EFFECT OF SPRING PASTURE BURNING, WEANING DATE AND SUPPLEMENTAL PROTEIN SOURCE ON PERFORMANCE, FORAGE UTILIZATION AND RUMINAL ENVIRONMENT OF FALL-CALVING BEEF CATTLE MAINTAINED ON NATIVE GRASS PASTURES IN EARLY SUMMER

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CHAPTER I

INTRODUCTION

Nutritional management of fall-calving cows is more difficult than traditional spring time calving. Poor quality native grass forage (4% CP, 40% TDN) necessitates supplemental protein and energy. Furthermore, lactation demands increase cow nutrient requirements. Supplementation is expensive (40 ¢/head/d), therefore, many fall-calving cows are fed below maintenance during the winter. Consequently, cows lose weight (45 to 90 kg) and body condition during winter. In addition, their calves have suppressed weight gain (Gonzalez, 1987).

Poor body condition at calving lengthens the time to first estrous and reduces conception rate (Selk et al., 1986; Wettemann et al., 1987). Therefore, fall-calving beef cows must rapidly replete body condition during early-summer grazing. One management practice that should hasten repletion of cow weight and body condition is early-weaning. With ample forage, however, fall-born calves may nurse through July without hindering cow performance (Hancock et al., 1985). If calves are weaned early (April), they require high quality forage. Native range quality peaks in May (10% CP) and declines through the summer (Waller et al., 1972). Thus, lightweight (155 kg) calves requiring 14% dietary CP should utilize supplemental protein efficiently (NRC., 1984). Supplemental ruminal degradable protein stimulates digestibility and intake of medium quality forage (Guthrie et al., 1984). Ruminal bypass protein, however, may be more beneficial for rapidly growing calves (Orskov, 1982).

An alternative management practice to improve cow herd performance is prescribed spring burning of native grass pastures. Burning improves forage quality and cattle gain (Woolfolk et al,. 1975). Delayed weaning combined with spring pasture burning may enhance cow-calf performance, especially when cows are thin. For weaned calves the relative value of burning and supplementation is unknown. Burning should increase forage digestibility and therefore intake. The ruminal environment which accomodates enhanced performance of cattle grazing burned forage has not been characterized.

The objectives of this research were to: a) compare the combined effects of delayed weaning and spring pasture burning on cow-calf performance, b) evaluate supplemental protein source for weaned calves and compare the value of supplementation versus pasture burning, and c) characterize the ruminal environment of grazing cattle maintained on unburned and burned native grass pastures.

CHAPTER II

REVIEW OF LITERATURE

Factors Affecting the Nutritional Status of Grazing Beef Cattle Maintained on Native Grass Pastures

Quality of Grazing Cattle Diets

Plant Chemical Components. The composition of forages can be divided into two classes, those of a concentrate nature and those of a less digestible fibrous fraction (Van Soest, 1985). The cellular contents are readily digested and mainly comprised of proteins, starches, sugars, lipids, and organic acids. The fibrous cell wall provides structural integrity to the plant and includes three carbohydrates - hemicellulose, cellulose and pectin plus cutins, tannins, silica, and lignin (Van Soest, 1982). Hemicellulose, cellulose, and lignin are the primary cell wall constituents. These structural carbohydrates of the forage cell wall serve as potential sources of carbon and energy for ruminants, which microorganisms ferment to provide volatile fatty acids and protein for the host.

Laboratory Analyses. Laboratory analyses can be utilized to establish the relative quality of forages. The proximate analysis system bases feedstuff classification upon chemical composition (Van Soest, 1982). In this system, crude fiber represents the fibrous fraction of a feedstuff. Since the degree of lignification of a plant is not reflected by crude fiber estimates, crude fiber does not lend itself for use in forage evaluation. In addition, some lignin and hemicellulose are solubilized in the acid-alkali step and thus, are incorrectly included in NFE. Consequently, the neutral detergent system was developed to fraction the cell wall into two categories: 1) neutral detergent fiber (NDF) composed of hemicellulose, cellulose, and lignin, and 2) acid detergent fiber (ADF) which includes cellulose and lignin (Van Soest, 1982). Hemicellulose can be calculated from the difference between NDF and ADF. Lignin content is found by solubilizing the ADF residue in permanganate solution or 72% sulfuric acid (acid detergent lignin, ADL). Permanganate and ADL solutions oxidize lignin and cellulose, respectively. The permanganate-lignin residue is then ashed to determine the cellulose fraction of the forage. Similarly, ashing the ADL residue determines lignin.

Predictive Value of Laboratory Analyses. In order to compare and evaluate forages for potential animal use, it is important to know their chemical composition. Dry matter, crude protein, in vitro dry matter digestibility, NDF, ADF, and lignin values are quantified in the laboratory and used to compare nutritive attributes of plants. Crude protein is the most widely used indicator of the quality of feedstuffs. Rao et al. (1973) reported that crude protein is a better indicator of digestibility than ADF. Furthermore, correlations above .90 have been reported between dietary crude protein and digestibility in grassland ranges (Brown et al., 1968; Rao et al., 1973). Milford and Minson (1965) reported that forage intake of sheep declines when dietary crude protein values were below 7%. Apparently, dietary crude protein concentrations below 7% do not meet the nitrogen requirements of ruminal microbial populations (Van Soest, 1982).

Forage digestibility affects the nutritional status of ruminants via effects on intake. Neutral detergent solubles represent the ideal nutritive fraction of forages since it contains proteins, lipids, soluble sugars, and starch, all of which have true digestibilities of 98% (Van Soest, 1967). Because the cell wall is the primary restrictive determinant of intake (Osbourn et al., 1974), the NDF fraction of forages must be determined. Van Soest (1965) and Osbourn et al. (1974) reported correlations between NDF and intake of -.65 and -.88, respectively.

Lignin not only is indigestible, but it apparently elicits deleterious effects upon forage quality by binding with protein, hemicellulose, and cellulose. Lignin interactions decrease the digestibility of fiber fractions by ruminal bacteria. Lignin is more closely associated with digestibility than intake (Van Soest, 1982). Jung and Vogel

(1986) suggest that lignin inhibits cell wall digestibility to a greater extent than dry matter digestibility. The authors also suggest that the relationship between digestibility and lignin is curvilinear.

Plant Maturity. As plants mature, there is generally an increase in the proportion of fiber and a concomitant decline of cell contents and crude protein. These changes reflect decreased leaf:stem and cell contents:cell wall ratios. More importantly, changes in plant chemical composition are associated with digestibility and subsequent animal intake. Data for chemical content of native grasses in western Oklahoma (Savage and Heller, 1947) central Oklahoma (Waller et al., 1972), and the Flint Hills of Kansas (Allen et al., 1976; Woolfolk et al., 1975) depict the general decline in forage quality throughout the season.

Standing forage quality is related to cell wall content, lignification, and maturity (Van Soest, 1985). Therefore, intake decreases as plants mature and become more lignified (Van Soest, 1982). Lignin (as previously mentioned), however, is more closely related to digestibility than intake. During maturation of forages, the proportion of cell wall constituents increases, while both potential digestibility (Wilkins, 1969) and rate of digestion (Smith et al., 1972) of the cell wall constituents decline. Decreased digestion is partially related to the time required to chew food particles to a size small enough to pass from the rumen (Welch and Smith, 1969; Balch, 1971).

Minson (1981) summarized and reported that the mean ruminal retention time of leaf and stem fractions of 26 forages was 24.6 and 33.3 hours, respectively. Thus, higher leaf:stem ratios of the same forage should promote greater voluntary forage intake.

Evaluating Ruminal Function

A multitude of bacterial, protozoal, and fungal species occupy the rumen in a symbiotic relationship. These microorganisms interact with consumed feedstuffs (substrate) and the host animal to establish the ruminal environment. Quantifying ruminal parameters allows us to evaluate ruminal interrelationships. If the ruminal environment is accurately characterized then animal performance may be explained.

Volatile Fatty Acids. Volatile fatty acids (VFA) provide 50-85% of the metabolizable energy for ruminants maintained on forage diets (Owens and Goetsch, 1988). The main VFA produced are acetate, propionate, and butyrate with typical molar ratios of 65:25:10, respectively, on forage diets (Owens and Goetsch, 1988). Blaxter (1962) proposed that animal performance was related to ruminal proportions of acetate to propionate. The energetic efficiencies of propionate, butyrate, and acetate compared to glucose are 109, 78, and 62 (Chalupa, 1979).

Molar proportions of VFA measured from ruminal fluid of cannulated steers are somewhat ambiguous, since they reflect the balance between rates of production, interconversions, and absorption. However, MacLeod and Ørskov (1984) suggest that molar VFA concentrations reflect actual production rates at pH values near 7.0, since absorption rates are similar at pH 7.0.

Ammonia. The primary nitrogen-containing compounds in ruminant diets are proteins, nucleic acids, and urea (Baldwin and Allison, 1983). Measurements with labeled ammonia indicate that less than 40% of bacterial protein is produced from the ammonia pool (Owens and Zinn, 1988). The authors suggested that with diets containing intact protein, much of the N used by ruminal bacteria is derived from amino acids or peptides and not from ammonia. Nonetheless, ruminal ammonia concentration provides a useful index of nitrogen status in the rumen (Kropp et al., 1977).

Cellulolytic bacteria require ammonia (Hungate, 1966). Thus, ruminal ammonia deficiencies may reduce the rate and extent of carbohydrate breakdown. When the diet is deficient in protein, or if the protein resists degradation, the concentration of ruminal ammonia will be reduced and microbial growth can be slowed (Satter and Slyter, 1974). Bunting et al. (1987) reported decreased ruminal NDF digestion for lambs with low mean ruminal NH3-N concentration (1.6 mg/dl). Therefore, if the concentration of ammonia in ruminal liquor is inadequate, cellulose degradation will be depressed. Consequently, inhibited cellulose digestion should decrease ruminal turnover rate and depress voluntary feed intake. Factors affecting ruminal ammonia concentration include time after feeding, type of diet (Wohlt et al., 1976), protein solubility (el Shazly, 1958), ruminal volume (Harrop, 1974) and ruminal protein degradability (Berger, 1986).

Ruminal pH. Ruminal pH is associated with diurnal variation and the time after supplementation. Mertens (1979) suggested that diurnal variation in ruminal pH modifies microbial activity and influences the rate and extent of ruminal digestion of dietary fiber. Typically, ruminal pH is lower for concentrate than forage diets. Forages, especially those of lower quality, require extensive rumination whereby copious quantities of saliva are excreted which buffer ruminal organic acids. Furthermore, cellulolytic bacteria require the bicarbonate ion for growth (Owens and Goetsch, 1988) and therefore proliferate at higher ruminal pH.

Efficiency of VFA and ammonia absorption are pH dependant. Unionized ammonia (NH_3) is readily absorbed through the ruminal wall. The pK of ammonia is 9.3, therefore large quantities of ammonia will be trapped in the ionized form (NH_4^+) at lower ruminal pH (Owens and Zinn, 1988). In contrast, VFA have pK's of about 4.1 and more rapid absorption of the nondissociated form occurs at lower pH (Owens and Goetsch, 1986). These reviewers also report that only 2 to 5% of VFA are nondissociated at pH 6 while at a pH of 5, about 25% are nondissociated.

Ruminal Digestion. Ruminal digestion proceeds at the discretion of ruminal bacteria (Owens and Isaacson, 1977) and therefore it may be referred to as a function of diet composition and the competition between bacterial species for substrates. Van Soest (1982) refers to the rate of digestion as the quantity of substrate that is fermented per unit of time. Not all particles within the rumen are digested at the same rate. Campling (1970) suggests that the delay in the rate of breakdown of digesta in the rumen is dependant upon one or more of the following processes: microbial digestion, mechanical disintegration, and the propulsive mechanism transferring digesta through the gut. Mertens (1977) referred to the span of time when digestion has not been initiated or is proceeding at a slow rate as lag time. Mertens and Ely (1982) further divide the digestive process into the potentially degradable fraction, rates of digestion, and digestion lag.

The rate of ruminal digestibility will influence the rate of passage, ruminal fill, and food intake (Mertens, 1977). Chestnut et al. (1987) suggested that the increased rate and extent of fiber digestion, rather than increased liquid and solid passage from the rumen, resulted in increased intake of ammoniated hay. Furthermore, Holechek et al. (1982) indicated that rate of digestion provides an important measure of forage quality, because faster rate of digestion promotes higher intake of forages with similar total digestibility.

The digestibility of fiber is dependant upon the degree to which structural carbohydrates are lignified (Van Soest, 1982). Digestion, however, is not the only factor controlling the disappearance of fiber from the rumen. Passage also competes with digestion for the disappearance of particles (Van Soest, 1982). Therefore, the potential extent of ruminal fiber digestion may be related to lignification and retention time. Because digestion and passage interact, depressed digestibility occurs when particles wash from the rumen prior to microbial digestion. Faichney and Gherardi (1986) observed that increased intake resulted in lower solute mean retention time which consequently depressed organic matter digestibility. Therefore, digestibility depression increases with forages of high digestible cell wall content (Van Soest, 1982).

Kinetics of Ruminal Digesta

Ruminal turnover is the average duration of time that digesta occupy the rumen. At steady state conditions, the rate of ingestion of plant parts will equal the rate at which they are comminuted to a size small enough to leave the rumen (Hungate, 1966). Removal of digesta is a competition between digestion and passage (Van Soest, 1982) and is collectively referred to as disappearance (Ellis, 1978). Microbial growth and efficiency is associated with fluid flow from the rumen (Owens and Isaacson, 1977). Bacterial efficiency improves with increasing dilution rates due to a lower proportion of microbial energy being expended for maintenance functions. Increased turnover of ruminal contents appears to enhance bacterial protein synthesis, increase ruminal acetate and methane production, and increase bypass of fiber and concentrate components of the ration (Owens and Isaacson, 1977). Mertens and Ely (1982) attribute the type of marker used, daily intake, physical form of the diet, and rumination differences among animals as factors affecting passage rate.

Hungate (1966) proposed that ruminal contents are partitioned into two components: a course particle rumination pool and a liquid-small particle pool. Current research methodology attempts to quantify passage of particulate and fluid phases.

Particulate Passage. Although ruminal particles of varying size and density are continuously distributed through the rumen, Owens and Goetsch (1986) classify particulate matter into three pools. Pool A is soluble, liberated upon consumption, or small enough (< 200 μm in diameter) to flow with free fluid. Pool B includes those particles able to pass from the rumen. Particles which are too large, too dense, or too light to exit are grouped into pool C. The authors propose that rumination and fermentation disintegrate particles from pool C to pools B and A, while indigestible particles may be found in all pools.

Physical characteristics of feed, and consequently the digesta, affect the passage of particles from the rumen. Grinding and pelleting of forages increases their passage from the reticulo-rumen (Van Soest, 1982). Physical determinants of passage through the reticulo-omasal orifice are particle size (Poppi et al., 1980), shape (Welch, 1982) and specific gravity (Church, 1976). Specific gravity or density is related to the ability of particles to hydrate and remove cellular gas (Van Soest, 1982). Welch (1982) stated that particle size reduction is the limiting process in clearance of indigestible fiber from the rumen and rumination plays a major role in this process. Particle size reduction is a function of both rumination and microbial fermentation. Pearce and Moir (1964) suggest that ruminal microbes are the primary determinant of particle size breakdown. Ruminal degradation without rumination, however, did not reduce stem particles to a small enough size to exit the rumen (Welch, 1982).

Fluid Passage. Ruminal liquor is either free flowing (pool A) or associated with particulate pools B or C (Owens and Goetsch, 1986). Fluids entering the rumen originate from dietary food, water, and saliva. Total ruminal fluid volume and fluid dilution rate are often negatively related (Owens and Goetsch, 1986).

