SUPPLEMENTAL PROTEIN LEVELS FOR SPRING CALVING BEEF COWS GRAZING OLD WORLD BLUESTEM OR TALLGRASS PRAIRIE

By

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FORMAT OF THESIS

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

CHAPTER I

INTRODUCTION

The Great Plains is one of the major cow-calf producing regions in the United States and Oklahoma is one of the states in this region (Vavra and Raleigh, 1976). Approximately fifty percent of its land area is rangeland which is not suitable for crop production (Waller et al., 1972). Some of this land is highly susceptible to wind erosion and frequent drought-like conditions (Sims, 1988). Due to these conditions, some of this land was placed in the Conservation Reserve Program (CRP) in the mid 1980's. Oklahoma had over 384,615 hectares placed in CRP by 1988 (Hutson, 1988). The CRP contracts were for a ten year period and began to expire in 1994. Most of the land that was placed in CRP is marginal cropland (McCoy et al., 1992). Therefore, producers may desire to find more profitable and ecologically sound alternatives for this land as it comes out of contract.

One alternative use for CRP land is beef production. A large percentage of this land was planted with Old World bluestems (OWB, *Bothriochloa* spp.) and other monocultures (McCoy et al., 1992). Old World bluestems have several desirable characteristics such as ease of establishment, drought tolerance, forage production, grazing tolerance, and palatability for livestock (Sims, 1988; Sims and Dewald, 1982). Old World bluestems have the potential to produce three to four times more forage per unit of land compared to tallgrass prairie (Horn et al., 1974). This increase in forage production allows OWB to produce more beef per hectare than tallgrass prairie (Sims and Dewald, 1982). The majority of forage production of OWB occurs after June 1 and requires heavy grazing to maintain adequate quality (Anderson and Matches, 1983; Dabo et al., 1987; Taliaferro et al., 1972). This rapid growth can result in increased stem production and decreased forage quality. The crude protein (CP) content has been found to fall below 7% when OWB was harvested after seven weeks of growth and as the forage approaches senescence (Anderson and Matches, 1983; Dabo et al., 1988; Gunter et al., 1995). A mature 454 kg cow in mid gestation requires 7% CP in her diet (NRC, 1984). If this cow grazes OWB during dormancy, then she would be expected to be protein deficient.

There are several types of supplementation programs available to cattle producers. These options include range cubes, liquids, blocks, and the use of small grain forages, i.e. rye or wheat. In the Great Plains region, the majority of producers use commercial range cubes. These supplements are sold based on total protein content which generally range from 12 to 41% CP. These are formulated from soybean meal or cottonseed meal blended with cereal grains, grain byproducts, and alfalfa. Research has illustrated that supplemental protein provided to beef cattle grazing low-quality forages improves performance (DelCurto et al., 1990b; Marston et al., 1995; Wagner et al., 1983). These production responses for beef cows include reduced body weight and condition loss, increased milk production, and higher calf gains. Increased performance is the result of increased forage intake, digestibility, and ruminal microbial protein synthesis (McCollum and Galyean, 1985).

Previous research on OWB has compared forage production and nutritional quality to tallgrass prairie. Most of the livestock research has evaluated the performance of stocker cattle on OWB during the growing season. Both of these areas have shown that intense forage removal in a timely matter is needed to keep OWB in adequate quality. As forage harvest is delayed, the forage becomes protein deficient for beef cattle. Supplementing protein would then be needed during the dormant season.

The objective of this research was to determine the response of spring calving beef cows to grazing OWB differing levels of a 41% CP supplement and to determine the optimal level of supplementation. In addition, beef cow performance on OWB or native tallgrass prairie was compared. This research should indicate the most efficient amount of supplemental protein needed in a cow-calf operation. Secondly, it should generate information allowing cow-calf producers to increase both the efficiency and production of operations based on OWB and tallgrass prairie.

CHAPTER II

LITERATURE REVIEW

Nutritional Status of Spring Calving Beef Cows

Supplemental Nutritional Demands of Spring Calving Beef Cows

There are two major factors which influence the supplemental nutritional demands of spring calving beef cows: the physiological state and her diet. The physiological state of the cow includes requirements for maintenance, gestation, growth, and lactation. The diet includes the quality and quantity of forage consumed daily. This review will address the maintenance requirements of cows, characteristics of old world bluestems and native tallgrass prairie, and the use of protein supplements.

Factors Affecting Maintenance and Production Requirements

The maintenance requirement for energy can be defined as the amount of feed energy that will result in neither gain or loss of body energy (NRC, 1984). Maintenance is an important factor determining efficient beef production. Sixty five to 75% of the energy required for beef production is used for maintenance of the cow herd (Gregory, 1972). Approximately 70% of the energy fed to the cow herd is just for cow maintenance (Ferrell and Jenkins, 1984). Several factors can affect maintenance. These factors include breed, physiological state, level of production, amount and location of fat, and environment (Fox et al., 1988). Reid et al. (1991) estimated maintenance requirements for *Bos taurus*, *Bos indicus*, and their crosses in a semiarid environment. Brahman crosses ranked lowest in $ME_m/BW^{.75}$. This was attributed this to the fact that Brahman crosses had lower ME content in their milk and a large amount of subcutaneous fat. Solis et al. (1988) also found Brahman cattle to have lower maintenance requirements and contributed this to low internal fat and smaller metabolically active organs. Breed effects on maintenance becomes of greater significance when animals are in stressful environments. Jenkins and Ferrell (1994) evaluated nine different beef breeds and found that Red Poll and Angus cattle were the most efficient, at low levels of DMI, in converting feed to weight and body condition. Efficiency of these two breeds was attributed to the fact that they had lower genetic potential for milk or growth compared to the other breeds. Also, the advantage in efficiency diminished as DMI was increased. Jenkins and Ferrell (1994) concluded that the effect of metabolic size on reproductive efficiency is the result of genetic potential for metabolic size and food energy availability.

Another major factor influencing maintenance is genetic potential for body weight gain and milk production. Several researchers have found that cattle with greater potential for production, growth or milk, have higher maintenance requirements (DiCostanzo et al., 1990; Ferrell and Jenkins, 1984; Jenkins and Ferrell, 1994; Montano-Bermudez et al., 1990; Reid et al., 1991; Solis et al., 1988). Factors affecting production are the nutritional demands for production, body condition, and pasture conditions (Fox et al., 1988). Factors affecting nutritional demands for production include calf birth weight, milk potential, body condition, and climate (Fox et al., 1988; NRC, 1984). The time of gestation and point on the lactation curve are important because of their influence on intake, as well as nutrient demands. Some data have shown little difference in maintenance requirements of a cow that is either nonpregnant or pregnant (Ferrell and Jenkins, 1985). Vital organs account for about a third of the maintenance requirements in cattle (Ferrell and Jenkins, 1985). This is due to high oxygen consumption (Solis et al., 1988) associated with protein synthesis and turnover (DiCostanzo et al., 1990). The effect of visceral organs on maintenance requirements vary due to production potential, physiological state, and previous plane of nutrition (DiCostanzo et al., 1991; Ferrell and Jenkins, 1985; Fox et al., 1988).

An increase in maintenance requirements with lactation has been attributed to increased blood flow through the portal system (Ferrell and Jenkins, 1985) and metabolic activity and size of internal organs (Ferrell and Jenkins, 1984). Cattle with greater potential for milk also have heavier vital organs, specifically the liver (Ferrell and Jenkins, 1984; Ferrell and Jenkins, 1985; Solis et al., 1988). As a ruminant animal shifts from a low plane to a high plane of nutrition, maintenance requirements increase. This increase can be attributed to an increase in the weight of internal orgains (Ferrell and Jenkins, 1985).

Also, nutritional demands are increased when a cow begins lactating. The energetic cost of lactation is associated with the amount of milk fat. NRC (1984) states a value of .75 Mcal/kg of milk production for beef cattle. Cows with low milk production required 12% less energy during both gestation and lactation, compared to cows with moderate and high milk production (Montano-Bermudez et al., 1990). Calves from moderate and high producing cows had more internal fat and less subcutaneous fat with higher maintenance requirements when fed to market weight (Montano-Bermudez et al., 1990). Van Oijen et al. (1993) completed an economical analysis on these cow groups. The low group was the most economically efficient when calves were sold at both weaning and slaughter. When all groups were assumed to have equal reproductive performance, the low cows had even higher efficiency and the difference among groups became greater.

Wright et al. (1994) evaluated biological efficiencies in two different nutritional environments. Crossbred cows with three levels of milk production were placed on pastures with either short grass (sward height of 4 to 5 cm) or tall grass (sward height of 7 to 8 cm). Short grass resulted in lower cow gains, milk production, and lower calf gains. Also heavier conditioned cows, regardless of pasture, had lower milk production, ADG, calf gains, and herbage intake. Although absolute production values were lower for cows on the short pasture, their biological efficiency was higher than on tall pasture based on energy inputs and land area.

A third factor influencing maintenance is body composition and site of adipose deposition. It has been well established that adequate fat stores are needed for efficient beef production. Buskirk et al. (1992) found that cows with restricted energy intake had reduced luteal activity and that fewer cows in thin condition were cycling at the beginning of the breeding season, illustrating body condition is important. Others have found that more highly conditioned cows have lower maintenance requirements compared to their thinner counterparts (DiCostanzo et al., 1990; Klosterman et al., 1968; Russel and Wright, 1983; Thompson et al., 1983). Adipose helps to insulate cows, lowering the amount of energy needed to generate heat during cold or wet conditions and thus decreasing maintenance requirements (Montano-Bermudez et al., 1990; Thompson et al., 1983).

It is energetically more efficient to maintain adipose versus lean due to lean having a higher turnover rate (Ferrell and Jenkins, 1985; Russel and Wright, 1983; Thompson et al., 1983). It has been shown that maintenance requirements are highly correlated with lean body mass (Ferrell et al., 1979). Lemenager et al. (1980) was able to predict TDN requirements with greater accuracy when weight and BCS were used together during gestation ($R^2 = .99$) and during lactation using weight, BCS, and milk production, accounted for 98% of the variation in TDN requirements. These cows were in drylot during gestation and part of lactation and not in a pasture environment. Thompson et al. (1983) also found that using $BW^{.75}$ and body composition accounted for a large percentage of the variation in nutritional demands. The cow's body condition has direct influence on her production performance since the amount of fat tissue variation from cow to cow is greater then protein mass (Thompson et al., 1983). Therefore, within a breed type, individuals or bloodlines would vary in their efficiency, depending on their genetic potential for leanness. It is this difference within breed types that produces the "easy keepers" in a cow herd. DiCostanzo et al. (1991) observed that inefficient cows had a higher rate of protein accretion then did average or efficient cows of the same breed.

Site of adipose deposition is also important in affecting maintenance demand. Cattle with dairy breeding have a higher maintenance requirement than beef breeding due to less subcutaneous fat and more internal fat deposits (DiCostanzo et al., 1990; Thompson et al., 1983), in addition to higher milk potential. Montano-Bermudez et al. (1990) also found that steers, with dams of moderate and high milk potential, had more internal adipose and less subcutaneous compared to steers from low milk potential dams. Solis et al. (1988) attributed the lower maintenance of Brahman cattle to lower amounts of internal fat and smaller vital organs.

Environmental conditions can account for variations in maintenance requirements of cattle. Maintenance demand is affected whenever the animal experiences temperatures outside their thermoneutral zone (NRC, 1984). Fox et al. (1988) adjusted for mud, hide, and body condition when predicting maintenance requirements. Maintenance demands vary with season. Laurenz et al. (1991)

noted that maintenance requirements for Angus and Simmental cattle were less in the winter and greater in the summer. This was due to cattle losing lean tissue and gaining empty body fat, as a percent of body weight, in the summer and the opposite occurred in the winter (Laurenz et al., 1992). During the fall, cattle may experience frequent swings in their maintenance needs due to not being totally acclimated to cold temperatures (Prescott et al., 1994). As a result, the range of temperatures where cattle are not affected by ambient temperature swings is small (2-8^0 C) due to not being acclimated. The variation in maintenance is due to an increase of 30 to 40% in resting metabolism during cooler temperatures (Prescott et al., 1994). Intake can vary as much as 30% in cattle due to environmental factors listed by Fox et al. (1988). One reason for the change in intake is the response to the temperature change. Prescott et al. (1994) found that grazing time decreased as daily temperature decreased and as short-term thermal stress increased. In addition OM intake increased with daily temperature.

Other authors have defined environment as nutritional conditions, such as pasture or range conditions (Jenkins and Ferrell, 1994; Kattnig et al., 1993; Wright et al., 1994). It can be concluded that there is a genotype x environment interaction and that leaner cows are biologically less efficient than cows of similar weight but higher percent of fat in the empty body.

