supplemented animals was not different from the unsupplemented controls. A decline in forage intake was observed at the two highest levels of supplemental energy indicating substitution of the supplement for forage.

As mentioned previously, the intake response to supplementation is highly variable. Moore and associates (1991) have suggested that the ratio of forage TDN and forage CP may be useful in predicting the intake response to supplemental protein. Forages with TDN:CP ratios below 8.0 tend to show little intake response to supplemental protein and may actually show a decline in intake when the TDN:CP ratio is around 3.5. Forages that are above an 8.0 ratio for TDN:CP tend to show a greater intake response to supplemental protein. Forages that have a high ratio (> 8.0) are typically very low in CP. Low levels of CP may be associated with a low level of ruminal ammonia causing a decline in forage intake. Therefore, supplemental protein may increase ruminal ammonia and subsequently increase forage intake. Mature range forage is generally low in both CP (<4.0 %) and TDN (<40 %) resulting in TDN:CP ratios that are intermediate (< 10). Moore et al. (1991) concluded that protein supplementation of some mature forages may not increase forage intake because the ratio between TDN and CP was intermediate (8-10) However, some level of protein supplementation may be necessary to meet the protein requirements of the animal. Previous studies that have shown improvements in the performance of cattle grazing low quality forages may have seen a response due to improving protein status of the animal instead of increasing the intake of the basal forage.

Other authors have suggested that the ratio between TDN and CP may be of some importance In his book on protein nutrition, Orskov (1982) addresses the relationship between DOM and degradability of nitrogen, but makes many assumptions relating to the relationship. Scott (1992) investigated the effect of supplemental ruminally degraded protein (RDP) on hay intake and utilization Digestible OM intake was maximized with 88.6 g of supplemental RDP per kg of digestible OM intake If a 500 kg lactating cow requires 5.6 kg of TDN (NRC, 1983), supplementation should provide 496 g of RDP Soybean meal is approximately 18% undegradable in the rumen (NRC, 1988) This computes to a feeding rate of 815 g/d of soybean meal which is very typical for beef cattle grazing native range

Future research related to supplementation of cows on native range should attempt to define more closely the response to supplemental protein or energy. Response curves could be potentially useful for predicting the type and level of supplementation would maximize forage utilization and optimize cow/calf performance.

Indicators of Nutritional Status

Timing of supplementation practices can be highly correlated to their effectiveness in correcting a nutritional deficiency. Changes in cow body condition are an effective evaluation tool for determining nutritional status of beef cows. Rebreeding rates may decline drastically if cows are loosing body condition during the last trimester or after calving. Gradual loss of condition is hard to detect and once body condition has changed enough to be noticed, long term damage may have already occurred. Consequently, a fast and efficient method to assess the nutritional status of the beef female is needed.

Blood and milk parameters such as urea, nonesterified fatty acids or glucose have been proposed as indicators of nutritional status (Hammond, 1983; Russel and Wright, 1983b). Russel and Wright (1983b) concluded that non-esterified fatty acids and 3-hydroxybutyrate were the most useful blood parameters for determining energy deficiency of pregnant beef cows. Blood glucose was also tested but plasma glucose is highly regulated insulin and glucagon and thus may not be suitable as a good indicator of nutritional status. Researchers at Florida evaluated blood urea nitrogen concentrations in steers grazing summer grass. They concluded that no significant increase in average daily gain would be obtained by feeding protein supplements when blood urea nitrogen concentrations were above 10 mg/dl (Hammond, 1992). In contrast, average daily gain was increased by protein supplementation when blood urea nitrogen concentrations were below 7 mg/dl. Positive responses to energy supplementation were observed over the range (9.6-17.6 mg/dl) of blood urea nitrogen concentrations evaluated (Hammond, 1992) However, little response to supplemental energy would be expected at blood urea concentrations below 7 mg/dl because protein would be the first limiting nutrient. Studies with beef cows and heifers provided evidence that blood urea nitrogen concentrations could be used to determine initiation and termination of protein supplementation (Hammond, 1992).

Several important factors are known to affect the concentrations of blood metabolites. Blood urea nitrogen concentrations can only be useful predictors of protein status for healthy ruminants in at least low to moderate condition (>4 BCS). Severe nutritional depletion as a result of prolonged undernutrition can cause catabolism of tissue protein and result in high levels of blood urea nitrogen (Hammond, 1983). Other factors affecting blood urea nitrogen concentrations include timing of sampling, stage of production, nitrogen content and degradability of the diet, energy content of the diet and level of feeding (Hammond, 1983). Some researchers have indicated that serum urea nitrogen may be more highly correlated with the ratio between energy and protein intake than with either energy intake or protein intake alone (Huntington, 1980). Hammond (1992) concluded that blood urea nitrogen concentrations are indicative of the protein to energy ratio in the diet. However, very few studies have attempted to quantify blood parameters of beef cows, across a wide range of supplemental protein and energy intakes All of these factors must be further defined before a standardized sampling procedure can be developed that will be useful as a diagnostic tool to detect nutrient deficiencies.

Literature cited

Akhtar, S., and T.L. Stanton 1992. Effects of protein supplements on the performance of gestating/lactating beef cows grazing winter range. Colorado Exp. Sta. Beef Program Report 189

Ansotegui, R 1993 Genetic and environmental factors affecting nutritional requirements. In: R P Gilbert (Ed.) Matching Beef Cattle to Western Environments, Phoenix, AZ.

Apple, K L , A L Hutson and K S Lusby 1993. Managing the cow-calf herd on wheat pasture. Oklahoma Sta Coop. Ext. Ser. Circ. E-916.

Brandyberry S.D., R C Cochran, E.S. Vanzant, T. DelCurto, J.E. Schneider, and L.R. Corah. 1990 Influence of supplementation method on forage use and grazing behavior of beef cattle grazing bluestem range Kansas State Univ Cattlemans Day Report of Progress MP-592 90

Buskirk, D D , R P Lemenager, and L A. Horstman 1992. Estimation of net energy requirements (NE_m and NE_v) of lactating beef cows. J. Anim. Sci. 70:3867.

Canas, R , J J Romero, and R L Baldwin 1982 Maintenance energy requirements during lactation in rats J Nutr 112:1876

Chase, C.C.,Jr. and C.A Hibberd 1987. Utilization of low quality native grass hay by beef cows fed increasing quantities of corn grain. J. Anim. Sci. 65:557.

Christopherson, R.J. 1985 The thermal environment and the ruminant digestive system. In: M K Yousef (Ed.) Stress Physiology in Livestock, Volume 1 Basic Principles. pp. 163-180 CRC Press, Inc , Florida

Clanton, D.C., and D R Zimmerman 1970 Symposium on pasture methods for maximum production in beef cattle: protein and energy requirements for female beef cattle J. Anim Sci 30:122

Clanton, D.C., M.E. England, and L.L. Berger 1980. Winter nutritional programs. Nebraska Beef Cattle Rep. EC 80-218.

Crooker, B.A., P.T. Anderson, and R.D. Goodrich. 1991. Maintenance energy requirements of tissue deposition and mobilization in cattle. In: F.T. McCollum and M.B. Judkins (Ed.). Proc. 2nd Grazing Livestock Nutrition Conference, Oklahoma Agr. Exp. Sta. MP-133.

Davis, D., R.R. Schalles, G.H. Kiracofe, and D.L. Good. 1977 Influence of winter nutrition on beef cow reproduction. J. Anim. Sci. 46:430.

DelCurto, T., R.C. Cochran, K.A. Jacques, D.L. Harmon, G. Towne, T.B. Avery, and E.S. Vanzant. 1987. Effect of supplemental protein:energy ratio on the intake, digestibility, fill, and turnover of dormant bluestem range-grass. Kansas State Univ. Cattlemans Day Report of Progress 514:91

DelCurto, T., R.C. Cochran, D.L. Harmon, A.A. Beharka, K.A. Jacques, G. Towne, and E.S. Vanzant. 1990a. Supplementation of dormant tallgrass-prairie forage: II Performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentrations. J. Anim. Sci. 68:532.

DelCurto, T., R.C. Cochran, T.G. Nagaraja, L.R. Corah, A.A. Beharka, and E.S. Vanzant 1990b. Comparison of soybean meal/sorghum grain, alfalfa hay and dehydrated alfalfa pellets as supplemental protein sources for beef cattle consuming dormant tallgrass-prairie forage. J. Anim. Sci. 68:2901.

DiCostanzo, A., J.C. Meiske, S.D. Plegge, T.M. Peters, and R.D. Goodrich. 1990. Within-herd variation in energy utilization for maintenance and gain in beef cows. J. Anim. Sci. 68:2156

DiCostanzo, A., J.C. Meiske, and S.D. Plegge. 1991. Characterization of energetically efficient and inefficient beef cows. J. Anim. Sci. 69:1337

Ferrell, C.L., and T.G. Jenkins. 1984. Energy utilization by mature, non pregnant, non lactating cows of different types. J. Anim. Sci. 58:234

Ferrell, C.L., and T.G. Jenkins. 1985. Cow type and the nutritional environment: nutritional aspects. J. Anim. Sci. 61:725

Fox, D.G., C.J. Sniffen, and J.D. O'Connor. 1988. Adjusting nutrient requirements of beef cattle for animal and environmental variations. J. Anim. Sci. 66:1475

Gregory, K.E. 1972. Beef cattle type for maximum efficiency: "Putting it all together". J. Anim. Sci. 34:881

Guthrie, M.J., and D.G. Wagner. 1988. Influence of protein or grain supplementation and increasing levels of soybean meal on intake, utilization and passage rate of prairie hay in beef steers and heifers. J. Anim. Sci. 66:1529.

Hammond, A.C. 1983. The use of blood urea nitrogen concentration as an indicator of protein status in cattle. Bovine Practitioner 18:114.

Hammond, A.C. 1992. Use of blood urea nitrogen concentration to guide protein supplementation in cattle. In: 3rd Annual Florida Ruminant Nutrition Symposium. Gainsville, Fl.

Hannah, S.M., R.C. Cochran, E.S. Vanzant, and D.L. Harmon. 1991. Influence of protein supplementation on site and extent of digestion, forage intake, and nutrient flow characteristics in steers consuming dormant bluestem-range forage. J. Anim. Sci. 69:2624.

Hibberd, C.A., R.R. Scott, B.D. Trautman, and C. Worthington. 1988. Bypass protein supplementation of lactating beef cows grazing dormant native grass in winter. Proc. West. Sec. Am. Soc. Anim. Sci. 39:324.

Horn, F.P. 1983. Chemical composition of wheat pasture. In: G.W. Horn (Ed.). Proc. National Wheat Pasture Symposium. Oklahoma Agr. Exp. Sta. MP-115

Huston, J.E., F.M. Byers, D.Cooper, and L.M. Schake. 1986. Feeding frequency and variation in supplement and forage intake in cows grazing dormant native rangeland. Beef Cattle Research in Texas. PR 4477. Texas A&M Univ., College Station.

Huntington, G 1980. Correlations of blood urea nitrogen with various nitrogen and energy intake parameters in feedlot steers. J. Anim. Sci. 51 (Suppl. 1):371 (Abst.).

Laurenz, J.C., F.M. Byers, G.T. Schelling, and L.W. Greene. 1991. Effects of season on the maintenance requirements of mature beef cows. J. Anim. Sci. 69:2168.

Lemenager, R.P., L.A. Nelson, and K.S. Hendrix. 1980. Influence of cow size and breed type on energy requirements. J. Anim. Sci. 51:566.

Lusby, K.S., D.F. Stephens, and R. Totusek. 1976. Influence of breed and level of winter supplement on forage intake of range cows. J. Anim. Sci. 43:543.

Lusby, K.S., S.L. Armbruster, and M.J. Dvorak. 1982. Condensed molasses solubles and corn steep liquor as protein supplements for range cows. Okla. Agr. Exp. Sta. MP-112:40.

Lusby, K.S., V. Stevens, K. Apple, M. Scott, and F. Bates. 1985. Feeding the cowherd. In: Oklahoma Beef Cattle Science Manual. pp. 1-18. Okla. Agr. Ext. Service.

Kartchner, R.J. 1981. Effects of protein and energy supplementation of cows grazing native winter range forage on intake and digestibility. J. Anim. Sci. 51:432.

Klosterman, E.W., L.G Sanford, and C.F. Parker. 1968. Effect of cow size and condition and ration protein content upon maintenance requirements of mature beef cows. J. Anim. Sci. 27:242.

Krysl, L.J. and B.W. Hess. 1993. Influence of supplementation on behavior of grazing cattle. J. Anim. Sci. 71:2546.

Martin, S.K. and C.A. Hibberd. 1990. Intake and digestibility of low-quality native grass hay by beef cows supplemented with graded levels of soybean hulls. J. Anim. Sci. 68:4319.

McCollum, F.T. and M.L. Galyean. 1985. Influence of cottonseed meal supplementation on voluntary intake, rumen fermentation and passage rate of prairie hay in beef steers. J. Anim. Sci. 60:570.

McCollum, F.T. and G.W. Horn. 1990. Protein supplementation of grazing livestock: A review. The Prof. Anim. Scientist. 6:1.

McCollum, F.T., and T.G. Bidwell. 1993. Grazing management on rangeland for beef production. Oklahoma Coop. Exp. Serv. E-926.

McDonald, P., R.R. Edwards, and J.F.D. Greenhalgh. 1981. Animal Nutrition. Longman Inc., New York.

McIlvain, E.H. and M.C. Shoop. 1962. Daily versus every-third-day versus weekly feeding of cottonseed cake to beef steers on winter range. J. Range Manage. 15:143.

Melton, A.A. and J.K. Riggs. 1964. Frequency of feeding protein supplements to range cattle. Texas Agr. Exp. Sta. Bull. B-1025.

Merrill, J. and T. Klopfenstein. 1985. Soyhull utilization in forage diets. Nebraska Beef Cattle Rep. MP:48:48.

Minson, D.J. 1990. Forage in Ruminant Nutrition. Academic Press, San Diego, CA.

Moore, J.E., W.E. Kunkle, and W.F. Brown. 1991. Forage quality and the need for protein and energy supplements. pp. 113-123. In: Proceedings of the 40th Annual Beef Cattle Short Course. University of Florida, Gainsville.

NRC. 1976. Nutrient Requirements of Beef Cattle (5th Ed.). National Academy Press, Washington, DC.

NRC. 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. National Academy Press, Washington, D.C.

NRC. 1984. Nutrient Requirements of Beef Cattle (6th Ed.). National Academy Press, Washington, D.C.

NRC. 1988. Nutrient Requirements of Dairy Cattle (6th Ed.). National Academy Press, Washington, D.C.

Orskov, E.R. 1982. Protein Nutrition in Ruminants. Academic Press, New York.

Ovenell, K.H., K.S. Lusby, G.W. Hom, and R.W. McNew. 1991. Effects of lactational status on forage intake, digestibility and particulate passage rate of beef cows supplemented with soybean meal, wheat middlings, and com and soybean meal. J. Anim. Sci. 69:2617.

Petersen, M.K., D.C. Clanton, and R.A. Britton. 1985. Influence of protein degradability in range supplements on abomasal nitrogen flow, nitrogen balance and nutrient digestibility. J. Anim. Sci. 60:1324.

Pope, L.S. 1967. Winter feeding and reproduction in cows. pp. 32-43. In: T.J. Cunha, A.C. Warnick and M. Koger. Factors Affecting Calf Crop. University of Florida Press, Gainsville.

Richards, M.W., J.C. Spitzer, and M.B. Wamer. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. J. Anim. Sci. 62:300.

Rittenhouse, L.R., D.C. Clanton, and C.L. Streeter. 1970. Intake and digestibility of winter-range forage by cattle with and without supplements. J. Anim. Sci. 31:1215.

Russel, A.J.F., and I.A. Wright. 1983a. Factors affecting maintenance requirements of beef cows. Anim. Prod. 37:329.

Russel, A.J.F., and I.A. Wright. 1983b. The use of blood metabolites in the determination of energy status in beef cattle. Anim. Prod. 37:335.

Scott, R.R. 1992. Ruminal protein degradation: effects on low quality forage intake and utilization by beef cows. Ph.D. Dissertation. Oklahoma State Univ., Stillwater.

Sunvold, G.D., R.C. Cochran, and E.S. Vanzant. 1991. Evaluation of wheat middlings as a supplement for beef cattle consuming dormant bluestem-range forage. J. Anim. Sci. 69:3044.

Thompson, W.R., J.C. Meiske, R.D. Goodrich, J.R. Rust, and F.M. Byers. 1983. Influence of body composition on energy requirements of beef cows during winter. J. Anim. Sci. 56:1241.

Trautman, B.D. 1987. Forage utilization and productivity of lactating beef cows fed cottonseed meal, corn or soybean hull supplements during the winter. M.S. Thesis. Oklahoma State Univ., Stillwater.

Van Soest, P.J. 1982. Nutritional Ecology of the Ruminant. O and B Books, Corvallis, OR.

Vanzant, E.S., and R.C. Cochran. 1991. Influence of increasing amounts of supplemental alfalfa hay on intake and utilization of dormant, winter-harvested, bluestem-range forage by beef steers. Kansas Sta. Univ. Report of Progress 623:50.

Wagner, J.J., K.S. Lusby, and J.W. Oltjen. 1988. Relationship between condition score, environmental conditions and metabolizable energy for maintenance during winter in mature, non pregnant, non lactating Hereford cows. Prof. Anim. Scientist. 4:28.

Waller, G.D., R D Morrison, and A.B. Nelson. 1972. Chemical composition of native grasses in central Oklahoma from 1947 to 1962. Okla. State Univ. Agr. Exp. Sta. Bull. B-697.

Webster, A.J.F. 1980. The energetic efficiency of growth. Livestock Prod. Sci. 7:243.

Wettemann, R.P., K.S. Lusby, R.J. Rasby, and M.W. Richards. 1987. Body condition at calving and postpartum nutrient intake influence reproductive performance of range cows. Okla. Agr. Exp. Sta. MP-119:70.

Whitman, R.W., E.E. Remmenga, and J.N. Wiltbank. 1975. Weight change, condition and beef cow reproduction. J. Anim. Sci. 41:387 (Abst.).