Fluid dilution rate increases with ruminal infusion of artificial saliva (Harrison et al., 1975) and sodium bicarbonate (Rogers et al., 1979). Molar proportions of propionate decrease while acetate increases as fluid dilution rate increases (Harrison et al., 1975; Estell et al., 1982; Estell and Galyean, 1985). Level of feed intake appears to increase fluid passage. Fluid dilution rate of steers increased with increasing roughage intake (Rogers et al., 1979; Bergen et al., 1982; Adams and Kartchner, 1984) and concentrate intake (Galyean et al., 1979). Adams and Kartchner (1984) concluded that the level of forage intake is an important determinant of fluid dilution rates and higher levels of intake are associated with reduced ruminal fluid volume.

Estimating Passage Rates. Both particulate and fluid flow rates may be obtained from indigestible markers (Grovum and Williams, 1973; Faichney, 1975; Ellis et al., 1979, 1982). Characteristics of the ideal marker are discussed by Faichney (1975). Estimates of fluid passage have been obtained with polyethylene glycol (Rogers et al., 1982), chromium·EDTA (Downes and McDonald, 1964) or cobalt·EDTA (Uden et al., 1980). Particulate phase markers include rare earth elements such as samarium and lanthanum (Hartnell and Satter, 1979), ytterbium (Teeter et al., 1984), and dysprosium (Ellis, 1968; Goetsch and Galyean, 1983). Forage or esophageal extrusa (McCollum and Galyean, 1985) have been labeled with a rare earth marker and dosed orally or ruminally. Subsequent timed samples are obtained from the rumen or feces. Ruminal dilution rate is obtained from first-order kinetics by regressing the natural logarithm of marker concentration in ruminal contents against time (Faichney, 1975). Concentrations of marker in the feces are measured to obtain total tract passage. Total tract passage estimates may utilize first-order kinetics or a two-compartment sequential flow process (Grovum and Williams, 1973; Ellis et al., 1979). Ruminal dilution rates tend to be faster than total tract passage rates, however, treatment rankings between ruminal and fecal rates are consistent (Faichney, 1975).

Regulation of Voluntary Forage Intake in Grazing Ruminants

Intake of feedstuffs is the most important variable that governs livestock productivity. The daily throughput of the rumen depends on its volume and on the rate of disappearance of digesta by the competing processes of microbial digestion and passage of undigested food particles (Freer, 1981). Grazing ruminants consume forage to a point where the indigestible portion of digesta limits further consumption by occupying ruminal space. This is the bulk fill theory of intake (Campling, 1970; Freer, 1981) whereby disappearance of ruminal contents dictates further consumption. Bulk fill is generally accepted as the primary factor affecting intake of low-quality forages. Intake of high-quality forages, however, may be governed by chemical, humoral, and physical mechanisms or chemical and humoral factors alone (Grovum, 1986). Intake is further modulated by central and peripheral factors (Baile and McLaughlin, 1987).

Voluntary intake is related to forage digestibility. The rate of passage through the reticulo-rumen increases with increasing digestibility, even when ruminal fill remains constant (Blaxter and Wilson, 1962). Using dairy cattle, Conrad et al. (1964) suggested that physical factors no longer limit intake of forages with digestibility coefficients above 67%; therefore, physiological factors (Baile and Forbes, 1974) may control voluntary intake of forages with higher digestibility. Van Soest (1982) cautions that although intake and digestibility are interdependant, they should be regarded as separate parameters of forage quality.

Particle size reduction influences passage, thus rumination and mastication processes are associated with intake (Pearce and Moir, 1964; Troelson and Bibsby, 1964; Weston and Hogan, 1967; Balch, 1971). Van Soest (1982) suggested that passage is a consequential function of intake, because consumption of more feed will pressure the flow of undigested residues. Level of roughage intake may influence the liquid and particulate passage of sheep (Weston and Hogan, 1967; Grovum and Williams, 1977; Mudgal et al., 1982). However, others have suggested that intake does not influence passage rate (Laredo and Minson, 1973; Varga and Prigge, 1982). Varga and Prigge (1982) found no effect of two levels of intake of orchardgrass or alfalfa on ruminal turnover in lambs. They concluded that the level of forage intake influences liquid turnover rate to a greater extent than solid turnover rate.

Chemical constituents of forages may also influence intake. Campling (1966) observed that intake is limited by reticulo-ruminal capacity and rate of digesta disappearance with roughages containing up to 8 to 10% crude protein. With forages possessing low crude protein, inadequate ruminal ammonia probably inhibits cellulose digestion and subsequent intake. However, Egan (1970) reported increased intake with duodenal infusions of casein. Thus, low intake of poor quality forages may also be due to inadequate nitrogen recycling to the rumen.

Protein in Ruminant Diets

Essential amino acid requirements have been studied extensively and are better-understood in nonruminants. Unfortunately, amino acid requirements are an enigma in ruminant nutrition. The primary reason for impeded knowledge in this area is that the dietary protein composition does not reflect nitrogen flow to the small intestine (NRC, 1985). Amino acids absorbed in the small intestine are variably supplied by microbial protein (synthesized in the rumen), undegraded or protected food proteins, amino acids (which have bypassed the rumen), and endogenous secretions. Furthermore, requirements for essential amino acids are difficult to assess quantitatively because of: 1) the intervention of ruminal fermentation between the diet and the duodenum, and 2) the variation in requirements due to amino acid utilization in various functions (Owens and Bergen, 1982).

Limiting Amino Acids. Despite these complications, essential amino acid requirements have been proposed. Williams and Smith (1974) reported that methionine was first-limiting in 110 of 116 steers fed semipurified diets composed of straw, flaked corn, corn starch, and glucose, with groundnut meal or corn gluten meal as the protein supplement. Similarly, Fenderson and Bergen (1975) suggest that methionine (or total sulfur amino acids) was the limiting amino acid for growing steers. Based on plasma amino acid concentrations and nitrogen retention, Richardson and Hatfield (1978) suggest that methionine, lysine, and threonine are the first three limiting amino acids in growing steers (when microbial protein is the only source). Lysine has been identified as limiting in urea-supplemented diets for cattle (Burris et al., 1976; Hill et al., 1980). More recently, Owens (1986) calculated that lysine and isoleucine both appear low in growing steer diets.

Meeting the protein requirements for ruminants is a challenging endeavor. Nitrogen deficiencies may occur at three points: the non-specific N supply may be inadequate for synthesis of non-essential amino acids by the liver; the ammonia supply may be inadequate for microbes in the rumen or large intestine; and the essential amino acid supply may limit growth or production at the tissue level (Owens, 1986). Consequently, animal performance may be depressed due to inadequate nitrogen at any of these points.

Bypass Protein. The first concern in feeding ruminants is to meet ruminal protein requirements. If nitrogen is deficient in the rumen, microbial growth will be depressed and animal performance reduced. When ruminal N requirements are met, the addition of feed protein which escapes ruminal degradation may be beneficial. In general, flow of ruminal microbial nitrogen can meet 50% or more of the amino acid requirements of ruminants under various states of production (Ørskov, 1982). Animals with high protein requirements, however, may benefit from dietary protein that escapes ruminal digestion (Ørskov, 1982). Consequently, bypass protein sources may be utilized most efficiently by lactating dairy cows and growing calves.

Basal diet affects bypass protein potential. For cattle consuming concentrate diets, a decreased rate and extent of ruminal protein degradation was observed in vitro (Ganev et al., 1979) and in vivo (Zinn and Owens, 1983b). This may be explained by ruminal pH lower than the 6 to 7 which is optimum for most proteolytic and deaminase enzymes (Owens and Zinn, 1988). Furthermore, Owens and Zinn (1988) suggested that the percentage of soluble feed protein is often greater at a higher pH; since proteolytic bacteria are more prevalent at neutral pH, more degradation of cellulose and cell walls should occur thereby exposing more protein to microbial attack.

Solubility is the most widely used estimator of ruminal protein degradability. Stern and Satter (1982) proposed that the amino acid composition of the soluble fraction of a feedstuff usually differs from that of the more insoluble fraction. Since ruminal microbes have the ability to adapt to soluble organic compounds (Owens and Bergen, 1982), correlations between in vitro and in vivo solubilities are open to question. Therefore, Owens and Bergen (1982) suggest that solubility alone is a poor indicator of the extent of ruminal degradation across a variety of diets and feeding conditions.

Rate of passage from the reticulo-rumen will further alter bypass potential. High bypass protein sources such as fish meal, meat meal, and distiller's products have relatively low rates of proteolysis through four hours of ruminal incubation (Owens and Bergen, 1982). In contrast, protein sources such as soybean, sunflower, and cottonseed meal are degraded rapidly, therefore increasing ruminal degradation. Furthermore, bypass potential is enhanced with increased feed intake in steers (Zinn and Owens, 1983a) and dairy cattle (Tamminga et al., 1979).

Methods to Improve Productivity of Fall Calving Beef Cows in the Summer

Burning Native Grass Pastures

Fire is an historic range management tool. Indians burned prairie and forest lands to bring about fresh growth of grass in the autumn which numerous game animals and wild fowl would gather to feed, thus making it easy for Indians to secure their winter meat supply (Sampson, 1929). In the 1880's, cattlemen observed that steers gained more weight on burned than on unburned range, consequently, grazing leases required annual burning (Kollmorgan and Simonett, 1965). Furthermore, Flint Hills settlers discovered that steers selected forage from burned range and gained more rapidly on burned than unburned range (Anderson et al., 1970). Perhaps the greatest attribute of burned range is improved palatability. Duvall and Whitaker (1964) utilized burned range instead of fences to divide areas for rotational grazing.

Regrowth of plants in the spring is dependant upon soil temperature and moisture. Accumulation of mulch will depress prairie herbage yield and reduce the number of plant species (Ehrenreich, 1959; Towne and Owensby, 1984). Burning, however, removes mulch (litter) which has accumulated from season to season thereby allowing sunlight to penetrate and warm the soil surface. Prescribed fires selectively suppress or promote particular species depending on the date of the fire in relation to the species phenology (Schacht and Stubbendieck, 1985). Anderson et al., (1970) suggest that species actively growing when the area is burned are much more susceptible to injury and death than dormant species or those initiating growth.

The bulk of data on burning has been conducted at the Flint Hills near Manhattan, Kansas. The species composition of Flint Hills warm season grasses is similar to those of Oklahoma native grass pastures: big bluestem, Andropogon gerardi; little bluestem, Shizachyrium scoparium; switchgrass, Panicum virgatum; and indiangrass, Sorghastrum nutans.

Quality of Burned Pastures. Smith and Young (1959) found that mid-spring burning increased the protein and ash content of little bluestem. Smith et al. (1960) reported that protein digestibility was not greatly affected by burning, however, burning improved digestibility of dry matter and crude fiber. Woolfolk et al. (1975) reported higher crude protein ($P<.01$) and hemicellulose ($P<.002$) values with lower ADF ($P<.005$) fractions for range burned in late-spring (April 28). Burning, however, did not affect cellulose or lignin content of diet samples. In addition to improved forage quality, burning decreases weed yield (Owensby and Anderson, 1967; Anderson et al., 1970).

Although quality improves, total herbage yield declines with early- and mid-spring burning (Owensby and Anderson, 1967; Anderson et al., 1970). Decreased forage yield is directly related to soil moisture reserves which are lowered by burning and subsequent rapid growth of warm season grasses (Anderson et al., 1970). Owensby and Anderson (1967) suggest that late-spring (May 1) burning of Flint Hills pastures does not affect herbage yield. Another negative aspect of burning is stimulation of reproductive versus vegetative growth (stem vs leaf) suggested by increased flower stalks of burned big bluestem and indiangrass pastures (Kucera and Ehrenreich, 1962).

Cattle Performance. Smith et al. (1959) reported improved steer gains on pastures burned in mid- or late-spring (April 1 to May 1). Furthermore, Smith et al. (1965) reported that the 15-year average of beef gains on mid-spring and late-spring burned pastures were higher (9 to 10.5 kg/steer) than gains on adjacent, unburned pasture. Anderson et al. (1970) summarized data from 17 years and reported that steers (14 mo. age, 231 kg initial weight in 10 trials; 26 mo. age, 332 kg initial weight in other trials) gained significantly more weight on mid- and late-spring burns compared to no burning. Furthermore, higher gains were observed early in the growing season. In 2 of 3 years, yearling steers grazing fall-burned gulf cordgrass in Texas gained at a faster rate (.17 kg/AU/d) than on unburned pastures (Angell et al., 1986).

Brahman cows grazing burned (February) Gulf Coast prairie in Texas, averaged one condition score unit higher and their calves were 14.5 kg heavier than those maintained on unburned pastures (Sprott et al., 1986). Furthermore, subsequent year's calving percentage was 77 and 61 for cows on burned and unburned pastures, respectively. They attributed the improved performance to increased forage quantity (46%), crude protein (84%), TDN (40%), and phosphorus (95%).

Increased performance of cattle grazing burned pastures is probably the result of increased intake, however, Smith et al. (1960) reported no statistical difference in forage consumption between burned and unburned pastures. In contrast, digestible energy intake was increased for steers grazing burned pasture although protein content between pasture treatments was not different (Rao et al., 1973).

Normal Versus Delayed Weaning

Increased maintenance energy demands due to cold weather and lactational stress cause fall-calving cows to lose body weight and condition during the winter. These factors, coupled with poor forage quality, subject cows to nutritional deficiencies. Many producers are unable to provide sufficient supplemental nutrients at this time, which can lead to winter weight losses as high as 100 kg/cow (Trautman, 1987). Fall-born calves are typically weaned in May or June. Early weaning (180 d) should divert the energy required for lactation into repletion of cow body weight and condition. If the quality and quantity of spring pastures will support protein and energy demands for both compensatory growth and extended lactation, then late weaning (270 d) should allow adequate cow performance and improved calf weaning weight (Hancock, et al. 1985). Succulent spring forage may stimulate milk production. Continued lactation coupled with increased milk, however, may limit the response of thin cows. Forage quality declines quickly (Waller, 1972), consequently, thin cows must replenish lost body reserves rapidly in the spring and early summer. Improved forage quality resulting from spring-burned pastures may enhance the performance of late-weaned cows and calves.

Many studies report the influence of early weaning on subsequent cow-calf performance for spring- (Green and Buric, 1953; Lusby and Parra, 1981; Basarab et al., 1986), fall- (Peterson et al., 1987), and winter- (Neville, JR. and McCormick, 1981) born calves. Early weaning may be a viable management tool during drought or when inadequate forage quality or availability limits milk production and hinders calf weight gain. Peterson et al. (1987) suggest that fall-born calves should be early-weaned when ownership of the calves is retained through finishing.

Late weaning has received little attention primarily due to lowered cow reproductive performance associated with extended milk production (Laster et al., 1973; Lusby et al., 1981). The advantage of delayed weaning is through improved weaning weight of nursing calves (Hancock et al., 1985). As much as 66% of the variation associated with weaning weight is due to milk production (Rutledge et al., 1971; Butson et al., 1980; Neville, JR. and McMormick, 1981). Boggs et al. (1980) reported that each additional kg of milk/d adds 7.2 kg of 205-d adjusted weight and improves average daily gain .04 kg/d. Similarly, Jeffery et al. (1971) concluded that a 1 kg increase in milk production per day would improve calf weaning weight by 11.3 to 14.6 kg. Cows grazing burned pasture may produce more milk resulting in increased weaning weight.