Factors Affecting Nutrient Composition of Old World Bluestem

Old World bluestem was introduced to the United States from Europe and Asia as early as 1929. The plant acts as a secondary plant species, not as a climax species (Sims and Dewald, 1982). Five major varieties of OWB are currently used in the United States: Caucasian, Plains, Ganada, WW-Spar, and WW-Iron Master. Caucasian bluestem is a separate species from the other varieties. It typically has higher DM yields but is less digestible than the other varieties. Plains and WW-Spar have similar production and digestibility values but Plains is more adaptable to diverse soils because it is a blend of 30 varieties, including WW-Spar and WW-Ironmaster. WW-Spar has an earlier growth curve and is winter hardy. Ganada produces the least amount of forage but generally is more digestible. WW-Iron Master was selected for production on iron deficient soils (Dewald et al, 1985; Dewald et al., 1988). Old World bluestem has several characteristics that make it a useful forage for beef production. These forages tolerate heavy grazing, respond to fertilization, tolerate drought, establish easily, and are palatable to livestock (Sims and Dewald, 1982; Sims, 1988). In addition, it is able to produce over 168 kg of beef per hectare in northwest Oklahoma (Sims and Dewald, 1982). As a result of these factors, producers are using OWB for beef production.

Forage quality and quantity Producers should manage their forages for optimum forage quality and quantity. Three management factors affecting quality and quantity include the stage of maturity at harvest, burning, and fertilization. Old World bluestem, like other forages, decreases in quality at progressive stages of maturity. Anderson and Matches (1983) studied Caucasian bluestem (*Bothriochloa caucasica*) and found that in vitro DM disappearance (IVDMD) declined approximately two percentage units per week and CP declined one percentage unit per week for each week harvest was delayed from the vegetative stage to heading. The IVDMD values, derived from the whole plant, ranged from 42 to 65%. These values should be lower than what grazing animals would consume due to selective grazing, which explains the adequate gains observed in dairy heifers and steers (Anderson and Matches, 1983). Dabo et al. (1987) graphically represented the decrease in IVDMD (g/kg). Whole plants and stems had similar slopes, whereas the slope for leaves did not decline as rapidly. Dabo et al. (1987) suggested that the low IVDMD values would have negative effects on animal performance. Although there was a decline in CP in late-summer, OWB had a higher percent of CP than native grasses (Sims, 1988). Gunter et al. (1995) found that both OWB and native grasses were deficient in ruminally degraded nitrogen (N) from June to August. Delaying the harvest date also resulted in an increase in (NDF) by 1.3 percentage units per week but the NDF was never below 65% (Anderson and Matches, 1983). Forages with NDF values greater then 60% may limit intake of ruminants by bulk fill. Gunter et al. (1995) reported NDF values for OWB exceeded 65% for May through October.

The DM yield for OWB is affected by both time and height of harvesting. A majority of the literature indicates the most of the growth occurs after June 1 (Anderson and Matches, 1983; Dabo et al., 1987; Taliaferro et. al., 1972). Delaying the time of harvest produces a linear increase in DM yeild at the expense of quality (Anderson and Matches, 1983; Dabo et al., 1987). Anderson and Matches (1983) suggested that harvesting Caucasian OWB at 8 cm vs 23 cm consistently yielded more DM due to the regrowth initiated from crown tillers without the negative effects on quality.

Grazing systems can aid in management of OWB to obtain optimum forage quality and quantity. One of the benefits of OWB is that it tolerates heavy grazing (Sims and Dewald, 1982). IVDMD improved with increased clipping frequencey (Taliaferro et al., 1984). There are several different grazing systems which may be used on OWB including continuous, frontal, intensive early stocking (IES), and rotational. The system that appears to best suit OWB is rotational, when compared to either continuous or frontal systems (McCoy et al., 1992; Volesky et al., 1994b). Volesky et al. (1994b) observed that stocker cattle had higher ADG and increased gains per hectare with rotational grazing than under continuous or frontal grazing. Enhanced performance, compared to continuous, was attributed to a decrease in patch grazing and maintaining quality of OWB. The type of grazing system used influences the way livestock graze the plants. Rotational grazing of OWB resulted in taller perimeter tillers than in the center. This resulted in new tiller growth, increased proportion of younger growth over older, and more efficient photosynthesis, all of which contributed to increased forage production (Volesky, 1994a).

The ways in which OWB responsed to grazing dictates its persistence and forage production. One method of plant survival is the partitioning of total nonstructural carbohydrates (TNC). Total nonstructural carbohydrate can be defined as the plant's carbon source for regrowth. As TNC increases there is a decrease in growth rate of the plant (Christiansen and Svejcar, 1987; Christiansen and Svejcar, 1988). As a plant is defoliated it must begin to tiller to maintain photosynthesis. The carbon source to initiate this tillering comes from TNC and as grazing pressure increases so does tillering. Plants partition TNC differently depending on grazing pressure. OWB accumulates TNC in the stem if lightly grazed or stores TNC in the stem base during heavy grazing (Christiansen and Svejcar, 1987). The structure of OWB allows it to withstand heavy grazing. It has a large pool of TNC in its crown and the crown has been described as a "pin-cushion" to protect the meristem (Christiansen and Svejcar, 1987; Christiansen and Svejcar, 1988). When OWB is grazed heavily, it is less susceptible to water stress (Svejcar and Christiansen, 1987a). The increased moisture efficiency could be attributed to an increase in the ratio of absorbing root surface to transpiring leaf surface in heavily grazed OWB. Heavily grazed a more constant number of roots per tiller than plants which were lightly grazed, therefore having a constant TNC pool to draw from for tiller growth (Christiansen and Svejcar, 1988).

Forage quality and quantity can be manipulated by management practices such as burning and the application of fertilizer. The benefits from burning include earlier green up, greater palatability, increased animal performance, more uniform grazing and increased N efficiency. Berg (1993) looked at the effects of burning OWB in western Oklahoma and found a 6 to 30% decrease in forage production over four growing seasons. Nitrogen efficiency was not improved. Animal performance was not studied. In summary, the use of fire should be used only to prevent the invasion of unwanted vegetation and to remove standing dead material in northwest Oklahoma.

Old World bluestem is more responsive to fertilizer than fire. Each kg of N applied to OWB results in 9 to 23 kg of additional forage production (Sims, 1988). Nitrogen fertilizer has more benefits than simply increasing forage yield. Fertilization also increases the CP content and keeps the plant in a vegetative stage of growth longer than nonfertilized OWB (Berg, 1990; Horn et al., 1974). Timing and amount of N fertilization also influence forage response. The optimum timing of N application is a single application in April to May (Berg, 1988; Horn et al., 1974; Sims and Dewald, 1982). The use of phosphorus and potassium were found to enhance forage production when combined with N, but had no effect when applied alone (Horn et al., 1974; Sims and Dewald, 1982; Taliaferro et al., 1972).

Nutritional deficiencies can result from either or a combination of low diet quality and restricted intake. Livestock grazing mature OWB could experience depressed intakes due to high levels of NDF (NDF > 60%) resulting in bulk fill, or distention, limiting intake (Anderson and Matches, 1983; Dabo et al., 1988; Forwood et al., 1988). Depressed intakes by growing, grazing animals may be due to a reluctance to consume less desirable forages (Forbes and Coleman, 1993). As the growing season progresses, herbage mass in warm-season bunchgrasses, such as OWB, shifts to predominantly stem and dead material of low quality (Forbes and Coleman, 1993).

Protein has been cited in several papers as the most limiting nutrient in dormant OWB (Dabo et al., 1988; Gunter et al., 1995; Rollins, 1985). As a forage matures, cell wall digestibility decreases, thus protein which is associated with the cell wall would be of limited availability to rumen microbes (Piwonka et al., 1991) resulting in a ruminal N deficiency, reduced forage digestion, and inhibited microbial protein sysnthesis. Although OWB has been found to contain more of ruminal digestible nitrogen than midgrass prairie, it would still limit animal performance (Gunter et al., 1995).

The protein requirements of a 454 kg mature cow in last third of pregnancy with average milking ability are 7.9% and 9.6%, respectively (NRC, 1984). OWB 7-8 weeks old or older, would have CP less than 7% in the whole plant (Dabo et al., 1988). Mature gestating cows should require protein supplementation from October to the end of April when OWB has CP less the 7%. Most of the literature indicates that protein limits animal performance on OWB but some data indicates that energy may be limiting with highly productive animals. Gunter et al. (1995) found that digestible OM intake (DOMI) was the first limiting factor for animals with superior performance. Supplementation should concentrate on increasing DOMI, thus improving the energy intake and improve animal performance by improving N retention without negative effects on forage intake (Gunter et al., 1995). The data clearly demonstrates that cattle on OWB require supplementation in order to achieve optimum performance.

Factors Affecting Nutrient Composition of Tallgrass Prairie

Approximately fifty percent of the land in Oklahoma is rangeland (Waller et al., 1972). This environment is appropriate for ruminants, particularly beef cattle. Several factors affect the availability of the tallgrass prairie including grass species, seasonal factors, burning, and grazing system.

Most of the grass species in central Oklahoma are components of the tallgrass prairie rangetype. Dominant species include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*; Gillen et al., 1987). These warm season grasses grow from April to August with peak production in early June (Hake et al., 1984). The majority of the growth occurs within the first 75 to 100 days of the growing season (Gillen and McNew, 1987). Amount of forage produced in the tallgrass prairie ranges from 1,300 kg/ha to 5,800 kg/ha with an average of 3,680 kg/ha (Powell et al., 1986). These grass species respond positively to burning (Gillen et al., 1987; Masters et al., 1992; Towne and Owensby, 1984).

Forage Quality and Quantity Seasonal factors and weather conditions have significant effects on forage quality and yield. Rate of forage growth declines with advance of the growing season (Gillen and McNew, 1987). Growth rate declines due to a decrease in soil moisture and an increase in daily temperatures. Hake et al. (1984) found that forage yield decreased as plant water potential values decreased. Water stress affected big and little bluestem more than the other tallgrass species, although little bluestem forage production was hindered more than big bluestem due to water stress (Hake et al., 1984). The growth rate decline was due to soil moisture and high temperatures, illustrating how weather conditions influence grasses in the tallgrass prairie. Powell et al. (1986) studied the effect of 22 years of weather on forage yield and quality in central Oklahoma. They were able to show a negative correlation (R^2= - 0.73) for average high temperatures during July on hay production. Other factors associated with declining quality include a decrease in leaf to stem ratio and an increased proportion of dead leaf material (Forwood and Magai, 1992).

The use of fire on the tallgrass prairie has several benefits. These advantages include increased numbers of desirable warm-season grasses and increased animal performance (Bernardo et al., 1988; Gillen et al., 1987; Masters et al., 1992; Svejcar, 1989; Towne and Owensby, 1984). Prescribed burning also has disadvantages such as decreased soil moisture and forage production in dry years (Bernardo et al., 1988; Gillen et al., 1987). Prescribed burning had a positive net present value per hectare over a ten year period (Bernardo et al., 1988). The increase in net present value comes from an increase in gains of stocker cattle (10 to 20%), decreasing forbs and cool-season grasses, increasing warm-season grasses, and suppression of eastern redcedar (Bernardo et al., 1988). Burning was also considered a risk-reducing practice because the variability of annual returns were lower for burning (Bernardo et al., 1988). A final benefit of prescribed burning is enhanced animal performance which has been recognized since the 1880's (Towne and Owensby, 1984). Stocker cattle on burned pastures, have increased summer gains from 10 to 20% over those on unburned pastures (McCollum et al., 1992). This improved performance may be due to increased IVOMD of burned forages (Svejcar, 1989). Burning also increased forage harvesting efficiency by improving grazing distribution of cattle (McCollum and Bidwell, 1993).

Fertilization on rangeland is generally not recommended (McCollum and Bidwell, 1993). Fertilization alone has been found to increase herbage production by doubling the forb content and increasing undesirable vegetation (Baker et al., 1980; Gillen et al., 1987). Fertilization plus burning or atrazine, has increased desirable grasses, forage production, and CP (Baker and Powell, 1982; Baker et al., 1980; Gillen et al., 1987; Masters et al., 1992). Furthermore, using fertilizer in combination with a herbicide or prescribed burning is not recommended (Gillen et al., 1987).