Wiltbank, J.N., W.W. Rowden, J.E. Ingalls, K.E. Gregory, and R.M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.

Wiltbank, J.N., W.W. Rowden, J.E. Ingalls, and D.R. Zimmermann. 1964. Influence of post-partum energy level on reproductive performance of Hereford cows restricted in energy intake prior to calving. J. Anim. Sci. 23:1049.

CHAPTER III

Running Head: BODY CONDITION AND ENERGY SUPPLEMENTATION

Effect of Supplemental Energy on Body Condition Change of Mid-gestation Beef Cows Fed Low Quality Native Grass Hay[1]

T. A. Thrift[2], C. A. Hibberd[3] and G. E. Selk

Department of Animal Science, Oklahoma State University, Stillwater 74078-0425

ABSTRACT

Seventy-two crossbred beef cows in mid-gestation were used to evaluate the effect of level of supplemental energy on body condition change. Cows were fed native grass hay (4.9% CP) in drylot for a 70-d trial (March 26 to June 6, 1992). Individually-fed supplements were formulated using soybean meal and soybean hulls to provide graded levels of energy (.5, 1.0, 1.5 or 2.0 kg TDN/d) with constant protein intake (.32 kg CP/d). Cows were weighed (24 h withdrawal from feed and water) and body condition scored (1=emaciated, 9=obese) at the beginning and end of the study. Hay OM intake was determined at the end of the study using fecal markers. Cow weight was not affected (P=.19) by level of supplemental energy. Body condition, however, was increased with graded levels of supplemental energy (cubic, P=.03; .02, .17, .22, .30 units, respectively). Body condition of thin cows (BCS<4.5) was more responsive (cubic, P=.03) to level of supplemental energy than moderately conditioned cows (BCS>4.5; linear, P=.18). Hay OM digestibility (linear, P=.02) and intake (cubic, P=.001) decreased as

[1] Approved for publication by the Director, Oklahoma Agricultural Experiment Station. This research was supported under project H-2018.

[2] Present address: Dept. of Anim. Sci., Texas A&M Univ., Kleberg Center, College Station 77843.

[3] To whom correspondence should be addressed.

supplemental energy increased Digestible OM intake was not affected by level of supplemental energy (P=.52) or initial body condition (P=.54). Feeding as much as 2 kg/d of supplement increased body condition only slightly (.30 units) during the course of this 70-d trial. Thus, normal energy supplementation (1 to 2 kg TDN/d) may not be adequate to return thin cows to optimal body condition (BCS 5.5 to 6) between weaning and calving.

Key Words: Beef Cattle, Body Condition, Energy, Hay Intake, Supplementation

Introduction

Spring calving beef cows grazing dormant native grass (<4% CP) require supplementation to maintain body condition through calving. Cows entering the winter in poor body condition may need to be reconditioned to avoid rebreeding problems and reduced calf gains. Although protein supplementation (.5 to 1.0 kg 40% CP/d) increases digestible OM intake of cows grazing dormant native grass, the response may not be adequate to increase body condition of thin cows (Trautman, 1987). Under these conditions, supplemental energy may be useful.

Unfortunately, the response of beef cows to energy supplementation is not very predictable. Factors such as forage quality, environment and initial body condition affect the utilization of supplemental energy (Horn and McCollum, 1987; Houghton et al., 1990). A net energy system has been developed (Buskirk et al., 1992) that utilizes net energy for maintenance (NE_m) and net energy for weight change (NE_x) to define the energy requirements of beef cows of differing body condition. The NE_x system appears useful but requires validation under a variety of circumstances. The objectives of this trial were to quantify the body condition changes of beef cows fed low quality native grass hay supplemented with graded levels of energy.

Materials and Methods

Calves were weaned from 72 fall-calving crossbred beef cows on March 19, 1992, one week prior to the start of this trial to mimic a post-weaning spring calving herd. Cows were ranked by initial body condition score and randomly allotted to one of four supplements. Pelleted (.5 cm) supplements were formulated with blends of soybean meal and soybean hulls to provide .5, 1.0, 1.5 or 2.0 kg TDN/d (Table 1). Protein concentration was decreased as feeding rate increased to equalize supplemental CP intake (.32 kg CP/d) at a level to exceed the protein requirement of beef cows in mid gestation (hay CP contribution included; NRC, 1984). In addition, calcium, phosphorus and vitamin A requirements were satisfied (NRC, 1984). Sodium sulfate was included to maintain a supplemental nitrogen:sulfur ratio of 12:1. Cows were individually fed their respective weekly allotment of supplement in five feedings (M, T, W, F, S). Supplements were sampled daily and ground (1-mm screen) prior to storage (5° C). Dry matter, ash and CP (N*6.25) contents were determined (AOAC, 1975).

The basal diet consisted of large, round bales of native grass hay (680 kg/bale) fed free choice in round bale feeders. All bales were weighed and core sampled prior to feeding. Hay samples were composited by pen, ground (1-mm screen) and subjected to the same chemical analysis as the supplements. Crude protein content of the hay averaged 4.9% (DM basis). Actual protein and energy intake were in excess of requirements for a 450 kg mid-gestation beef cow at maintenance (NRC, 1984).

Cows were weighed at the beginning and end of the study following a 24-h withdrawal from feed and water. Body condition (1=emaciated, 9=obese; Wagner, 1988) was evaluated by three independent observers.

At the end of the study, hay intake was determined utilizing chromic oxide to estimate fecal output and acid detergent lignin to estimate hay indigestibility. Each day, cows received 100 g (as-is) of a chromic oxide pellet (20% Cr_2O_3, 75% wheat midds, 5% molasses) for a 6-d adaptation period. The pellet was top-dressed on the supplement and fed once daily (0800).

Fecal grab samples were collected six times over a 52-h period (2400 on day 6; 1200 and 2000 on day 7; 0800 and 1600 on day 8; 0400 on day 9). Samples were initially frozen (-25° C) and then thawed and composited by cow. Composites were dried (60° C) in a forced-air oven and ground (1-mm screen). Three cows were deleted from the intake analysis due to sample compositing errors. Dry matter and ash content was determined (AOAC, 1975). Chromium was analyzed by atomic absorption flame spectroscopy (nitrous oxide/acetylene flame). Lignin content of fecal and hay samples was determined with the acid detergent lignin procedure of Goering and Van Soest (1975). Hay intake and digestibility were calculated as outlined by Kartchner (1981).

Statistics. Cow weight change and body condition change were analyzed by least squares procedures with treatment, parity and initial cow body condition score (covariate) included in the model. A second analysis was performed with cows sorted by initial body condition into two groups (BCS<4.5 and BCS>4.5). This model included the previous effects plus BCS group and BCS group*treatment added to the model. Intake and digestibility variables were analyzed by least squares procedures with treatment, parity and cow body weight (covariate for all variables not expressed on % BW) included in the model. Orthogonal polynomials (linear, quadratic, cubic) were used to evaluate treatment responses. When the initial BCS group*treatment interaction was significant, orthogonal polynomials were conducted within initial BCS group. Five cows were removed from the study when they failed to calve the following fall.

Results and Discussion

Cow weight increased an average of 50.5 kg across all treatments (Table 2). Although a cubic trend (P=.07) was observed, cow weight did not respond consistently to level of supplemental TDN. Cow body condition, however, was increased (cubic, P=.05) as supplemental energy increased. It is not clear why body condition responded to energy supplementation while body weight increases were similar for all treatments. These cows were relatively thin at the start of the study (average initial condition score 4.7, range 2.8 to 6.5). Crooker et al. (1991) noted that increasing body condition from a condition score 4 to a 5 constitutes a large increase in body protein reserves. Some of the increase in protein stores may be accounted for by increases in the size of the metabolically active organs such as the liver (Ferrell and Jenkins, 1984a). The cows utilized in this study were previously on a supplementation study that provided 80 to 125% of their daily protein requirement. Cows changed from a low to a high plane of nutrition often respond with increased weight of metabolically active organs (Ferrell and Jenkins, 1984b). Typically when cattle deposit fat, the first site of deposition is internal (Boggs and Merkel, 1979). When thin cows replenish their energy stores, the first site of fat deposition may be internal where it cannot be detected by visual condition score In the current study, muscle repletion, increased size of metabolically active organs and internal fat deposition may explain the large increase in body weight that was not reflected by concomitant increases in body condition.

Feeding two kg/d of supplemental TDN for 70 days increased body condition by only .30 units (Table 2). Thus, substantial quantities of energy (140 kg TDN) produced only marginal improvements in body condition. These cows were fed low quality native grass hay (4.9% CP) in drylot during the spring when environmental influences were minimal. In addition, these cows were in mid-gestation. Cows in late gestation would require additional energy for conceptus growth (NRC, 1984) which would further reduce the impact of supplemental energy on body condition. The small response to supplemental energy observed under these conditions illustrates the difficulty in changing body condition of gestating beef cows when forage quality is low.

Cows were sorted into two groups (BCS <4.5 or >4.5) to evaluate the effect of initial body condition on responses to supplemental TDN. An initial BCS by level of supplemental TDN interaction (P=.09) for body condition indicated that thin cows gained more condition in response to energy supplementation (cubic, P=.03) than moderately conditioned (BCS >4.5) cows (linear, P=.18; Figure 1). Wagner et al. (1988) concluded that thin (BCS=3) and fat (BCS=7) cows had lower maintenance energy requirements per kg of body weight than cows in moderate (BCS=5) condition. Other researchers have concluded that body condition affects the maintenance requirements of mature beef cattle (Thompson et al., 1983; DiConstanzo et al., 1990; Houghton et al., 1990). Thus, thin cows may utilize a smaller proportion of ingested energy for maintenance leaving a larger quantity of energy available for weight gain.

It is generally accepted that an increase in body weight of 27 to 36 kg equates to a one unit increase in body condition score (Corah et al., 1991). However, Crooker et al. (1991) suggested that this relationship is dependent on the initial body condition of the cows. A weight gain of 81 kg is required to increase BCS from 3 to 5 while only 47 kg is required to increase BCS from 5 to 7. In our study, thin cows (BCS<4.5) responded to supplemental energy with an increase of 52 kg of body weight and .53 units of body condition (98 kg/unit of body condition). In contrast, moderately conditioned cows (BCS>4.5) increased body weight by 57 kg and body condition by .09 units (635 kg/unit of body condition). Thus, our study supports the concept that weight gain per unit of body condition is not fixed but dependent on initial body condition score.

Hay OM intake (kg/d and % BW) decreased (cubic, P=.001) with added supplemental TDN (Table 3). The highest hay OM intake was observed with the low level of supplemental TDN which was primarily soybean meal fed at a rate of .69 kg DM/d. High protein supplements have been shown to increase the intake and digestibility of low quality forages when fed at low to moderate rates (McCollum and Galyean, 1985; Fleck et al., 1988). Hay OM intake was fairly similar (mean=2.3 % BW) for the first three levels of supplemental TDN but declined with 2.0 kg supplemental TDN. These results agree with Martin and Hibberd (1990) in that soybean hulls did not reduce hay intake until the supplemental feeding rate approaches 2 kg TDN/day. Hay OM digestibility decreased (linear, P=.02) as the level of supplemental TDN increased. In contrast, Martin and Hibberd (1990) found that increasing supplemental TDN with soybean hulls increased hay digestibility. To formulate these supplements for increased supplemental TDN supply, soybean hulls were substituted for soybean meal. Although supplemental protein intakes were similar, there is some evidence that the ruminal protein degradation of soybean hull protein is less than that of soybean meal (Martin and Hibberd, 1990; Scott, 1992). Thus, the low TDN, high soybean meal supplements may have more effectively stimulated hay fermentability.

As supplement intake increased, hay OM intake declined so that total OM intake was not altered (cubic, P=.12, Table 3). Similarly, digestible OM intake was not affected (cubic, P=.25) by level of supplemental TDN indicating all cows consumed a similar quantity of energy. Although increased supplemental TDN was expected to increase total energy intake, decreased hay intake and digestibility negated this response. Typically, energy supplementation increases total energy in take as evidenced by previous studies with late gestation/early lactation beef cows where supplemental energy reduced body weight and condition losses (Trautman, 1987; Lusby et al., 1991)

Changes in hay OM intake due to level of supplemental TDN were not dependent (P=.73) on initial body condition (Figure 2). Hay OM intake decreased (cubic, P<.05) for both groups as the level of supplemental TDN increased. The response in hay OM digestibility due to level of supplemental TDN was affected (P=.12) by initial body condition score (Figure 3). Supplemental TDN decreased (linear, P=.01) hay OM digestibility for the thin cows (BCS<4.5) but had little effect (cubic, P=.32) on moderately conditioned cows (BCS>4.5). Digestible OM intake (Figure 4) was not affected by level of supplemental TDN (P=.52), initial body condition (P=.41) or the interaction between these variables (P=.54). Similar energy intakes for thin and moderately conditioned cows coupled with reduced maintenance energy requirements for thin cows (Wagner et al., 1988) may explain why thin cows gained more body condition and were more responsive to increases in the level of supplemental energy than moderately conditioned cows.

Metabolizable energy requirement for maintenance (Wagner et al., 1988) was compared to metabolizable energy supply (calculated from digestible OM intake; NRC., 1984) to explain the increased body condition responsiveness of thin cows (BCS<4.5) to level of supplemental energy. Thin cows required 6.4% less ME/d than moderately conditioned cows. However, when expressed on the basis of metabolic body weight, ME requirements for maintenance were .158

Mcal ME/MBW for thin cows vs. .157 Mcal ME/MBW for moderately conditioned cows. Thus, weight differences accounted for the difference in ME requirements for maintenance (Mcal ME/d) for thin and moderately conditioned cows. Metabolizable energy intake expressed as a multiple of maintenance was 1.54 X for thin cows compared to 1.52 X for moderately conditioned cows. Consequently, the increased responsiveness of thin cows must be attributable to factors such as efficiency of energy use in either the rumen or the tissue. For example, Martin and Hibberd (1990) demonstrated that soybean hulls increased ruminal VFA concentrations and the molar proportion of propionate when fed at a similar rate as in the current trial. When thin cows are reconditioned, nutrients must be partitioned to both muscle and fat while moderately conditioned cows utilize nutrients primarily for fat deposition. Perhaps thin cows utilized propionate more efficiently for tissue repletion than moderately conditioned cows.

Implications

These results suggest that it may be very difficult to substantially increase visual body condition of beef cows consuming low quality forage using normal supplementation rates (up to 2 kg supplemental TDN/d). To effectively alter the body condition of spring calving beef cows, management should be altered before forage quality and ambient temperatures decline. Because thin cows are more responsive to supplemental TDN, cows should be sorted by body condition prior to reconditioning. For moderately conditioned cows, a small quantity (.69 kg DM/d) of a high protein supplement maintained body condition as effectively as a large quantity (2.72 kg DM/d) of a lower protein supplement.

Literature Cited

AOAC. 1975. Official Methods of Analysis (12th Ed.) Association of Official Analytical Chemists, Washington D.C.

Boggs, D.L., and R.A. Merkel. 1979. Live Animal Carcass Evaluation and Selection Manual. (3rd Ed.) Kendal/Hunt Publishing Co. Dubuque, Iowa.

Buskirk, D.D., R.P. Lemenager, and L.A. Horstman. 1992. Estimation of net energy requirements (NE_m and NE_Δ) of lactating beef cows. J. Anim. Sci. 70:3867.

Corah, L.R., R.P. Lemenager, P.L. Houghton, and D.A. Blasi. 1991. Feeding your cows by body condition. Kansas State Univ. Coop. Ext. Bulletin. C-842.

Crooker, B.A., P.T. Anderson, and R.D. Goodrich. 1991. Maintenance energy requirements and energetics of tissue deposition and mobilization in cattle. In: F.T. McCollum and M.B. Judkins (Ed.) Proc. 2nd Grazing Livestock Nutrition Conference. Oklahoma Agr. Exp. Sta. MP-133.

DiCostanzo, A., J.C. Meiske, S.D. Plegge, T.M. Peters, and R.D. Goodrich. 1990. Within-herd variation in energy utilization for maintenance and gain in beef cows. J. Anim. Sci. 68:2156.

Ferrell, C.L., and T.G. Jenkins. 1984a. Energy utilization by mature, nonpregnant nonlactating cows of different types. J. Anim. Sci. 58:234.

Ferrell, C.L., and T.G. Jenkins. 1984b. A note on energy requirements for maintenance of lean and fat Angus, Hereford and Simmental cows. Anim. Prod. 39:305.

Fleck, A.T., K.S. Lusby, F.N. Owens, and F.T. McCollum. Effects of corn gluten feed on forage intake, digestibility and ruminal parameters of cattle fed native grass hay. J. Anim. Sci. 66:750.

Goering, H.K., and P.J. Van Soest. 1975. Forage fiber analysis. Agr. Handbook No. 379., ARS, USDA, Washington, D.C.

Houghton, P.L., R.P. Lemenager, K.S. Hendrix, G.E. Moss, and T.S. Stewart. 1990. Effects of body composition, pre- and postpartum energy intake and stage of production on energy utilization by beef cows. J. Anim. Sci. 68:1447.

Horn, G.W., and F.T. McCollum. 1987. Energy supplementation on grazing ruminants. In: Proc. Grazing Livestock Nutrition Conf., Jackson, WY. pp. 125-136.

Kartchner, R.J. 1981. Effects of protein and energy supplementation of cows grazing native winter range forage on intake and digestibility. J. Anim. Sci. 51:432.

Lusby, K.S., R.P. Wettemann, K.H. Ovenell, and D.A. Cox. 1991. The value of wheat middlings in winter supplements for beef cows. Prof. Anim. Sci. 7:24.

Martin, S.L., and C.A. Hibberd. 1990. Intake and digestibility of low-quality native grass hay by beef cows fed graded levels of soybean hulls. J. Anim. Sci. 68:4319.

McCollum, F.T., and M.L. Galyean. 1985. Influence of cottonseed meal supplementation on voluntary intake, rumen fermentation and rate of passage of prairie hay in beef steers. J. Anim. Sci. 60:570.

NRC. 1984. Nutrient Requirements of Beef Cattle. (6th Ed.). National Academy Press, Washington, D.C.