Pate et al. (1985) reported that late-fall calves may be left on their dams for up to 10.5 months of age to obtain a sizeable advantage in calf weaning weight without affecting long-term reproduction of the cow. Hancock et al. (1985) indicated that cows with late-weaned (285 d) calves regain sufficient body reserves and their calves gain 59 kg more than normally weaned (210 d) calves at the same age. Extended nursing may be an effective management tool if forage availability, condition of the cow herd, and existing or predicted feeder calf prices justify a later weaning date (Pate et al., 1985).

Supplemental Protein for Fall-Born, Early-Weaned Beef Calves

Crude protein content of tallgrass native range averages 2.91, 10.01, 7.84, 6.04, and 4.92 for the months of April through August, respectively (Waller et al., 1972). The protein requirement for a 150 kg calf to gain .80 kg/d is 14.8% of the diet (NRC, 1985). Therefore, fall-born calves weaned in the spring (180 d) and maintained on native grass pastures should respond to supplemental dietary protein.

Supplemental crude protein (.3 to .7 kg SBM/d) increased while supplemental energy depressed the weight gain of steers grazing native grass in late summer (Lusby et al., 1982; Lusby and Horn, 1983). The response to supplemental protein can be attributed to improved dry matter digestibility which stimulates intake of low (Kartchner et al., 1980; Rittenhouse et al., 1980) and medium quality forage (Guthrie et al., 1984). In addition, salt-limited high-protein creepfeed increases performance of suckling spring-born calves from June 1 through August 3 (Lusby et al., 1985). Readily fermentable carbohydrates (corn starch) coupled with low ruminal ammonia (Chase et al., 1986), however, decreases in vivo cellulose digestibility and intake of low-quality forage (Lusby et al., 1976). Therefore, protein rich supplements (40% protein) should improve performance of calves grazing poorly digestible native pastures more than grain-based supplements.

Dietary protein may be the first-limiting nutrient for lightweight calves (<300 kg) grazing spring native grass pastures. Supplemental protein could increase bacterial fermentation of ingested forage. Forage protein in early summer, however, may supply adequate ruminal degradable protein to meet the ammonia requirements of ruminal bacterial. Thus, supplemental protein in the form of ruminal bypass protein could increase the supply of protein reaching the duodenum and stimulate animal performance. Unfortunately, ruminal degradable protein and bypass protein requirements of grazing calves are not fully understood. Furthermore, it is unknown if bypass protein will improve the performance of lightweight calves grazing medium-quality native grass pastures compared to a ruminally degradable protein source. Finally, pasture burning of native range improves daily gain of calves (Smith et al., 1960; Anderson et al., 1970; Woolfolk et al., 1975). The relative efficiency of protein supplementation or prescribed spring burning is unknown.

CHAPTER III

PRESCRIBED SPRING BURNING OF NATIVE GRASS PASTURES FOR LATE-WEANED, FALL-CALVING BEEF COWS

Abstract

Trials were conducted in two consecutive years to evaluate the effects of prescribed spring burning of native grass pastures and delayed weaning on cow weight, cow body condition (1=emaciated, 9=obese) and calf growth rate. Calves were weaned early (late April, 170 d of age) or late (early August, 275 d of age). Weaned cows and suckling cow/calf pairs were maintained on either unburned (control) or burned pastures. Weaned calves grazed an adjacent control or burned pasture. In year 1, weaning increased ($P<.05$) cow weight gain by .24 and .46 kg/d for cows grazing control and burned pastures, respectively. Burning also increased cow weight gain (.08 kg/d for suckled cows and .30 kg/d ($P<.05$) for weaned cows). Cow body condition was increased ($P<.01$) by weaning (+.61 units) and burning (+.42 units). In year 2, weaned cows gained 30.6 kg (.31 kg/d) more weight ($P<.01$) and body condition (+.54 units) than suckled cows. Burning increased cow weight and body condition by .08 kg/d ($P<.01$) and .61 units ($P<.13$), respectively. During the course of the study, late-weaned calves gained 101 kg (87 d) in year 1 and 98 kg (98 d) in year 2. In addition, late-weaned calves were 41.7 kg (.48 kg/d) and 42.3 kg (.43 kg/d) heavier than their weaned counterparts grazing control pastures in years 1 and 2, respectively. Burning increased ($P<.10$) weight gain (7.4 kg) of both weaned and suckled calves in year 1. In year 2, burning increased weight of weaned calves by 4.0 kg while suckled calves grazing burned pasture gained an additional 15.9 kg ($P<.05$) during the trial. These studies illustrate that delayed weaning substantially increases calf weight with little additional economic input. In addition, grazing late-weaned, fall-calving beef cows on native grass pasture burned in late spring enhanced repletion of cow body weight and condition and calf growth rate.

(Key Words: Beef Cattle, Body Condition, Delayed Weaning, Prescribed Spring Burning, Native Grass)

Introduction

Fall-calving beef cows grazing dormant native range typically lose large quantities of body weight and condition during the winter. Therefore, body energy stores must be rapidly repleted in the summer to ensure adequate calving, lactation, and rebreeding performance in the fall (Hancock et al., 1985; Selk et al., 1986; Wettemann et al., 1987).

Weaning fall-born calves late (9 to 10 months of age) allows both lactating cows and calves to efficiently utilize high quality early summer forage. Late-weaned calves outperform their early-weaned contemporaries by 30 kg, with minimal effects on cow performance (Hancock, et al. 1985).

Burning native grass pastures in the spring increases nutritional quality due to removal of dormant forage residue (Ehrenreich, 1959; Towne and Owensby, 1984) and decreased quantity of low-quality winter annual weeds (Owensby and Anderson, 1967; Anderson et al., 1970). Pasture burning improves performance of stocker cattle (Smith et al., 1959; Smith et al., 1965; Anderson et al., 1970; Woolfolk et al., 1975; Angell et al., 1986) and cow/calf herds (Southwell and Hughes, 1965; Kirk et al., 1974; Sprott et al., 1986). The value of burning for late-weaned, fall-born calves and their dams is unknown. Thin, lactating beef cows should respond to improved forage quality with faster compensatory gain and enhanced milk production. In addition, suckling calves with access to increased milk and higher quality forage should grow faster. The objective of this study was to evaluate the performance response of fall-calving cows and their calves to delayed weaning and spring-burning of native grass pastures.

Materials and Methods

Trial 1 (1985). Ninety-two Angus X Hereford cows (417 kg) bred to Limousin bulls calved from September through November, 1984 at the Southwest Livestock and Forage Research Laboratory near El Reno, Oklahoma. Sixty-four cows were selected based on low body condition scores (3.0 to

5.5, scale = 1 to 9). A 2 X 2 factorial design was utilized in which two groups of 32 cow-calf pairs were randomly allocated by body condition into two pasture groups: unburned (control) and burned. Each pasture group was further subdivided into two weaning groups: weaned and lactating. Pasture and weaning treatments were replicated, thereby providing four pastures (two unburned and two burned) with four groups of cattle (8 lactating cow-calf pairs and 8 dry cows per pasture). Weaned calves (16 calves/group) were maintained on adjacent unburned or burned pastures.

Burning was conducted April 11 and 12 on the three burn pastures. Weaned calves were weaned April 22 at an average age of 169 d. Calves were 256 d of age at the end of the trial (August 1). Prior to the start of the trial, weaned calves were placed on a weaning ration (table I) plus grass hay in drylot while their dry dams grazed the same pasture as the suckled pairs. The trial was initiated May 6 when regrowth of burned pastures was approximately 15 cm in height. Cow-calf and weaned calf pastures were stocked at 1.3 and 2.7 ha/AU for 87 d, respectively. All cattle had free access to water and a mineral mix (50% trace mineralized salt, 50% dicalcium phosphate).

Cow weight, body condition score, and calf weight were evaluated at three-week intervals following a 15-h shrink from water and forage. Two independent condition scores were averaged for each cow (1=emaciated, 9=obese). The

TABLE I. COMPOSITION OF WEANING RATION

Item	% (Dry matter basis)
Feed Composition	
Rolled corn	50.00
Rolled oats	15.00
Dehydrated alfalfa meal	5.00
Soybean meal	22.50
Molasses	3.00
Dicalcium phosphate	2.50
Limestone	1.00
Trace mineralized salt[a]	1.00
Vitamin A (30,000 IU/g)	.05
Deccox (6% decoquinate)	.09
Chemical composition[b]	
Crude protein	19.4
TDN	81.0
Calcium	.9
Phosphorus	1.1

[a] Trace mineralized salt contained 92.0% NaCl, .25% Mn, .20% Fe, .03% S, .033% Cu, .0025% Co, .007% I and .005% Zn.

[b] Estimated.

weigh-suckle-weigh method (Totusek et al., 1973) was utilized to measure milk production on May 30, June 20, and August 1. Calves were separated from their dams at 1600 h and allowed to suckle at 0900 h and 1800 h the following day. Daily milk production estimates were obtained by summing the two sucklings.

Four mature heifers, fitted with esophageal cannulae, were equipped with extrusa bags to obtain diet samples on May 6, May 30, June 20, July 9, and July 27 and 28 from one replicate of each cow-calf pasture. Diet samples were obtained from the weaned calf pastures on July 27 and 28 only. Esophageal masticates were immediately placed on ice for transport to the laboratory and stored at -15 C prior to lyophylization. Dried masticate was allowed to air-equilibrate and then ground through a Wiley mill equipped with a 1-mm screen, composited by date (July 27 and 28 composited together) and treatment, and stored at -15 C prior to laboratory analysis. Sample analyses included dry matter (DM), ash, crude protein (CP; N x 6.25) by Kjeldahl (AOAC, 1975), NaCl-soluble protein (Waldo and Goering, 1979), neutral detergent fiber (NDF), and a sequential acid detergent fiber (ADF) and permanganate lignin (PL) procedure (Goering and Van Soest, 1970). Concentrations of hemicellulose (NDF minus ADF) and cellulose (ADF minus PL minus ADF-ash) were calculated by difference.

Two lactating cows on burn pastures became ill, consequently 62 cows were included in the statistical analyses. The cow performance data were analyzed by least squares procedures with calf sex, weaning, burn, pasture, pasture * wean, and wean * burn interactions included in the model. The calf performance model included sex, wean, burn, wean by burn interaction, and calf age as a covariate. When the wean * burn interaction was deemed nonsignificant (P>.05), significant treatment responses were detected by F-test. When treatment interactions were significant, all treatment means were then evaluated by Protected LSD. Differences in chemical composition of forage diet samples at each date were evaluated by F-test. Chemical components were regressed against sampling date to evaluate linear and quadratic trends in forage quality as the season progressed.

<u>Trial 2 (1986).</u> The same herd of Angus X Hereford cows from year 1 were bred to Angus bulls for year 2. Calves were born from October through November, 1985. Sixty cows were randomly selected from 84 head to randomize previous winter treatment effects upon calf growth potential, consequently initial body condition scores ranged from 3.33 to 7.50. Cows were blocked by calf sex and body condition, then randomly allocated to treatment. The experimental design was identical to year 1. The number of dry cows and cow-calf pairs was reduced from 16 to 14 per treatment. Non-experimental grazer cows were added to increase stocking densities (1.3 ha/AU) for all treatments. Calves weighed 170.6 kg when they were weaned at 174 d of age. Burning was implemented April 5 and 6 and the trial began April 29. The

trial was concluded after 98 d (August 5) when suckled calves were 272 d of age. All groups were allowed access to a 50% dicalcium phosphate, 45% trace mineralized salt, and 5% potassium chloride mix.

Diet samples were obtained from one replicate of each dry cow and cow-calf pasture on April 29, May 13, June 3, June 24, July 15, and August 5. Weaned calf pastures were sampled on May 15, June 19, and July 24. Subsequent processing and laboratory analyses were described in year 1.

Cow weight, condition score, and calf weight were evaluated at two to three week intervals. Three independant condition scores were averaged for each cow. Milk production was estimated on June 3, July 15, and August 5. Two calves from the burn-wean treatment were deleted prior to analyses because of illness and aberrant data. One cow from the burn-lactating group was deleted because of aberrant data. Statistical analyses were the same as for year 1.

Results and Discussion

Pasture Quality. Dietary crude protein content was initially higher ($P<.01$) on burned pasture in both years (tables II and III). Crude protein content of burned forage declined more rapidly than control forage. Thus, CP content of control pastures exceeded burn pastures after May 30 in year 1 and July 15 in year 2. Burned forage may mature more

TABLE II. CHEMICAL COMPOSITION OF DIET SAMPLES FROM CONTROL AND BURNED COW/CALF PASTURES (YEAR 1-1985)[a]

	Date					
Component	May 6	May 30	June 20	July 9	July 28	SEM[b]
Crude protein, %						
Control[i]	13.9[c]	12.1[g]	10.4[c]	10.6[c]	8.8[c]	.14
Burn[j]	16.4[d]	11.7[h]	9.1[d]	8.8[d]	7.4[d]	.14
Soluble protein, %						
Control	2.2	2.8[c]	1.4	1.7[g]	1.5[e]	.12
Burn	2.5	2.0[d]	1.5	1.4[h]	1.1[f]	.12
Neutral detergent fiber, %						
Control[j]	77.7	76.6[e]	72.9[c]	80.4	81.8[c]	.45
Burn	78.4	78.3[f]	80.2[d]	81.2	78.8[d]	.45
Acid detergent fiber, %						
Control[i]	40.8[c]	44.6[c]	42.5	47.1[c]	48.2[c]	.30
Burn[j]	38.4[d]	41.6[d]	42.3	44.5[d]	43.3[d]	.30
Permanganate lignin, %						
Control[i]	5.5[g]	8.2[c]	7.2[c]	7.1[c]	8.4[c]	.16
Burn[i]	5.1[h]	6.2[d]	6.0[d]	6.3[d]	6.4[d]	.16

[a] Organic matter basis.

[b] SEM=standard error of least square treatment means.

[c,d] Treatment means within columns differ ($P<.01$).

[e,f] Treatment means within columns differ ($P<.05$).

[g,h] Treatment means within columns differ ($P<.10$).

[i] Linear period response ($P<.05$).

[j] Quadratic period response ($P<.05$).

TABLE III. CHEMICAL COMPOSITION OF DIET SAMPLES FROM CONTROL AND BURNED COW/CALF PASTURES (YEAR 2-1986)[a]

	Date				
Component	May 6	June 3	July 15	August 5	SEM[b]
Crude protein, %					
Control[j]	14.5[c]	13.0[c]	11.2[c]	8.3[e]	.09
Burn[i]	15.8[d]	13.6[d]	10.1[d]	8.0[f]	.09
Soluble protein, %					
Control[j]	3.2[g]	3.9	2.8[c]	1.1	.14
Burn[j]	2.7[h]	3.8	2.0[d]	1.3	.14
Neutral detergent fiber, %					
Control	78.4[c]	86.9[c]	82.8	86.2[c]	.38
Burn[j]	80.9[d]	84.3[d]	83.4	83.0[d]	.38
Acid detergent fiber, %					
Control	45.8[c]	52.2[c]	48.2	51.8[c]	.32
Burn[i]	43.2[d]	47.3[d]	47.6	49.6[d]	.32
Permanganate lignin, %					
Control	8.9	9.9[g]	9.3	10.1	.53
Burn	7.6	8.3[h]	8.4	9.5	.53

[a] Organic matter basis.

[b] SEM=standard error of least square treatment means.

[c,d] Treatment means within columns differ (P<.01).

[e,f] Treatment means within columns differ (P<.05).

[g,h] Treatment means within columns differ (P<.10).

[i] Linear period response (P<.05).

[j] Quadratic period response (P<.05).