A common recommendation used on rangelands is "take half and leave half" (McCollum and Bidwell, 1993). By using this rule, cattle are expected to consume 25% of the forage while another 25% will disappear due to trampling, consumption by wildlife, and decomposition of dead material; and the remaining 50% is for ground cover to aid in reducing soil erosion. The stocking rates for grazing are based on animal unit months (AUM), which is the amount of forage a 454 kg cow would consume (354 kg/month of grazing; McCollum and Bidwell, 1993). The use of a grazing system has many benefits compared to continuous grazing. Grazing systems allow for increased stocking rates, improved diet quality, and enhanced vegetation response (Cassels et al., 1995; Derner et al., 1994; McCollum and Bidwell, 1993). In managing grazing systems, i.e. rotational grazing, the timing of movement is critical for adequate forage regrowth (Tate et al., 1994). Periodic rest from grazing, during the growing season, is the most beneficial management practice for the tallgrass prairie (McCollum and Bidwell, 1993). The data would indicate that plants in the tallgrass prairie need approximately 40 days of rest after 7 to 10 days of grazing in an 8 paddock rotational system (Tate et al., 1994). Tate et al. (1994) cited the time to reach maximum net growth by plants was constant and the rate to reach maximum growth decreased as the season progressed. Rotational grazing increased the amount of standing forage over continuous grazing but it was not clear wether this was due to depressed intakes by the livestock or improving the growth of vegetation due to frequency and pattern of defoliation (Cassels et al., 1995; Derner et al., 1994). Continuous grazing had a greater percent of tillers defoliated and spot grazing than with rotational grazing (Derner et al., 1994). This improved control was the result of increased harvest efficiency by reducing selectivity through decreased herbage allowance (Jensen et al., 1990). The use of grazing systems which allow for rest during the growing season should improve range condition in the long run.

Nutritional deficiencies Forages in the tallgrass prairie decline in quality as the growing season progresses (Forwood and Magai, 1992; Waller et al., 1972). This decline in quality has been attributed to a lower leaf to stem ratio and a higher percent of senesecent leaves, with leaf quantity being the major factor affecting quality (Forwood and Magai, 1992). Big bluestem decreased IVDMD and CP values with increased height at harvest (Forwood and Magai, 1992). Several researchers have found that protein supplementation is needed for livestock performance above maintenance (Lusby and Horn, 1983; Delcurto et al., 1990a and c; Marston et al., 1995; Scott, 1992; Vanzant and Cochran, 1994). The protein requirements of a 454 kg mature cow in last third of pregnancy and then with average milking ability are 7.9% and 9.6%, respectively (NRC, 1984). Based on whole plant analysis, tallgrass prairie fluctuates from a peak in May of 10% CP to a low of 3% CP in January (Waller et al., 1972). Protein content during the winter would be deficient for both ruminal function and animal growth. The studies reviewed show that cattle grazing tallgrass prairie would benefit from supplementation during forage dormancy (Lusby and Horn, 1983; Delcurto et al., 1990a and c; Marston et al., 1995; Scott, 1992; Vanzant and Cochran, 1994).

Correcting Nutritional Deficiencies With Protein Supplementation

Types of Protein Supplementation It has been well established that livestock grazing low-quality forages respond positively, in terms of production performance, to protein supplementation (Lusby and Horn, 1983; Gonzalez et al., 1988; Delcurto et al., 1990a and c; Marston et al., 1995; Scott, 1992). Protein supplementation options include hay, protein concentrates (i.e. cottonseed meal, soybean meal), by-products, non-protein nitrogen (NPN), and wheat pasture. Utilizing alfalfa hay as a protein source allows livestock to achieve performance levels equivalent to soybean meal (Delcurto et al., 1990c; Vanzant and Cochran, 1994) and cottonseed meal (Judkins et al., 1987) at equal protein levels. Although performance was similar between the two supplements, haying requires an increase in both equipment and labor costs.

Protein concentrates are both economical and effective in enhancing animal performance for cattle grazing low-quality forages. Generally, when adequate forage is available, the recommendation is to feed a high protein supplement (38-41% natural protein) when forage no longer meets the cows protein requirement of the cow. These concentrates, in a cube or cake form, are easy to store, handle, and feed compared to hay. In addition, this form of supplement can be feed daily, alternating days, or self fed allowing for management flexibility. After calving, soybean meal fed at 2.4 kg/d, maintained cows weight more effectively than an energy supplement (Marston et al., 1995).

Animal by-products, i.e. blood meal and feather meal, can be utilized as a supplemental ruminally undegradable protein (RUP) source. Many animal by-products are resistant to ruminal degradation and alter the amino acid (AA) profile reaching the small intestine (Gibb et al., 1992). This improvement in the duodenal AA profile by animal by-products, has allowed animals to experience improved performance, such as increased ADG, milk production, and less weight change (Gutierrez-Ornelas and Klopfenstein, 1994; Gutierrez-Ornelas and Klopenstein, 1991; Hibberd et al., 1988; Lee et al., 1985; Sinclair et al., 1994b; Wiley et al., 1991). Another advantage to by-products, is that they are generally cheaper than SBM when expressed on per unit of CP (Leme, 1978). Sinclair et al. (1994b) found that cows fed 31 g/kg DM of RUP lost less weight and produced more milk than those on low RUP (14 g/kg DM). Ruminally undegradable protein has been found to be 20% more effective in improving live weight gains in growing cattle on silage diets compared to SBM (Veira et al., 1994). The effectiveness of RUP on ADG in growing cattle grazing high quality forage, such as wheat pasture, has shown mixed results (Lee, 1985; Vogel et al., 1989). In addition, some data have shown that animal response to bypass protein was similar or hindered compared to degradable protein. Although Sinclair et al. (1994a and b) found positive effects on weight and body condition, reproductive performance of cows on a low energy-high RUP supplement had a longer postpartum interval and tended to be less fertile. Scott (1992) found that increasing RUP resulted in greater body condition losses, less milk production, and slower calf gains.

Non-protein nitrogen (NPN) supplements are another option in supplementing the cow herd. Urea is frequently used as a protein replacement (NRC, 1984). These NPN sources have been found to positively affect animal performance compared to cattle which received no supplemental protein (Hafley et al., 1993; Horton, 1979; Rush et al., 1976; Shiehzadeh and Harbers, 1974). Urea is rapidly hydrolyzed in the rumen (NRC, 1984). Nitrogen utilization efficiency is optimized when an energy source, that is readily available, is also supplied (Shiehzadeh and Harbers, 1974). The decreased performance can be attributed to a decrease in palatability, the rapid degradability, and lack of performed AA. When urea degradation is slowed, a more constant release of ammonia occurs. Urea that is degraded slower has improved both palatability of the supplement and weight change (Forero et al., 1978; Rush et al., 1976). In many liquid supplements, the purpose is to supply both energy and protein replacements (Bond and Rumsey, 1973). These liquid supplements contain NPN supplements and would allow animals to be self fed, therefore decreasing labor costs associated with supplementation.

An alternative to purchased protein supplements is the use of a small grain pasture (Apple et al., 1991). This green forage source would include wheat and rye pastures. Grazing one day on the wheat and two to three days off is generally recommended for mature cows in adequate body condition (Apple et al., 1991). If the cows are thin in condition (BCS< 4), then it is suggested that they graze the wheat pasture continuously (Apple et al., 1991; Apple et al., 1993). In one example, grazing wheat pasture produced a $45.00 advantage per cow over other management strategies (Apple et al., 1991). Producers should be aware of "wheat pasture poisoning". Older cows nursing calves under three months of age are the most susceptible. This problem can be prevented by supplying a mineral which contains at least 15% calcium (Apple et al., 1993). Wheat pasture can also be an economical creep for calves (Apple et al., 1991).

<u>Frequency and Method of Supplementation</u> The frequency and method of supplementation can influence the grazing behavior of cattle. Daily delivery can be expensive in terms of labor and equipment costs, therefore decreasing the frequency of supplementation could be economically beneficial. The frequency of cottonseed meal supplementation had no significant effect on performance in steers fed hay (CP=6.6%; Hunt et al., 1989). Beaty et al. (1994) observed an increase in weight loss of cows grazing tallgrass prairie when supplementation frequency was decreased with a soybean meal supplement.

Although the differences were significantly different, the magnitude was not large (9.5 kg). The increase in weight loss was attributed to less time spent grazing when supplement frequency was decreased (Beaty et al., 1994).

The method of supplementation can also have an impact on the profitability of a cattle operation. If producers utilized a step-up program, supplementation would be more efficiently utilized by the cattle. Vanzant and Cochran (1993) observed that cows in moderate condition performed similarly using a step-up program versus a level program. This could allow producers to feed less supplement over the winter and reduce supplementation costs. The feeding of bulky supplements, i.e. hay, is more expensive to handle than pelleted supplements. It has also been shown that chopped hay decreased the harvesting efficiency of cattle compared to a pelleted supplement (Krysl and Hess, 1993). Therefore, by feeding a pelleted supplement one would improve forage utilization of the livestock. Self-feeding has also been found to be an effective method of supplementation. Brandyberry et al. (1991) and Riggs et al. (1953) both found that cattle self-fed, using salt to limit intake, had similar performance compared to those hand fed. Self-feeding would allow producers to reduce labor costs.

<u>Responses to Protein Supplementation</u> Cows consuming low-quality forages (CP< 7%) have shown increases in production (body weight, body condition, and milk production) due to protein supplementation (DelCurto et al., 1990a; Lee et al., 1985; Rush et al., 1976; Wagner et al., 1983; Vanzant and Cochran, 1994). Several studies have illustrated that as the quantity of CP is increased, body weight and condition loss of cows after calving is reduced in a linear fashion (DelCurto et al., 1990a; Lee et al., 1985; Rush et al., 1976; Wagner et al., 1983; Vanzant and Cochran, 1994). Milk production and calf gains, in those studies, increased as quantity of CP increased. A possible disadvantage to feeding cows large amounts of protein (over 1 kg/d), during postpartum, have been numerically longer postpartum interval and decreased fertility compared to those with lower protein (Marston et al., 1995; Vanzant and Cochran, 1994).

The increase in animal production, as a result of protein supplementation, can be attributed to increased forage intake and digestibility (DelCurto et al., 1990a; McCollum and Galyean, 1985; Ovenell et al., 1991). In addition to increased forage intake, an increase in passage rate has also been observed with supplemental protein (DelCurto et al., 1990a; McCollum and Galyean, 1985). The increase in passage rate could be an indirect result of increased intake or higher intake could be due to higher passage rate. Additional protein increases ruminal ammonia N to allow for adequate N for microbial requirements (Freeman et al., 1992; McCollum and Galyean, 1985). Ruminal ammonia stimulates the utilization of ingested fiber by cellulolytic bacteria (Van Soest, 1982). By supplying supplemental protein, an alteration in VFA concentrations has been observed (DelCurto et al., 1990a; McCollum and Galyean, 1985). Both studies found a decrease in the ratio of acetate to propionate and an increase in branched VFA. These alterations would possibly allow the animal to become energetically more efficient by reducing methane production. Livestock grazing low quality forages respond positively to protein supplementation by increased production performance. The single factor that is responsible for improved performance is not clear.

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CHAPTER III

Running Head: PROTEIN SUPPLEMENTATION AND COW CALF PERFORMANCE

Supplemental Protein Levels for Spring Calving Beef Cows Grazing Old World Bluestem or Tallgrass Prairie[1]

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ABSTRACT

Eighty spring calving, crossbred beef cows were utilized to determine the comparative value of old world bluestem and tallgrass prairie. Twenty cows grazed tallgrass prairie and were fed cottonseed meal cubes (41% CP) to meet 100% of their estimated requirement for supplement protein. Sixty cows grazed Old World bluestem (OWB) and were fed cottonseed meal at either 25, 75, 125, or 175% of the rate fed to the cows on tallgrass prairie. Cow weight (8 h withdrawl from feed and water), calf weight (6 h withdrawl from feed and water), and body condition scores (1=emaciated, 9=obese) were monitored at 28 day intervals prepartum and postpartum until weaning. Milk production was estimated at 60, 120, and 180 days postpartum by machine-milking. Prepartum weight and condition losses on prairie were similar to the three lower feeding levels on OWB. Weight and condition losses on OWB increased (linear and quadratic P<.05) as the level of supplement was reduced. From calving until the end of supplementation

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in April, cows grazing prairie lost less weight than cows on OWB (-21 kg vs -53 kg, respectively; P<.05). From the end of supplementation until weaning, OWB cows gained more weight than prairie cows (97 kg vs 48 kg, respectively; P<.05). This difference can be attributed to compensatory gain and a relatively poor forage production year on the prairie. Birth weights and weaning weights were not affected by treatment. However, calves on prairie tended to gain more weight than OWB calves (48 kg vs 40 kg, respectively; P<.10) from birth until the end of supplementation while calf gains tended to increase with level of supplement on OWB (P<.10). Milk production during this period reflected this difference in calf gains between prairie and OWB (10.1 kg vs 8.7 kg, respeictively; P<.05). Within OWB treatments, calf weight gain and milk production during supplementation increased linearly with level of supplement (P<.05). During peak grass quality, milk production was not affected by winter treatments but in late summer the 75% and 125% groups produced more milk than the other OWB groups. Cows grazing prairie had a higher conception rate than cows grazing OWB (P<.05). Among cows on OWB, the 25% group had a higher conception rate than the 75 and 125% treatments (P<.10). Conception dates were not affected by forage type but were influenced by level of supplemental protein on OWB. Cows on the 175% treatment conceived later in the breeding season than cows on the 25 and 100% levels (P<.10). Based on the response to supplementation, cows grazing OWB with the 75% supplement level, achieved similar performance as cows consuming prairie. The nutritional value of tallgrass prairie was higher than OWB during the postpartum period until the end of supplementation.