Scott, R.R. 1992. Ruminal protein degradation: effects on low quality forage intake and utilization by beef cows. Ph.D. Dissertation (Ch 3) Oklahoma State Univ., Stillwater.

Trautman, B.D. 1987. Forage utilization and productivity of lactating beef cows fed cottonseed meal, corn or soybean hull supplements during the winter. M.S. Thesis. Oklahoma State Univ., Stillwater.

Thompson, W.R., J.C. Meiske, R.D. Goodrich, J.R. Rust, and F.M. Byers. 1983. Influence of body composition on energy requirements of beef cows during winter. J. Anim. Sci. 56:1241.

Wagner, J.J., K.S. Lusby, J.W. Oltjen, J. Rakestraw, R.P. Wettemann, and L.E. Walters. 1988. Carcass composition in mature Hereford cows: estimation and effect on daily metabolizable energy requirement during winter. J. Anim. Sci. 66:603.

Table 1 Feed composition, feeding rate and nutrient supply of supplements formulated to provide four levels of energy (TDN)

	Supplemental TDN, kg/d			
Item	.5	1.0	1.5	2.0
Supplement composition, %, DM basis				
Soybean meal	91.20	30.99	10.39	
Soybean hulls		63.17	84.73	95.64
Molasses	3.00	2.99	3.01	3.00
Dicalcium phosphate	1.37	.57	31	15
Trace mineralized salt[a]	3.59	1.83	1.23	.92
Sodium sulfate	72	40	29	25
Vitamin A (30,000 IU/g)	.12	.06	.04	.03
Feeding rate, kg DM/d	69	1.36	2.04	2.72
Nutrient content, %, DM basis				
CP[b]	45.2	26.1	19.6	16.1
TDN[c]	78.8	75.6	74.4	73.9
Supplemental nutrient supply, kg/d				
CP[b]	.31	35	.39	.44
TDN[c]	.54	1.03	1.52	2.01

[a] Trace mineralized salt contained 92% NaCl, .25% Mn, .20% Fe, .033% Cu, 007% I, 005% Zn, and 0025% Co

[b] Actual analysis

[c] Estimated from NRC (1984)

Table 2. Weight and body condition change of beef cows fed low quality native grass hay with increasing levels of supplemental energy

	Supplemental TDN, kg/d				
Item	.5	1.0	1.5	2.0	SE[a]
Cow weight, kg					
Initial	403.5	402.7	404.1	399.1	9.57
Final	452.6	455.5	450.4	453.0	10.93
Change[b]	49.0	52.8	46.2	53.9	3.69
Body condition score, units					
Initial	4.63	4.67	4.60	4.70	.000
Final	4.73	4.88	4.93	5.01	.065
Change[c]	.02	.17	.22	.30	.065

[a] Standard errors reported represent the largest SE for each variable.
[b] Cubic response to level of supplemental TDN (P=.07).
[c] Cubic response to level of supplemental TDN (P=.05).

Table 3. Effect of energy supplementation on OM intake and digestibility by cows consuming low quality native grass hay

	Supplemental TDN, kg/d				
Item	.5	1.0	1.5	2.0	SE[a]
No. of cows	16	18	14	16	-
Fecal output, kg/d	5.3	5.3	5.5	5.1	.18
Hay intake, kg/d[b]	11.3	10.7	10.8	9.3	.40
Hay intake, % BW[b]	2.39	2.23	2.27	1.94	.086
Total intake, kg/d	11.9	11.9	12.7	11.8	.40
Total intake, % BW	2.52	2.50	2.68	2.47	.088
Hay digestibility, %[c]	53.4	52.4	51.9	49.7	1.36
Total diet digestibility, %	55.2	55.6	56.2	56.3	1.11
Digestible OM intake, kg/d	6.6	6.6	7.1	6.6	.29
Digestible OM intake, % BW	1.41	1.40	1.52	1.40	.066

[a] Standard errors reported represent the largest SE for each variable.
[b] Cubic response to level of supplemental TDN (P=.001).
[c] Linear response to level of supplemental TDN (P=.02).

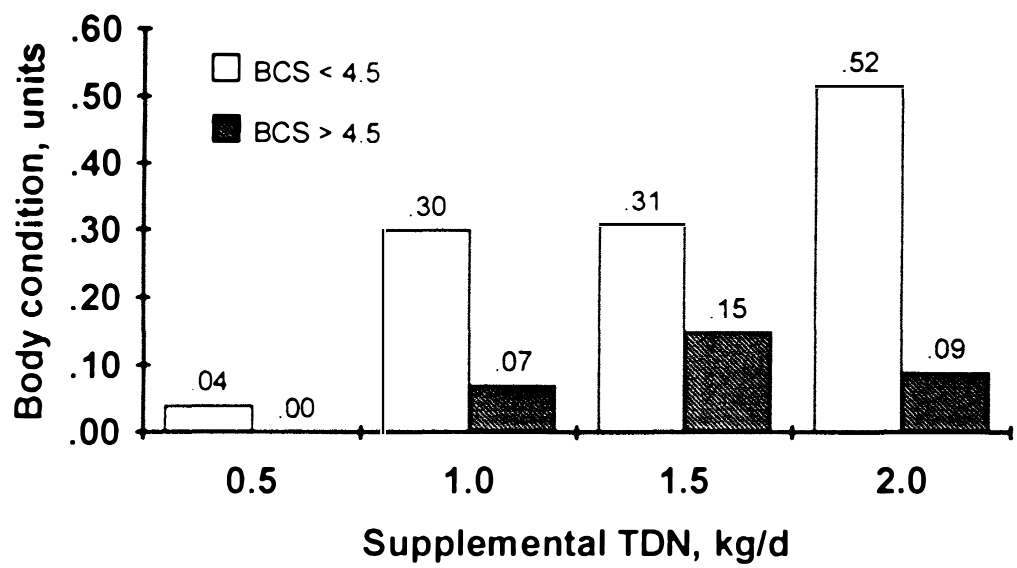

Figure 1. Change in body condition(BCS) of thin (BCS<4.5; cubic, P=.03) and moderately conditioned (BCS>4.5; linear, P=.18) gestating beef cows fed native grass hay supplemented with graded levels of energy (SE=.121)

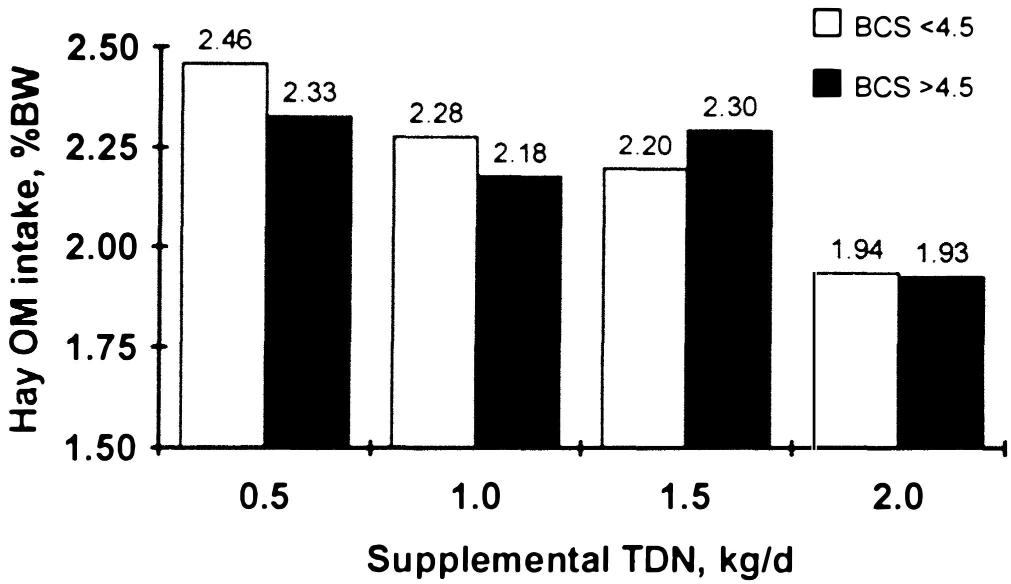

Figure 2 Effect of supplemental energy on hay OM intake (% BW) of thin (BCS<4.5; cubic, P=.04) vs. moderately conditioned (BCS>4.5; cubic, P=.02) gestating beef cows (SE=.125)

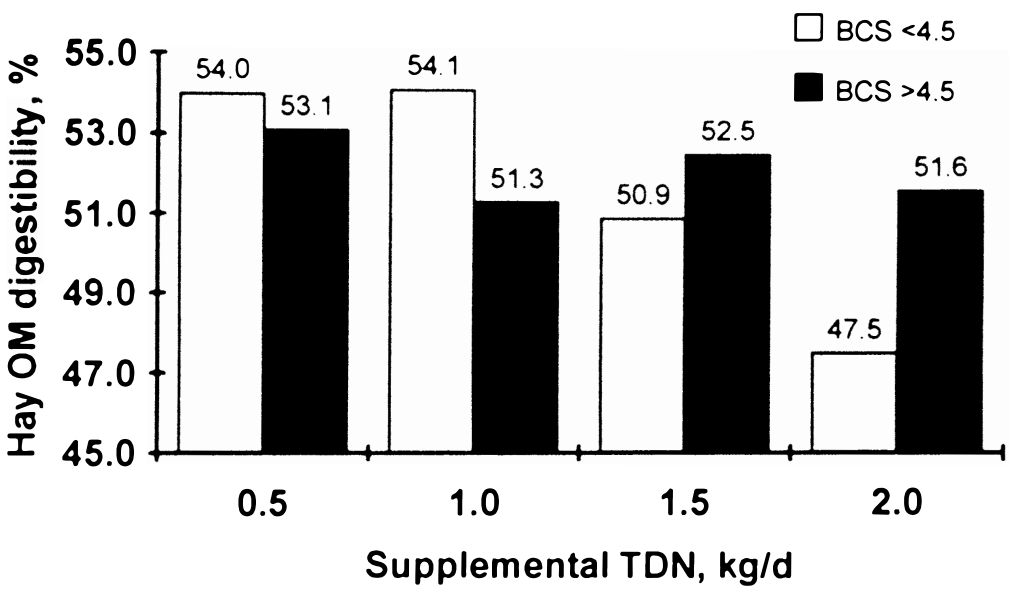

Figure 3. Effect of supplemental energy on hay OM digestibility (%) of thin (BCS<4.5; linear, P=.01) vs. moderately conditioned (BCS>4.5; cubic, P=.32) gestating beef cows (SE=2.40).

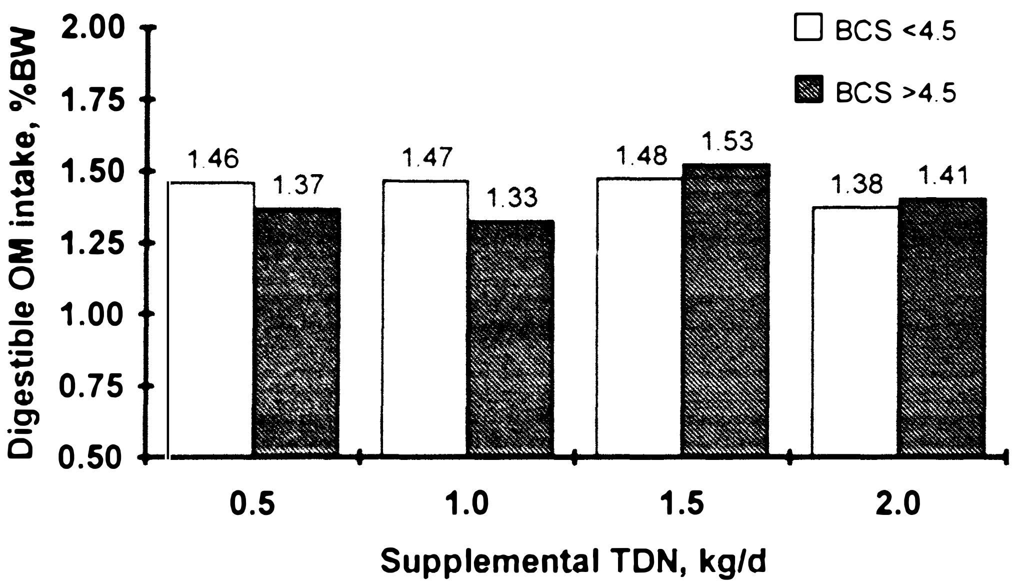

Figure 4. Effect of supplemental energy on digestible OM intake (% BW) of thin (BCS<4.5; quadratic, P=.48) vs. moderately conditioned (BCS>4.5; cubic, P=.31) gestating beef cows (SE=.102).

CHAPTER IV

Running Head: SUPPLEMENTAL NUTRIENTS AND COW PERFORMANCE

Interaction Between Supplemental Protein and Energy for Lactating Beef Cows Grazing Dormant Native Tallgrass: Cow and Calf Performance[1]

T.A. Thrift[2] and C.A. Hibberd[3]

Department of Animal Science, Oklahoma State University, Stillwater 74078-0425

ABSTRACT

For two consecutive years fall calving, crossbred beef cows and their calves were assigned to 12 supplements (72 cows/year, 6 pairs per supplement) providing four levels of protein and three levels of energy to evaluate the interaction between supplemental protein and energy. Cows grazed a native tallgrass pasture (4.0 % CP, OM basis) and were fed supplements individually for the 85-d studies. Supplements were formulated using soybean meal and soybean hulls to provide three levels of energy (Low, 1.32 kg TDN/d; Medium, 1.76 kg TDN/d; High, 2.22 kg TDN/day) and four levels of protein (80, 95, 110, 125% of protein requirement, including estimated forage CP contribution). Cow weight (8 h withdrawal from feed and water), calf weight (6 h withdrawal from feed and water), and body condition scores (1=emaciated, 9=obese) were recorded. Cows were machine-milked for determination of milk yield. Supplemental CP*TDN interactions were not significant for cow weight change (P=.46), cow body condition change (P=.23), calf weight gain (P=.21) and milk yield (P=.33). Consequently,

---

[1] Approved for publication by the Director, Oklahoma Agricultural Experiment Station. This research was supported under project H-2018.

[2] Present address: Dept. of Anim. Sci., Texas A&M Univ., Kleberg Center, College Station 77843.

[3] To whom correspondence should be addressed.

the main effects of CP and TDN were evaluated independently. Supplemental protein reduced cow weight loss (linear, P=.0001), cow body condition loss (linear, P=.002) and increased calf weight gain (linear, P=.0001) and milk yield (quadratic, P=.10). Similarly, supplemental TDN reduced cow weight loss (linear, P=.009), cow body condition loss (linear, P=.004) and increased calf weight gain (linear, P=.0001) and milk yield (linear, P=.0001). Regression analysis indicated that cow and calf performance was more responsive to supplemental protein than energy. This study suggests that protein (up to 125% of NRC requirements) or energy supplementation will incrementally increase the performance of lactating beef cows grazing dormant native range with supplemental protein being 2 to 5 fold more effective than supplemental energy. The economic response, however, will depend on the relative cost of these nutrients.

(Key Words: Beef Cattle, Lactation, Native Tallgrass, Supplementation, Protein, Energy.)

Introduction

Nutritional management of fall calving beef cows grazing dormant grass presents a major challenge to cow/calf producers. High nutrient requirements of the cow coincide with low forage quality (forage CP 2-4%) and cold environmental temperatures to make proper nutrition a high priority. Additionally, purchased feed is one of the major costs associated with cow/calf production. Therefore, it is important for producers to utilize supplemental feed efficiently in an effort to maintain profitability. Unfortunately, the response to supplementation is often highly variable. Much of this variation can be attributed to the environment as well as forage quality and quantity. A significant portion of this variation may be attributable to deficiencies in our knowledge of responses to supplemental CP and TDN.

Previous supplementation studies have directly compared energy to protein supplementation. These studies are useful for making producer recommendations but do not accurately define the response to supplementation over a wide range of CP and TDN levels. Other studies have evaluated protein effects at a single energy level. Extrapolation of those results to other energy levels may be inappropriate. The few studies that have attempted to quantify the interaction between supplemental protein and energy have also utilized cereal grains as the supplemental energy source (Clanton and Zimmerman, 1970; Rittenhouse et al., 1970; Kartchner, 1981). Cereal grain supplementation can negatively affect forage utilization (Chase and Hibberd, 1987). The objective of this study was to improve the accuracy of predicting supplemental feed requirements for lactating beef cows grazing dormant native tallgrass by quantifying the interaction between supplemental protein and energy.

Materials and Methods

This study was conducted during the winters of 1992 and 1993. Seventy-two fall calving, crossbred beef cows (average calving dates September 29, 1991 and September 26, 1992) were allotted to one of 12 supplementation treatments on December 12, 1991 and December 17, 1992. Cows were allocated to treatment by cow age, calving date and calf sex. Cows were reallocated to treatment for the second year of the trial. Cow/calf pairs grazed a 130 ha native tallgrass pasture composed primarily of Andropogon gerardi, Schizachyrium scoparium, Panicum vergatum and Sorghastrum nutans. This pasture was divided into two paddocks and deferred from grazing from April until November. Cows grazed the first paddock until forage supplies were depleted and then were moved to the second paddock (February 13, 1992 and February 17, 1993).

Supplements were formulated to provide four levels of protein and three levels of energy (Table 1). The level of supplemental protein was increased so that total protein intake (forage plus supplement) provided 80, 95, 110, and 125% of the NRC (1984) protein requirements of a 500 kg lactating beef cow. Previous research on tallgrass prairie in this region was utilized to estimate forage parameters for supplement formulation: forage intake, 2.0% BW; 3.8% CP (Trautman, 1987); .06% P, .30% Ca (Waller et al., 1972); 40% TDN (Lusby et al., 1985). Actual protein intake was similar to calculated intake in both years (Table 2). Soybean meal was used to increase supplemental protein intake while soybean hulls were used to increase supplemental energy. Calcium, phosphorus and vitamin A were added to meet NRC (1984) requirements. In addition, sodium sulfate was included to maintain a supplemental nitrogen:sulfur ratio of 12:1. Cows were individually fed their respective weekly allotment of pelleted (.5 cm) supplement in five feedings (M, T, W, F, S). In addition to supplement, cows had free choice access to a mineral mix composed of 50% trace mineralized salt (92% NaCl, .25% Mn, .20% Fe, .033% Cu, .007% I, .005% Zn and .0025% Co), 45% dicalcium phosphate and 5% potassium chloride. Daily supplement samples were obtained and composited at 21-d intervals for later analysis. All samples were ground (1-mm screen) and subjected to DM, ash, and CP (N*6.25) determination (AOAC., 1975) Diet samples were collected every 21 d with esophogeally fistulated steers to quantify forage quality. Esophageal samples were lyophilized, ground (1-mm screen) and subjected to the same chemical analyses as the supplements.