TABLE IV. EFFECT OF WEANING AND BURNED PASTURE ON COW BODY WEIGHT

Item	Lactating		Weaned			Response (kg) to:[b]	
	Control	Burn	Control	Burn	SEM[a]	Wean	Burn
Trial 1-1985							
Initial weight, kg	414	409	416	430			
Weight gain, kg							
Day 24	35.0	35.6	41.0	48.8	2.61	9.6[c]	4.2[c]
Day 45	45.4	60.5	66.2	82.1	3.34	21.2[c]	15.5[c]
Day 64	62.1	76.2	82.4	107.7	3.99	25.8[c]	18.8[c]
Day 87	68.2[f]	75.0[fg]	88.7[gh]	114.5[i]	4.46	30.0[e]	16.4[e]
Trial 2-1986							
Initial weight, kg	447	452	452	449			
Weight gain, kg							
Day 14	16.7	27.6	23.6	30.8	3.02	5.0[d]	9.0[c]
Day 35	28.2	44.3	45.7	55.9	3.26	14.6[c]	13.2[c]
Day 56	42.8	62.0	64.3	82.0	3.57	20.7[c]	18.4[c]
Day 77	49.9	65.3	76.0	96.4	4.22	28.6[c]	17.9[c]
Day 98	69.2	76.5	99.3	107.6	5.10	30.6c	7.8

[a] SEM=largest standard error of least square treatment means.

[b] Additional weight gain attributed to main effects.

[c] Significant treatment response (P<.01).

[d] Significant treatment response (P<.10).

[e] Significant Wean X Burn interaction (P<.05).

[fghi] Treatment means within a row differ (P<.05).

rapidly than control forage resulting in rapid declines in CP (Woolfolk et al., 1975).

In year 1, soluble CP content varied by sampling date (table II). In year 2, soluble CP tended to be greater for control pastures through July 15. Soluble CP of control pastures declined (P<.05) linearly in year 1 and quadratically (P<.01) in year 2, while soluble CP of burned pasture decreased quadratically (P<.10) in both years.

Contribution of dead herbage in control pastures is reflected by a consistent trend for higher concentrations of NDF, ADF, and lignin (tables II and III). Although CP trends suggest that burned forage matured more rapidly, trends in forage fiber analyses do not.

Cow Performance. In year 1, dry cows gained 9.6 kg more (P<.01) body weight than lactating cows, through day 24 (table IV). Weight gain was also increased (P<.01) by burning, but by a smaller amount (4.2 kg). In year 2, cows grazing burned pastures gained an additional 9.0 kg of body weight (P<.01) during the first 14 d while dry cows gained only 5.0 kg (P<.10) more than their lactating counterparts.

Weaning further improved (P<.01) cow weight gain throughout the course of the grazing season in both years resulting in weaned cows that were 30.0 and 30.6 kg heavier than lactating cows in years 1 and 2, respectively (table IV). In contrast, the response to burning peaked by July 9 (77 d post burning) in year 1 and June 24 (71 d post burning) in year 2 (figure 1). In year 2, the peak response

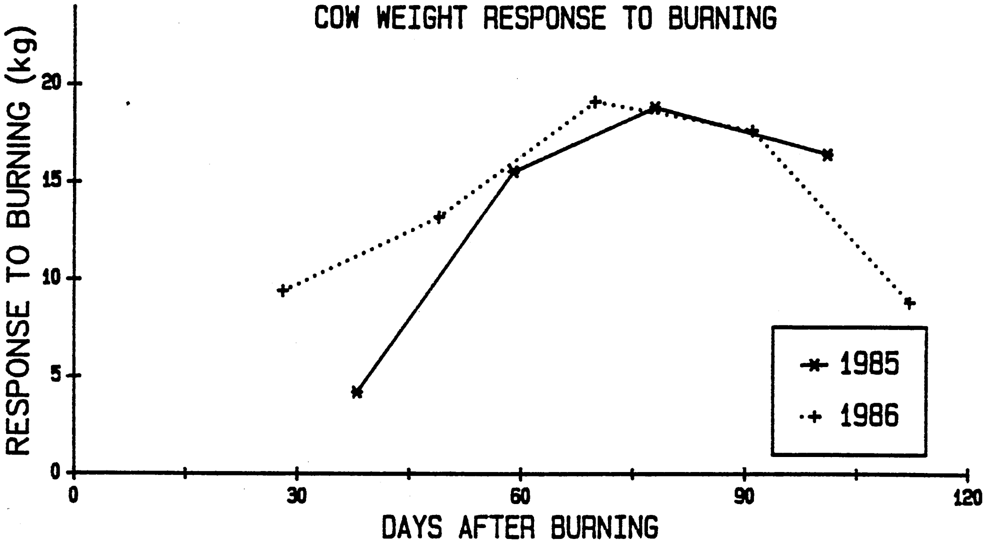

Figure 1. Seasonal Changes in Cow Weight Response to Pasture Burning

in cow weight gain to burning occurred earlier in the season, and declined slower than in year 1. During the last 23 d of the study in year 1, dry cows grazing burned pasture gained 6.8 kg while lactating cows grazing burned pasture lost 1.2 kg. This response resulted in a significant wean by burn interaction for cummulative gain through d 87. Although cows grazing burned pastures in year 2 gained less weight during the final 21 d than cows grazing control pastures, the burn by wean interaction was not observed.

Cow Body Condition. Both weaning and burning increased ($P<.01$) body condition gain in both years (table V). In year 1, the response of body condition to weaning (+.61 units) was greater than the response to burning (+.42 units). In contrast, burning increased ($P<.01$) body condition by .61 units compared to +.54 units for weaning in year 2. The response to burning appeared to peak on d 45 in year 1 and d 56 in year 2. The peak response to weaning, however, was observed later in the season (d 64 in year 1 and day 77 in year 2).

Lactating cows grazing control pastures achieved only marginal body condition (5.09 units in year 1, 5.30 units in year 2) by the end of the trial (table V). Poor nutritional quality of native grass in late summer (Waller et al., 1972) coupled with fetal nutrient demands may prevent thin, late-weaned cows from attaining adequate body condition (5.5 to 6.0 units) by calving in October. Early weaning increased the average body condition to acceptable levels (5.97 and in

TABLE V. EFFECT OF WEANING AND BURNED PASTURE ON COW BODY CONDITION

Item	Lactating		Weaned		SEM[a]	Response (kg) to:[b]	
	Control	Burn	Control	Burn		Wean	Burn
Trial 1-1985	units[c]						
Initial body condition	4.36	4.41	4.75	4.73			
Body condition change							
Day 24	-.08	.35	.38	.64	.112	.38[d]	.34[d]
Day 45	.31	.76	.91	1.41	.114	.62[d]	.48[d]
Day 64	.42	.56	1.05	1.45	.135	.76[d]	.27[e]
Day 87	.73	1.03	1.22	1.76	.138	.61[d]	.42[d]
Trial 2-1986							
Initial body condition	4.93	5.12	5.08	5.07			
Body condition change							
Day 14	.07	.13	.18	.38	.080	.18[e]	.13[f]
Day 35	.20	.68	.62	.88	.091	.31[d]	.37[d]
Day 56	.18	.92	.86	1.58	.111	.67[d]	.73[d]
Day 77	.30	1.10	1.04	1.75	.127	.70[d]	.76[d]
Day 98	.37	.90	.83	1.51	.134	.54[d]	.61[d]

[a] SEM=largest standard error of least square treatment means.

[b] Additional body condition attributed to main effects.

[c] Units=body condition units (1=emaciated, 9=obese).

[d] Significant treatment response (P<.01).

[e] Significant treatment response (P<.05).

[f] Significant treatment response (P<.10).

year 1, and 5.91 units in year 2). Alternatively, placing lactating cows on burned pastures also increased body condition (5.44 units in year 1, 6.02 units in year 2). Thus, late-weaned, fall-calving beef cows maintained on burned pastures are able to replete body energy stores and supply milk for use by late-weaned calves.

Milk Production. Milk production decreased linearly (P<.02) over the grazing season (table VI). This response is attributed to declining forage quality and prolonged lactation (Wagner et al., 1986). Daily milk production tended to be greater for cows maintained on burned pastures in year 1 (P<.25) and year 2 (P<.11). Apparently, burning improves nutrient supply to the extent that both weight gain and milk production are increased in late-lactation beef cows.

Calf Performance. In year 1, suckled calves gained 40.8 kg more weight (P<.01) than weaned calves by the end of the trial (table VII). Burning further improved (P<.01) total calf gain by 7.4 kg. These responses correspond to a 67% and 10% improvement in calf weight gain for suckling and burning, respectively. In year 2, greater responses (P<.01) to suckling and burning (74% and 27%, respectively) were noted through d 77. From July 15 to August 5, however, calves maintained on burned pastures lost weight resulting in a suckle * burn interaction (P<.05) for total weight change on d 98. Burned pasture tended to improve weight gain of weaned calves by 4 kg and further increase (P<.01)

TABLE VI. AVERAGE DAILY MILK PRODUCTION OF FALL-CALVING COWS GRAZING CONTROL AND BURNED PASTURES[a]

Item	Time Late Spring	 Early Summer	 Mid-Summer	Overall Mean	Prob.[b]
	--------------------kg/d	--------------------	--------------------	--------------------	
Year 1-1985					
Control[c]	8.1 ± .42	5.6 ± .34	2.5 ± .44	5.4 ± .20	.25
Burn[c]	8.4 ± .46	6.1 ± .36	2.6 ± .46	5.7 ± .21	.25
Year 2-1986					
Control[c]	6.0 ± .63	4.4 ± .49	3.4 ± .53	4.6 ± .30	.11
Burn[c]	7.1 ± .57	5.2 ± .46	3.5 ± .54	5.3 ± .27	.11

[a] Least square means ± standard error of the mean.

[b] Probability.

[c] Linear response ($P<.05$).

TABLE VII. EFFECT OF SUCKLING AND BURNED PASTURE ON CALF BODY WEIGHT

Item	Suckled		Weaned		SEM[a]	Response (kg) to:[b]	
	No Burn	Burn	No Burn	Burn		Suckle	Burn
Trial 1-1985							
Initial weight, kg	152	150	148	153			
Weight gain, kg							
Day 24	33.4	37.0	15.8	18.2	1.03	18.2[c]	.6[c]
Day 45	59.0	66.5	34.0	38.6	1.35	26.4[c]	6.0[c]
Day 64	79.4	84.6	47.5	51.6	1.85	32.3[c]	4.8[d]
Day 87	97.8	104.2	56.1	64.4	2.28	40.8[c]	7.4[c]
Trial 2-1986							
Initial weight, kg	165	173	178	165			
Weight gain, kg							
Day 14	15.3	20.0	.5	7.6	.97	13.6[c]	5.9[c]
Day 35	38.5	46.1	16.6	26.8	1.29	20.6[c]	8.9[c]
Day 56	56.6	68.2	26.8	43.8	4.78	27.1[c]	14.3[c]
Day 77	71.5	85.6	37.6	52.5	2.12	33.5[c]	14.5[c]
Day 98	90.3[g]	106.2[h]	48.0[f]	52.0[f]	2.49	48.2[e]	10.0e

[a] SEM=largest standard error of least square treatment means.

[b] Additional weight gain attributed to main effects.

[c] Significant treatment response (P<.01).

[d] Significant treatment response (P<.02).

[e] Significant suckle by burn interaction (P<.02).

[f,g,h] Treatment means within a row differ (P<.01).

gain of suckled calves by 6.4 kg. Suckling improved ($P<.01$) calf gain by 88% and 104% on control and burned pastures, respectively.

Discussion. Suckled calves gained an average of 99.6 kg (1.1 kg/d) during the course of the study. In contrast, weaned calves of the same age gained only 44.5 kg (.48 kg/d) during the same grazing period. Thus, lactational input for fall-born calves in early summer efficiently stimulates weight gain (Hancock et al., 1985). In addition, the benefits of late weaning are accrued with little added cost. Burning further increased calf gain by an average of 8.7 kg in both years. Improved forage quality from burning appears to benefit suckled calves as effectively as weaned calves.

The benefits of increased weight gain for late-weaned calves would be negated if late-weaned cows were unable to achieve adequate body condition to calve, lactate and rebreed normally. Indeed, late-weaned cows maintained on control pastures attained only marginal body condition scores in both years. Grazing late-weaned cows on burned pastures improved cow body condition (+.30 units in year 1, +.53 units in year 2). Thus, late-weaned, fall-calving beef cows maintained on burned forage should optimize calf weaning weight with minimal effects on cow performance.

CHAPTER IV

RESPONSE OF FALL-BORN, EARLY-WEANED BEEF CALVES TO RUMINAL DEGRADABLE VERSUS BYPASS PROTEIN SUPPLEMENTS OR SPRING BURNING OF NATIVE GRASS PASTURES

Abstract

The response of fall-born, early-weaned beef calves to protein supplementation (ruminally degradable and bypass) or prescribed spring pasture burning was evaluated for two consecutive years. Fall-born calves (155 kg) were weaned in mid- to late-April and assigned to one of four groups. Three groups of calves were placed on an unburned pasture and received soybean meal (SBM), corn gluten meal (CGM), or no supplement (control). The fourth group grazed an adjacent native grass pasture which was burned in April (Burn). Grazing was initiated May 6, 1985 and April 29, 1986 and continued for 87 d and 98 d in years 1 and 2, respectively. Both supplements were calculated to provide similar levels of total protein (190 g/d) in year 1. Year 2 supplements supplied similar quantities (100 g) of ruminal degradable protein (RDP), however, the SBM/CGM supplement offered 61 g of additional bypass protein. Supplemented calves gained more weight ($P<.01$) than control calves in both years. In year 1, calves fed SBM gained .09 kg/d more weight (P<.03) than calves fed CGM suggesting that RDP was inadequate in CGM supplements. In year 2, calves fed SBM/CGM gained more weight (P<.03) than calves fed SBM through d 14 although rates of gain were simliar for the remainder of the trial. Thus, RDP plus additional bypass protein may benefit newly weaned calves. Supplemented calves gained more weight (P<.01) than calves grazing burned pasture in year 1. In contrast, calves grazing burned pasture in year 2 gained more weight (P<.01) than supplemented calves through d 77 (July 15). Because of the low initial input cost for burning ($2.70/ha) compared to the feed cost for supplements, cost/kg of additional gain was lower for burning. These studies illustrate that lightweight calves grazing early summer native grass pastures respond to supplemental RDP. Prescribed spring burning, however, improves calf performance more economically than protein supplementation.

(Key words: Beef, Calves, Protein Supplement, Bypass, Pasture Burning, Native Grass)

Introduction

Fall-calving beef cows maintained on dormant native range frequently lose excessive quantities of body weight and condition throughout the winter. Early weaning (170 d) allows cows to regain adequate body condition prior to subsequent fall calving.

Crude protein content of native tallgrass species peaks in May at approximately 10% and declines rapidly (Waller et al., 1972). The protein requirement of a 140 kg calf to gain .7 kg/d is 13.2% (NRC., 1985). Thus, lightweight, early-weaned calves grazing native grass pastures are probably protein deficient. Small quantities (.5 kg) of protein-rich supplements stimulate forage digestibility, intake and calf weight gain in late summer (Lusby et al, 1982; Guthrie et al., 1984).

Ruminal microbial protein synthesis may not meet the protein requirements of a rapidly growing calf maintained on native grass pasture because of marginal forage fermentability (Smith et al., 1960; Woolfolk et al., 1975). Under these circumstances, protein sources that bypass ruminal fermentation may augment microbial protein supply to the duodenum and stimulate calf growth (Ørskov, 1982). Corn gluten meal increases amino acid flow to the small intestine (Koeln and Patterson, 1986) and improves growth rate of beef calves above soybean meal (Klopfenstein et al., 1978; Rock et al., 1983).