(Key Words: Beef Cattle, Supplementation, *Bothriochloa* spp., Rangeland, Forage.)

Introduction

In recent years, large acreages of old world bluestem (OWB, *Bothriochloa* spp.) have been established in the southern rolling plains and prairies. These introduced grasses establish easily, tolerate drought, yield relatively greater quantities of forage, and tolerate heavy grazing pressure. In addition, most of the forage production occurs after June 1, when tallgrass species are growing at a slower rate

(Sims and Dewald, 1982). This increase in forage production has been found to increase beef production on OWB an additional 45 kg of beef per hectare over sandsage prairie (Sims and Dewald, 1982).

Previous studies have compared forage quality of OWB with tallgrass prairie species during the growing season and during dormancy. These studies have shown that protein becomes limiting for cattle and may hinder animal performance (Anderson and Matches, 1983). Gunter et al. (1995) found that both midgrass prairie and OWB had N content below requirements for a 272-kg medium frame steer gaining .9 kg/d from June to August. It would appear that mature gestating cows would require supplementation from October to April when OWB is less than 7% CP (Anderson and Matches, 1983).

Supplementation of the cow herd is one of the more costly aspects of cow-calf production. Little research has been conducted to determine the amount of supplemental protein needed for spring-calving beef cows grazing OWB. The objectives of this study were to (1) evaluate the performance of spring-calving beef cows grazing OWB and fed different levels of supplemental protein while grazing OWB, and (2) compare cow performance with that of cows grazing tallgrass prairie and supplemented to meet their protein requirements.

Materials and Methods

This study was conducted from November 1993 to September 1994 at the Bluestem Research Range in Payne County, OK (36^{o}N; 97^{o}W). The research site is located 11.3 km west of Stillwater, Oklahoma with an elevation of 330 m. Average long-term annual precipitation is 760 mm, although precipitation was 595 mm during the study (Table 1). Mean long-term annual temperature was 15.5^{o} C and the mean temperature for the study was 15.5^{o} C. Soils for the tallgrass prairie site included Stephenville-Darnell complex, Harrah-Pulaski complex, Stephenville fine sandy loam, and Zaneis-Huska complex. The tallgrass prairie was composed primarily of big bluestem, little bluestem, switchgrass, and indiangrass (*Andropogon gerardii*, *Schizachyrium scoparium*, *Panicum virgatum*, and *Sorghastrum nutans*, respectively). Soils for the OWB site included Grainola-Lucien complex, Grainola-Ashport complex, Pulaski fine sandy loam, and Renfrow loam. The OWB (*Bothriochloa ischaemum* var. Plains) was established in 1989. A single application of 46 kg N/ha (46-0-0 fertilizer) was applied in early May.

Eighty multiparous crossbred cows (average calving date February 16, 1994) were assigned to one of five treatment groups. Cows were allocated to treatment by weight and body condition score (BCS). One group of 20 cows grazed 65 ha of tallgrass prairie and were fed pelleted 41% CP cottonseed meal to supply 100% of their estimated requirements for supplemental protein. The remaining 60 cows were allotted to four groups that grazed a common 81 ha pasture of OWB. The four treatments on OWB were supplemented with cottonseed meal fed in amounts equal to 25, 75, 125, or 175% of the amount fed to the cows grazing tallgrass prairie. The cows were supplemented between November 2, 1993 to April 18, 1994. The initial feeding rate on tallgrass prairie was 1.0 kg/day. This rate was increased by 0.5 kg/day on December 16 and then by another 0.5 kg/d as each cow calved. All cows were individually fed 5 d/week in stalls and had free access to a salt-mineral mixture and water.

Grazing was managed with a 4-paddock rotation on both forage types. During the winter, each paddock was grazed once for a 6 week interval. On April 1, three paddocks on both forage types were burned. Pasture rotations were for 7-10 day intervals at the beginning of the growing season and then were adjusted for each forage type based on utilization score. During the growing season, all pastures were given a forage utilization score (1=little or no use, 5=heavy use; Anderson and Currier, 1973) by two independent observers after cows were rotated. In addition, forage disappearance was monitored in one paddock of each forage type. Forty 0.1 M^2 plots were clipped, dried and then weighed to estimate standing forage DM before and after each rotation through the paddock. Diet samples were collected every 28 d with 4 esophogeally fistulated heifers. Masticates from each collection date were composited across heifers and within forage type. Also, masticates were lyophilized, ground (1-mm screen) and subjected to DM, ash, and CP (N*6.25) determination (AOAC, 1975).

Cows were weighed every 28 d following an 8 h withdrawal from feed and water. Body condition scores (1=emaciated, 9=obese) were also evaluated to the nearest half score by three independent observers. During the calving season, gestating cows were weighed weekly and all cows were weighed and BCS every 14 d. Calves were weighed within 24 h of birth and then were weighed at the same intervals as the mature cows following a 6 h withdrawal of feed and water. All bull calves were banded within 24 h of birth.

Milk yield was estimated by machine milk-out on days 60, 120, and 180 postpartum. Due to time and labor requirements, the herd was divided into two groups which were milked on consecutive days. Calves were removed from the cows at 2200 the night before milking and cows were milked between 0800 and 1300 the following day. An intramuscular injection of 40 IU of oxytocin was administered in the rear quarter immediately prior to milking. Milking was completed in 5 to 12 minutes. Udders were palpated to ensure thorough milk removal. Total milk quantity was weighed then adusted to a 24 h basis.

Cows were naturally serviced by Limousin and Simmental bulls (20 cows per bull). Bulls were placed with cows on May 6 and removed on July 15. During the breeding season, bulls were rotated among the herds every 14 d. Conception rate was determined by rectal palpation 90 days after the bulls were removed. Estimated date of conception was determined based on calving dates assuming a 283 d gestation period.

Statistical analysis. Changes in cow weight, body condition, calf weight, forage type, milk yield, conception rate, and conception date were analyzed by least squares procedures. The model included treatment; no covariates were included. Orthogonal polynomials were used to evaluate linear, quadratic, and cubic responses to supplement level. Analyses which produced P values less than 0.10 were considered significant because of limited observations. LSD's were used to separate individual treatment means.

Results and Discussion

The peak in CP content of OWB in early May followed the application of N fertilizer (Figure 1). Both forages reached maximum CP in early May and then steadily declined. In addition, forages leveled off at 4.6% CP from December to February. IVOMD also peaked in May and declined (Figure 2). Standing herbage mass for OWB was generally higher than tallgrass prairie (Figure 3). Herbage mass of OWB suggested that most of the forage growth occurred after June 1 which agrees with Anderson and Matches (1983). Standing crop on tallgrass prairie was limited by relatively poor growing conditions in

May and June. Monthly precipitation during May and June was 53 and 81% below the long-term average, respectively (Table 1). Forage DM disappearance is illustrated in Appendix A with utilization scores shown in Appendix B.

Prepartum Phase. Weight loss by the prairie cows was similar to losses by OWB cows on the 25, 75, and 125% treatments (Table 2). Among the supplement groups on OWB, weight loss decreased (linear P=.005; quadratic P=.02) as supplementation increased from the 175% to 25% rate. Cows on the 175% treatment maintained weight while the other groups on OWB lost weight (P<.05; Table 2). The 25% group lost more weight (P<.05) than the cows on the 175% feeding level. DelCurto et al. (1990) observed a similar response and concluded that weight losses of gestating, spring calving cows grazing dormant tallgrass prairie were reduced by increasing supplemental CP.

Body condition losses by tallgrass prairie cows was similar to cows on the higher treatments among OWB. The similarity in performance among the tallgrass prairie cows (100% supplement rate) and the OWB cows receiving the 25, 75, and 125% supplementation levels suggests that the nutritional value of the forages were similar during this period. Changes in body condition across the different feeding levels on OWB reflected weight losses of the cows. Other research has shown that increasing the amount of supplemental protein reduces body condition losses (DelCurto et al., 1990; Vanzant and Cochran, 1994).

Postpartum Phase. During the supplementation period following calving, cows grazing tallgrass prairie lost less weight (P<.05) than the cows grazing OWB (Table 2). This response could be attributed to earlier growth of prairie species (Taliaferro et al., 1972). In contrast to the prepartum period, weight loss and body condition for cows grazing OWB was not affected by level of supplemental cottonseed meal (P=.11). Similar weight losses may have resulted from cows on the higher treatment levels on OWB having higher nutritional demands due to higher milk production. The lower treatments continued to lose weight due to the low level of supplement combined with lactation demands. Therefore the net weight change was similar amoung OWB groups. Changes in body condition were similar among all treatments. These responses contradict other research where increased protein supplementation decreased weight and body condition loss in lactating beef cows consuming tallgrass prairie (Scott, 1992; Thirft and Hibberd, 1994; Wagner et al., 1983).

At 60 d postpartum, cows on tallgrass prairie produced more milk than the average of the cows grazing OWB (P=.05). The increased milk production may be attributed to earlier forage growth on prairie and higher BCS. Milk production increased linearly (P<.05) with supplement level on OWB (Table 3). Thrift (1994) and Scott (1992) found that increasing CP level also increased milk yield in fall calving cows.

Calf birth weight was similar for the cows grazing the two forage types and across the supplementation groups on OWB (Table 3). DelCurto et al. (1990) reported a linear increase in birth weights as protein level increased (P=.17). Wettemann et al. (1980) also found that cows which were fed cottonseed meal (41% CP) to lose 3.5% BW had heavier birth weights than cows that lost 14% BW. Calf weight gain during the supplementation period increased linearly (P<.10) with supplementation level on OWB. Wagner et al. (1983) and Thrift (1994) also reported calf weight gains to increase with supplemental protein. Calves on tallgrass prairie gained more weight (P<.05) than the average of calves nursing cows grazing OWB. Calf weight gains reflected dam's milk production.

Postsupplementation to Weaning. Cows grazing OWB gained more weight and BCS than cows consuming prairie (P<.05; Table 2) from the end of supplementation period until weaning. The higher weight and BCS gains for cows consuming OWB can be partially attributed to its ability to tolerate drought conditions and respond to late summer precipitation (Figure 2) but also for compensatory gain by the cows. The weight gain among the OWB groups increased linearly (P<.05). DelCurto et al. (1990) also reported a linear compensation in weight gains. This linear trend may be reflective of the cows maintenance requirements. The low treatment level produced less milk and possibly had smaller organ sizes due to the plane of nutrition in the winter. Both of these factors would reduce maintenance requirements (Jenkins et al., 1984). The lower maintenance requirements mean the surplus of nutrients can go body weight and condition gain.

At 120 d postpartum, milk production was similar among all groups (Table 3). The similar milk yields would indicate that net impact on cows was similar. However, at 180 d postpartum, there was quadratic response (P=.03) and the OWB cows on the 75% group producing more milk than the 175% cows on OWB and cows on prairie (P<.05). Thrift (1994) reported a quadratic response in fall calving beef cows at approximately the same point in their lactation curve.

Calf gains from April until weaning (Table 3) were not affected by forage type. Among OWB treatment groups, calf gain decreased linearly with respect to level of winter supplementation (P<.10). As milk yield decreases calves become more dependent on forage intake (Lusby et al., 1976). Higher calf gains at the lower supplement level may be the result of the calves learning to graze earlier. Other research has shown either no effect of dam's previous winter supplementation on calf ADG or a positive linear effect of protein supplementation on weaning weights (DelCurto et al., 1990; Vanzant and Cochran, 1994). However, in both of these trials, protein supplementation treatments were for the prepartum period only. After calving, all cows were given .83 and 1.0% BW of alfalfa hay daily in those studies.

Cows grazing tallgrass prairie had a higher conception rate than cows on OWB (P<.05; Table 4). This higher conception rate may be attributed to prairie cows losing less weight postpartum. Cows on prairie were able to consume forage which had a slightly higher percent IVOMD than the OWB. The 25% treatment had a higher conception rate than 75 and 125% treatments on OWB (P<.10). This difference in conception rates among cows grazing OWB may reflect weight changes. Cows fed the 25% level gained weight at a faster rate than the other treatments from the end of supplementation until June 1 (.65 and .32 kg/d, 25% and 175% respectively). Wettemann et al. (1986) reported first calf heifers which gained weight had increased ovarian activity and conception rates. Cows on both forage types had similar dates of conception on average (P>.30). Among cows on OWB, conception date increased linearly with level of winter supplementation (P<.10) with cows in the 25% group conceiving earlier than cows in the 175% group (P<.10). This difference in ovarian activity could be attributed to the rate of weight gain prior to breeding. In addition, other studies have documented a decrease in reproductive performance and lengthened postpartum interval in cows receiving levels of protein similar to the 175% treatment (Marston et al., 1995; Sinclair et al., 1994). Elrod and Butler (1993) reported that Holstein heifers fed high levels of protein (soybean meal and urea) had reduced firtst-service conception rates (P<.05) compared of heifers fed to meet their requirement (21.8 and 15.45% CP in the ration respectively).