Cows were fed 2.25 kg cottonseed meal/d for five days prior and five days following the trial to equalize fill. Cows were weighed utilizing a computer assisted scale. Initial and final weights were recorded after a 8 h withdrawal from feed and water. Body condition score (1=emaciated, 9=obese) was evaluated to the nearest half score by three independent observers. Calves were weighed after a 6 h withdrawal from feed and water.

Milk yield was estimated by machine milk-out utilizing a portable milking unit. Cows were milked at the beginning and end of the first year and at the beginning, middle and end of the second year. Due to time and labor requirements for milking range cows by machine, the herd was divided into two groups which were milked on consecutive days. Calves were removed from the cows at 2200 the night before milking and cows were milked from 0800 to 1400 the following day. Cows received a intramuscular injection of 40 IU of oxytocin in the rear quarter immediately prior to milking. Milking time varied from 5 to 12 minutes depending on milk yield potential and stage of production. Udders were palpated to ensure thorough milk removal. Total quantity was recorded and samples were taken for analysis of fat, protein, lactose and solids non-fat (DHIA lab, Oklahoma State University).

Statistics. Changes in cow weight, body condition, calf weight and milk yield were analyzed by least squares procedures with year, calving date (covariate), calf sex, level of protein (CP), level of energy (TDN), CP*TDN and all year and calf sex interactions included in the model. Interactions with calf sex were not significant and were deleted from the model. All two way year*TDN or CP interactions were not significant (P>.18). Orthogonal polynomials were used to evaluate linear, quadratic and cubic responses to supplemental CP and TDN. Level of CP or TDN was regressed against changes in cow body weight, cow body condition, calf weight and milk yield to quantify the response to supplemental CP or TDN.

Results and Discussion

The CP content of the grazed forage was 4.0% (OM basis) averaged over both years (Figure 1). Forage CP increased during the last three weeks of both years of the study indicating spring forage growth had begun.

The interaction between supplemental protein and energy for cow body weight change was not significant (P=.46, Figure 2). A linear response (P=.0001) to CP was observed indicating that cows fed higher levels of CP lost less body weight. DelCurto et al. (1990) found similar linear responses and concluded that weight losses of gestating, spring calving cows were reduced by increasing supplemental CP. A linear response (P=009) to supplemental TDN was also observed indicating that cows that were fed higher levels of energy lost less body weight. Trautman (1987) observed similar results for fall calving cows fed energy supplements.

The supplemental CP•TDN interaction for cow body condition change was not significant (P=.23, Figure 3). Cow body condition loss was reduced (linear, P=.02) as level of supplemental protein increased. DelCurto et al. (1990) decreased body condition loss by increasing the concentration of supplemental protein fed to gestating cows grazing dormant native range. Body condition loss was also decreased (linear, P=.004) as supplemental energy increased. Other researchers have found that increasing energy intake with supplementation can minimize cow body condition losses during the winter (Trautman, 1987; Wagner et al., 1988; Houghton et al., 1990).

The supplemental CP*TDN interaction for calf weight gain was not significant (P=.21, Figure 4). A linear CP response (P=.0001) indicated that cows fed higher levels of supplemental CP produced faster gaining calves. In contrast, Bond and Wiltbank (1970) found that protein level in the diet of the dams had no significant effect on calf weight gains. Calf weight gain responded linearly (P=.0001) to level of supplemental TDN. Davis et al. (1977) increased calf gains by feeding supplemental TDN to their dams. Similarly, low levels of energy after calving has been shown to decrease calf gains (Lusby et al., 1991; Perry et al., 1991).

The supplemental CP*TDN interaction for milk yield (measured at the end of the study) was not significant (P=.33, Figure 5). Level of supplemental CP increased milk yield (quadratic, P=.10) Each increment of supplemental TDN consistently increased milk yield (linear, P=.0001) Milk yield followed similar trends as calf weight gain. The supplemental CP*TDN interaction for change in milk yield was not significant (P=.21, Figure 6). Cows that were supplemented with higher levels of CP had a smaller decline in milk yield (linear, P=.01). Low protein diets have been associated with lower milk yields (Bond and Wiltbank, 1970). Higher levels of supplemental TDN also reduced the decline in milk yield (linear, P=.0001). Consequently, either supplemental CP or TDN can increase the persistency of milk yield. Cows on the low and medium energy diets showed a decline in milk yield while cows receiving 2.22 kg TDN/d actually increased milk yield even though they were in mid lactation. Bond and Wiltbank (1970) observed that cows on a high energy diet peaked later (120 d) in lactation than cows fed medium and low energy diets.

Feeding high levels of energy to maintain milk yield may not be an efficient practice. As milk yield and calf milk consumption decrease, calves become more dependent on other nutrient sources such as forage (Lusby et al., 1976; Boggs et al., 1980). This situation could be detrimental for a fall born calf maintained on dormant native grass. Overall efficiency may be enhanced, however, if supplemental energy is fed directly to the calf rather than to the cow.

The production variables measured in this study responded linearly to level of supplemental protein over the range of 80 to 125% of NRC (1984) requirements. Scott (1992) observed that supplemental protein increased hay intake and digestibility through 140% of the NRC requirement. Either protein requirements of lactating cows are not accurate or crude protein intake may not reflect digestible protein available to the cow. Scott (1992) demonstrated that the protein digestibility of unsupplemented native tallgrass hay is very low (5.8%, determined at the duodenum, corrected for microbial protein). Thus, the digestible protein contribution from forage may be overestimated when crude protein is considered. Supplemental protein levels were selected for this study in an attempt to determine the peak or plateau for protein intake of lactating beef cows to help clarify the economic value of protein supplementation. Because responses to supplemental protein were linear, the point of diminishing return to protein supplementation cannot be determined from this information.

Supplemental CP*TDN interactions were not significant for milk fat (P=.43, Figure 7) and milk protein (P=.47, Figure 8). Supplemental CP increased milk fat content (quadratic, P=.05) with a peak at 95 to 110% of the cow's CP requirement (NRC., 1984). Supplemental energy also increased milk fat content (linear, P=.0006). Supplemental protein increased (linear, P=.0004) milk protein content while supplemental energy had little effect (quadratic, P=.23). Although both supplemental protein and energy altered milk composition, the changes were relatively small. Lowman et al. (1979) found that a high plane of nutrition increased total milk yield but had very little effect on milk composition.

The two lowest levels of CP (80 and 95% of NRC requirement) appeared to have the most detrimental effects on cow weight loss regardless of supplemental energy intake (Figure 2). The lowest level of supplemental CP had the most detrimental effects on calf weight gain (Figure 4) and cow body condition loss (Figure 3), irrespective of TDN level. Consequently, this study supports the NRC (1984) recommendations for protein supplementation to maintain at least some minimum level of productivity.

Cows fed the low energy, high protein supplement (1.32 kg TDN/d, 43% CP) lost 40 kg of body weight and less than one half of a condition score (Figures 2 and 3). This level of performance is comparable to higher levels of protein and energy supplementation used in this study. High protein supplements (40% CP) are commonly recommended for cows grazing dormant native range in central Oklahoma. Calf performance when cows were fed this supplement, however, was slightly lower than supplements providing higher levels of energy indicating that these cows may have been deficient in energy for maximum milk yield.

Level of supplemental TDN or CP was regressed against changes in cow body weight, cow body condition, calf gains and milk yield to evaluate the responsiveness of these variables to supplemental nutrients (Table 2). One kg TDN reduced cow weight loss by .12 kg while 1 kg of CP reduced cow weight loss by .68 kg. When fed to meet the nutrient deficiencies of a 500 kg lactating beef cow, energy supplementation would reduce cow weight loss by approximately .15 kg/d while protein supplementation would reduce cow weight loss by approximately .38 kg/d. Over the course of a 100-d wintering period, this difference would amount to a 23 kg advantage for protein supplementation Similar results were observed for body condition, however, milk yield and calf weight gain were less responsive to protein. In fact, calf weight gain was only twice as responsive to supplemental protein as compared to energy. From a nutritional standpoint, protein was a more effective supplement than energy. The comparative cost of these nutrients, however, will affect their economic value to cow-calf producers.

Implications

The responses to supplemental protein or energy were independent in this study. Thus, added supplemental nutrients would be expected to incrementally increase cow and calf performance regardless of their source. Supplemental protein more effectively increased cow and calf performance than supplemental energy. The relative cost of these nutrients, however, will affect their economic value. Because the response to supplemental protein was linear up to 125% of NRC protein requirements, as much as 25% extra supplemental protein above NRC requirements should increase cow and calf performance. The high cost of supplemental protein, however, may limit the usefulness of overfeeding protein.

Literature Cited

AOAC. 1975. Official Methods of Analysis (12th Ed.) Association of Official Analytical Chemist, Washington, D.C.

Boggs, D.L., E.F. Smith, R.R. Schalles, B.E. Brent, L.R. Corah, and R.J. Pruitt. 1980. Effects of milk and forage intake on calf performance. J. Anim. Sci. 51:550.

Bond, J., and J.N. Wiltbank. 1970. Effect of energy and protein on estrus, conception rate, growth and milk production of beef females. J. Anim. Sci. 30:438.

Chase, C.C., Jr and C.A Hibberd. 1987. Utilization of low-quality native grass hay by beef cows fed increasing quantities of corn grain. J. Anim. Sci. 65:557.

Clanton, D.C., and D.R. Zimmerman. 1970. Symposium on pasture methods for maximum production in beef cattle: protein and energy requirements for female beef cattle. J. Anim Sci 30:122

Davis. D., R R Schalles. G.H. Kiracofe, and D.L. Good. 1977. Influence of winter nutrition on beef cow reproduction. J Anim. Sci. 46:430.

Delcurto. T., R C. Cochran. L.R. Corah, A.A. Beharka, E.S. Vanzant, and D.E. Johnson. 1990. Supplementation of dormant tallgrass-prairie forage: II. performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentrations J. Anim. Sci. 68:532.

Houghton. P.L., R.P. Lemenager, K.S. Hendrix, G.E. Moss, and T.S. Stewart. 1990. Effects of body condition, pre- and postpartum energy intake and stage of production on energy utilization by beef cows. J. Anim. Sci. 68:1447.

Kartchner, R.J 1981. Effects of protein and energy supplementation of cows grazing native winter range forage on intake and digestibility. J. Anim. Sci. 51:432.

Lowman, B.G., R.A Edwards, S.H. Somerville, and G.M. Jolly. 1979. The effect of plane of nutrition in early lactation on the performance of beef cows. Anim. Prod. 29:293.

Lusby, K.S., D.F Stephens, and R. Totusek. 1976. Influence of breed and level of winter supplement on forage intake of range cows. J. Anim. Sci. 43:543.

Lusby, K.S., V Stevens, K Apple, M. Scott, and F. Bates. 1985. Feeding the cowherd. In: Oklahoma Beef Cattle Science Manual. pp. 1-18. Oklahoma Agr. Ext. Ser.

Lusby, K.S., R.P. Wettemann, K.H. Ovenell, and D.A. Cox. Effects of lactation on performance of grazing beef cows wintered with supplements containing soybean meal, wheat middlings, or soybean meal-wheat middlings mixtures. 1991. Prof. Anim. Sci. 7:30.

NRC. 1984. Nutrient Requirements of Beef Cattle (6th Ed.). National Academy Press, Washington, DC.

Perry, R.C., L.R. Corah, R.C. Cochran, W.E. Beal, J.S. Stevenson, J.E. Minton, D.D. Simms, and J.R. Brethour. 1991. Influence of dietary energy on follicular development, serum gonadotropins, and first postpartum ovulation in suckled beef cows. J. Anim. Sci. 69:3762

Rittenhouse, L.R., D.C. Clanton and C.L. Streeter. 1970. Intake and digestibility of winter-range forage by cattle with and without supplements. J. Anim. Sci. 31:1215.

Rutledge, J.J., O.W. Robison, W.T. Ahlschwede and J.E. Legates. 1971. Milk yield and its influence on 205-day weight of beef calves. J. Anim. Sci. 33:563.

Trautman, B.D. 1987. Forage utilization and productivity of lactating beef cows fed cottonseed meal, corn or soybean hull supplements during the winter. M.S. Thesis. Oklahoma State Univ. ,Stillwater.

Wagner, J.J., K.S. Lusby and J.W. Oltjen. 1988. Relationship between condition score, enviromental conditions and metabolizable energy for maintenance during winter in mature, nonpregnant, nonlactating Hereford cows. Prof. Anim. Scientist 4:28.

Waller, G.D., R.D. Morrison and A.B. Nelson. 1972. Chemical composition of native grasses in central Oklahoma from 1947 to 1962. Okla. State Univ. Agr. Exp. Sta. Bull. B-697.

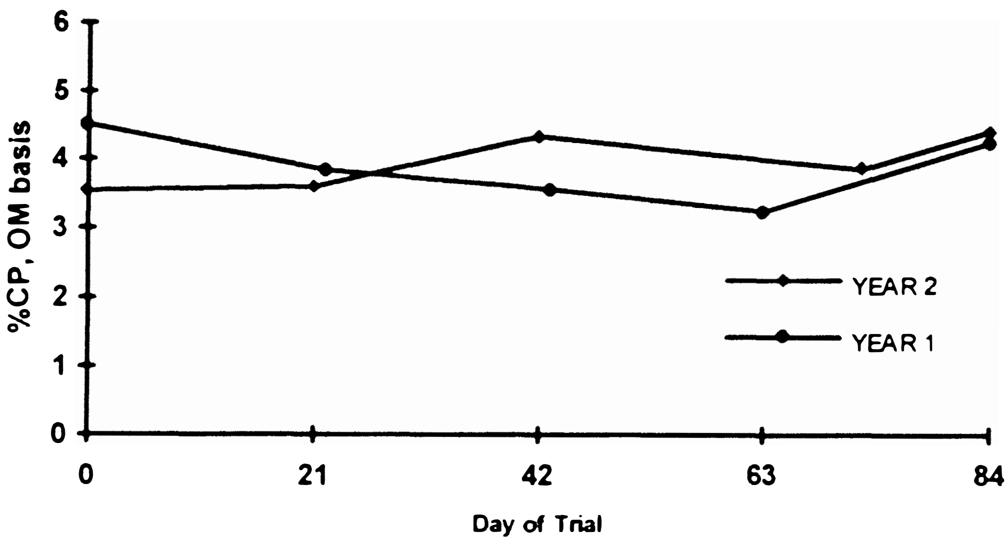

Figure 1. Changes in CP content (OM basis) of native tallgrass during both years of the study.

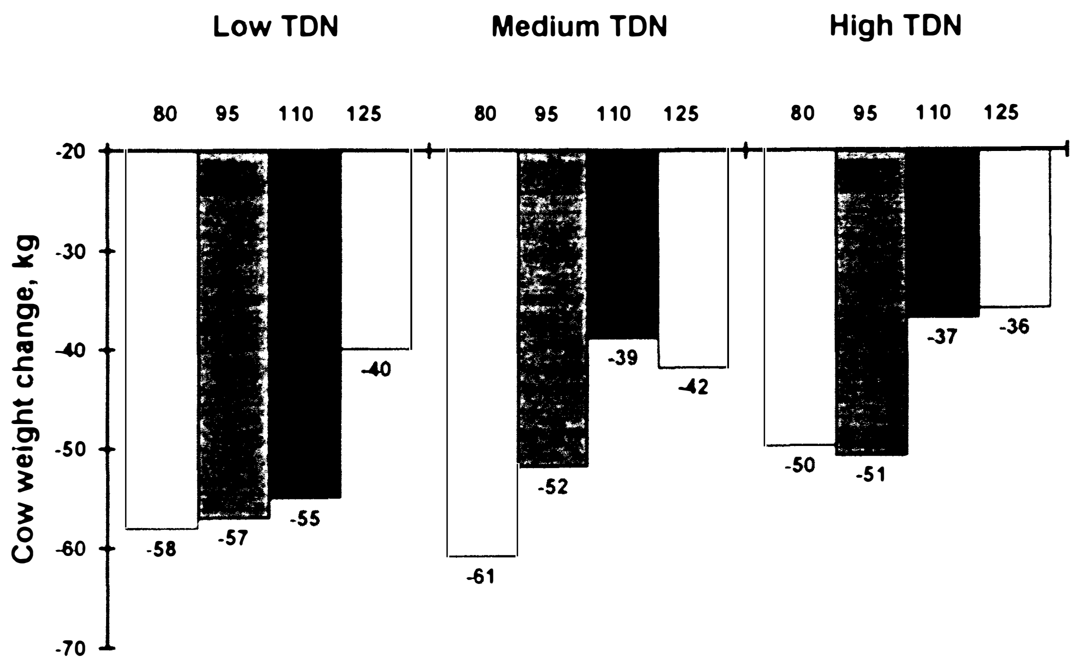

Figure 2. Changes in cow body weight (kg) of lactating cows grazing dormant native tallgrass due to level of supplemental energy (linear, P=.009; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and supplemental protein (linear, P=.0001; expressed as a percent of NRC protein requirement; SE=4.9).