An alternative to supplementation is to improve forage quality by spring burning of native grass pastures. Burning removes dead, accummulated forage thereby improving forage quality, palatibility, and cattle performance (Smith et al., 1959; Smith et al., 1965; Anderson, 1970; Woolfolk et al., 1975). In addition, pasture burning offered a more reasonable return above fall and winter supplemental feed and labor costs on wiregrass rangeland.

Although both supplementation and burning should improve the performance of growing calves, the relative value of each practice is unknown. The objectives of this study were to evaluate: 1) the need for protein supplementation in early-summer, 2) compare burning to supplementation, and 3) evaluate ruminally degradable versus bypass protein sources for lightweight beef calves.

Materials and Methods

Year 1 (1985). Sixty fall-born, Limousin-sired calves from Angus x Hereford dams were weaned April 22 (average age 169 d) at the Southwest Livestock and Forage Laboratory near El Reno, Oklahoma. Calves were maintained on a weaning ration (table VIII) plus grass hay in drylot for 14 d. A 25 ha native grass pasture (primarily Schizachyrium scoparium and Andropogon gerardi) was burned April 12. The trial was initiated May 6, when regrowth of the burned pasture was 10 to 15 cm in height.

Calves were randomly assigned to four groups. Three groups were maintained on a 30 ha unburned pasture and received either no supplemental protein (control), soybean meal (SBM), or corn gluten meal (CGM) while the fourth group grazed the burned pasture. All groups were provided with a free choice mineral mix (50% trace mineralized salt and 50% dicalcium phosphate) and fresh water. All calves were weighed at three-week intervals following a 15-h shrink.

Calves grazing the unburned pasture were gathered in

TABLE IX. COMPOSITION OF CALF SUPPLEMENTS (YEAR 1-1985)

	Supplement Composition	
Item	SBM	CGM
Feed, % (DM basis)		
Soybean meal	98.56	---
Corn gluten meal	---	91.03
Molasses	---	4.04
Limestone	1.44	---
Dicalcium phosphate	---	4.93
Cost, ¢/kg[a]		
Feeding rate, g DM/d	410	320
Crude protein		
Total, g/d[b]	190	189
Ruminally degradable, g/d[c]	138	94
Bypass, g/d[c]	52	95

[a] Supplement costs assume 19.8¢/kg for soybean meal and 27.5¢/kg for corn gluten meal.

[b] Actual analysis.

[c] Estimated from NRC., 1985.

the morning 5 d/week, separated into .6 x 2.4 m feeding stalls, and fed individually. Supplements were formulated to provide 190 g of total protein/d (table IX). Soybean meal (SBM) and corn gluten meal (CGM) supplements were fed at 410 and 320 g DM/d. Soybean meal supplied 138 g ruminally degradable and 52 g bypass protein while CGM provided 94 g ruminally degradable and 95 g bypass protein (NRC, 1985).

Year 2 (1986). Fifty-six fall-born, Angus-sired calves from Angus x Hereford dams were weaned April 15 (average age 174 d) and maintained on a weaning ration (table VIII) plus grass hay in drylot for 2 weeks. The same pastures from year 1 were utilized in year 2. Both pastures were decreased in size for year 2 to provide a stocking rate of 1.3 AU/ha for 98 d. Burning was implemented April 6 and the trial was initiated when regrowth was 10 to 15 cm in height. All calves were allowed free access to fresh water and a mineral mix consisting of 50% trace mineralized salt, 45% dicalcium phosphate, and 5% potassium chloride. Calves received their weekly allowance of supplement 5 days/week. All calves were weighed at 2 to 4 week intervals following a 15-h shrink.

Results from year 1 (1985) suggested that ruminally degradable protein (RDP) was first-limiting in calf diets. Therefore, year 2 (1986) supplements were formulated to provide similar quantities of RDP, while the CGM supplement offered 61 g additional bypass protein (table X). Soybean

TABLE VIII. COMPOSITION OF WEANING RATION

Item	% (Dry matter basis)
Feed Composition	
Rolled corn	50.00
Rolled oats	15.00
Dehydrated alfalfa meal	5.00
Soybean meal	22.50
Molasses	3.00
Dicalcium phosphate	2.50
Limestone	1.00
Trace mineralized salt[a]	1.00
Vitamin A (30,000 IU/g)	.05
Deccox (6% decoquinate)	.09
Chemical composition[b]	
Crude protein	19.4
TDN	81.0
Calcium	.9
Phosphorus	1.1

[a] Trace mineralized salt contained 92.0% NaCl, .25% Mn, .20% Fe, .03% S, .033% Cu, .0025% Co, .007% I and .005% Zn.

[b] Estimated.

TABLE X. COMPOSITION OF CALF SUPPLEMENTS (TRIAL 2-1986)

Item	Supplement Composition (DM Basis) SBM	 CGM
Feed, % (DM Basis)		
Soybean Meal	89.03	17.71
Corn Gluten Meal	---	67.37
Alfalfa, Dehy	10.11	9.58
Molasses	---	4.06
Limestone	.24	---
Dicalcium Phosphate	---	.22
Sodium Sulfate	.86	.81
Cost, ¢/kg[a]		
Feeding Rate, g DM/d	395	444
Crude Protein		
Total, g/d[b]	175	243
Ruminally Degradable, g/d[c]	120	127
Bypass, g/d[c]	55	116
Total, %[b]	44.3	54.7
Bypass[c]	31.4	47.7
Bypass[d]	33.4	66.6

[a] Supplement costs assume 19.8¢/kg for soybean meal and 27.5¢/kg for corn gluten meal.

[b] Actual analysis.

[c] Estimated from NRC., 1985.

[d] Predicted from rate of crude protein digestion and particulate rate of passage.

meal and SBM/CGM were fed at daily rates of 395 g and 444 g, which supplied 175 g and 243 g of total protein, respectively. The soybean meal supplement provided 120 g ruminal degradable and 55 g of bypass protein, while SBM/CGM provided 127 g RDP and 116 g bypass protein (NRC, 1985).

Diet samples were collected on May 15, June 19, and July 24 from four mature heifers fitted with esophageal cannulae. Esophageal masticates were immediately placed on ice, transported to the lab, and stored at -15 C prior to initial drying in a forced-air oven at 40 C for 60 h. Dried masticate was allowed to air equilibrate and then ground through a Wiley Mill equipped with a 1-mm screen, composited within treatment, and stored at -15 C prior to laboratory analysis. Sample analyses included dry matter (DM), ash, crude protein, (CP; N x 6.25) by Kjeldahl (AOAC, 1975) and a sequential acid detergent fiber (ADF) and permanganate lignin (PL) procedure (Goering and Van Soest, 1970).

Supplement digestibility coefficients were estimated from in situ incubation of masticate on May 15, June 19, and July 24. Duplicate dacron bags (10 x 6 cm; pore size 25 to 75 µm) containing 1 g (as-is), ground (1-mm screen) supplement were placed in the rumen of a mature ruminally cannulated Hereford cow to represent 4, 12, 24, 36, 48, and 72 h of incubation. Immediately following removal from the rumen, all bags were washed with lukewarm water until effluent was clear. Bags containing supplement not subjected to ruminal incubation were washed in a similar manner. Each bag was then dried at 60 C for 72 h and weighed. Following drying, bag residues were subsampled and analyzed for organic matter and crude protein. Organic matter and crude protein disappearance were determined by difference. Solubility, potential digestibility, and rate of disappearance of crude protein (organic matter basis) were predicted from the model described by Mertens and Loften (1980). Crude protein bypass potential was averaged over the three periods and estimated from the equation: $1 - [a + (bc)/(c + k_d)]$ where a is the soluble fraction, b is potential digestbility, c is rate of disappearance, and k_d is the particulate passage rate constant (Ørskov and McDonald, 1979). The particulate passage rate constant was obtained from a companion trial (Chapter V).

Statistics. Data were analyzed by least squares procedures with calf age (covariate), calf sex, date, treatment and date * treatment interaction included in the model. Contrasts used to compare least squares treatment means for cummulative calf weight change were: 1) control vs supplementation, 2) SBM vs CGM, and 3) supplementation vs burning.

Results and Discussion

Forage Quality. Chemical composition (OM basis) of diet samples is reported for year 2 (table XI). Crude protein was initially higher ($P<.01$) in diets from the burned pasture but declined more rapidly than the unburned

TABLE XI. CHEMICAL COMPOSITION OF DIET SAMPLES FROM WEANED CALF PASTURES[a]

Component	Date May 15	 June 19	 July 24	SEM[b]
Crude protein, %				
Control[c]	13.6[e]	11.9[e]	9.6[e]	.14
Burn[d]	14.2[f]	10.9[f]	8.7[f]	.14
Acid detergent fiber, %				
Control[c]	48.0[e]	48.9[e]	48.9	.42
Burn[c]	45.4[f]	46.1[f]	48.1	.42
Permanganate lignin, %				
Control[d]	9.6[g]	11.6[e]	9.0	.35
Burn	8.5[h]	8.0[f]	9.2	.35

[a] Organic matter basis.

[b] SEM=standard error of least square treatment means.

[c] Linear period response ($P<.05$).

[d] Nonlinear period response ($P<.05$).

[e,f] Treatment means within columns differ ($P<.01$).

[g,h] Treatment means within columns differ ($P<.10$).

pasture. Consequently, CP content of unburned pasture diets was higher ($P<.01$) at the middle and end of the trial. Acid detergent fiber content increased ($P<.05$) linearly for both pasture treatments as the season progressed. Control diets were initially higher ($P<.01$) in ADF than burn diets. Similarly, lignin content was higher ($P<.06$) for control near the beginning of the trial. Lignin concentrations over time responded in a curvilinear fashion. Concentration of ADF and lignin were similar by the end of the trial.

Year 1 (1985). Calves receiving protein supplements gained more weight ($P<.05$) than calves grazing control pastures (table XII). Significant responses to supplemental protein were observed as early as d 24. Supplementation increased ($P<.01$) calf growth rate by .20 kg/d (31%) compared to control. Lusby et al. (1982) also reported a 31% improvement in steer gain with 143 g supplemental protein/d, although their cattle were older steers (263 kg) supplemented in late summer. Calves utilized both supplements efficiently, converting 1.7 (SBM) and 2.1 (CGM) kg feed into additional gain.

Calves receiving SBM supplement gained 3.7 kg more ($P<.01$) weight than calves fed CGM by d 24 (table XII). Supplementation responses continued to segregate as the trial progressed, so that SBM calves were 7.9 kg heavier ($P<.03$) than CGM calves by the end of the trial. Because SBM supplied 44 g/d more ruminally degradable protein (RDP), diets of CGM-fed calves may have been deficient in RDP.

TABLE XII. EFFECT OF PASTURE BURNING OR SUPPLEMENTATION ON PERFORMANCE OF WEANED CALVES (TRIAL 1-1985)

Item	Treatment				SEM[b]	Contrasts[a]		
	Control	SBM	CGM	Burn		1	2	3
Number	16	14	14	16				
Initial weight, kg	147	139	145	153	10.5			
Weight gain, kg								
Day 24	15.7	23.6	19.9	18.5	3.61	.01	.11	.11
Day 45	34.0	46.6	41.6	39.0	4.16	.01	.07	.03
Day 64	47.5	62.0	55.8	52.3	4.60	.01	.05	.02
Day 87	56.1	77.5	69.6	65.3	5.32	.01	.03	.01
Conversion[c]		1.7	2.1					
Cost[d]		16.5	27.7	7.5				

[a] Contrasts:

1=Control vs supplementation.

2=SBM vs CGM.

3=Burn vs supplementation.

[b] SEM=standard error of least squares treatment means.

[c] Conversion=kg supplement/kg additional gain.

[d] Cost=¢/kg additional gain.

Supplemented calves gained more weight ($P<.05$) than calves grazing burned pasture (table XII). Although burning may increase forage quality (table XI), ruminal protein supply may remain inadequate to maximize forage utilization.

Calves receiving protein supplements gained more weight ($P<.01$) than calves grazing burned pasture but supplementation resulted in higher cost/kg added gain (table XII). The advantage for burning is primarily due to the low initial input cost ($2.70/ha). In addition, labor costs for feeding supplements are not included in these figures.

Year 2 (1986). Supplemented calves gained more ($P<.01$) weight than control calves in year 2 (table XIII). Estimated supplemental crude protein bypass potentials reflect the difference in ruminal degradablility between supplemental protein sources (table X). During the first two weeks of the trial, calves fed SBM/CGM gained more ($P<.03$) weight than calves fed SBM supplements. The initial advantage (3.3 kg) for SBM/CGM supplemented calves was maintained ($P<.28$) throughout the trial. Thus, recently-weaned calves may benefit from additional bypass protein during adjustment to a medium-quality, forage-based diet. Once this transition is complete, supplemental RDP may be more important to assure microbial activity.

In contrast to year 1, calves maintained on burned pasture gained more weight ($P<.01$) than supplemented calves through d 77 (table XIII). From d 77 through 98 (July 15 to August 5), however, calves grazing burned pasture lost .56

TABLE XIII. EFFECT OF PASTURE BURNING OR SUPPLEMENTATION ON PERFORMANCE OF WEANED CALVES (TRIAL 2-1986)

	Treatment					Contrasts[a]		
Item	Control	SBM	SBM/CGM	Burn	SEM[b]	1	2	3
Number	13	15	15	13				
Initial weight, kg	177	158	160	166	5.8			
Weight gain, kg								
Day 14	-.1	.1	3.2	7.2	1.00	.14	.03	.01
Day 35	15.0	17.7	21.3	26.6	1.44	.02	.08	.01
Day 56	25.7	30.7	34.2	35.9	1.74	.01	.14	.10
Day 77	35.7	42.6	45.7	52.6	2.05	.01	.28	.01
Day 98	45.2	55.8	59.2	52.0	2.30	.01	.29	.05
Conversion[c]		3.8	2.2					
Cost[d]		34.7	37.8	10.3				

[a] Contrasts:

1=Control vs supplementation.

2=SBM vs SBM/CGM.

3=Burn vs supplementation.

[b] SEM=standard error of least square treatment means.

[c] Conversion=kg supplement/kg additional gain.

[d] Cost=¢/kg additional gain.

kg. Poor performance may be partially attributed to low rainfall (1.34 cm) from July 12 to August 4. Chemical composition of burn forage, however, does not account for decreased calf performance in year 2.

Supplements in year 2 were poorly converted into additional gain (table XIII). Daily gain of control calves was considerably less in year 2, while forage composition was similar by the end of both trials. Therefore, poor conversion of supplements in year 2 may be a reflection of breed type rather than forage quality. The cost of added gain averaged 36.0¢ for supplements. The cost of additional gain calculated for the entire 98 d trial (even though calves grazing burned pasture gained no weight the final three weeks) remained 25.8¢ cheaper for burning than supplementation.

Discussion. These studies suggest that lightweight calves maintained on lush spring and early summer native grass pastures are protein deficient. Low ruminal capacity limits the ability of young calves to meet their high nutrient requirements from forage consumption. Supplementation with RDP may stimulate microbial activity, increase forage intake, and hasten ruminal adaptation to forage diets.

Ruminal degradable protein appears to be more limiting than bypass protein for growing lightweight calves grazing native grass pastures in early-summer. Thus, supplementation programs for grazing calves should be developed to insure adequate RDP. Bypass protein may be useful in weaning diets when ruminal volume and feed intake are low. Once adaptation to forage diets has occurred, supplemental RDP may be more beneficial.

Both protein supplementation and burning significantly improved calf growth rates. Burning, however, is a more economically efficient management tool (Kirk et al., 1974). Low initial input costs are responsible for this response. Because calves grazing burned pasture in year 2 performed poorly from mid July to August 5, it may be advisable to implement a supplementation program in July when forage quality declines.