Implications

Old World bluestem used in a complementary grazing system with tallgrass prairie should allow cow-calf producers to be more efficient. During the prepartum period, cow performance was similar for both forage types. This would indicate that feeding the 75% level was optimal for cows grazing OWB and would produce cow performance similar to cows grazing tallgrass prairie at 100%. If repeatable, this would result in a 25% savings in protein supplementation compared to cows grazing tallgrass prairie. From calving to the end of supplementation, cows grazing tallgrass prairie experienced less weight loss, produced more milk, and had greater calf gains than cows on OWB. In addition, cows grazing tallgrass prairie had higher conception rates than cows consuming OWB. From end of supplementation until weaning , cows grazing OWB had higher body weight, body condition gains, and similar weaning weights. As a result, cows should remain on tallgrass prairie from time of calving until the first of June when OWB forage production begins to exceed tallgrass prairie. From June until weaning cows should remain on OWB to allow stockpiling to occur on tallgrass prairie for winter grazing.

Utilizing OWB in a integrated forage system with tallgrass prairie should allow cow-calf producers to increase their production efficiency by lowering the amount of land and protein supplement required to maintain production goals. These results would suggest that the optimum level of protein supplementation was 75% level for cows grazing OWB during perpartum. Protein supplementation was not able to increase performance of cows grazing OWB to a level similar or greater than cows grazing tallgrass prairie.

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Table 1. Temperature and precipitation from November 1993 to September 1994.

	Current Study			Long-Term Average[a]		
	Temperature, °C		Precipitation, mm	Temperature, °C		Precipitation, mm
Month	High	Low		High	Low	
November	13.3	-0.4	44.7	16.4	2.8	52.1
December	12.0	-0.8	45.0	10.4	-2.3	33.5
January	7.8	-3.9	3.81	8.8	-4.3	27.9
February	10.6	-3.4	39.6	11.6	-2.0	32.3
March	19.0	4.5	59.7	17.2	2.8	55.6
April	23.5	9.0	126.0	22.6	8.9	85.3
May	26.3	14.6	57.8	26.4	14.0	122.3
June	33.6	21.3	19.8	31.3	18.6	102.1
July	33.6	20.7	97.3	34.2	21.4	93.1
August	34.2	20.2	64.0	34.3	20.7	76.5
September	28.6	15.7	34.3	30.0	16.2	94.5

[a] 87 year average.

Table 2. Body weight and body condition score changes for spring calving cows.

Forage type	Old world bluestem					Tallgrass prairie		Probability			
Supplement rate	25%	75%	125%	175%	SE	100%	SE[e]	Forage Type[f]	Linear[g]	Quad[h]	Cubic[i]
Prepartum											
Body weight, kg	-83^{a}	-35^{ab}	-40^{ab}	0^{c}	18.60	-56^{a}	16.11	.37	.005	.02	.24
Condition score[j]	-1.2^{a}	-.9^{ab}	-.7^{ab}	-.6^{b}	.11	-.9^{ab}	.09	.60	.0002	.08	.99
Calving to 4/18/94											
Body weight, kg	-43^{a}	-56^{a}	-53^{a}	-58^{a}	5.69	-21^{b}	4.89	.0001	.11	.14	.39
Condition score	-.8	-.8	-.7	-.7	.16	-.7	.13	.89	.43	.99	.69
4/19/94 to weaning											
Body weight, kg	112^{c}	98^{bc}	87^{b}	92^{b}	4.90	48^{a}	4.20	.001	.02	.64	.50
Condition score	1.8^{a}	1.4^{ab}	1.3^{b}	1.1^{b}	.14	1.0^{b}	.12	.004	.002	.34	.61

[a,b,c,d] Means in the same row with different superscripts differ ($P<.05$).
[e] Standard errors reported represent the largest SE for each variable.
[f] Response to tallgrass prairie vs old world bluestem.
[g] Linear response to increased level of supplemental protein.
[h] Quadratic response to increased level of supplemental protein.
[i] Cubic response to increased level of supplemental protein.
[j] Based on 1=emaciated, 9=obese.

Table 3. Calf weights, weight changes, and cow milk production for calves and cows respectively.

Forage type	Old world bluestem					Tallgrass prairie		Probability			
Supplement rate	25%	75%	125%	175%	SE[c]	100%	SE	Forage Type[d]	Linear[e]	Quad[f]	Cubic[g]
Birth to 4/18/94											
Birth weight, kg	39	41	42	40	1.2	39	1.1	.81	.30	.95	.65
Weight gain, kg	34^{a}	39^{ab}	42^{ab}	44^{ab}	3.7	48^{b}	3.2	.04	.07	.35	.90
4/19/94 to weaning											
Weight gain, kg	146	147	139	137	4.7	140	4.0	.54	.08	.90	.47
Weaning weight, kg	220	229	224	223	6.5	228	5.5	.52	.86	.54	.55
Milk production, kg											
60 d postpartum	7.2^{b}	8.5^{ab}	9.7^{a}	9.3^{a}	.70	10.1^{a}	.60	.05	.03	.21	.66
120 d postpartum	10.0	11.0	11.6	10.0	.85	10.1	.68	.46	.84	.12	.61
180 d postpartum	7.2^{ab}	8.2^{a}	7.9^{ab}	6.7^{b}	.56	6.8^{b}	.44	.15	.42	.03	.85

[a,b] Means in the same row with different superscripts differ (P<.05).
[c] Standard errors reported represent the largest SE for each variable.
[d] Response to tallgrass prairie vs old world bluestem.
[e] Linear response to increased level of supplemental protein.
[f] Quadratic response to increased level of supplemental protein.
[g] Cubic response to increased level of supplemental protein.

Table 4. Conception rates and estimated conception dates for spring calving cows.

Forage type	Old world bluestem					Tallgrass prairie		Probability			
Supplement rate	25%	75%	125%	175%	SE[d]	100%	SE	Forage Type[e]	Linear[f]	Quad[g]	Cubic[h]
Conception Rates, %	77[ab]	46[c]	46[c]	54[ab]	.13	89[a]	.11	.01	.23	.37	.69
Conception Date, 1994	5/26[a]	5/30[ab]	6/5[ab]	6/11[b]	6.6	5/26[a]	6.0	.31	.08	.43	.99

a,b,c Means in the same row with different superscripts differ ($P<.10$).
[d] Standard errors reported represent the largest SE for each variable.
[e] Response to tallgrass prairie vs old world bluestem.
[f] Linear response to increased level of supplemental protein.
[g] Quadratic response to increased level of supplemental protein.
[h] Cubic response to increased level of supplemental protein.

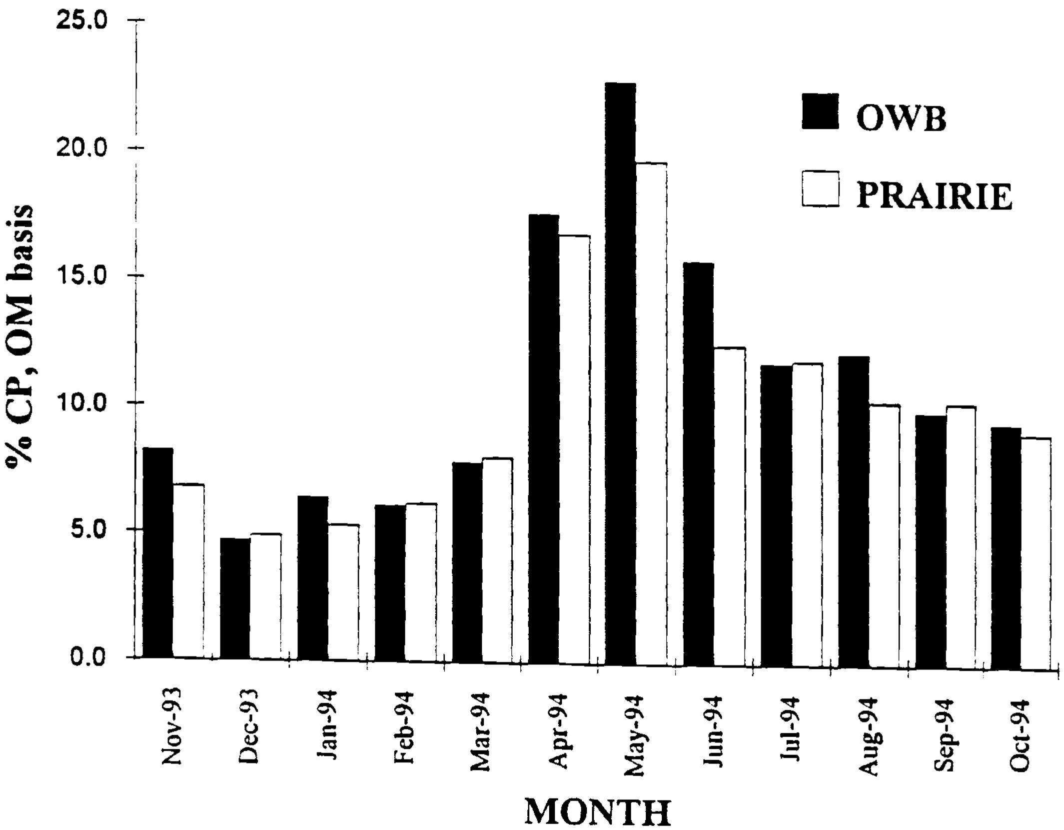

Figure 1. Changes in CP content of old world bluestem (OWB) and tallgrass prairie masticate samples grazed by spring calving beef cows.

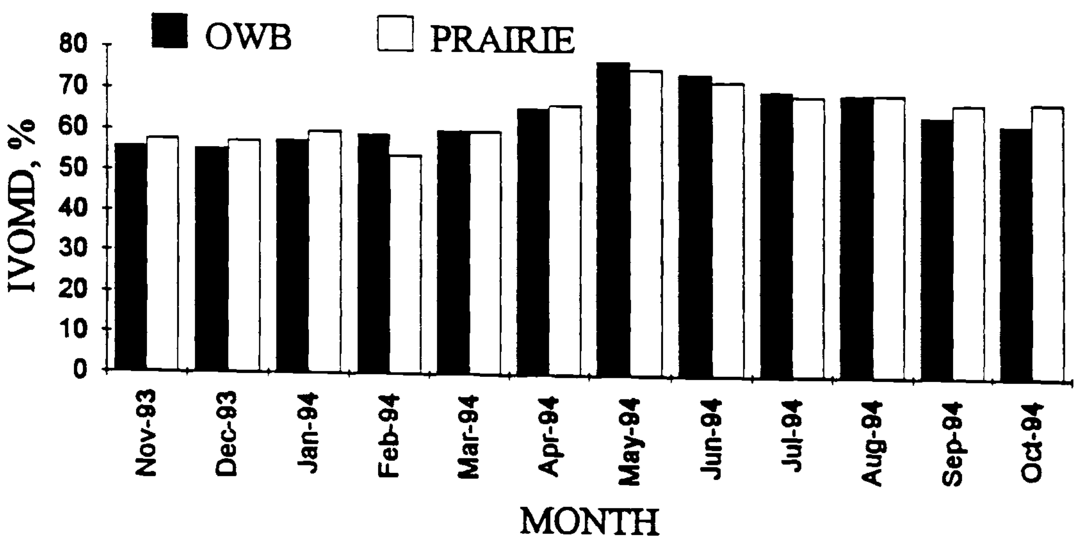

Figure 2. Changes in in vitro OM disappearance (IVOMD) of old world bluestem (OWB) and tallgrass prairie grazed by spring calving beef cows.