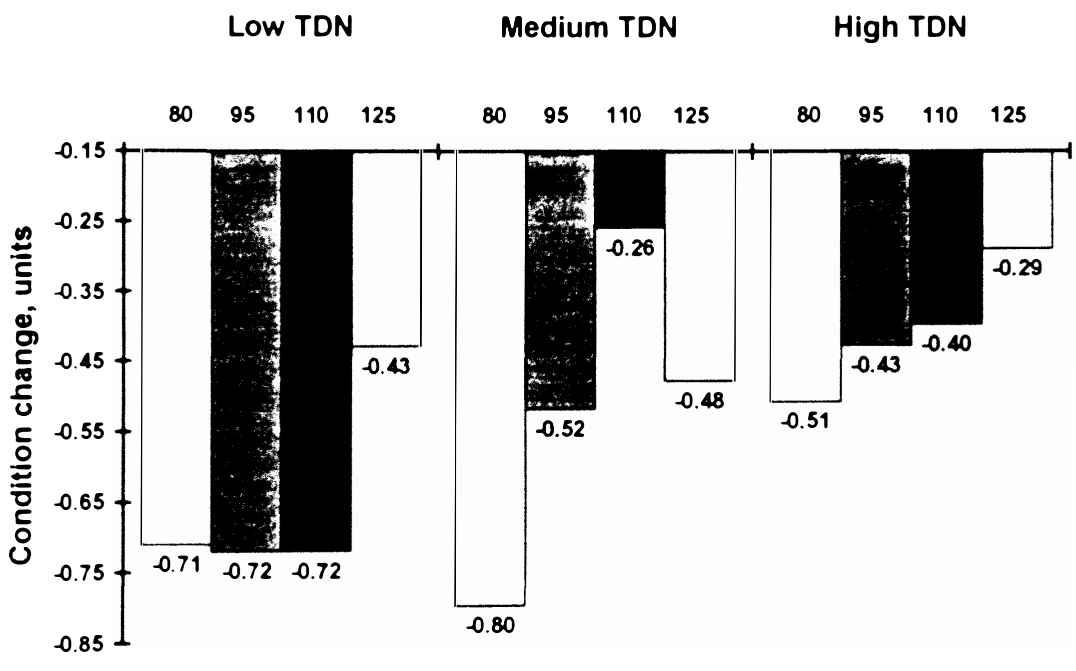

Figure 3. Effect of level of supplemental energy (linear, P=.004; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and supplemental protein (linear, P=.002; expressed as a percent of NRC protein requirement) on changes in cow body condition (units) for lactating cows grazing dormant native tallgrass (SE=.114).

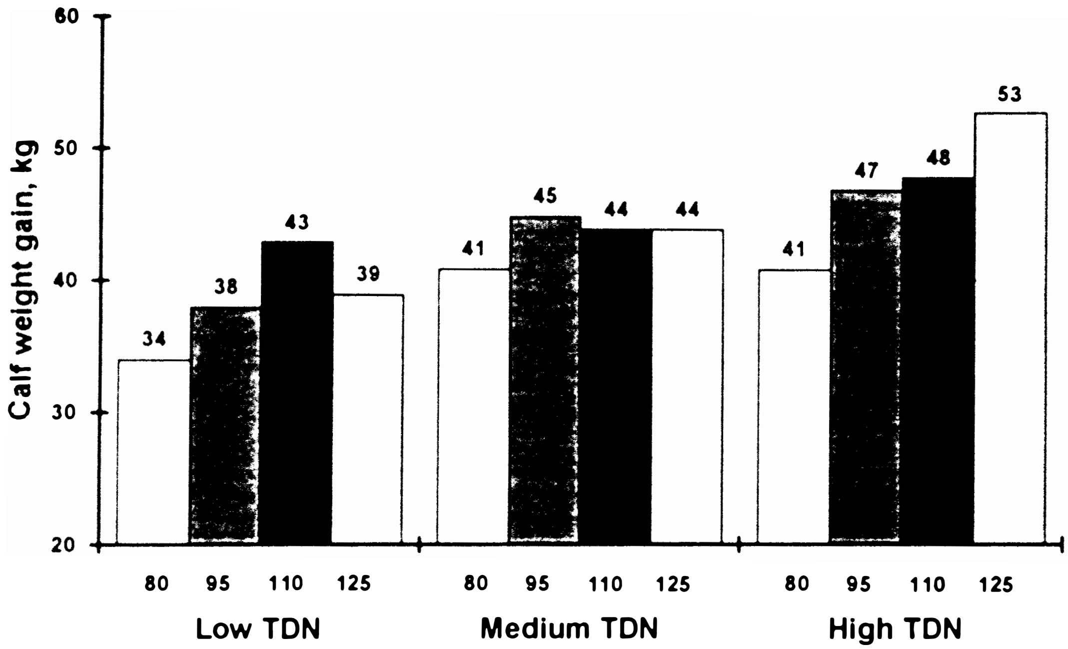

Figure 4. Weight gain (kg) of fall born calves suckling dams fed graded levels of supplemental energy (linear, P=.0001; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and supplemental protein (linear, P=.0001; expressed as a percent of NRC protein requirement; SE=2.0).

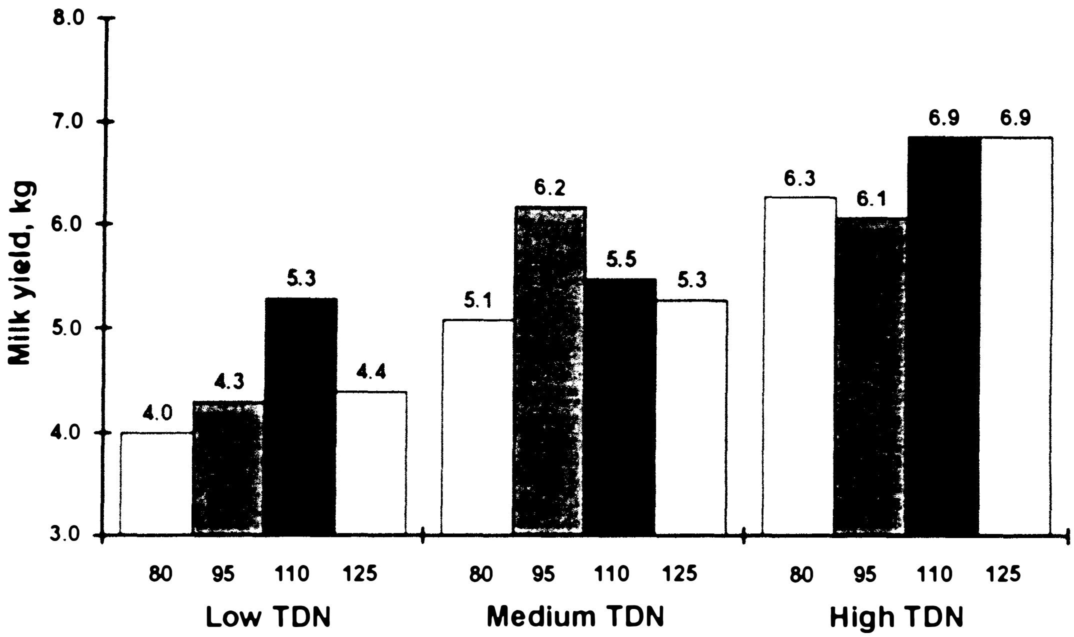

Figure 5. Final milk yield (kg) of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (linear, P=.0001; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (quadratic, P=.10; expressed as a percent of NRC protein requirement; SE=.44).

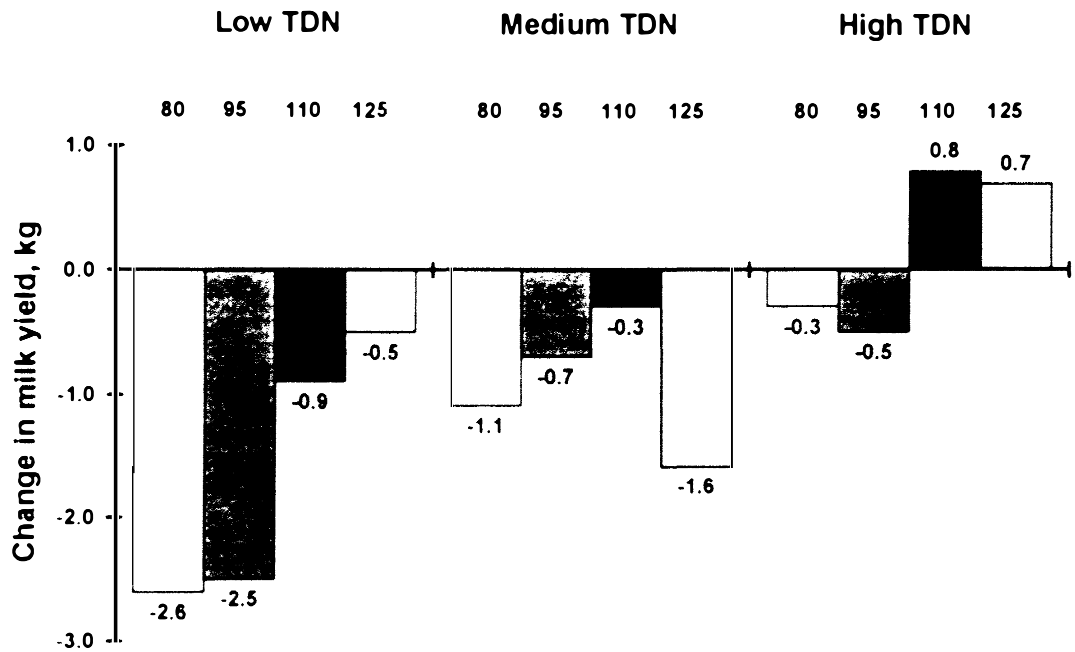

Figure 6. Changes in milk yield (kg) of lactating cows grazing dormant native tallgrass due to level of supplemental energy (linear, P=.0001; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and supplemental protein (linear, P=.01; expressed as a percent of NRC protein requirement; SE=.55).

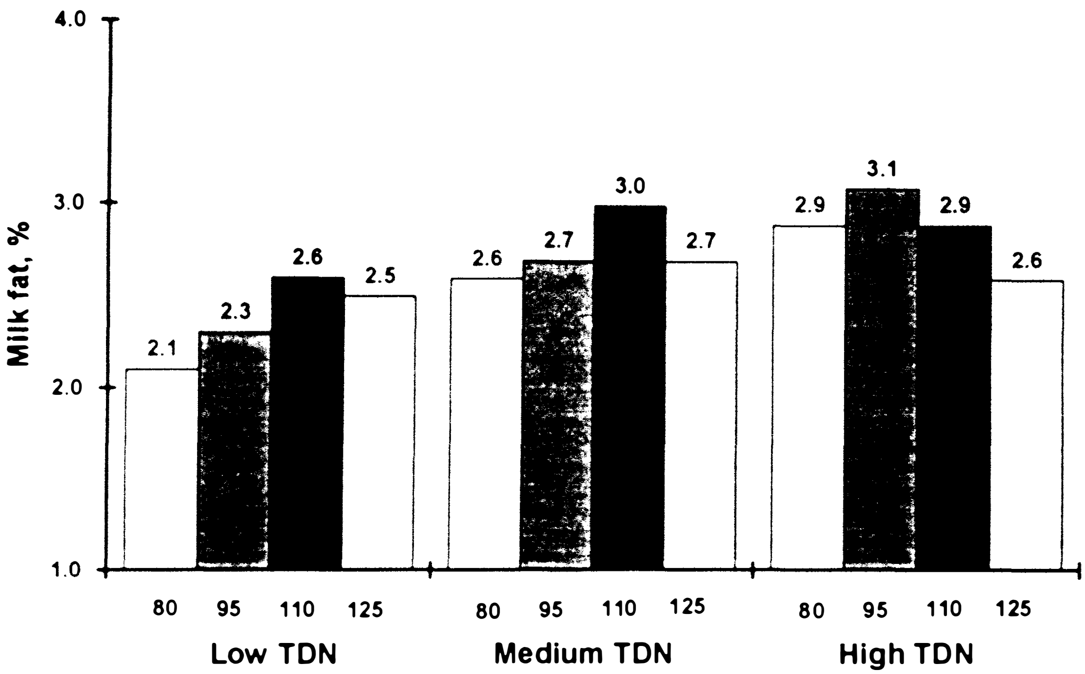

Figure 7. Final milk fat percentage of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (linear, P=.0006; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (quadratic, P=.05; expressed as a percent of NRC protein requirement; SE=.19)

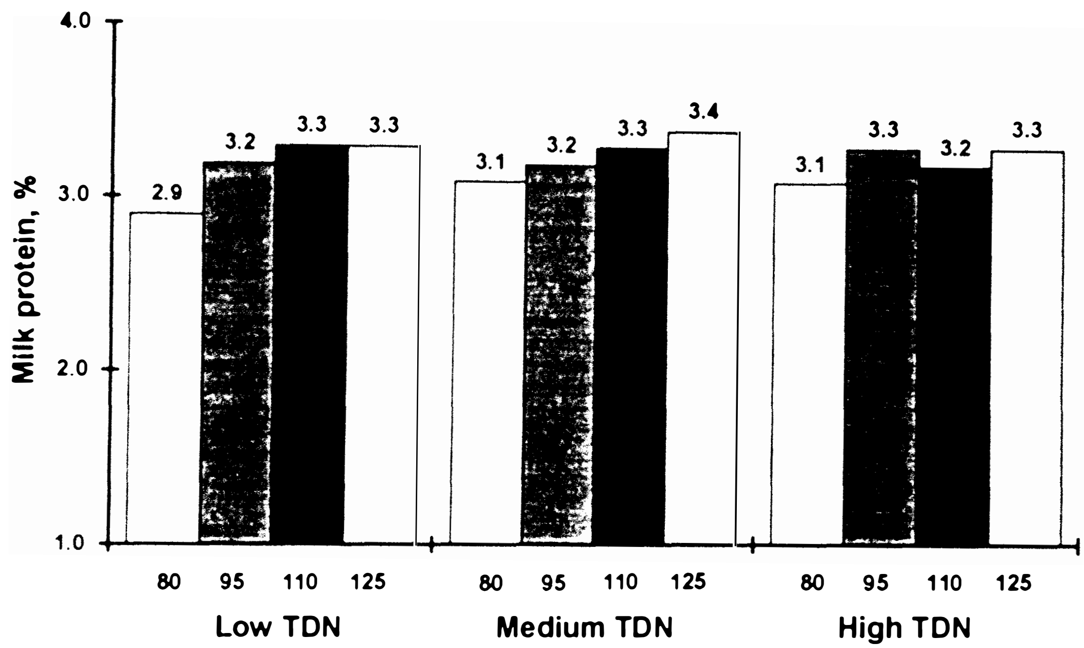

Figure 8 Final milk protein percentage of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (quadratic, P=.23: Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (linear, P=.0004; expressed as a percent of NRC protein requirement; SE=.10).

Table 1. Composition, feeding rate and nutrient supply of supplements providing graded levels of protein and energy.

Item	Low (1.32 kg) TDN				Medium (1.76 kg) TDN				High (2.22 kg) TDN			
	80[a]	95	110	125	80	95	110	125	80	95	110	125
Supplement composition (%, DM basis)												
Soybean meal	21.5	43.8	67.7	92.9	8.0	24.3	41.3	59.1	-	12.8	26.1	39.7
Soybean hulls	70.4	48.5	24.8	-	85.3	69.3	52.4	35.0	94.1	81.5	68.4	55.0
Trace mineralized salt[b]	1.4	1.5	1.5	1.5	1.1	1.1	1.1	1.1	.8	.9	.9	.9
Dicalcium phosphate	3.2	2.7	2.3	1.8	2.3	2.0	1.6	1.2	1.8	1.5	1.2	.9
Sodium sulfate	.4	.5	.6	.8	.3	.4	.5	.6	.3	.3	.4	.4
Vitamin A (30,000 IU/g)	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
Molasses	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Feeding rate (kg DM/d)	1.8	1.7	1.7	1.7	2.4	2.4	2.3	2.3	3.0	3.0	2.9	2.9
Nutrient content (%, DM basis)												
CP[c]	22.2	27.6	33.9	43.0	17.3	21.9	28.7	31.7	13.7	19.0	24.6	25.3
TDN[d]	73.1	75.3	77.6	80.2	72.9	74.5	76.2	78.0	72.7	74.0	75.3	76.8
Nutrient supply (kg/d)												
CP[c]	.37	.47	.59	.71	.41	.53	.66	.74	.46	.52	.65	.73
TDN[d]	1.31	1.32	1.32	1.33	1.76	1.76	1.76	1.76	2.21	2.20	2.20	2.20
Supplemental CP:TDN	.28	.36	.45	.54	.23	.30	.38	.42	.21	.23	.30	.33

[a] % of total CP requirement including the estimated CP contribution form the forage.

[b] Trace mineralized salt contained 92% NaCl, .25% Mn, .20% Fe, .033% Cu, .007% I, .005% Zn and .0025% Co.

[c] Actual analysis.

[d] Estimated from NRC (1984).

Table 2. Comparison of calculated and actual CP intake (% of NRC requirement) for years 1 and 2.

	Calculated CP intake (% of NRC requirement)			
Actual CP intake	80	95	110	125
Year 1	82.5	97.6	112.3	118.2
Year 2	76.5	86.1	102.5	115.8

Table 3. Regression of cow weight, body condition, calf gain and milk yield on supplemental TDN or CP (kg).

	TDN	CP
Cow weight, kg	.12 ± .09	.68 ± .22
Cow body condition, units	.003 ± .002	.011 ± .006
Calf weight gain, kg	.11 ± .04	.23 ± .10
Milk yield, kg	.023 ± .010	.041 ± .027

CHAPTER V

Running Head: SUPPLEMENTAL NUTRIENTS AND FORAGE UTILIZATION

Interaction Between Supplemental Protein and Energy for Lactating Beef Cows Grazing Dormant Native Tallgrass: Forage Utilization[1]

T.A. Thrift[2] and C.A. Hibberd[3]

Department of Animal Science, Oklahoma State University, Stillwater 74078-0425

ABSTRACT

Seventy-two lactating, crossbred beef cows were assigned to 12 supplements (6 cow/calf pairs per supplement/year) for a 2-year study to evaluate the effect of supplemental protein and energy on forage utilization. Cows grazed native grass (4.0 % CP, OM basis) and were individually-fed supplements that were formulated with soybean meal and soybean hulls to provide three levels of energy (Low, 1.32 kg TDN/d; Medium, 1.76 kg TDN/d; High, 2.22 kg TDN/day) and four levels of protein (80, 95, 110, 125% of protein requirement). Forage intake and digestibility were determined in both years (February 14 to 25, 1991 and January 7 to 16, 1992). Forage CP and lignin were higher in year 2 (3.8 vs 4.2% CP and 8.0 vs 10.8% lignin, OM basis, for year 1 and year 2, respectively). In year 1, CP*TDN interactions were not significant ($P>.05$) so the main effects of CP and TDN were evaluated independently. Supplemental CP increased ruminal ammonia (linear, $P=.0001$), forage OM digestibility (linear, $P=.001$) and digestible OM intake (linear, $P=.09$) but not forage OM intake (quadratic, $P=.28$). In contrast,

---

[1] Approved for publication by the Director, Oklahoma Agricultural Experiment Station. This research was supported under project H-2018.