CHAPTER V

EFFECT OF PRESCRIBED SPRING BURNING ON FORAGE DIGESTIBILITY, RUMINAL FERMENTATION, FLUID AND PARTICULATE PASSAGE, AND INTAKE OF NONPREGNANT BEEF COWS GRAZING NATIVE GRASS PASTURE

Abstract

Eight ruminally cannulated, dry, nonpregnant beef cows were assigned to adjacent unburned (control) or burned native grass pastures to study the effect of spring pasture burning on forage utilization and ruminal environment. An additional cow grazed the control pasture and was utilized to evaluate differences in forage fermentability. Burning was performed on April 6, 1986 and sampling initiated on May 9, June 13, and July 18. Burned pasture was higher ($P<.01$) in crude protein in May but decreased below the control in June and July. Acid detergent fiber and lignin were higher ($P<.01$) for control pasture in May and June. Cows grazing burned pasture had lower ruminal pH, ammonia-N, and total VFA concentrations. Rate and extent of digestion tended to be greater for burn forage. Cows grazing burned pasture consumed more ($P<.01$) digestible organic matter. Fecal output and indigestible organic matter intake, however, tended to be greater for control cows. Ruminal fluid and particulate dilution rates (%/h) were faster for cows grazing control pasture. Burned forage decreased ruminal fluid volume and particulate dry matter fill. Cows grazing control forage adapted to low forage quality by increasing ruminal fill, passage rate, and fecal output. Decreased digestion rate of control forage limited the adaptability of cows grazing unburned forage. This study suggests that increased performance of cattle grazing burned native range is primarily attributable to increased rate of forage digestion.

(Key words: Intake, Passage Rate, Fermentation, Burned Pasture, Free Grazing, Beef Cattle)

Introduction

Fire is a management tool utilized for range improvement (Sampson, 1923). Burning improves digestibility and crude protein content of native grass pastures (Smith, 1960; McMurphy et al., 1965; Woolfolk et al.,, 1975).

Unburned pasture contains both dormant and live green forage, while, the regrowth of burned pastures is primarily live green forage (Ehrenreich, 1959; Towne and Owensby, 1984). Burning reduces the selectivity required for grazing which further enhances the palatability of higher quality burned pastures. Consequently, pasture burning improves cattle performance (Anderson et al., 1970; Woolfolk et al., 1975; Scott et al., 1986; Sprott et al., 1986). Improved performance of cattle grazing burned pastures is probably related to forage utilization. Smith et al. (1960) reported higher apparent dry matter digestibilities for burned pasture, however, dry matter intake was not changed. In contrast, burned pastures increased digestible energy intake of steers (Rao et al., 1973). If burning does not increase voluntary intake then performance responses must be the result of substantial increases in rate, extent, or efficiency of ruminal fermentation. The objectives of this study were to evaluate fermentation parameters, digesta dynamics, and voluntary intake of dry, nonpregnant beef cows grazing unburned and burned native grass pastures in early summer.

Materials and Methods

The study was undertaken at the Southwest Forage and Livestock Research Laboratory located at El Reno, Oklahoma. Native grass pastures were dominated by little bluestem, (Schizachyrium scoparium) with smaller quantities of big bluestem (Andropogon gerardi), switchgrass (Panicum virgatum), and indiangrass (Sorghastrum nutans). Burning was implemented April 6, 1986 and grazing initiated on April 29 when burned pasture regrowth was 10 to 15 cm in height.

Four mature, nonpregnant Hereford cows (average weight, 464 kg) and four mature Angus x Hereford heifers (average weight, 420 kg) fitted with ruminal cannulae were blocked by breed and weight and assigned to an unburned (control) or burned native grass pasture. An additional nonpregnant, Hereford cow (420 kg) grazed the control pasture and was utilized to estimate burning effects on rate of digestion. Both pastures were stocked with 150-kg calves at 1.3 AU/kg during the study. Cattle were maintained on the pastures from May through August 6. All cattle were allowed free access to a mineral mix composed of 50% trace mineralized salt, 45% dicalcium phosphate, and 5% potassium chloride.

Three trials were conducted at intervals reflecting the transient decline of forage quality in early summer: May 9-18 (Period 1), June 13 to 22 (Period 2), and July 18 to 27 (Period 3). Ten-day experimental periods consisted of diet sampling on d 1 and 7, 6-d Yb dosing (d 2 to 7), 2-d fecal sampling (d 7 to 8); 5-d in situ (d 6 to 10); and 3-d ruminal sampling (d 8 to 10).

Initial cow weights were obtained on April 29. Subsequent body weight gain for each period was extrapolated from a companion trial which utilized dry, barren Angus x Hereford cows maintained on adjacent control and burned pastures (Chapter III).

Ytterbium-labeled prairie hay was prepared by immersion (Teeter et al., 1984) and introduced ruminally on a daily basis to predict fecal output. In period 1, each cow received 100 g Yb-hay (358 mg Yb/d) at 0900 on d 2 to 4 and 50 g at 0900 and 2100 on days 5 to 7. Periods 2 (662 mg Yb/d) and 3 (668 mg Yb/d) utilized 200 g Yb-hay in an identical dosing regime.

Fecal grab samples (450 g, as-is) were obtained on d 7 (0100, 0900, and 2100) and d 8 (0500, 1300, and 1700), composited by animal, frozen (-20 C), and initially dried at 55 C for 48 h in a forced-air oven. Following air equilibration, samples were ground through a Wiley Mill equipped with a 1-mm screen, and stored at -20 C. Air-dry fecal composites (2 g) were dried at 100 C for 24 h and ashed (500 C, 8 h). Ash residues were digested in 20 ml of 3 N HNO_3:3 N HCl for 24 h and diluted to 25 ml with digestion mix and .5 ml KCl solution (9.54 g KCl/100 ml). Fecal samples obtained on d 1 (representing 0 h Yb) were composited by treatment and period, and processed in a similar manner as fecal composite samples. Ytterbium doses were diluted with 0 h fecal matrix containing 1,000 ppm K. Fecal output was calculated as g Yb dose divided by fecal Yb concentration.

Four mature esophageally-cannulated heifers were utilized to collect esophageal extrusa samples on d 1 of each study period. Individual extrusa samples were composited (~8.2 kg/pasture) within pasture treatment. Aliquots (1000 g/each) were removed for in situ digestion. The remaining masticate was washed three times with tap water and immersed for 24 h in a solution containing 70 g $DyCl_3$:6 H_2O. After immersion, masticate was washed three times to remove unbound Dy. Labeled forage was divided into 5 portions; 4 portions were ruminally dosed for particulate phase markers while the remaining portion was stored (-20 C) for Dy analysis. Dy-labeled masticate was refrigerated (6 C) until intraruminal dosing on d 7. Individual pulse doses contained 4.0, 2.6, and 3.0 g Dy in 1010, 912, and 949 g DM of control masticate and 2.5, 2.5, and 2.3 g Dy in 877, 1010, and 916 g DM of burn masticate for periods 1, 2, and 3, respectively.

On d 8, samples of whole ruminal digesta (500 ml each) were withdrawn from four intraruminal locations in each cow and thoroughly mixed. A 500-ml subsample was removed to represent 0 h Dy. Dysprosium-labeled masticate was then placed in each of the four ruminal locations. Timed whole ruminal samples (500 ml) were obtained at 12, 24, 36, and 48 h postdosing, frozen at -20 C, dried in a forced-air oven at 100 C for 60 h, and ground through a Wiley Mill equipped with a 2-mm screen.

Dysprosium concentrations were determined by EDTA extraction (Hart and Polan, 1984) and atomic absorption spectrophotometry. Zero-h samples were composited within treatment to provide the matrix for Dy standards. Particulate passage rate constants were estimated from regression of the natural logarithm of Dy concentration over time. Ruminal particulate volume was predicted by dividing the Dy dose by the extrapolated concentration at 0 h. Ruminal fill (g DM) was adjusted for body weight.

To evaluate the effect of burning on forage digestion rate, masticate (1000 g from d 1) was dried at in a forced-air oven (40.5 C) and ground through a Wiley mill equipped with a 1-mm screen. Drying time was reduced to 12 h by thinly spreading masticate to increase the surface area available for drying. Duplicate dacron bags (10 x 6 cm; pore size 25 to 75 μm) containing 1 ± .0050 g (as-is) ground masticate were suspended in the rumen of the extra Hereford cow maintained on the control pasture on d 6 (2100). Bags were added to represent incubation times of 4, 12, 24, 36, 48, and 72 h. All bags were removed from the rumen at 2100 on d 9 and washed with lukewarm water until effluent was clear. Bags containing masticate not subjected to ruminal incubation were washed in a similar manner.

Bags were dried at 60 C for 72 h and reweighed. Subsamples were either ashed (500 C, 8 h) or subjected to Kjeldahl analysis (AOAC, 1975). Solubility, potential digestibility, rate of disappearance of organic matter (OM) and CP were predicted from the model described by Mertens and Loften (1980). Digestibility coefficients from each period for OM and CP were then estimated from the equation: $a + [(bc)/(c + k_d)]$ where a is the soluble component, b is potential digestibility, c is rate of disappearance, and k_d is the particulate passage rate constant (Ørskov and McDonald, 1979).

Immediately after Dy dosing on d 7, Co·EDTA (Uden et al. 1980) was administered (Period 1: 1.1 g Co in 100 ml; Periods 2 and 3: 1.4 g Co in 200 ml). Timed ruminal samples (500 ml) were obtained from the ventral sac anterior to the ventral coronary groove at 4, 8, 12, 24, 28, 32, 36, and 48 h postdosing. Ruminal pH was measured immediately on whole fluid which was then strained through four layers of cheesecloth. A 250-ml aliquot was acidified (1 ml 20% H_2SO_4/50 ml ruminal fluid) and frozen (-15 C).

Ruminal fluid samples were thawed overnight at room temperature and two 40-ml subsamples centrifuged at 1000 x g for 15 min. A 20-ml portion of supernatant was analyzed for ammonia (Broderick and Kang, 1980) and cobalt by atomic absorption spectrophotometry using a nitrous oxide-acetylene flame. Fluid dilution rate (FDR, %/h) constants were estimated by regressing the natural logarithm of Co concentration over time. Ruminal fluid volume (RFV) was estimated from dividing the dose by the extrapolated Co concentration at zero hour. The remaining supernatant was decanted and composited over time (20 ml/time) for each cow. Two ml of 25% (w/v) metaphosphoric acid were added to 10 ml of the composite and centrifuged at 25,000 x g for 20 min. A 1-ml aliquot was withdrawn and .200 ml 2-ethylbutyric acid (internal standard) added. Volatile fatty acid (VFA) analysis was performed by gas chromatography.

To compare pasture effects on ruminal environment, cotton string (.5 g, as-is), was placed in nylon bags and ruminally incubated for 24, 36, 48, 60, 72, and 84 h. Cotton residue was removed from the bags, washed until effluent was clear, dried at 100 C for 48 h, and weighed. Dry matter disappearance was calculated by difference and rate of cellulose digestion estimated from the slope of cotton disappearance over time. Plots indicated that 72 and 84 h samples contained substantial quantities of ruminal contamination and were therefore deleted from the data analysis.

Diet samples were obtained twice on d 7 of each period at 1000 and 1500 and immediately frozen (-20 C) to prevent microbial fermentation. Frozen masticate was thawed at room temperature (24 C), dried at 40.5 C for 30 h in a forced-air oven, air equilibrated, ground through a 1-mm screen, and stored at 24 C. Sample analyses included dry matter (DM), ash, crude protein (CP; N x 6.25) by Kjeldahl (AOAC, 1975); NaCl-soluble protein (Waldo and Goering, 1979), neutral detergent fiber (NDF), and a sequential acid detergent fiber (ADF) and permanganate lignin (PL) procedure (Goering and Van Soest, 1970). Concentrations of hemicellulose (NDF minus ADF) and cellulose (ADF minus PL minus ADF-ash) were calculated by difference.

Ruminal data were analyzed by least squares procedures with period, treatment, cow nested within treatment, and period by treatment interaction included in the model. The model used to evaluate diet parameters included replicate, treatment, period, and period by treatment interaction. Treatment differences were evaluated by F-test. When the period by treatment interaction was deemed non-significant (P>.05), overall treatment means were calculated. Forage and ruminal paramters were regressed against period for linear and nonlinear trends over time. A cow from the control treatment was deleted from the ruminal particulate analysis for aberrant particulate dilution rates.

Results and Discussion

Forage Quality. Crude protein content of control pastures decreased linearly ($P<.01$) during the course of the trial (table XIV). Crude protein content of burned pasture was initially higher ($P<.01$) than the control pasture, but declined more rapidly (nonlinear, $P<.01$). Consequently, the protein content of burned pasture was lower ($P<.01$) than the control pasture in periods 2 and 3. Soluble CP (OM basis) decreased linearly ($P<.01$) throughout the study. Although differences were small, soluble CP was consistently higher in control diets. Increased protein content of burned pasture in period 1 may be due to increased photosynthetic rate and uptake of carbohydrate reserves caused by soil warming. Increased photosynthetic rate in the early season would deplete available soil nutrients more rapidly in burned pastures and thus, slow photosynthetic rate as the season progressed.

As CP content of both pastures decreased during the trial, corresponding acid detergent fiber (ADF) concentrations increased ($P<.05$) linearly (table XIV). Although NDF and ADF content of the control pasture was consistently higher, ADF concentration in burned pasture increased more rapidly so that little difference was observed by period 3. The lignin content of grasses should

TABLE XIV. CHEMICAL COMPOSITION OF DIET SAMPLES FROM CONTROL AND BURNED PASTURES[a]

Component	Period			SEM[b]
	1	2	3	
Crude protein, %				
Control[c]	13.6[e]	11.9[e]	9.6[e]	.14
Burn[d]	14.2[f]	10.9[f]	8.7[f]	.14
Soluble protein, %				
Control	2.1	2.0	1.6	.15
Burn	1.9	1.8	1.5	.15
Neutral detergent fiber, %				
Control[d]	86.1	82.8	86.8[g]	.48
Burn[d]	85.5	82.4	84.5[h]	.48
Acid detergent fiber, %				
Control[c]	48.0[e]	48.9[e]	48.9	.42
Burn[c]	45.4[f]	46.1[f]	48.1	.42
Permanganate lignin, %				
Control[d]	9.6[i]	11.6[e]	9.0	.35
Burn	8.5[j]	8.0[f]	9.2	.35

[a] Organic matter basis.

[b] SEM=standard error of the mean.

[c] Linear period response (P<.05).

[d] Nonlinear period response (P<.05).

[e,f] Treatment means within columns differ (P<.01).

[g,h] Treatment means within columns differ (P<.05).

[i,j] Treatment means within columns differ (P<.10).

increase as plants mature (Van Soest, 1982). Although variable, the lignin content of burned pasture tended to increase during the season. The lignin content of control pastures, however, tended to decline which may reflect decreased contribution of standing, dead forage to the total diet. Rapidly decreased protein content coupled with increased rate of ADF accumulation suggests that burned forage may grow faster and thus, mature more rapidly than unburned forage. Consequently, the major nutritional advantage for pasture burning probably occurs in early summer (Anderson et al., 1970).

Digestibility and Intake. Forage organic matter digestibility, obtained from in situ incubation, decreased for both pastures as the season progressed (table XV). Decreased protein and increased fiber concentrations are responsible for decreased digestibility of maturing forage (Van Soest, 1982). Organic matter digestibility of burned forage was consistently higher than control forage. Lower lignin content (table XIV) may be responsible for increased OM digestibility of burned forage in periods 1 and 2.