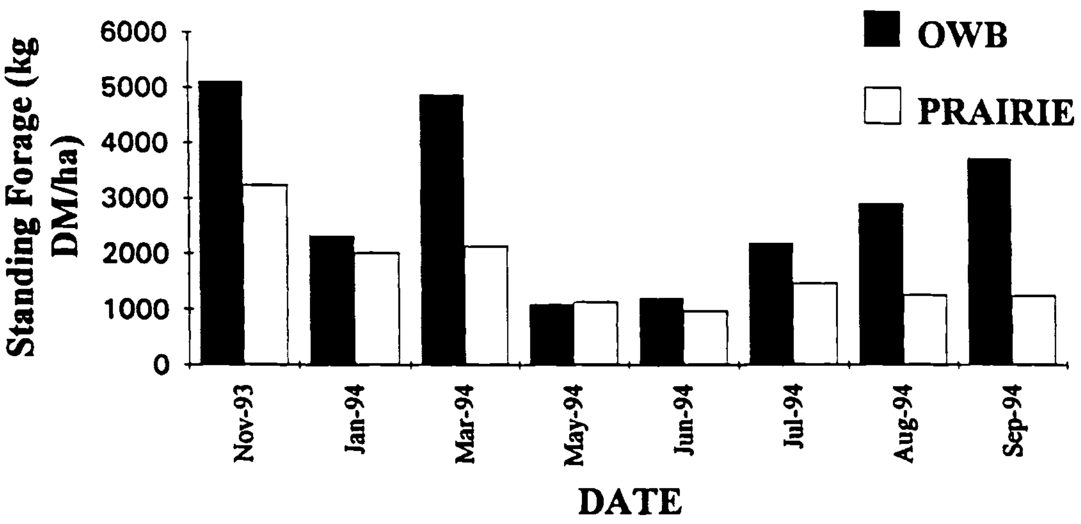

Figure 3. Changes in standing forage (kg DM/ha) for old world bluestem (OWB) and tallgrass prairie grazed by spring calving beef cows.

CHAPTER IV

Running Head: SUPPLEMENTAL PROTEIN AND FORAGE UTILIZATION

Supplemental Protein Levels for Spring Calving Beef Cows Grazing Old World Bluestem or Tallgrass Prairie: Forage Utilization[1]

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ABSTRACT

Eighty pregnant crossbred beef cows were assigned to one of five treatments. Twenty cows grazed tallgrass prairie and were fed cottonseed meal cubes (41% CP) to meet 100% of their estimated requirement for supplement protein. Sixty cows grazed old world bluestem (OWB) and were fed cottonseed meal at either 25, 75, 125, or 175% of the rate fed to the cows on tallgrass prairie. All cows were individually-fed the protein supplement 5X per week. Eight cows were randomly selected from each treatment group to estimate forage intake and digestibility during the last third of gestation and 30 d postpartum (December 15 to 18, 1993 and March 15 to 17, 1994). During gestation, OWB had significantly greater forage OM digestibility and total diet OM digestibility than prairie (P=.0001, Table 2) and cows grazing OWB had higher total digestibile OM intake (P=.02). Forage OM intake was not influenced by level of supplemental protein during gestation. During the lactation phase, fecal output was not effected by forage type (P=.38) but was increased as level of supplement increased on OWB (P=.003,

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Table 3). Because of differences in estimated digestibility, forage OM intake (kg/d) was higher for cows grazing OWB than for cattle consuming prairie (P=.04). Also, forage intake increased among treatments on OWB (P=.03 and .04, linear and cubic respectively). On average, total OM intake (kg/d) was greater for lactating cows consuming OWB than for prairie (P=.04) and increased as supplement level increased (P=.04 and .04, linear and cubic, respectively). Forage OM digestibility was greater for OWB than for prairie (P=.0001) and increased as supplement amount was increased on OWB (P=.06 and .07, linear and quadratic respectively). Total diet OM digestibility followed similar patterns. Digestible OM intake was greater on OWB (P=.0002) and increased linearly among treatments on OWB (P=.0001). Based on forage digestion and intake, the optimum level of protein supplementation, during both gestation and lactation, was the 75% treatment for cows grazing OWB.

(Key Words: Cattle, *Bothriochloa* spp., Rangeland, Intake, Digestibility, Protein)

Introduction

Dormant old world bluestem (*Bothriochloa* spp., OWB) (Sims and Dewald, 1982) and tallgrass prairie (Waller et al., 1972) are both deficient in protein for the last third of gestation and during lactation of beef cows (NRC, 1984). As a result of this protein deficiency, supplemental protein improves cow performance (DelCurto et al., 1990; Marston et al., 1995; Scott, 1992; Thrift and Hibberd, 1994).

Old world bluestem has a relatively large proportion of stem and dead material as it approaches senescence (Forbes and Coleman, 1993). This low quality forage has also been found to have high NDF levels (NDF >60%) which may contribute to depressed intake (Anderson and Matches, 1983; Dabo et al., 1988). In addition to high NDF, digestible organic matter content may also limit animal performance (Gunter et al., 1995). Gunter et al. (1995) also found that midgrass prairie and OWB were unable to meet nitrogen (N) requirements for ruminal bacteria during the majority of the growing season. Protein supplementation has been shown to increase in forage intake and digestibility for cattle consuming native prairie grasses (DelCurto, 1990; Marston and Lusby, 1995; McCollum and Galyean, 1985). The objective of this study was to quantify the effects of supplemental protein on the intake and digestibility of dormant OWB and tallgrass prairie by gestating and lactating beef cows.

Materials and Methods

This study was conducted from November, 1993 to September, 1994 at the Bluestem Research Range, Stillwater, OK. The site description has been reported (Lawrence, 1995). Eighty spring calving crossbred cows (average calving date February 16, 1994) were allotted to one of five treatments on November 2, 1993. Twenty cows were randomly placed on 65 hectares of tallgrass prairie and received 100% of their estimated supplemental protein needs from 41% CP cottonseed meal pellet. Sixty cows were placed on 81 hectares of Old World bluestem (*Bothriochloa ischaemum* var. Plains) and received either 25, 75, 125, or 175% of the amount fed to cows grazing tallgrass prairie. Cattle and forage management have been previously reported (Lawrence, 1995). Cow weight and body condition changes as well as calf gain and milk production have been reported (Lawrence, 1995).

Trials were conducted from December 11 to 18, 1993 (gestation) and March 11 to 18, 1994 (lactation) to estimate forage intake and digestion. During the gestation trial, eight cows were randomly selected from each treatment (total n=40). The cows remained with the larger herds grazing OWB and prairie pastures (20 and 16 ha, respectively). These paddocks had been grazed since November 2, 1993. For the lactation trial, eight cows per treatment were selected that had calved at approximately the same date and were 30d postpartum. The paddocks grazed during this trial had been occupied since March 4, 1994. Fecal output was estimated with chromic oxide and forage indigestibility by ADL. A chromic oxide pellet (.48 cm) containing 76% wheat midds, 4% molasses, and 20% chromic oxide (as-is) was top dressed (100 g/cow) on the supplement each morning at 0800 throughout adaptation and fecal sampling. During these trials, the cows were individually fed in stalls 7 d a week. Chromic oxide was administered for a 5-d adaptation period followed by a 3-d sampling period. Fecal grab samples (n=6, 600g as-is/sample) were collected twice daily (0700 and 1900) and frozen (-25^{o} C). Following the study, fecal samples were thawed, composited by cow, lyophilized, and ground (1-mm screen). Diet samples were obtained for each forage type on two consecutive days with 4 esophageally fistulated heifers. Samples were placed on ice in the field and then frozen (-25^{o} C) prior to lyophilization and grinding (1-mm screen). Masticate samples were composited across day and heifers within forage type.

Fecal, diet, and supplement samples were analyzed for dry matter and ash (AOAC, 1991), NDF and ADF (Goering and Van Soest, 1970), and Kjeldahl N (AOAC, 1991). Chromium content of fecal samples and the chromic oxide pellet were analyzed by atomic absorption spectrophotometry using an oxygen-acetylene flame. Lignin content of all samples was determined with the ADL procedure of Goering and Van Soest (1975). Forage intake and digestibility were calculated as outlined by Kartchner (1981).

In vitro organic matter disappearance (IVOMD) from diet samples was determined using modified 48 hr Tilley and Terry (1963) in vitro procedure. The procedure was modified by including trypticase as a protein source in the buffer during the initial step. Rather than an acid-pepsin digestion, the second stage was a cell wall extraction (Van Soest and Wine, 1967). Incubation tubes were inoculated with a 10 ml of rumen fluid, 40 ml of medium and 2 ml of reducing solution. Ruminal fluid was collected from ruminally cannulated cows maintained on prairie hay and the 100% supplement level.

Statistical Analysis. All forage utilization variables were analyzed by least squares procedures. Orthogonal polynomials were used to evaluate forage type, linear, quadratic, and cubic responses to level of protein supplement. The model included treatment; no covariates were included. LSD's were used to separate individual treatment means. Each trial was analyzed independently.

Results and Discussion

The CP content of the esophageal masticates during the intake studies was similar for both forage types during the gestation trial (4.7, and 4.9%; OWB and prairie, respectively, Figure 1) and the lactation trial (7.8%, and 7.9% respectively). Neutral detergent fiber content was greater than 60% for both forages (74.53 and 69.34% for OWB and prairie respectively, Table 1). The lignin content of the masicates were one percent lower for the OWB during both intake studies (6.24 and 7.20%, and 7.01 and 8.32% for OWB and prairie, and gestation and lactation respectively). A possible explanation for the increase in both CP and lignin during the lactation trial where the combined influence of weather and changes in species composition of the diet. For the lactation trial, esophageal fistulated heifers were selecting for green forage from downy brome. Also snow covered the forages for a 3-d period one week prior to the intake study. This would have leached the readily soluble nutrients, thereby increasing the percent of lignin in the standing dead forage.

Gestation Trail. Fecal OM output (kg/d) was similar for all treatments (Table 2). Fecal output expressed as percent of body weight are within the range for normal estimates (.58 to 1.32% of BW) for beef cattle (Owens et al., 1991).

The forage type did not effect forage OM intake (P>.40; Table 2). Forage OM intake was not affected by level of protein supplementation (linear, P=.42). This response contrasts other studies where supplemental protein increased forage intake (DelCurto et al., 1990; Marston and Lusby, 1995; McCollum and Galyean, 1985). However, others have noted no response, or a decrease of intake, with supplemental protein (Thirft, 1994; Vanzant and Cochran, 1994, respectively). A possible explanation for the lack of response to level of supplement could be the quality of available forage. Based on clipping data, the estimated DM disappearance/cow/d was 13.7 kg for cows grazing OWB (Appendix A) which is similar to the intake estimates (Table 2). This would suggest that forage availability may have limited the intake response. The gestation trial was conducted after the six weeks of grazing in the paddocks. Cattle will graze selectivily. For instance, Ellis (1978) found a large percent of stem in hand-clipped samples of dormant Coastal bermudagrss (66 and 34% respectively for stem and leaf), but the diet consumed by the cattle contained 18% stem and 82% leaf. Intake is the product of grazing time, bite size, and rate of biting (Forbes, 1987). If cows selectively graze leaves, then the bite size and rate of bites would be decreased after six weeks in one pasture due to limited availability of the desired forage parts. Hence, the only way intake can be maintained would be to increase grazing time. Cattle do most of their grazing during daylight hours and in December when daylength is short, grazing time is limited. In addition, supplement may produce a satiety response, especially at the higher intakes. This satiety response, combined with a short day length, may have reduced grazing time under conditions in which grazing time had to be maximized in order to maintain intake. It was casually observed that cows in the 25% treatment were more reluctant to be moved to the feeding area than cows in the higher feeding levels. Adams (1985) reported that steers which were supplemented had lower forage intakes and grazed 2 to 4 hr shorter than steers which were not supplemented.

Forage OM digestibility was higher for OWB than prairie (P=.0001; 52.3 and 46.5% respectively). The IVOMD was numerically higher for OWB than prairie (57.2 and 55.3% respectively, Figure 2), which supports the digestibility values. Increasing supplemental protein did not influence forage OM digestibility among cows grazing OWB (linear, P=.87). These results contrast findings of other studies where supplemental protein increased forage digestibility (Marston and Lusby, 1995; McCollum and Galyean, 1985; Scott, 1992; Thrift, 1994). Total diet OM digestibility was higher for OWB (P=.0001, Table 2). This increase is due to both forage OM digestibility and the increased level of supplement. A possible explanation for the lack of response in forage OM digestibility to supplementation level could be the quality of the consumed forage. The DOM:CP ratio of the basal forage has been suggested as an indicator of supplemental protein needs (Moore et al., 1991). High ratios (>8.0) indicate a deficiency of protein relative to energy in the rumen. The total diet DOM:CP showed that the 25 and 75% treatments had ratios of 9.86 and 8.11, respectively, while the other treatments were under 7.0 (Table 2). The 25% level may have been sufficient to correct protein deficiency, resulting in similar forage OM intakes and digestibilities among cows grazing OWB.

On average, cows grazing OWB tended to have higher total digestible OM intake than cows consuming prairie (P=.03, Table 2). The 175% treatment did have a higher total digestible OM intake than cows grazing prairie (P<.05). Total digestible OM intake was not affected by supplement level on OWB (P=.40). The difference between required TDN and total digestible OM intake (kg/d) illustrates these same relationships (Figure 3). This difference could be attributed to the 75% extra supplemental protein fed to the 175% treatment, since forage OM intakes were similar.