[2] Present address: Dept. of Anim. Sci., Texas A&M Univ., Kleberg Center, College Station 77843.

[3] To whom correspondence should be addressed.

supplemental TDN decreased ruminal ammonia (linear, P=.01) but increased forage OM intake (linear, P=.07) and digestible OM intake (linear, P=.0001). Forage OM digestibility was not altered (quadratic, P=.22) by level of supplemental TDN. In year 2, the supplemental CP*TDN interactions were significant for ruminal ammonia (P=.0001), forage OM intake (P=.08), forage OM digestibility (P=.05) and digestible OM intake (P=.02). In general, supplemental CP tended to increase forage OM intake, forage OM digestibility and digestible OM intake while the main response to level of supplemental TDN was an increase in digestible OM intake. Forage utilization appeared to be more responsive to supplementation in year 1 when lignin content was lower. Thus, the effectiveness of protein vs energy supplementation may be dependent upon forage quality.

(Key Words: Beef Cattle, Forage, Intake, Digestibility, Protein, Energy.)

Introduction

Dormant native grass is deficient in both protein (Waller et al., 1972) and energy (Lusby, 1985) for lactating beef cows (NRC., 1984). Therefore, supplementation with protein and/or energy is essential to maintain adequate rebreeding performance and milk production.

Because beef cows utilize forage as a major source of nutrients, it is important to understand the factors affecting forage utilization. Unfortunately, the response to supplementation is highly variable and is dependent on several factors, the most important of which is forage quality (McCollum and Hom, 1990). Supplementing low quality forages with high protein concentrates has been shown to increase forage intake and digestibility (Guthrie and Wagner, 1988; Stokes et al., 1988). In those studies, supplemental energy was increased along with supplemental protein, confounding the effects of supplemental protein and energy. Energy supplements composed of soybean hulls have been shown to increase energy intake with little or no effect on forage utilization (Martin and Hibberd, 1990). Very few studies have attempted to quantify the intake and digestibility responses to both supplemental CP and TDN. The studies that have attempted to quantify this interaction have also utilized cereal grains as the supplemental energy source (Clanton and Zimmerman, 1970; Rittenhouse et al., 1970; Kartchner, 1981) which have been shown to decrease utilization of low quality forages (Chase and Hibberd, 1986). The objective of this study was to quantify the effects of supplemental protein and energy on the intake and digestibility of low quality forage by lactating beef cows.

Materials and Methods

Seventy-two fall calving crossbred beef cows (average calving date year 1=September 29, 1991; year 2=September 26, 1992) were allotted to one of 12 supplements on December 12, 1991 (year 1) and December 17, 1992 (year 2). Supplement composition, grazing and cattle management have been reported (Thrift and Hibberd, 1994). Individually-fed supplements were formulated to provide four levels of protein and three levels of energy (Thrift and Hibberd, 1994). Cow weight and body condition changes as well as calf gain and milk production have been reported (Thrift and Hibberd, 1994).

Intake studies were conducted in both years (February 14 to 25, 1992 and January 7 to 16, 1993) to quantify forage utilization. In 1992, cows grazed a deferred pasture (65 ha) that had not been grazed prior to February 13. In 1993, cows grazed a pasture (65 ha) that had been grazed continuously since December 17 (21 d). Fecal output was estimated with chromic oxide and forage indigestibility by acid detergent lignin. A chromic oxide pellet (.48 cm) containing 76% wheat midds, 4% molasses and 20% chromic oxide (as-is) was top dressed (100 g/cow) on the supplement each morning at 0700 throughout adaptation and fecal sampling. In year 1, cows were dosed with chromic oxide for a 7-d adaptation period followed by a 4-d sampling period. Fecal grab samples (n=8, 600 g as-is/sample) were collected twice each day (0700 and 1900) and frozen (-25^{o} C). Following the study, fecal samples were thawed, composited by cow, dried (60° C, forced-air oven) and ground (1-mm screen). Diet samples were obtained utilizing esophageally fistulated steers. Samples were placed on ice and frozen (-25°C) prior to lyophilization and grinding (1-mm screen). In year 2, cows were dosed with the same chromic oxide pellet for a 7-d adaptation period followed by a 3-d sampling period. Sample collection procedures were identical to year 1 except that only six fecal samples were collected.

Dry matter and ash content of fecal, diet and supplement samples were determined according to AOAC (1975). Chromium content of fecal samples and the chromic oxide pellet was analyzed by atomic absorption spectrophotometry using an oxygen-acetylene flame. Because the chromium content of diet samples and supplements was negligible (<25 ppm), the contribution of forage and supplement chromium was ignored. Lignin content of all samples was determined with the acid detergent lignin procedure of Goering and Van Soest (1975). Forage intake and digestibility were calculated as outlined by Kartchner (1981).

Ruminal fluid samples were obtained (500 ml) at the end of the trials in both years for determination of ruminal ammonia concentration. Ruminal fluid was collected via a vacuum pump with a suction strainer attached to a stomach tube. Samples were strained (four layers of cheesecloth) and acidified (1 ml 20% H_2SO_4/50 ml ruminal fluid) to halt fermentation. A 7-ml aliquot was then frozen (-15° C). Prior to laboratory analysis, acidified ruminal fluid was centrifuged at 10,000 X g for 20 min. Ruminal ammonia concentrations were analyzed by the phenol-hypochlorite assay (Broderick and Kang, 1980).

Statistics All forage utilization variables were analyzed by least squares procedures with calf sex, calf age (covariate), level of protein (CP), level of energy (TDN), CP*TDN interaction and cow weight (included as a covariate for variables not expressed on % BW) included in the model. Orthogonal polynomials were used to evaluate linear, quadratic and cubic responses to supplemental CP and TDN. When supplemental CP*TDN interactions were significant, orthogonal polynomials were used to evaluate the response to protein within level of energy and the response to energy within level of protein.

Results and Discussion

The CP content (OM basis) of the esophageal masticates during the intake studies was 3.8% in the first year and 4.2% during the second year. Forage CP was similar during both years of the trial despite the fact that the year one intake was performed in late February while the year 2 intake was conducted in early January. During year one, cows were allowed access to a defered pasture one week before the start of the trial so that forage quantity would not be a limiting factor During year two the intake study was conducted on a pasture that had been previously grazed for one month. Lignin content of forage was higher in year 2 (10.8%, OM basis) than in year 1 (8.0%) indicating that previous grazing during year two reduced the quality of available forage . In addition, protracted cold, wet weather in year 2 may have also reduced the nutritional value of forage more rapidly than in year 1.

Year 1. The supplemental CP•TDN interaction for forage OM intake (% BW) was not significant (P=.80; Figure 1). Forage OM intake was increased (linear, P=.07) by supplemental TDN but was not affected by level of supplemental protein (quadratic, P=.28). This response contradicts most studies where supplemental protein increased forage intake (McCollum and Galyean, 1985; Guthrie and Wagner, 1988; Stokes et al., 1988) while supplemental energy, especially if fed at high levels, reduced forage intake (Chase and Hibberd, 1987).

Supplemental CP and TDN did not interact (P=.46) to affect forage OM digestibility (Figure 2) Supplemental CP increased (linear, P=.001) forage OM digestibility. Level of supplemental TDN, however, had little effect (quadratic, P=.22) on forage OM digestibility. Supplemental CP increases forage digestibility, especially when forage protein is low (Scott, 1992; Guthrie and Wagner, 1988).

The supplemental CP*TDN interaction for total digestible OM intake (% BW) was not significant (P=.78, figure 3). Total digestible OM intake tended to increase (linear, P=.15) with added supplemental CP. A linear response (P=.0001) to supplemental TDN was observed. Increased energy intake with either supplemental protein or TDN was expected (Martin and Hibberd, 1990; Ovenell et al., 1991). In this study, however, supplemental TDN increased energy intake by increasing forage intake while supplemental CP increased energy intake by increasing forage digestibility. Although the supplemental CP*TDN interaction was not significant (P=.78), the response to supplemental CP appeared to be larger at higher levels of TDN intake.

The CP*TDN interaction for ruminal ammonia approached significance (P=.23, figure 4). Supplemental CP increased (linear, P=.0001) ruminal ammonia concentrations. In contrast, supplemental TDN decreased (linear, P=.01) ruminal ammonia concentrations. Supplementation of low quality native grass hay with ruminally degraded protein has been shown to increase ruminal ammonia concentrations and forage digestibility (Guthrie and Wagner, 1988; Scott, 1992). Increased supplemental TDN should stimulate microbial growth and ammonia consumption which may explain the reduction in ruminal ammonia concentrations with added supplemental energy.

Year 2. The interaction between supplemental CP and TDN was significant for forage OM intake (P=.08, figure 5). Within each level of energy, level of supplemental protein increased (cubic, P=.07 or less) forage OM intake. The effects of supplemental TDN on forage OM intake were inconsistant. In contrast to year 1, supplemental protein appeared to affect forage OM intake more than supplemental TDN.

The CP*TDN interaction for forage OM digestibility was significant (P=.05, figure 6). Within level of supplemental energy, supplemental CP tended to increase forage OM digestibility (cubic, P=.10 or less). As with forage intake, the effect of level of supplemental TDN on forage OM digestibility was highly variable.

A significant CP*TDN interaction was also observed for total digestible OM intake (P=.02, figure 7). Within level of supplemental energy, supplemental CP increased digestible OM intake (cubic, P=.03 or less). Likewise, increasing levels of energy supplementation increased digestible OM intake at the 80% (linear, P=.05) and 110% (linear, P=.0002) of CP requirement. In general, both supplemental protein and energy increased digestible OM intake.

The interaction between supplemental CP and TDN was significant (P=.001) for ruminal ammonia (figure 8). Increasing levels of protein supplementation increased ammonia concentration at low (quadratic, P=.007), medium (quadratic, P=.004) and high (linear, P=.01) levels of supplemental energy. In contrast, increasing energy supplementation decreased ruminal ammonia concentrations at the 95% (linear, P=.03), 110% (linear, P=.0001) and 125% (quadratic, P=.05) of the NRC protein requirement.

The DOM:CP ratio of the basal forage has been suggested as an indicator of supplemental protein needs (Moore et al., 1991). High ratios (>8.0) indicate a deficiency of protein relative to energy. In year 1, the forage DOM:CP ratio averaged 14.0 but decreased to 9.6 in year 2. Under these circumstances, protein supplementation would be expected to increase forage intake. In year 1, however, forage intake was more responsive to energy than to protein supplementation. In year 2, forage intake was more responsive to supplemental protein. Supplementation with protein or energy in this study improved the DOM:CP ratio of the total diet to 7.3 in year 1 and 5.6 in year 2. In our studies, correction of the DOM:CP ratio with supplementation generally increased forage utilization and cow/calf performance (Thrift and Hibberd, 1994).

Interactions between supplemental protein and energy were not observed during the first year of the study, but were observed during the second year. Therefore, responses were dependent upon year. In year 1, responses to supplemental protein and energy were generally linear over the range of supplemental protein and energy levels that were studied. Responses to supplemental protein and energy during year 2 were inconsistant and tended to be highly variable. Overall means for forage intake, forage digestibility, digestible OM intake and ruminal ammonia were lower during year 2. Differences in weather may account for some of this variation between years. High precipitation and colder environmental conditions may have reduced forage quality and animal responses to supplementation during year 2.

Implications

Although the CP content of forage consumed by lactating cows during these two intake studies was similar (3.8% CP in year 1 vs 4.2% in year 2), the lignin content was higher in year 2 (8.0 vs 10.8% lignin, OM basis). Effects of CP and TDN supplementation on forage OM intake and digestibility in year 2 were inconsistent suggesting that more lignified forage may not be as responsive to supplementation as higher quality forage. In addition, most of the responses to supplemental CP in year 1 were linear over the levels of supplemental CP (80 to 125% of NRC requirement) used in this study. Thus, performance of lactating cows may be increased by protein supplementation in excess of NRC requirements although the economic impact of this practice must be considered.

Literature Cited

AOAC 1975 Official Methods of Analysis (12th Ed.) Association of Official Analytical Chemist, Washington, D.C

Broderick, G.A., and J.H Kang. 1980. Automated simultaneous determinations of ammonia and total amino acids in rumin fluid and in vitro media. J. Dairy Sci. 33:64.

Chase, C.C., Jr. and C.A Hibberd. 1987. Utilization of low-quality native grass hay by beef cows fed increasing quantities of com grain. J. Anim. Sci. 65:557.

Clanton, D.C., and D.R. Zimmerman. 1970. Symposium on pasture methods for maximum production in beef cattle: protein and energy requirements for female beef cattle. J. Anim Sci 30:122

Goering, H.K., and P.J. Van Soest. 1975. Forage fiber analysis. Agr. Handbook No. 379., ARS, USDA. Washington, D.C

Guthrie, M.J., and D.G Wagner. 1988. Influence of protein or grain supplementation and increasing levels of soybean meal on intake utilization and passage rate of prarie hay in beef steers and heifers J. Anim. Sci. 66:1529.

Kartchner, R.J. 1981. Effects of protein and energy supplementation of cows grazing native winter range forage on intake and digestibility. J. Anim. Sci. 51:432.

Lusby, K.S., D.F Stephens, K Apple, M. Scott, and F. Bates. 1985. Feeding the cowherd. In: Oklahoma Beef Cattle Science Manual. pp. 1-18. Oklahoma Agr. Ext. Ser.

Martin S.K and C.A Hibberd 1990 Intake and digestibility of low-quality native grass hay by beef cows supplemented with graded levels of soybean hulls. J. Anim. Sci. 68:4319.

McCollum, F.T., and M.L Galyean 1985 Influence of cottonseed meal supplementation on voluntary intake, rumen fermentation and rate of passage of prairie hay in beef steers. J. Anim Sci 60:570

McCollum, F.T., and G.W Horn 1990. Protein supplementation of grazing livestock: a review. Prof Anim Sci 6:1

Moore, J.E., W.E Kunkle, and W.F Brown. 1991. Forage quality and the need for protein and energy supplements pp 113-123. In: Proceedings of the 40th Annual Beef Cattle Short Course University of Florida, Gainsville.

NRC. 1984 Nutrient Requirements of Beef Cattle (6th Ed.). National Academy Press, Washington, DC

Ovenell, K.H., K.S. Lusby, G.W. Horn, and R.W. McNew. 1991. Effects of lactational status on forage intake, digestibility, and particulate passage rate of beef cows supplemented with soybean meal, wheat middlings, and com soybean meal. J. Anim. Sci. 69:2617.

Rittenhouse, L.R., D.C. Clanton, and C.L. Streeter. 1970. Intake and digestibility of winter-range forage by cattle with and without supplements. J. Anim. Sci. 31:1215.

Scott, R.R. 1992 Ruminal protein degredation:effects on low quality forage intake and utilization by beef cows. Ph.D. Dissertation. Oklahoma State Univ., Stillwater.

Stokes, S.R., A.L. Goetsch, A.L. Jones, and K.M. Landis. 1988. Feed intake and digestion by beef cows fed prarie hay with different levels of soybean meal and recieving postruminal administration of antibiotics. J. Anim. Sci. 66:1778.

Thrift, T.A., and C.A. Hibberd. 1994. Supplemental protein:energy interactions for fall calving beef cows grazing dormant native range. M.S. Thesis. Oklahoma State Univ., Stillwater.

Trautman, B.D. 1987. Forage utilization and productivity of lactating beef cows fed cottonseed meal, corn or soybean hull supplements during the winter. M.S. Thesis. Oklahoma State Univ. ,Stillwater.

Waller, G.D., R.D. Morrison, and A.B. Nelson. 1972. Chemical composition of native grasses in central Oklahoma from 1947 to 1962. Oklahoma Agr. Exp. Sta. B-697.