Forage organic matter intake was highest in period 1 when forage quality and digestibility were high and declined as the season progressed (table XV). Cows grazing burned pasture consumed more forage organic matter at all sampling dates. In addition, cows maintained on burned forage consumed more (P<.01) digestible organic matter throughout the study. This response represents an 18 to 30% increase

TABLE XV. FORAGE ORGANIC MATTER DIGESTIBILITY AND INTAKE OF NONPREGNANT BEEF COWS GRAZING CONTROL AND BURNED PASTURES[a]

Item	Period		
	1	2	3
Digestibility	%		
Control	51.8 ± .85	44.2 ± .85[b]	45.4 ± .85
Burn	58.0 ± .85	53.8 ± .85[c]	52.7 ± .85
Intake	g/kg body weight		
Organic matter			
Control[d]	21.4 ± .62	17.7 ± .62[b]	16.2 ± .62
Burn[e]	22.5 ± .62	18.7 ± .62[c]	18.0 ± .76
Digestible organic matter			
Control[e]	11.1 ± .32[f]	7.8 ± .32[f]	7.3 ± .32[f]
Burn[e]	13.1 ± .32[g]	10.0 ± .32[g]	9.5 ± .39[g]
Indigestible organic matter[h]			
Control[d]	10.3 ± .30[b]	9.9 ± .30[i]	8.8 ± .30
Burn[d]	9.4 ± .30[c]	8.6 ± .30[j]	8.5 ± .37

[a] Least square mean ± standard error of the mean.

[b,c] Treatment means within columns differ (P<.10).

[d] Linear period response (P<.05).

[e] Nonlinear period response (P<.05).

[f,g] Treatment means within columns differ (P<.01).

[h] Indigestible organic matter intake = fecal organic matter output.

[i,j] Treatment means within columns differ (P<.05).

in energy intake which explains increased performance of cattle grazing burned pastures (Anderson et al., 1970; Woolfolk et al., 1975; Scott et al., 1986).

Indigestible organic matter intake and fecal output tended to be higher for cows grazing control pastures at all sampling dates (table XV). Cows grazing control pasture may have attempted to consume more forage to compensate for low forage quality. Decreased organic matter digestibility may have increased bulk fill to the extent that physical factors limited intake of cows grazing control pastures (Campling, 1970; Freer, 1981).

Forage Fermentability. Rate of forage OM digestion decreased throughout the study (table XVI). In addition, digestion rates were .9 to 1.1 percentage units higher for burned forage on all sampling dates. Potentially degradable OM tended to increase for control pastures but decreased for burned forage as the season progressed (table XVI). The proportion of degradable OM would be expected to decline with forage maturation as illustrated with burned forage. Increased degradable OM in control forage may be attributable to a decreased proportion of standing, dead forage in the diet as current year's growth extended above the canopy of, dead forage.

Ruminal Environment. Concentrations of ruminal ammonia were higher ($P<.01$) in cattle grazing control forage in each period (table XVI). Higher soluble protein content of control forage (table XIV) may be responsible. Increased

TABLE XVI. RUMINAL FERMENTATION PARAMETERS OF NONPREGNANT BEEF COWS GRAZING CONTROL OR BURNED PASTURES

Item	Period 1	Period 2	Period 3	SEM[a]	Overall Mean	SEM[a]
Organic matter						
Rate of digestion, %/h						
Control	6.4[b]	6.1[b]	5.4[d]	.06	6.0	.05
Burn	7.3[c]	7.1[c]	6.5[e]	.06	7.0	.05
Potential degradability, %						
Control	55.6	56.8	62.4	2.25	58.2	1.84
Burn	67.4	66.5	65.6	2.25	66.5	1.84
Cellulose disappearance, %/h						
Control	1.68	1.72	1.77	.15	1.72	.089
Burn	1.49	1.71	1.58	.15	1.59	.089
Ruminal ammonia, mg/dl[f]						
Control[g]	8.4[h]	4.4[h]	2.0[h]	.22		
Burn[g]	5.8[i]	2.8[i]	1.0[i]	.22		
Ruminal pH						
Control[g]	6.32	6.25[b]	6.39[b]	.025	6.32[c]	.014
Burn[g]	6.28	6.18[c]	6.32[c]	.025	6.26[d]	.014

[a] SEM=standard error of least square means.

[b,c] Treatment means within columns differ (P<.10).

[d,e] Treatment means within columns differ (P<.05).

[f] Period * treatment interaction (P<.01).

[g] Nonlinear period response (P<.05).

[h,i] Treatment means within columns differ (P<.01).

ruminal ammonia concentrations in control cows suggest that physical factors such as lignification limited the digestion of control forage rather than a ruminal ammonia deficiency. Lower ruminal ammonia concentrations for cows grazing burned pasture may be the result of increased microbial growth and faster incorporation of ammonia into bacterial protein (Adams and Kartchner, 1984). Alternately, increased mastication and rumination of control forage probably increased salivary flow which could increase the ruminal ammonia pool.

There was no significant effect of advancing season or pasture on rate of cellulose digestion estimated from in situ cotton string disappearance (table XVI). Rate of cellulose digestion, however, was consistently higher for cows grazing control pasture. Increased ruminal ammonia concentrations in control cows may have stimulated cotton string fermentation.

Ruminal pH tended to be lower for cows grazing burned pastures (table XVI). Increased fermentability of burned forage may have decreased ruminal pH due to increased production of volatile fatty acids. Perhaps more importantly, increased salivation due to consumption of lower quality control forage may have increased ruminal pH.

Total VFA concentrations decreased linearly ($P<.05$) during the study (table XVII). In addition, the molar proportion of acetate increased ($P<.05$) while propionate tended to decrease. These trends typify VFA characteristics

TABLE XVII. RUMINAL VOLATILE FATTY ACIDS OF NONPREGNANT BEEF COWS GRAZING CONTROL OR BURNED PASTURES

Item	Period 1	Period 2	Period 3	SEM[a]	Overall Mean	SEM[a]
Total VFA, mmol/ml						
Control[b]	78.2	72.7	59.8[e]	2.79	70.2	1.61
Burn[b]	79.3	71.1	68.7[f]	2.79	73.0	1.61
Acetate, mol/100 mol						
Control[b]	77.4	78.7	79.6	.48	78.6	.28
Burn[b]	76.2	78.4	79.3	.48	77.9	.28
Propionate, mol/100 mol						
Control	13.8	13.4	12.4	.36	13.2	.21
Burn[b]	13.8	13.0	12.2	.36	13.0	.21
Butyrate, mol/100 mol						
Control	7.5[c]	7.9	8.3	.31	7.9[c]	.18
Burn[b]	8.9[d]	8.6	8.5	.31	8.7[d]	.18

[a] SEM=standard error of least square means.

[b] Linear period response (P<.05).

[c,d] Treatment means within columns differ (P<.01).

[e,f] Treatment means within columns differ (P<.05).

as forages mature (McCollum et al., 1985; Adams et al., 1987). Total VFA concentrations were higher (P<.05) for burned forage in period 3, only. Molar proportions of VFA were not affected by forage source except in period 1 where butyrate was higher (P<.01) for cows grazing burned forage.

Passage Rates. Particulate passage rate decreased for control (P<.20) and burn (P<.02) forages as the season progressed (table XVIII). As forages mature, the ratio of leaf to stem decreases (Van Soest, 1982). Increased quantities of stem in the diet should extend the amount of time required to reduce forage particles to a size small enough to exit the rumen (Laredo and Minson, 1973). Poppi (1980) concluded that ruminal retention time will increase due to lower NDF digestion and decreased intake. Although nonsignificant, particulate retention time tended to increase during our study. Ruminal dry matter fill tended to decrease as the season progressed, especially for burn forage (P<.02). Because of the spatial characteristics of stems, more mature forages containing a larger proportion of stem should decrease dry matter fill (Van Soest, 1982). Decreased ruminal fill and passage rate coupled with increased retention time should decrease forage intake, a trend discussed previously (table XVIII).

Particulate passage rate tended to be higher for control forage at all sampling times (table XVIII). In addition, retention time tended to be shorter and dry matter fill higher for control forage. These relationships suggest

TABLE XVIII. RUMINAL PARTICULATE PARAMETERS OF NONPREGNANT BEEF COWS GRAZING CONTROL AND BURNED PASTURES

Item	Period 1	Period 2	Period 3	SEM[a]	Overall Mean	SEM[a]
Dilution rate, %/h						
Control	5.5	4.4	4.7	.50	4.9	.29
Burn	4.5	4.1	4.2	.43	4.3	.25
Passage rate, g DM/h						
Control	316.5[h]	273.7	278.8[d]	16.68	289.6[d]	9.63
Burn[b]	270.1[i]	260.6	197.3[e]	14.44	242.7[e]	8.34
Retention time, h						
Control	18.7	23.8	21.4[h]	2.83	21.3	1.63
Burn	22.2	24.6	25.2[i]	2.45	24.0	1.41
Volume, g DM						
Control	5,930	6,518	5,874	522	6,108	302
Burn	6,007	6,407	4,908	452	5,774	261
Fill, g DM/kg body weight						
Control	13.0	13.5	11.4	1.08	12.6	.62
Burn[b]	12.7	12.6	9.2	.93	11.5	.54
Fill, g indigestible DM/kg body weight						
Control	5.5	7.0	6.3[f]	.52	6.3[f]	.30
Burn[c]	5.2	6.0	4.8[g]	.45	5.3[g]	.26

[a] SEM=standard error of least square means.

[b] Linear period response (P<.05).

[c] Nonlinear period response (P<.05).

[d,e] Treatment means within columns differ (P<.01).

[f,g] Treatment means within columns differ (P<.05).

[h,i] Treatment means within columns differ (P<.10).

that cows grazing control forage attempted to increase forage intake to compensate for inadequate energy intake (Weston, 1984). In so doing, control cows increased particulate passage rate, dry matter fill and fecal output. In spite of these adaptive changes, control cows were unable to achieve a level of energy intake comparable to cows grazing burn pasture (table XV).

Ruminal fluid dilution rate (%/h) decreased linearly ($P<.05$) as the season progressed (table XIX). Fluid dilution rate appears to decline as forages mature (McCollum and Galyean, 1985; Adams et al., 1987). Fluid passage rate (liters/h), however, tended to increase in response to increased ruminal fluid volume (linear, $P<.08$). Ruminal fluid volume increased approximately two-fold from period 1 to periods 2 and 3. Adams et al. (1987) also observed increased ruminal fluid volume as forage matured.

Cows grazing control pasture tended to have increased ruminal fluid dilution rate and fluid volume at all sampling dates (table XIX). Increased proportion of dead, standing forage in the control pasture may have increased initial mastication and rumination time and consequently, increased salivary flow. Therefore, increased ruminal size in control cows due to adaptive changes in ruminal fill, may explain higher ruminal liquid volume.

Discussion. Voluntary intake decreased in response to declining rate and extent of forage digestion as the season progressed. This response explains decreased performance of

TABLE XIX. RUMINAL FLUID PARAMETERS OF NONPREGNANT BEEF COWS GRAZING CONTROL AND BURNED PASTURES

	Period				Overall	
Item	1	2	3	SEM[a]	Mean	SEM[a]
Dilution rate, %/h						
Control[b]	13.0	11.4	10.3	.74	11.6	.43
Burn[b]	12.8	11.0	9.4	.74	11.1	.43
Passage rate, liters/h						
Control	8.2	11.8[f]	11.0[d]	.82	10.4[d]	.48
Burn	8.0	9.5[g]	8.3[e]	.82	8.6[e]	.48
Turnover time, h						
Control[b]	7.7	8.8	9.9	.77	8.8	.44
Burn[b]	7.9	9.4	11.2	.77	9.5	.44
Volume, liters						
Control[b]	62.6	103.1	106.0	8.28	90.6	4.78
Burn[b]	62.5	89.0	90.7	8.28	80.7	4.78
Volume, liters/kg body weight						
Control[c]	.13	.21	.20	.016	.86	.01
Burn	.13	.17	.17	.016	.75	.01

[a] SEM=standard error of least square means.

[b] Linear period response ($P<.05$).

[c] Nonlinear period response ($P<.05$).

[d,e] Means within columns differ ($P<.05$).

[f,g] Means within columns differ ($P<.10$).

cattle grazing native pastures from spring through summer (Scott, 1988). Low ruminal ammonia concentrations and molar proportions of propionate may justify supplemental protein in order to improve forage utilization and cattle performance (Judkins et al., 1987).

Cattle grazing burned native grass pastures have access to improved quality forage as evidenced by increased performance (Anderson et al., 1970; Woolfolk et al., 1975)). Differences in the chemical composition of burned and control forages are small, however, and do not account for improved performance. In addition, crude protein content of burned forage fell below control forage after mid-June.

Thus, the major response to burning appears to be increased rate of digestion (table XVI). Increased digestion rate allowed cows grazing burned forage to increase forage intake without large changes in passage rate. In contrast, slower digestion rate for control forage forced cows to increase passage rate and fecal output in an attempt to increase forage intake. Physical or structural barriers associated with control forage, however, limited the adaptive response of control cows.

Although cows grazing burned forage consumed more forage organic matter, passage rate and fecal output remained lower than control cows. Thus, cows on burned pastures may have been capable of higher forage intake. In our study, burned forage may have satisfied the energy requirements of mature, nonpregnant beef cows. Younger or higher-producing cattle may better utilize burned pasture.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Fall-calving beef cows must attain adequate body condition during the summer or poor calving, lactation, and rebreeding performance will result. Similar to Hancock et al. (1985), our studies verify that weaning weight can be increased approximately 50 kg by delayed weaning (9 month of age). Producers may be leary of implementing a 'delayed weaning' program because of poor cow reconditioning associated with prolonged lactation, however, cows may continue lactating if forage quantity is not limiting (Hancock et al., 1985). Our studies support 'delayed weaning' and further indicate that thin cows rapidly increase body condition in May and June when maintained on burned pasture, even while lactating. Furthermore, daily gain of suckling calves is also improved by pasture burning. Thus, prescribed spring burning appears to be a management practice that rapidly improves cow body weight and condition. When pasture burning is combined with delayed weaning, both cow and calf performance is optimized with little additional economic input. Therefore, if cow body condition is not too low in April (≤4.0) and pasture quantity is not limiting, then a combination of delayed weaning and pasture burning can be a very effective management practice. It is interesting to note that suckling calves were considerably fat at the end of the trial. Thus, they would be docked on the market. An earlier weaning date of July 1, should find the calves with a more marketable composition of gain. In addition, earlier weaning (July 1 rather than Ausust 1) would be near the peak response in cow weight gain to pasture burning (figure 1).

Pasture burning is not a foolproof management tool. Burning decreases soil moisture (Anderson, 1965) and the leaf:stem ratio (Kucera and Ehrenreich, 1962). If little rainfall occurs after the burn, forage production and quality will be reduced. Thus, it may be risky to burn the entire acreage. Our studies indicate that the advantage to burning declines around late-June to mid-July (75 d after burning). Therefore, stockpiled unburned pasture would complement the grazed burned pasture for late-summer grazing. It may also be advantageous to intensively stock burned pasture for two months following the burn, this should increase gain per acre and return over operating costs (Bernardo and McCollum, 1987).

Weaned calves receiving protein supplement gained more weight than controls and calves grazing burned pasture in year 1. In contrast, burning increased daily gain above supplementation for 77 d in year 2. After d 77, burned pasture supplied only enough nutrients for maintenance. Pasture burning provided the least expensive cost per kg of additional gain due to low initial input costs and effectively increased economic efficiency of gain. In addition, labor costs for feeding supplements were not included. Therefore, spring pasture burning should be recommended for lightweight stocker cattle grazing native pastures during late-spring and early-summer rather than protein supplementation. The poor performance exhibited in July by both cows and calves grazing burned pasture may justify a protein supplementation program for burned pastures. Research is needed to evaluate the growth response of calves receiving protein supplements on burned pasture.