Lactation Trial. Fecal output (kg/d) was not influenced by forage type (P=.38, Table 3). Among cows grazing OWB fecal output was increased as supplement level increased (P=.003) and the 175% treatment had higher fecal output than the 25% treatment (P<.05). The linear increase in fecal output was accompanied by a linear increase in forage OM intake with level of supplement (Table 3). Marston and Lusby (1995) reported a similar same relationship between hay DM intake and fecal output.

Forage OM digestibility (%) was higher for cattle grazing OWB than prairie (P=.0001). Among the OWB treatments, forage OM digestibility increased as supplement level increased (linear, P=.06 and quadratic, P=.07) with the 25% treatment having the lowest forage digestibility compared to the other treatments. The increase in forage digestibility by increasing protein supplementation is the result of increasing nitrogen supply to rumen microbes (McCollum and Galyean, 1985).

Forage OM intake (kg/d) was greater for cows grazing OWB (P=.04). The increase on forage OM intake by cows grazing OWB was due to the higher OM digestibility of OWB. Forage OM intake responded (linear, P=.03 and cubic, P=.04) to supplement treatments on OWB.

Forage OM intake (kg/d) was numerically lower during lactation compared to gestation. This contrasts findings reported by Marston and Lusby (1995), Ovenell et al. (1991), and Stanley et al. (1993). However, Ovenell et al. (1991) recorded that hay DM intake was similar between lactating and nonlactating (P=.19) when expressed as quantity consumed (kg). In this study, if compared at equal diet digestibility, the lactation intake would have been higher than the gestation intake.

On average, cows consuming OWB had higher total OM intake (kg/d) than cows grazing prairie (P=.04, Table 3). This elevated OM intake can be attributed the increase in forage OM intake. Among cows grazing OWB, there was an increase in total OM intake as supplement level increased (linear, P=.0001 and cubic, P=.04). The increase in OM intake is partially due to improved forage OM digestibility but primarily associated with higher fecal output.

Forage type had a significant effect on digestible OM intake (kg/d) with cows grazing OWB having higher intakes (P=.0001, Table 3) than cows grazing prairie. The 25% OWB treatment and cows grazing prairie had similar differences between TDN required and digestible OM intake (Figure 4). Among cattle grazing OWB, as the level of supplement was increased so was the digestible OM intake (P=.0001).

The ratio of digestible OM:CP intake (kg/d) were all below 4, suggesting that protein was not limiting performance. Cows grazing prairie had the lowest ratio and the 75% treatment had the highest, numerically (2.43 and 3.60, respectively). Gunter et al. (1995) suggested that additional energy may improve animal performance by increased ruminal nitrogen efficiency. If ruminally degraded OM is lacking the microbes will not have the necessary substrates to synthesis microbial protein.

Implications

During gestation, forage OM digestibility and digestible OM intake were higher for cows grazing OWB. Increasing the level of protein supplementation to cows grazing OWB had no effect on forage OM intake. These results would indicate that during gestation cows grazing OWB would have adequate total digestible OM intakes, if supplemented at the 75% level. This is in agreement with the production data reported by Lawrence (1995).

During lactation, forage OM intake and digestibility, and total digestible OM intake was higher for cows grazing OWB. Also forage OM intake, digestibility, and digestibile OM intake were increased with additional supplement intake. The total digestible OM:CP intake for all treatments were below 4.0, suggesting that protein was not the first limiting nutrient in the rumen. Results suggest that, during lactation, cows grazing OWB have higher total digestible OM intake than cows consuming prairie. Based on forage consumption , the optimum level of protein supplementation needed would be 1.75 kg/d (75% level) for cows grazing OWB. Also the data indicated that energy was potentially limiting in all treatments and that by supplying a small amount of energy could enhance performance.

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Table 1. Percent of acid detergent fiber (ADF) and neutral detergent fiber (NDF) of masticate samples, expressed on organic matter basis, for each forage type during the study.

Forage type	Old World bluestem		Tallgrass prairie	
Month	ADF	NDF	ADF	NDF
November 1993	35.21	65.62	40.16	58.34
December 1993	42.93	74.53	43.90	69.34
January 1994	41.36	71.22	44.92	67.05
Febuary 1994	39.60	68.69	41.33	63.08
March 1994	39.20	67.11	41.74	62.67
April 1994	32.60	56.54	33.02	54.65
May 1994	27.49	49.39	31.52	55.01
June 1994	31.71	61.92	33.93	59.43
July 1994	32.36	63.47	33.92	52.40
August 1994	33.53	63.02	32.26	56.08
September 1994	33.68	64.75	27.68	44.02
October 1994	36.75	61.67	31.29	48.32

Table 2. Effect of protein supplementation on forage digestibility and intake by gestating beef cows grazing old world bluestem or tallgrass prairie.

Forage type	Old world bluestem					Tallgrass prairie		Probability			
Supplement rate	25%	75%	125%	175%	SE[c]	100%	SE	Forage[d]	Linear[e]	Quad[f]	Cubic[g]
Fecal output, kg OM/d	6.4	6.9	6.4	6.7	.28	7.0	.28	.16	.83	.67	.25
Forage OM intake, kg/d	13.2	13.8	12.6	12.7	.65	12.5	.65	.44	.34	.74	.30
Forage OM intake, %BW	2.28	2.44	2.23	2.22	.11	2.19	.11	.41	.42	.45	.25
Total OM intake, kg/d	13.5	14.6	13.8	14.4	.65	13.5	.65	.44	.53	.74	.30
Forage OM digestibility, %	52.3[a]	52.0[a]	52.3[a]	52.4[a]	1.1	46.5[b]	1.1	.0001	.87	.88	.88
Total diet OM digestibility, %	52.5[a]	52.6[a]	53.2[a]	53.6[a]	1.0	47.7[b]	1.0	.0001	.39	.88	.86
Digestible OM intake, kg/d	7.1[ab]	7.7[a]	7.4[ab]	7.8[a]	.41	6.5[b]	.41	.03	.40	.83	.40
Digestible OM intake, %BW	1.23[ab]	1.36[a]	1.30[ab]	1.35[a]	.07	1.13[b]	.07	.02	.32	.56	.34
Digestible OM:CP intake, kg/d	9.86	8.11	6.73	6.00		6.44					

[a,b] Means in the same row with different superscripts differ (P<.05).
[c] Standard errors reported represent the largest SE for each variable.
[d] Response to tallgrass prairie vs old world bluestem.
[e] Linear response to increased level of supplemental protein.
[f] Quadratic response to increased level of supplemental protein.
[g] Cubic response to increased level of supplemental protein.

Table 3. Effect of protein supplementation on forage intake and digestibility by lactating beef cows grazing Old World bluestem or Tallgrass prairie.

Forage type	Old world bluestem					Tallgrass prairie		Probability			
Supplement rate	25%	75%	125%	175%	SE[d]	100%	SE	Forage[e]	Linear[f]	Quad[g]	Cubic[h]
Fecal output, kg OM/d	6.6^{a}	7.4^{ac}	7.0^{ac}	8.6^{b}	.38	7.8^{bc}	.38	.38	.003	.28	.07
Forage OM intake, kg/d	10.5^{a}	12.3^{ab}	11.1^{a}	13.2^{b}	.66	10.2^{a}	.66	.04	.03	.85	.04
Forage OM intake, %BW	2.45^{ab}	2.79^{a}	2.38^{b}	2.63^{ab}	.13	2.30^{b}	.13	.08	.83	.70	.02
Total OM intake, kg/d	11.1^{a}	13.8^{b}	13.5^{b}	16.5^{c}	.66	12.1^{ab}	.66	.04	.0001	.85	.04
Forage OM digestibility, %	38.9^{a}	44.8^{b}	45.2^{b}	44.2^{b}	1.8	31.0^{c}	1.8	.0001	.06	.07	.65
Total diet OM digestibility, %	40.0^{a}	46.4^{b}	48.0^{b}	47.5^{b}	1.5	35.6^{c}	1.5	.0001	.001	.03	.68
Digestible OM intake, kg/d	4.4^{a}	6.4^{b}	6.6^{b}	8.0^{c}	.39	4.4^{a}	.39	.0001	.0001	.45	.09
Digestible OM intake, %BW	1.0^{a}	1.5^{b}	1.4^{b}	1.6^{b}	.08	$.99^{a}$	.08	.0002	.0001	.16	.07
Digestible OM:CP intake, kg/d	3.10	3.60	3.51	3.54		2.43					

[a,b,c] Means in the same row with different superscripts differ ($P<.05$).
[d] Standard errors reported represent the largest SE for each variable.
[e] Response to tallgrass prairie vs old world bluestem.
[f] Linear response to increased level of supplemental protein.
[g] Quadratic response to increased level of supplemental protein.
[h] Cubic response to increased level of supplemental protein.

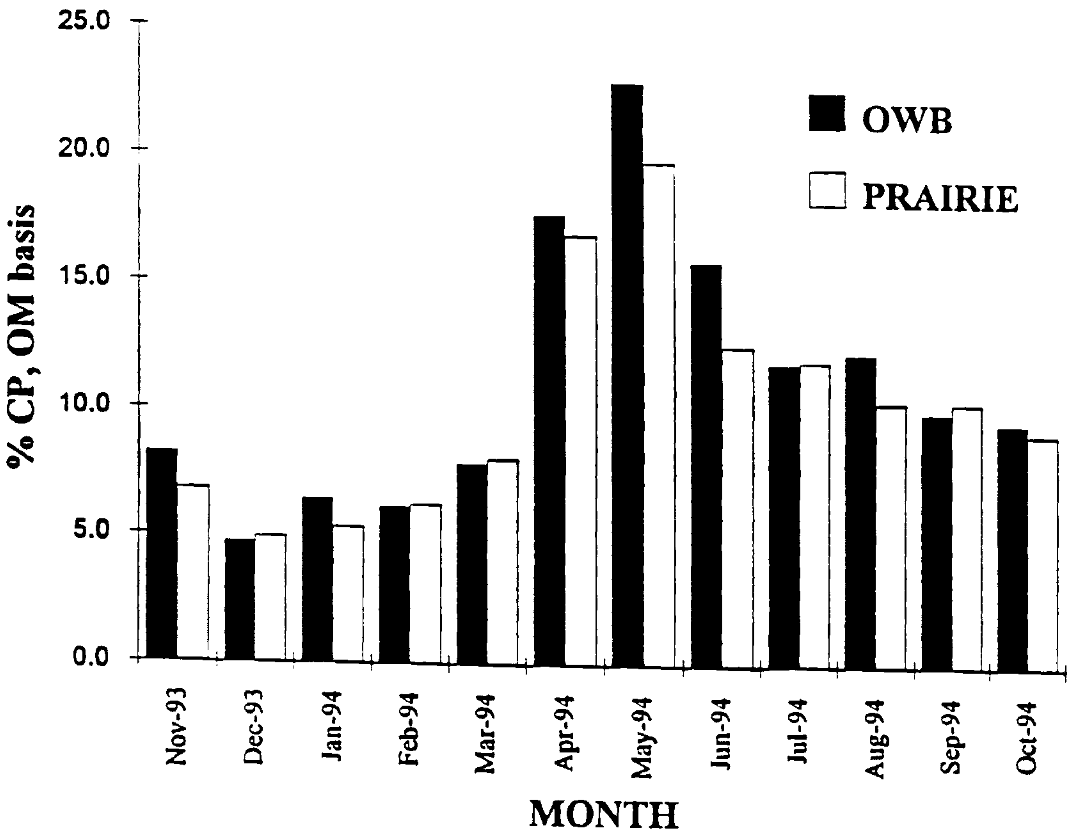


Figure 1. Changes in CP content of old world bluestem (OWB) and tallgrass prairie masticate samples during the study.