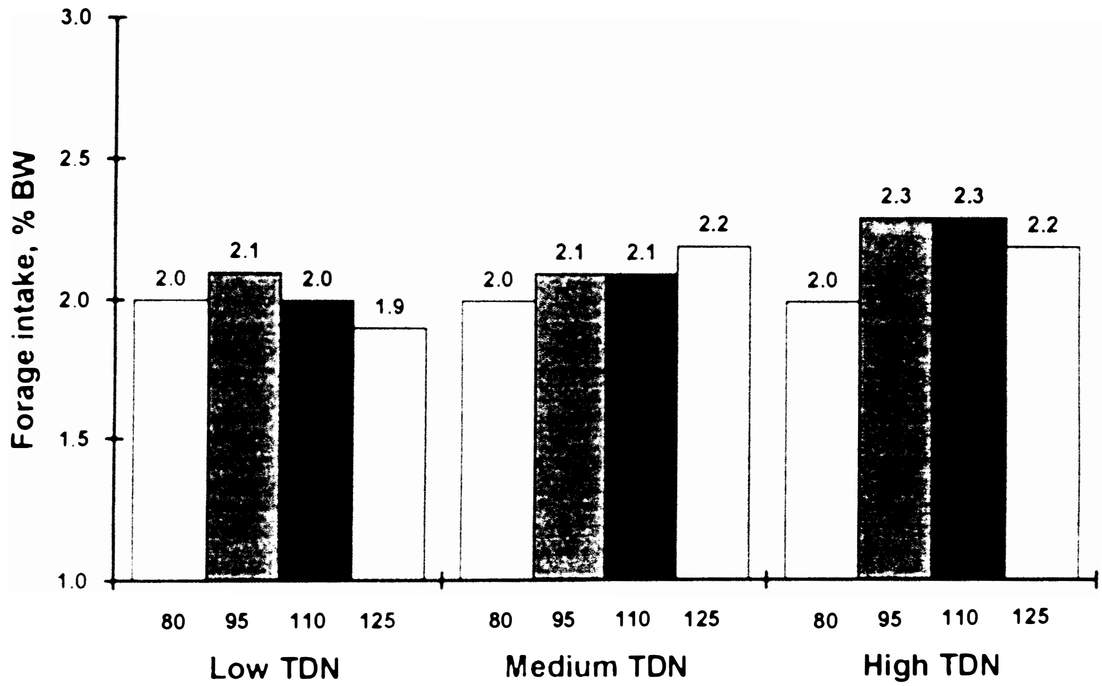

Figure 1 Forage intake (Year 1) of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (linear, P=.07; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (quadratic, P=.29; expressed as a percent of NRC protein requirement; SE=.14)

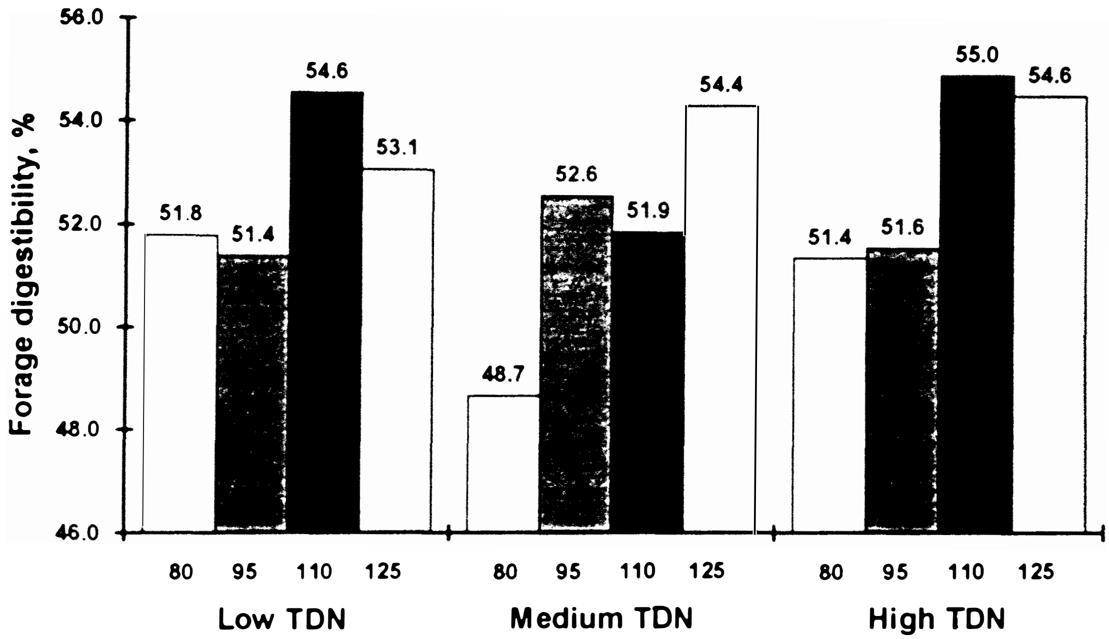

Figure 2. Effect of level of supplemental energy (quadratic, P=.22; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and supplemental protein (linear, P=.001; expressed as a percent of NRC protein requirement) on forage digestibility (Year 1) of lactating beef cows grazing dormant native tallgrass (SE=1.39).

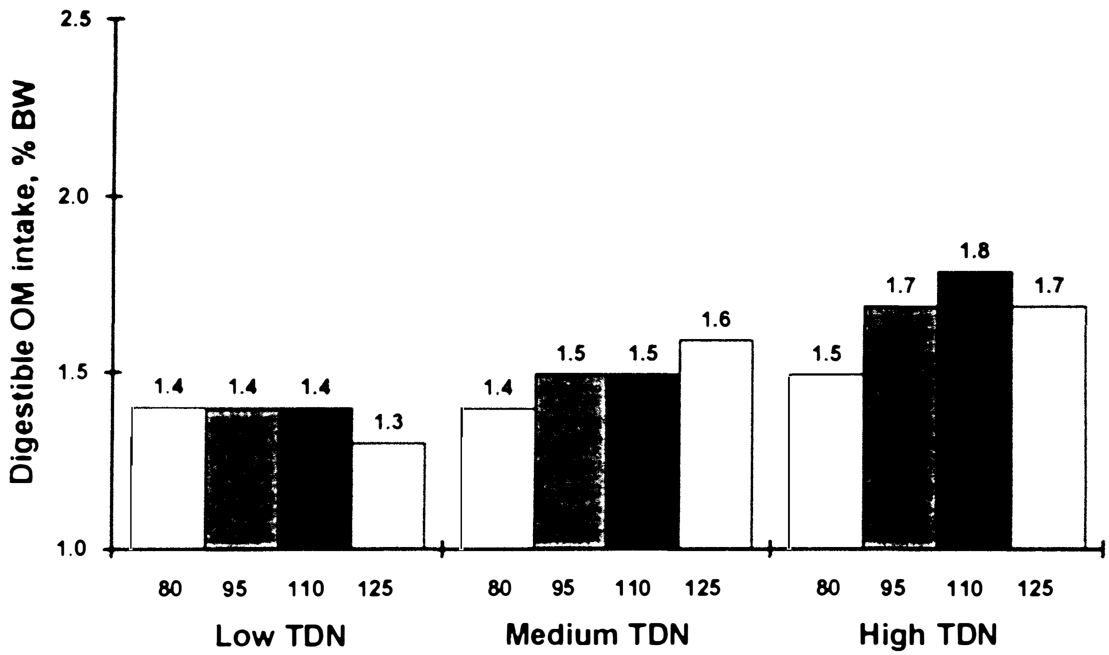

Figure 3. Digestible OM intake (Year 1) of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (linear, P=.0001; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (linear, P=.15; expressed as a percent of NRC protein requirement; SE=.10).

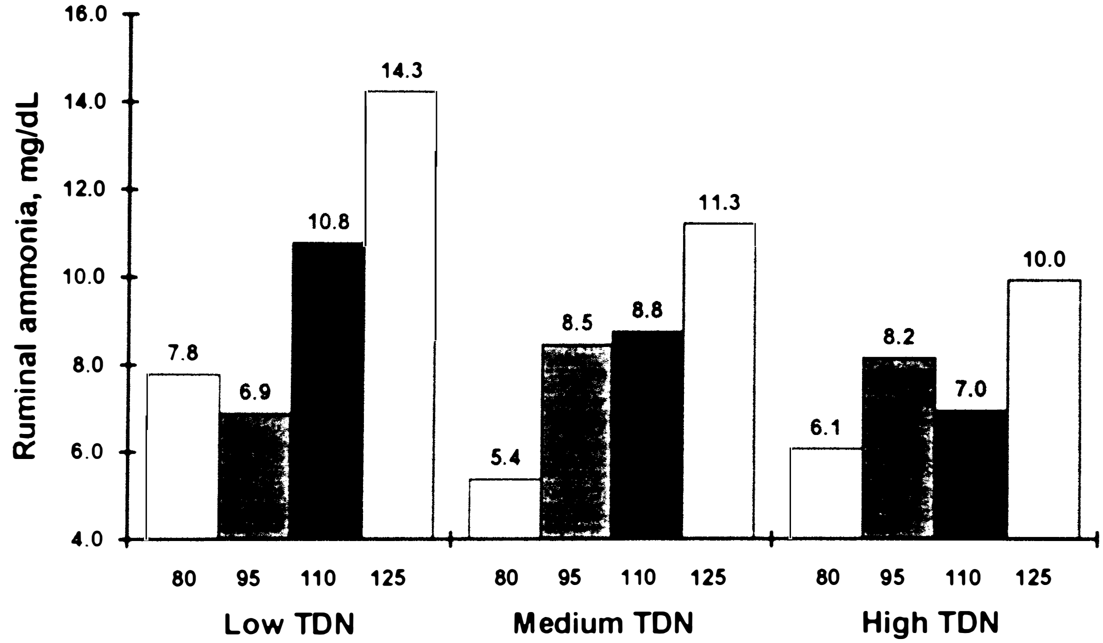

Figure 4. Ruminal ammonia concentrations (Year 1) of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (linear, P=.01; Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (linear, P=.0001; expressed as a percent of NRC protein requirement; SE=1.20).

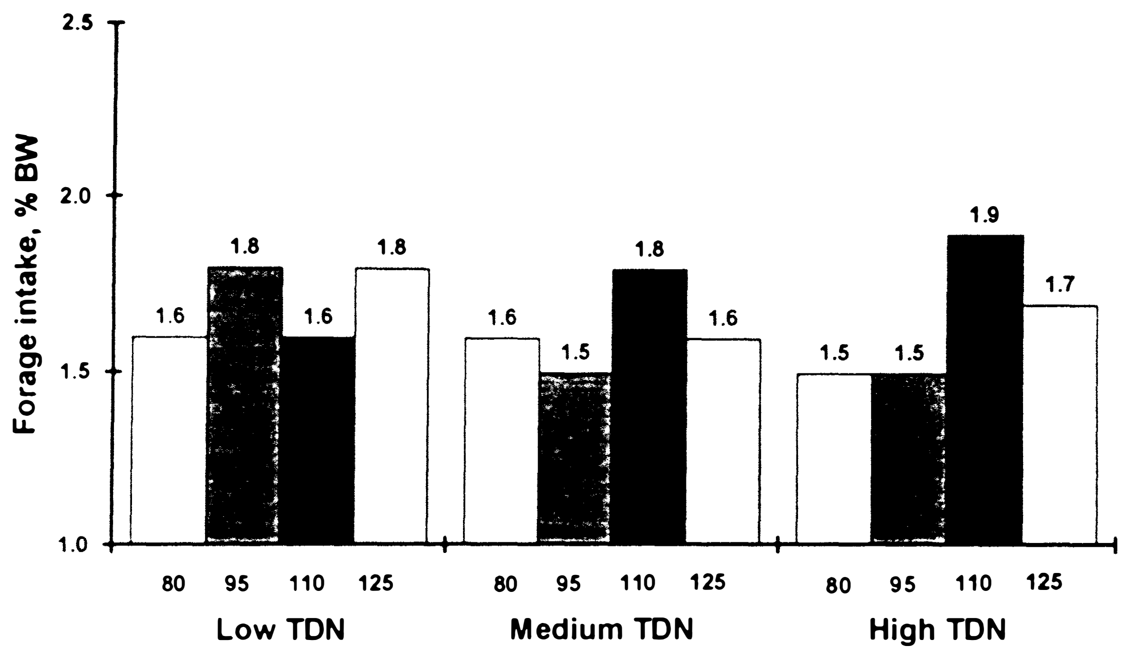

Figure 5. Forage intake (Year 2) of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (expressed as a percent of NRC protein requirement; SE=.105). Supplemental CP*TDN interaction was significant (P=.08).

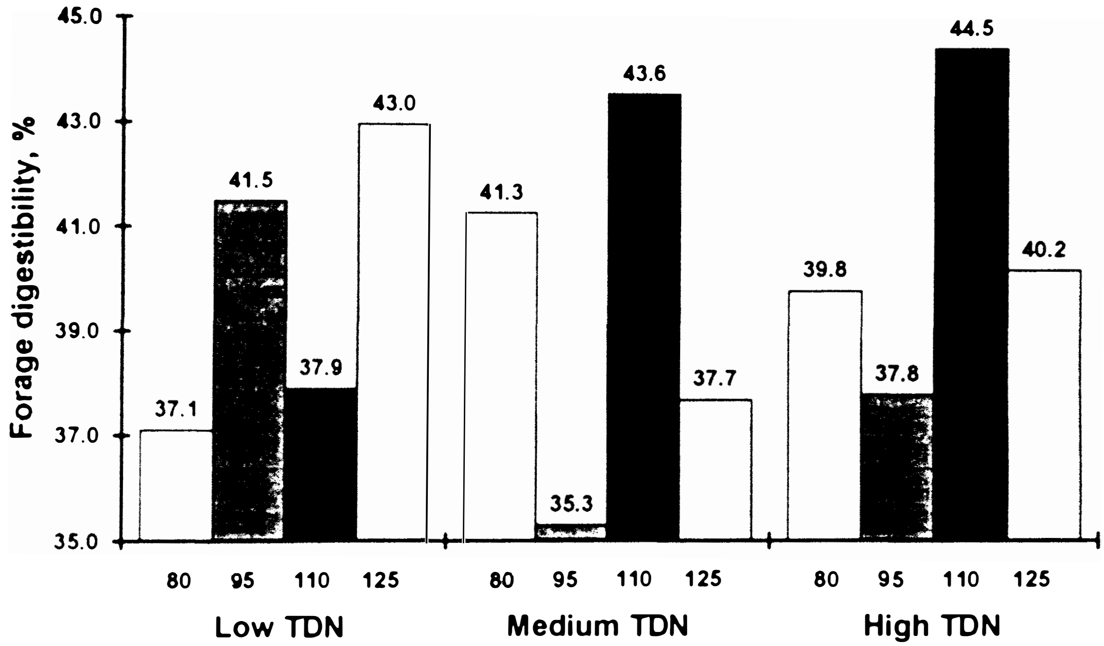

Figure 6. Effect of level of supplemental energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and supplemental protein (expressed as a percent of NRC protein requirement) on forage digestibility (Year 2) of lactating beef cows grazing dormant native tallgrass (SE=2.25). Supplemental CP*TDN interaction was significant (P=.05).

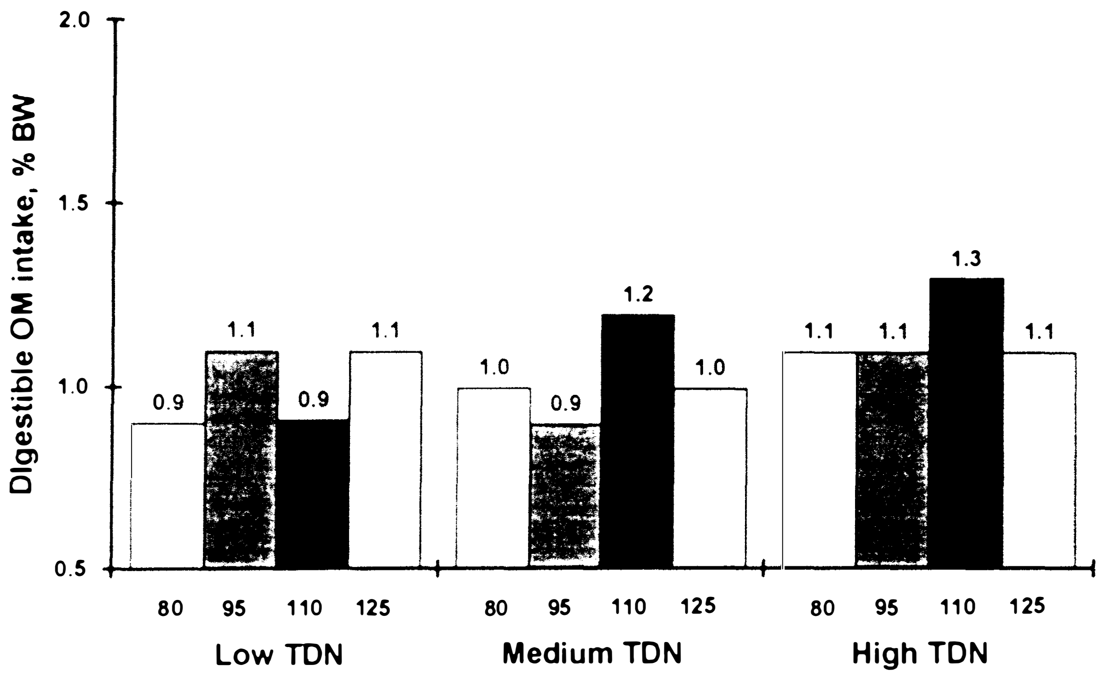

Figure 7. Digestible OM intake (Year 2) of lactating beef cows grazing dormant native tallgrass supplemented with graded levels energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (expressed as a percent of NRC protein requirement; SE=.07). Supplemental CP*TDN interaction was significant (P=.02)

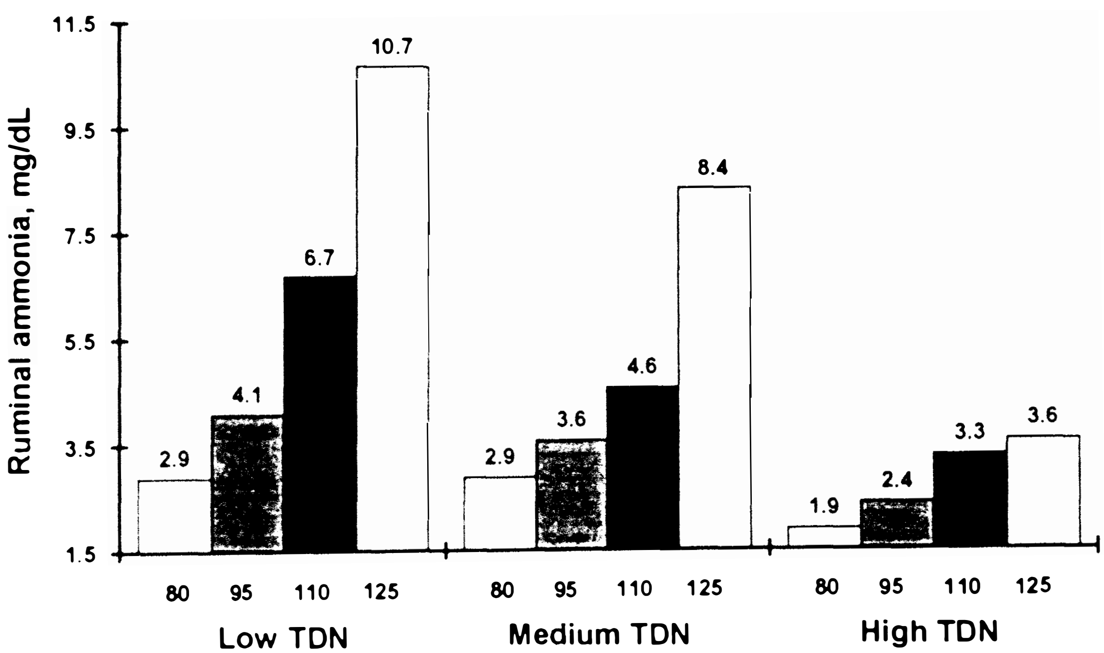

Figure 8. Ruminal ammonia concentrations (Year 2) of lactating beef cows grazing dormant native tallgrass supplemented with graded levels of energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and protein (expressed as a percent of NRC protein requirement; SE=.54). Supplemental CP*TDN interaction was significant (P=.0001).