Supplementation studies in year 1 indicated that ruminally degradable protein (RDP) is deficient for lightweight calves maintained on early summer native grass pasture. Once RDP requirements are met, then growing calves should benefit from additional ruminal bypass protein. In year 2, daily gain increased the first two weeks of the trial when RDP and additional bypass protein were fed. Daily gain for RDP versus RDP + bypass protein, however, was similar for the remainder of the trial. Apparently the growth rate of these calves was not limited by the quantity of protein reaching the small intestine. Additional research is needed to evaluate the primary nutrient deficiencies of lightweight cattle grazing native grass in early summer.

Increased performance of cattle grazing burned pastures appears to result from increased digestible organic matter intake due to a more rapid rate of forage digestion. In addition, burning increased total VFA by the end of the summer and decreased ruminal ammonia. Lower ruminal ammonia results from faster incorporation of ruminal ammonia-N into bacterial CP (Adams and Kartchner, 1984). Greater intake has been associated with faster fluid and particulate passage rates, however, cows grazing control pasture had lower forage intake and faster passage rates. This probably resulted from increased saliva production due to the higher fiber content of control pasture.

Ruminal dry matter volume and consequently indigestible fiber fill were probably underestimated. Ruminal evacuation, although difficult, is probably the most accurate estimator of ruminal fill. In addition, NDF analysis of particulate matter would provide a better estimate of bulk fill. Faster passage and greater indigestible organic matter intake should force passage of larger particles from the rumen. Therefore, measurement of duodenal or fecal particle size distributions may have supported this conjecture.

Lower ruminal volume combined with higher performance in these studies, may partially support the theory that chemical factors also influence intake of high quality forages (Grovum, 1986). Bulk fill is the main regulator of forage intake, however, the interaction between chemical, humoral, and physical regulation needs further study.

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APPENDIX

FECAL ORGANIC MATTER OUTPUT
DISCUSSION AND PROCEDURES

Discussion

Fecal output was predicted for all cattle in year 1 (1985) and weaned calves in year 2 (1986). Inconsistent digestibility estimates prevented prediction of forage organic matter intake.

Procudures

Year 1 (1985). Fecal output was evaluated on July 28 and 29 on six individuals (cows and calves) randomly selected from each treatment. Weaned calf supplements were fed 7 d/wk during the intake collection period. Ytterbium (519.6 mg) was blended with 7 g ground prairie hay (1-mm screen) and stuffed into a gelatin capsule. One capsule was dosed in the morning on days 1 through 6. Individual fecal grab samples were obtained six times (day 6: 0800 h, 1600 h, 2400 h and day 7: 0400 h, 1200 h, 2000 h), composited by animal, and stored (-15 C).

Fecal composites were initially dried in a forced-air oven at 55 C for 48 h and ground through a Wiley mill equipped with a 1-mm screen. Dry matter content of air-dry fecal samples (1 g) was determined at 100 C for 24 h followed by ashing at 500 C for 8 h. Ash residues were digested in 20 ml of 3 N HNO_3 : 3 N HCL for 24 h. Five ml KCl solution (9.54 g KCl/100 ml) were added to each residue and diluted to 25 ml with digestion mix. Diluted samples were analyzed for Yb concentration by atomic-absorption spectophotometry using a nitrous oxide-acetylene flame. Fecal output was estimated from the ratio of marker concentration in the dose and feces.

Year 2 1986. Fecal grab samples were collected on July 24 and 25 from weaned calves. Ytterbium-blended prairie hay was prepared in a manner similar to year 1. Each bolus contained 445.57 mg Yb. Two boluses were dosed at 0800 for three days, followed by a single bolus dosed at 0800 and 1800 h for 3 1/2 days. Fecal grab sampling and Yb analysis were described in year 1.

TABLE XX. FECAL ORGANIC MATTER OUTPUT OF SUCKLING AND WEANED COWS AND CALVES GRAZING CONTROL OR BURNED PASTURES

Item	Suckling		Weaned		
	Control	Burn	Control	Burn	SEM[a]
	g/d				
Calves	2,044[c]	1,763[b]	1,773[b]	2,342[d]	113.4
Cows	7,031[d]	5,335[b]	6,040[c]	5,490[b]	213.6
	g/kg body weight				
Calves	7.8[ef]	7.1[e]	8.4[f]	10.2[g]	.65
Cows	14.5[g]	11.4[f]	12.2[f]	10.4[e]	.37

[a] SEM=standard error of least square treatment means.

[b,c,d] Treatment means within rows differ (P<.10).

[e,f,g] Treatment means within rows differ (P<.05).

TABLE XXI. FECAL ORGANIC MATTER OUTPUT OF WEANED CALVES (YEAR 1-1985)

Item	Treatment Control	 SBM	 CGM	 Burn	SEM[a]
Fecal organic matter output,					
g/d	1,760	2,120	2,120	2,384	132.4
g/kg body weight	8.5	9.6	10.0	10.0	.55

[a] SEM=standard error of least square treatment means.

TABLE XXII. FECAL ORGANIC MATTER OUTPUT OF WEANED CALVES (YEAR 2-1986)

Item	Treatment Control	SBM	SBM/CGM	Burn	SEM[a]
Fecal organic matter output,					
g/d	1,683	1,690	1,597	1,557	116.4
g/kg body weight	8.2	7.9	7.4	7.5	.54

[a] SEM=standard error of least square treatment means.

TABLE XXIII. AVERAGE COW WEIGHT, INTAKE, AND FECAL OUTPUT OF NONPREGNANT BEEF COWS GRAZING CONTROL AND BURNED PASTURES[a]

Item	Period 1	2	3
Average cow weight, kg			
Control	470	494	522
Burn	475	512	535
Forage Intake, g/d			
Organic matter			
Control[b]	10,006 ± 275.6	8,765 ± 275.6[h]	8,460 ± 275.6[f]
Burn[c]	10,635 ± 275.6	9,522 ± 275.6[i]	9,669 ± 337.5[g]
Digestible organic matter			
Control[c]	5,187 ± 133.5[d]	3,879 ± 133.5[d]	3,837 ± 133.5[d]
Burn[c]	6,175 ± 133.5[e]	5,125 ± 133.5[e]	5,096 ± 163.5[e]
Indigestible organic matter			
Control	4,819 ± 142.8	4,886 ± 142.8[f]	4,623 ± 142.8
Burn	4,460 ± 142.8	4,397 ± 142.8[g]	4,573 ± 174.9
Fecal output, g/d			
Control	6,073 ± 165.8	5,946 ± 165.8[h]	5,633 ± 165.8
Burn	5,750 ± 165.8	5,508 ± 165.8[i]	5,600 ± 203.0

[a] Least square mean ± standard error of the mean.

[b] Linear period response ($P<.05$).

[c] Nonlinear period response ($P<.05$).

[d,e] Treatment means within columns differ ($P<.01$).

[f,g] Treatment means within columns differ ($P<.05$).

[h,i] Treatment means within columns differ ($P<.10$).

TABLE XXIV. CHEMICAL COMPOSITION OF DIET SAMPLES FROM CONTROL AND BURNED COW/CALF PASTURES (YEAR 1-1985)[a]

	Date					
Component	May 6	May 30	June 20	July 9	July 28	SEM[b]
Hemicellulose, %						
Control[l]	36.8[e]	32.1[e]	30.4[e]	33.4[e]	33.6	.60
Burn[k]	39.9[f]	36.9[f]	37.9[f]	36.7[f]	35.4	.60
Cellulose, %						
Control	30.9[e]	31.4	30.9	33.6	33.9[e]	.30
Burn[l]	29.6[f]	31.0	31.3	32.6	31.8[f]	.30
Pepsin insoluble CP[c], % of CP						
Control[l]	37.4[i]	42.2[e]	41.1[e]	50.2	59.8	.46
Burn[k]	38.9[j]	46.7[f]	49.9[f]	50.2	59.9	.46
Pepsin available CP[d], %						
Control[k]	8.7[e]	7.0[e]	6.1[e]	5.3[e]	3.5[e]	.11
Burn[l]	10.0[f]	6.2[f]	4.6[f]	4.4[f]	3.0[f]	.11
Soluble CP, % of CP						
Control	15.7	22.8[e]	13.8[g]	16.3	17.1	1.12
Burn	15.0	16.8[f]	16.9[h]	16.2	15.0	1.12
Organic matter, % of dry matter						
Control[k]	89.0[e]	89.4[e]	90.0[e]	89.0[e]	89.2[e]	.07
Burn[k]	90.6[f]	90.7[f]	90.6[f]	90.3[f]	90.5[f]	.07

[a] Organic matter basis.

[b] SEM=standard error of least square treatment means.

[c] CP=Crude protein.

[d] Pepsin available CP=CP-pepsin insoluble CP.

[e,f] Treatment means within columns differ (P<.01).

[g,h] Treatment means within columns differ (P<.05).

[i,j] Treatment means within columns differ (P<.10).

[k] Linear period response (P<.05).

[l] Nonlinear period response (P<.05).

TABLE XXV. CHEMICAL COMPOSITION OF DIET SAMPLES FROM CONTROL AND BURNED COW/CALF PASTURES (YEAR 2-1986)[a]

	Date				
Component	May 6	June 3	July 15	August 5	SEM[b]
Hemicellulose, %					
Control	32.6[e]	34.7[e]	34.6[k]	34.4	.44
Burn[j]	37.7[f]	37.0[f]	35.8[l]	33.4	.44
Cellulose, %					
Control	31.2	31.5	32.7	35.9	.30
Burn	30.6	33.5	32.5	33.5	.30
Pepsin insoluble CP[c], % of CP					
Control[i]	68.1[e]	62.8[e]	71.1[e]	82.6[e]	.43
Burn[j]	51.6[f]	61.1[f]	78.7[f]	80.1[f]	.43
Pepsin available CP[d], %					
Control[i]	4.6[e]	4.8[e]	3.2[e]	1.4	.07
Burn[j]	7.6[f]	5.3[f]	2.2[f]	1.6	.07
Soluble CP, % of CP					
Control[i]	22.1[g]	30.0	24.6[g]	13.0	1.27
Burn[i]	17.4[h]	27.7	19.4[h]	16.2	1.27
Organic matter, % of dry matter					
Control	87.0[e]	82.2[e]	88.2[g]	89.2[k]	1.45
Burn	88.6[f]	87.9[f]	88.8[h]	88.7[l]	1.45

[a] Organic matter basis.

[b] SEM=standard error of least square treatment means.

[c] CP=Crude protein.

[d] Pepsin available CP=CP-pepsin insoluble protein.

[e,f] Treatment means within columns differ (P<.01).

[g,h] Treatment means within columns differ (P<.05).

[i] Linear period response (P<.05).

[j] Nonlinear period response (P<.05).

[k,l] Treatment means within columns differ (P<.10).

TABLE XXVI. CHEMICAL COMPOSITION OF DIET SAMPLES FROM WEANED CALF/RUMINALLY CANNULATED COW PASTURES[a]

	Date			
Component	May 15	June 19	July 24	SEM[b]
Hemicellulose, %				
Control[c]	38.1[e]	33.9[e]	37.8[k]	.36
Burn[c]	40.0[f]	36.3[f]	36.4[l]	.36
Cellulose, %				
Control[c]	32.3[e]	31.8[e]	33.9	.17
Burn[d]	31.2[f]	33.3[f]	33.6	.17
Pepsin insoluble CP[g], % of CP				
Control[d]	67.4	75.8[e]	77.7[h]	1.64
Burn	65.4	65.3[f]	73.0[i]	1.64
Pepsin available CP[j], %				
Control[d]	4.4	2.9[k]	2.2	.19
Burn[d]	4.9	3.8[l]	2.4	.19
Soluble CP, % of CP				
Control	15.7	16.6	16.9	1.10
Burn	13.5	16.4	16.8	1.10
Organic matter, % of dry matter				
Control[c]	88.3[e]	89.7[e]	88.6[e]	.10
Burn[c]	89.4[f]	90.5[f]	89.7[f]	.10

[a] Organic matter basis.

[b] SEM=standard error of least square treatment means.

[c] Nonlinear period response ($P<.05$).

[d] Linear period response ($P<.05$).

[e,f] Treatment means within columns differ ($P<.01$).

[g] CP=crude protein.

[h,i] Treatment means within columns differ ($P<.10$).

[j] Pepsin available CP=CP-pepsin insoluble CP.

[k,l] Treatment means within columns differ ($P<.05$).

Table XXVII. CRUDE PROTEIN COMPOSITION OF WEANED CALF PASTURES (YEAR 1-JULY 28, 1985)

Item	%(Organic matter basis)	SEM[a]
Crude protein		
Control	8.9[b]	.01
Burn	7.8[c]	.01
Pepsin insoluble CP[d], % of CP		
Control	58.0	.13
Burn	56.2	.13
Pepsin available CP[e]		
Control	3.7[b]	.02
Burn	3.4[c]	.02
Soluble CP		
Control	1.2	.05
Burn	1.2	.05
Soluble CP, % of CP		
Control	13.7	.58
Burn	14.9	.58
Organic matter, % of dry matter		
Control	90.3[b]	.01
Burn	91.1[c]	.01

[a] SEM=standard error of least square treatment means.

[b,c] Treatment means within columns differ ($P<.05$).

[d] CP=crude protein.

[e] Pepsin available CP=CP-pepsin insoluble CP.

Table XXVIII. FORAGE FIBER COMPOSITION OF WEANED CALF PASTURES (YEAR 1-JULY 28, 1985)

Item	%(Organic matter basis)	SEM[a]
Neutral detergent fiber		
Control	81.6[b]	.50
Burn	77.8[c]	.50
Acid detergent fiber		
Control	46.2[b]	.04
Burn	41.9[c]	.04
Permanganate lignin		
Control	8.4[b]	.20
Burn	6.8[c]	.20
Hemicellulose		
Control	35.4	.76
Burn	35.8	.76
Cellulose		
Control	33.7[d]	.67
Burn	14.9[e]	.67
Organic matter, % of dry matter		
Control	90.3[b]	.01
Burn	91.1[c]	.01

[a] SEM=standard error of least square treatment means.

[b,c] Treatment means within columns differ ($P<.05$).

[d,e] Treatment means within columns differ ($P<.10$).

TABLE XXVIV. CRUDE PROTEIN IN SITU DIGESTION PARAMETERS FROM CONTROL AND BURNED PASTURE[a]

Component	Period 1	Period 2	Period 3	SEM[b]
Crude protein, %				
Soluble				
Control	38.5	14.8	13.5	1.29
Burn	38.6	19.7	17.8	1.29
Potentially degradable				
Control	44.2	54.1	60.2	3.65
Burn	51.8	54.6	53.2	3.65
Rate of digestion				
Control	10.0	6.1	5.4	1.34
Burn	6.0	5.9	6.6	1.34
Predicted digestibility[c]				
Control	67.0	46.2	45.7	1.20
Burn	68.2	51.9	50.2	1.20

[a] Organic matter basis.

[b] SEM=standard error of the mean.

[c] Predicted from rate of crude protein digestion and particulate passage rate.

VITA2

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Candidate for the Degree of

Master of Science

Thesis: EFFECT OF SPRING PASTURE BURNING, WEANING DATE AND SUPPLEMENTAL PROTEIN SOURCE ON PERFORMANCE, FORAGE UTILIZATION AND RUMINAL ENVIRONMENT OF FALL-CALVING BEEF CATTLE MAINTAINED ON NATIVE GRASS PASTURES IN EARLY SUMMER

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