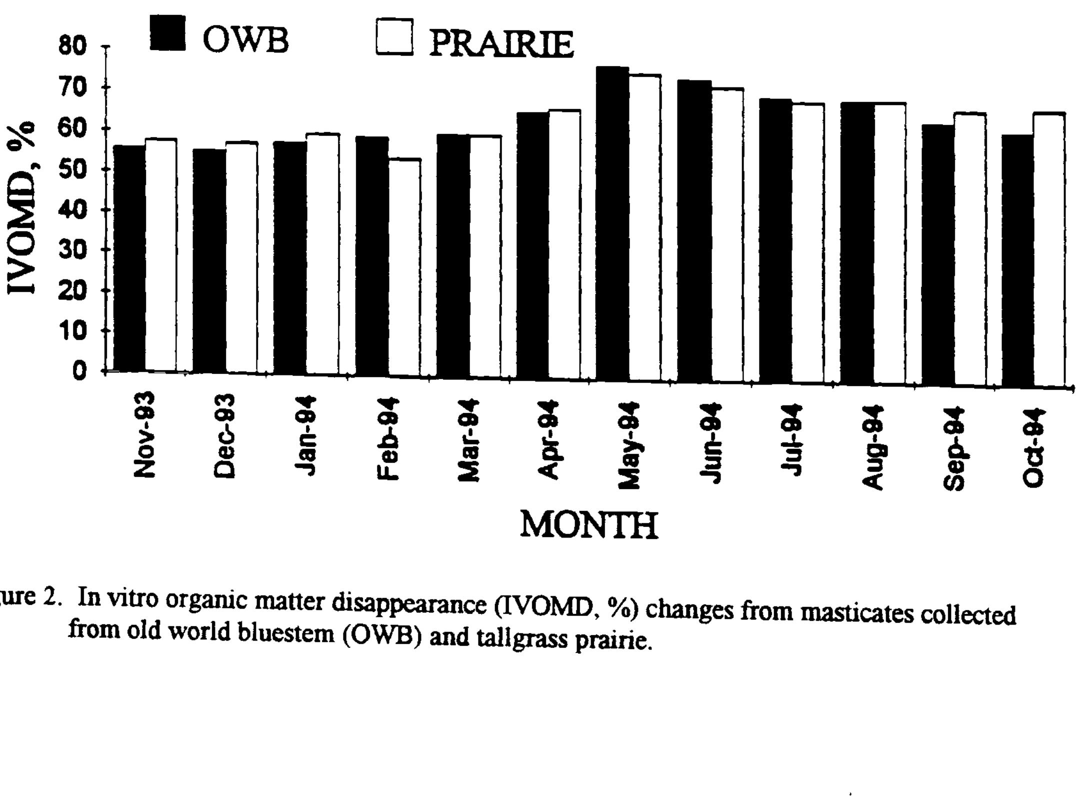


Figure 2. In vitro organic matter disappearance (IVOMD, %) changes from masticates collected from old world bluestem (OWB) and tallgrass prairie.

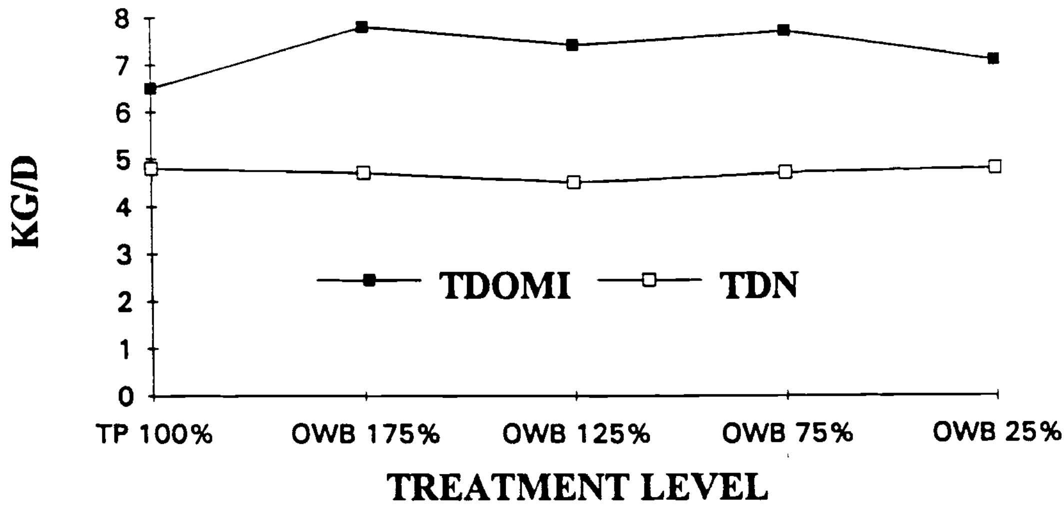


Figure 3. Comparison of total digestible organic matter intake (TDOMI) by cows grazing and total digestible nutrients (TDN) requirements of mid-gestating beef cows (NRC, 1984).

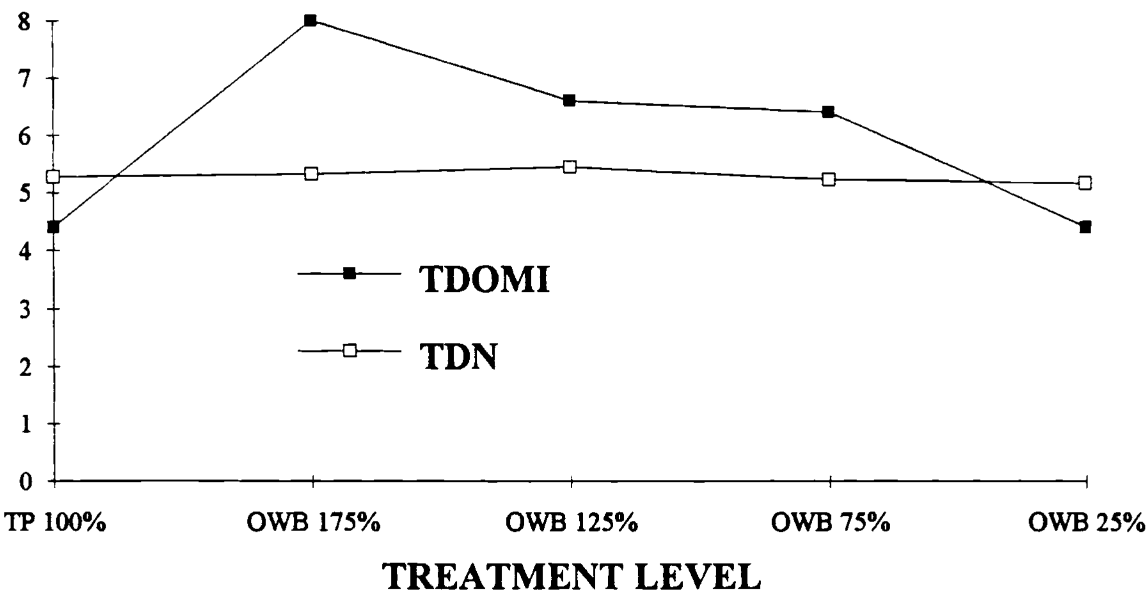


Figure 4. Comparison of total digestible organic matter intake (TDOMI) by cows grazing and total digestible nutrients (TDN) requirements of lactating beef cows (NRC, 1984).

CHAPTER V

SUMMARY AND CONCLUSIONS

In recent years, large acreages of old world bluestem (*Bothriochloa* spp., OWB) have been established in the southern rolling plains and prairies. Old World bluestem has been found to be deficient in protein for spring calving beef cows in late gestation or lactation. Supplemental protein is required to maintain cow performance. The level of protein supplementation needed to obtain adequate performance has not been quantified.

An experiment was conducted to determine the amount of protein supplementation required by beef cows grazing dormant OWB to achieve adequate performance levels. In this study, forage type (OWB or tallgrass prairie) and level of supplemental protein did influence cow performance. Prepartum weight and condition losses on prairie were similar to the three lower feeding levels on OWB. Weight and condition decreased as the level of supplemental protein was increased. These results suggest that for cows grazing OWB, during this trial, supplementation with 75% the level of prairie optimized weight and condition loss. But subsequent milk production and calf gains suggest that the additional condition noted with higher supplementation may be beneficial during the postpartum period.

From calving until end of supplementation in April, cows grazing prairie lost less weight than cows consuming OWB. Calf birth weights were not influenced by either forage type or level of supplementation. However, calves on prairie tended to gain more weight than OWB calves from birth until the end of supplementation, while calf gains tended to increase with level of supplementation on OWB. Milk production reflected calf gains. Cows grazing OWB did not perform as well as cows grazing tallgrass prairie from calving until end of supplementation. Among cows consuming OWB, increasing amount of supplement resulted in increased performance. OWB cows gained more weight than prairie in the summer.

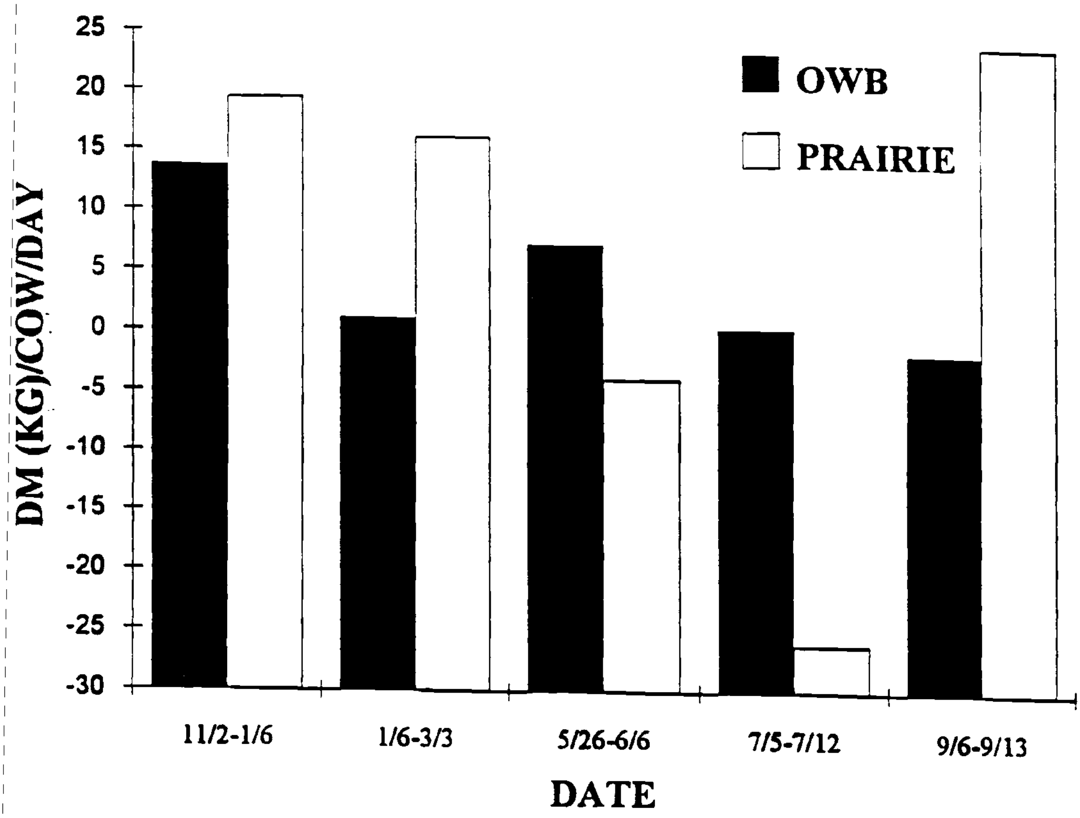
Also, summer weight gain was higher for cows fed the low levels winter supplement. Calf weaning weights and gains were similar for all treatments during this time period. Milk was similar for all cows in early summer, but in late summer cows fed the two moderate winter supplement levels produced more milk than the other two OWB groups.

Cows grazing prairie had higher conception rates than cows on OWB. Supplement levels also affected conception rates, among OWB cows, with the lowest supplement level having the highest conception rate. Conception date was not influenced by forage type but was affected by level of supplement on OWB. Cows consuming the highest level conceived later in the breeding season than the lowest level. Cows and calves grazing OWB from end of supplementation until weaning were able to achieve greater weight gains than those grazing prairie. This difference can be attributed to compensatory gain by the OWB cows and a relatively poor forage conditions on the prairie. However, as suggested by the reproductive data, this compensation on OWB may have occurred too late in the breeding season to maintain adequate rebreeding performance.

A study was conducted to quantify the effects of supplemental protein on utilization of low quality forage by gestating and lactating beef cows. Intake studies were conducted during late gestation and during peak lactation (30 d postpartum) to determine the intake and digestibility response to forage type and supplementation of protein. During gestation, forage type influenced forage and total diet OM digestibility, with higher digestibility for OWB. Cows consuming OWB had a greater total digestible OM intake than cows grazing prairie. Increasing level of protein supplementation had no effect on forage intake. During lactation, cows grazing OWB had higher forage digestibility, intake, and digestible OM intake than cows grazing prairie. Among cows consuming OWB, as level of protein supplement increased, there was an increase in forage intake, fecal output, and digestible OM intake. Based on forage digestion and intake, the optimum level of protein supplementation for both phases of production was the 75% level. This is in agreement with the performance data.

APPENDIX

ACCESSORY DATA TABLES AND FIGURES



Appendix A. Forage dry matter (DM) disappearance per cow per day for each forage type throughout the study.

Appendix B. Estimated utilization of key grass species during the 1994 growing season.

	Forage Type	
	Tallgrass Prairie	Old World bluestem
Date	Utilization Score[a]	Utilization Score
June 8	1.70	3.20
June 17	1.98	2.11
June 28	2.38	3.05
July 8	2.33	2.83
July 20	2.83	2.66
August 3	3.02	3.07
August 15	3.04	2.93
September 1	2.48	2.67
September 13	3.02	2.57
September 27	3.34	3.07

[a] 1=Light or no use of key species; 5=Heavy use of key species.

VITA

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Master of Science

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