CHAPTER V

SUMMARY AND CONCLUSIONS

Beef cow body condition is one of the most important factors affecting rebreeding performance. Cows that are thin (BCS<4.0) at calving tend to have reduced conception rates and reduced calf weight gains. Normal supplementation rates (.5 to 1.0 kg 40% CP/d) may not be adequate to return thin cows to adequate body condition in a restricted period of time. Under these conditions supplemental energy is required.

An experiment was designed to quantify the body condition changes of beef cows fed low quality native grass hay supplemented with graded levels of energy. In experiment 1, increasing supplemental energy increased cow body weight to a similar extent for all treatments. Body condition, was increased linearly with increased supplemental energy. Thin cows were more responsive to supplemental energy than moderately conditioned cows. However, body condition was increased a maximum of only .5 units during the course of the 70-day trial. Hay intake and digestibility decreased as the level of supplemental energy increased so that digestible OM intake was not affected by level of supplementation. Feeding a high protein supplement (40%) was just as effective as a high energy supplement in maintaining TDN intake but was less efficient at increasing body condition of thin cows. Thin cows had similar calculated ME requirements as moderately conditioned cows when expressed on a metabolic body weight basis. The results of experiment 1 suggest that it may be very difficult to substantially increase body condition of beef cows, in a restricted time period using normal supplementation rates (.5-1.5 kg of supplemental TDN/day). Sorting cows based on body condition may prove beneficial. Thin cows typically weigh less and thus have a lower maintenance requirement allowing them to utilize supplemental feed for body condition gain. Care should be taken to avoid masking genotype with supplemental feed. Excessive levels of milk production or large mature size may predispose cows to be thin throughout their lifetime if they are managed in a restrictive environment. Matching the beef cow to her nutritional environment is an important consideration overlooked by many producers. When deciding on how, when and to what extent body condition score of beef cows should be modified, it is important to consider all inputs (cost/cow) and outputs (% conception and $/calf weaned).

Nutritional management of the fall calving beef cow grazing dormant native range presents a major challenge to cow/calf producers. High nutrient requirements coincide with low forage quality (CP 2-4%) and cold environmental temperatures to make proper nutrition a high priority. Supplemental protein and energy are often supplied to fall calving cows to correct nutritional deficiencies. The interaction between supplemental protein and energy, however has not been fully quantified.

An experiment was conducted to improve the accuracy of predicting supplemental feed requirements for lactating beef cows grazing dormant native grass by quantifying the interaction between supplemental protein and energy. In this study, interactions between supplemental protein and energy were not observed for cow weight change, cow body condition change, calf weight gain or milk yield. Responses to supplemental protein and energy were linear over the range of protein and energy levels that were studied. Supplemental protein reduced cow weight loss, cow body condition loss and increased calf weight gain and milk yield. Similarly, supplemental energy reduced cow weight loss, cow body condition loss and increased calf weight gain and milk yield. No plateau was observed in the responses measured even at the highest level of CP or TDN. It appears that, for the variables measured, the response to supplemental CP was greater (2-5 fold) in all instances. This response has been well documented, however this is the first study that has attempted to quantify the difference between supplemental CP and TDN. The economic response, however, will depend on the relative cost of these nutrients.

Since beef cows utilize forage as a major source of nutrients, it is important for producers to understand the factors affecting forage utilization. Supplementing low quality forage with high protein concentrates has been shown to increase the intake and digestibility of forages. Energy supplementation often decreases forage utilization when the source of supplemental energy is cereal grains. However, digestible fiber supplements such as soybean hulls typically do not have adverse affects on forage intake and digestibility. Despite this, the intake and digestibility responses to supplementation are still variable and hard to quantify.

A study was conducted to quantify the effects of supplemental protein and energy on utilization of low quality forage by lactating beef cows. Intake studies were conducted during two years to determine the intake and digestibility response to supplementation of CP and TDN. During year 1 interactions between supplemental CP and TDN were not observed. Responses to increasing levels of supplemental CP were generally linear for all variables except forage intake. Increasing supplemental TDN also caused linear responses for all variables except forage digestibility CP*TDN interactions were significant for forage OM intake, forage OM digestibility, digestible OM intake and ruminal ammonia during year 2. Responses observed for year 2 were highly variable and illustrate the dynamics of forage utilization by beef cows grazing native grass

APPENDIX

ACCESSORY DATA TABLES

Table 1. Weight and body condition change of thin (BCS<4.5) and moderately conditioned (BCS>4.5) gestating beef cows fed low quality native grass hay with increasing levels of supplemental energy

Item	Supplemental TDN, kg/d					Probability		
	.5	1.0	1.5	2.0	SE[a]	Linear[b]	Quad[c]	Cubic[d]
Thin cows (BCS<4.5)								
Cow weight, kg	47.8	48.1	42.3	51.5	5.30	.78	.30	.28
Condition score,units	.04	.30	.31	.52	.121	.002	.83	.03
Moderately conditioned cows (BCS>4.5)								
Cow weight, kg	48.8	56.8	47.9	57.1	5.15	.42	.88	.05
Condition score,units	.00	.07	.15	.09	.073	.18	.30	.95

[a] Standard errors reported represent the largest SE for each variable.
[b] Linear response to increased level of supplemental energy.
[c] Quadratic response to increased level of supplemental energy.
[d] Cubic response to increased level of supplemental energy.

Table 2. Effect of energy supplementation on hay intake and digestibility by thin (BCS<4 5) and moderately conditioned (BCS>4.5) gestating beef cows fed low quality native grass hay with increasing levels of supplemental energy

	Supplemental TDN, kg/d					Probability		
Item	.5	1 0	1 5	2 0	SE[a]	Linear[b]	Quad[c]	Cubic[d]
Thin cows (BCS<4 5)								
Fecal output, kg OM/d	5.2	5.0	5 2	5.1	27	.98	.74	.46
Hay OM intake, kg/d	11 2	10.4	9 9	8 8	59	.001	.69	05
Hay OM intake, % BW	2.46	2.28	2 20	1 94	.125	.001	.68	.04
Total OM intake, kg/d	11.8	11.7	11.8	11 3	.59	.57	.70	.51
Hay OM digestibility, %	54.0	54.1	50.9	47.5	2.40	.01	.35	.38
Total diet OM digestibility, %	55.8	57.3	55.8	54.7	1.97	.48	.43	.89
Digestible OM intake, kg/d	6.6	6.7	6.6	6.2	.46	.46	.50	.67
Digestible OM intake , % BW	1.46	1.47	1.48	1.38	.102	.50	.48	.60
Moderately conditioned cows (BCS>4.5)								
Fecal output, kg OM/d	5.4	5.5	5.7	5.1	.26	.50	.12	.22
Hay OM intake, kg/d	11.4	10.8	11.3	9.6	.56	.02	.24	.02
Hay OM intake, % BW	2.33	2.18	2.30	1.93	.121	.02	.29	.02
Total OM intake, kg/d	12.0	12.1	13.1	12.1	.56	.49	.24	.31
Hay OM digestibility, %	53.1	51.3	52.5	51.6	1.66	.58	.72	.32
Total diet OM digestibility, %	54.8	54.5	56.5	57.7	1.35	.04	.49	.68
Digestible OM intake, kg/d	6.6	6.6	7.4	7.0	.39	.15	.52	.53
Digestible OM intake , % BW	1.37	1.33	1.53	1.41	.090	.33	.60	.31

[a] Standard errors reported represent the largest SE for each variable.
[b] Linear response to increased level of supplemental energy.
[c] Quadratic response to increased level of supplemental energy.
[d] Cubic response to increased level of supplemental energy.

Table 3. Changes in cow body weight, cow body condition and calf weight of lactating cows grazing dormant native range due to level of supplemental energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d) and supplemental protein (80, 95, 110 and 125 % of the NRC protein requirement)

	Low (1.32 kg) TDN				Medium (1.76 kg) TDN				High (2.22 kg) TDN					Probability				
Item	80[a]	95	110	125	80	95	110	125	80	95	110	125	SE[b]	Lin[c]	Quad[d]	Cub[e]	Lin[f]	Quad[g]
Cow weight, kg	-58	-57	-55	-40	-61	-52	-39	-42	-50	-51	-37	-36	4.9	.001	.78	.32	.009	.85
Body condition, units	-.71	-.72	-.72	-.43	-.80	-.52	-.26	-.48	-.51	-.43	-.40	-.29	.114	.002	.66	.93	.004	.86
Calf weight gain, kg	34	38	43	39	41	45	44	44	41	47	48	53	2.0	.0001	.08	.87	.0001	.44

[a] % of total CP requirement including the estimated CP contribution from the forage.
[b] Standard errors reported represent the largest SE for each variable.
[c] Linear response to increased level of supplemental protein.
[d] Quadratic response to increased level of supplemental protein.
[e] Cubic response to increased level of supplemental protein.
[f] Linear response to increased level of supplemental energy.
[g] Quadratic response to increased level of supplemental energy.

Table 4. Milk yield and composition of beef cows grazing dormant native range supplemented with graded levels of protein (80, 95, 110 and 125 % of the NRC protein requirement) and energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d)

	Low (1.32 kg) TDN				Medium (1.76 kg) TDN				High (2.22 kg) TDN					Probability				
Item	80[a]	95	110	125	80	95	110	125	80	95	110	125	SE[b]	Lin[c]	Quad[d]	Cub[e]	Lin[f]	Quad[g]
Milk yield (kg/d)																		
Final milk yield	4.0	4.3	5.3	4.4	5.1	6.2	5.5	5.3	6.3	6.1	6.9	6.9	.44	14	.10	.50	.0001	.95
Change in milk yield	-2.6	-2.5	-.9	-.5	-1.1	-.7	-.3	-1.6	-.3	-.5	8	.7	.55	.01	.45	.08	.0001	.52
Milk composition (final yield, %)																		
Fat	2.1	2.3	2.6	2.5	2.6	2.7	3.0	2.7	2.9	3.1	2.9	2.6	.19	58	.05	.36	.0006	.39
Protein	2.9	3.2	3.3	3.3	3.1	3.2	3.3	3.4	3.1	3.3	3.2	3.3	.10	.0004	.24	.65	.53	.23
Lactose	4.6	4.9	4.9	4.9	5.0	5.0	5.1	5.0	5.0	5.0	5.0	5.0	.13	.24	.30	.76	..06	.27
SNF	8.1	8.8	9.0	8.9	8.8	9.0	9.1	9.1	8.8	9.0	8.9	9.0	.24	.02	.26	.67	.15	.22
Milk composition (Change in yield, g)																		
Milk fat	-154	-128	-82	-42	-64	-64	-25	-100	-41	-41	-1	-28	32.1	.11	.42	.24	.001	.96
Protein	-73	-77	-29	-17	-38	-22	-14	-56	-7	-10	21	24	18.0	.03	.58	.16	.0001	.29
Lactose	-128	-123	-48	-29	-67	-45	-10	-77	-14	-24	41	37	27.4	.005	.46	.07	.0001	.41
SNF	-220	-220	-86	-51	-114	-74	-28	-146	-25	-38	66	66	49.1	.01	.51	.09	.0001	.36

[a] % of total CP requirement including the estimated CP contribution from the forage.
[b] Standard errors reported represent the largest SE for each variable.
[c] Linear response to increased level of supplemental protein.
[d] Quadratic response to increased level of supplemental protein.
[e] Cubic response to increased level of supplemental protein.
[f] Linear response to increased level of supplemental energy.
[g] Quadratic response to increased level of supplemental energy.

Table 5. Forage utilization during year one by lactating beef cows supplemented with graded levels of protein (80, 95, 110 and 125 % of the NRC protein requirement) and energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d)

	Low (1.32 kg) TDN				Medium (1.76 kg) TDN				High (2.22 kg) TDN					Probability				
Item	80[a]	95	110	125	80	95	110	125	80	95	110	125	SE[b]	Lin[c]	Quad[d]	Cub[e]	Lin[f]	Quad[g]
Fecal output, kg	4.56	4.56	4.35	4.20	5.08	4.85	4.98	4.78	4.95	5.66	5.20	4.93	.255	.19	.20	.61	.0001	.43
Forage intake, kg	8.88	8.98	9.15	8.69	9.09	9.47	9.65	9.91	8.99	10.61	10.58	9.90	.572	.26	.13	.90	.009	.87
Total intake, kg	10.46	10.52	10.65	10.15	11.27	11.58	11.72	11.92	11.74	13.30	13.23	12.47	.572	.44	.13	.91	.0001	.87
Forage dig., %	51.8	51.4	54.6	53.1	48.7	52.6	51.9	54.4	51.4	51.6	55.0	54.6	1.39	.001	.51	.47	.65	.22
Total diet dig., %	56.3	56.4	59.2	58.5	54.9	58.0	57.6	59.8	57.9	57.6	60.5	60.7	1.06	.0001	.74	.44	.04	.21
Forage DOMI, kg	4.62	4.65	5.00	4.64	4.46	5.00	5.00	5.41	4.63	5.47	5.86	5.38	.367	.04	.14	.87	.02	.77
Total DOMI, kg	5.91	5.95	6.30	5.95	6.20	6.73	6.74	7.14	6.79	7.64	8.03	7.54	.367	.04	.14	.86	.0001	.77
Forage intake, %BW	2.04	2.10	2.04	1.93	2.05	2.11	2.12	2.23	2.01	2.31	2.33	2.21	.141	.47	.29	.73	.07	.17
Total DOMI, %BW	1.36	1.40	1.40	1.32	1.40	1.50	1.48	1.61	1.52	1.65	1.76	1.68	.096	.15	.38	.92	.0001	.78
NH3, mg/dL	7.78	6.91	10.82	14.31	5.39	8.53	8.77	11.28	6.07	8.18	6.97	9.97	1.202	.0001	.27	.42	.01	.60

[a] % of total CP requirement including the estimated CP contribution from the forage.
[b] Standard errors reported represent the largest SE for each variable.
[c] Linear response to increased level of supplemental protein.
[d] Quadratic response to increased level of supplemental protein.
[e] Cubic response to increased level of supplemental protein.
[f] Linear response to increased level of supplemental energy.
[g] Quadratic response to increased level of supplemental energy.

Table 6 Forage utilization during year two by lactating beef cows supplemented with graded levels of protein (80, 95, 110 and 125 % of the NRC protein requirement) and energy (Low=1.32 kg TDN/d, Medium=1.76 kg TDN/d, High=2.22 kg TDN/d)

	Low (1.32 kg) TDN				Medium (1.76 kg) TDN				High (2.22 kg) TDN					Probability				
Item	80[a]	95	110	125	80	95	110	125	80	95	110	125	SE[b]	Lin[c]	Quad[d]	Cub[e]	Lin[f]	Quad[g]
Fecal output, kg	4.62	5.01	4.66	4.64	4.81	4.71	4.82	4.87	4.79	4.90	5.28	5.37	.265	.29	.75	.90	.06	.51
Forage intake, kg	6.85	8.27	7.15	7.93	7.37	6.68	7.92	7.34	7.00	6.97	8.62	8.19	.440	.01	.53	.36	.64	.27
Total intake, kg	8.46	9.83	8.65	9.41	9.55	8.81	10.00	9.38	9.76	9.71	11.29	10.82	.440	.03	.54	.38	.0001	.25
Forage dig., %	37.1	41.5	37.9	43.0	41.3	35.3	43.6	37.7	39.8	37.8	44.5	40.2	2.25	.26	.84	.07	.65	.60
Total diet dig., %	45.3	48.4	46.3	50.4	50.1	46.5	52.0	48.1	50.8	49.6	53.2	50.5	1.73	.24	.90	.17	.007	.88
Forage DOMI, kg	2.55	3.52	2.70	3.47	3.01	2.37	3.45	2.77	2.79	2.64	3.84	3.29	.292	.03	.52	.15	.70	.26
Total DOMI, kg	3.84	4.82	4.00	4.77	4.74	4.10	5.18	4.51	4.96	4.82	6.01	5.46	.292	.03	.52	.15	.0001	.25
Forage intake, %BW	1.56	1.83	1.60	1.79	1.61	1.46	1.81	1.62	1.53	1.52	1.87	1.73	.105	.03	..46	.23	.61	.38
Total DOMI, %BW	.88	1.07	.91	1.09	1.04	.89	1.20	.99	1.08	1.05	1.30	1.14	.072	.07	.44	.09	.003	.42
NH3, mg/dL	2.93	4.05	6.66	10.72	2.90	3.56	4.58	8.43	1.95	2.41	3.31	3.63	.539	.0001	.0016	.73	.0001	.21

[a] % of total CP requirement including the estimated CP contribution from the forage.
[b] Standard errors reported represent the largest SE for each variable.
[c] Linear response to increased level of supplemental protein.
[d] Quadratic response to increased level of supplemental protein.
[e] Cubic response to increased level of supplemental protein.
[f] Linear response to increased level of supplemental energy.
[g] Quadratic response to increased level of supplemental energy.

VITA

Todd Aaron Thrift

Candidate for the Degree of

Master of Science

Thesis: SUPPLEMENTAL PROTEIN: ENERGY INTERACTIONS FOR FALL CALVING BEEF COWS GRAZING DORMANT NATIVE RANGE

Major Field: Animal Science

Biographical:

Personal Data: Born in Lexington, Kentucky, November 1, 1968, the son of Frederick and Barbara Thrift.

Education: Graduated from Lafayette High School, Lexington, Kentucky in May 1987; earned Bachelor of Science in Animal Science (production option) from the University of Kentucky in May 1991: completed the requirements for the Master of Science Degree at Oklahoma State University in May, 1994.

Professional Experience: Summer Farm Hand, Brewer Farms, 1985 to 1991; Graduate Research and Teaching Assistant, Department of Animal Science, Oklahoma State University, 1991 to 1993.

Professional Organizations: Alpha Zeta Agricultural Fraternity; American Society of Animal Science; Gamma Sigma Delta.