Forage Quality Influences Beef Cow Performance and Reproduction

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Introduction

Among the factors which influence the profitability of a cow/calf producer are 1) the yearly feed and nonfeed costs of keeping a cow, 2) the number of cows exposed to the bull that wean a calf, 3) the weaning weight of calves and 4) the price received for calves and cull cows (Rasby and Rush, 1996). Unlike the swine and poultry industries, the beef industry in the Western United States is dynamic and ever changing because of arid environments and the subsequent effects of unpredictable precipitation on forage quantity and quality. The western ranch is usually more extensive in nature and optimal livestock production is a function of the forage resources each ranch has available and how successfully the manager can match the nutritional needs of the cowherd to the available forage (Del Curto et al., 2000). It appears that successful producers are able too demonstrate a balance between input costs for the cowherd and production. The aim of this paper is to review research focused at understanding how forage quality, especially crude protein and energy influences reproductive efficiency of the beef cow.

Reproductive Expectations of the Range Cow

For a producer to ensure that each cow calves on a yearly basis, cows are required to conceive within 83 days after parturition. Because body condition score at calving influences return to estrus, it is suspected that many cows have not resumed their estrous cycles by this point (Selk et al. 1988). The energy requirements necessary to support follicle growth, ovulation and early pregnancy are extremely low compared to requirements for maintenance, milk production and growth (O'Callaghan and Boland, 1999). Two factors, which influence return to estrus by the cow, are nutritional status during the breeding season and suckling stimulus by the calf (Lamb, 1999). Richards et al. (1986) concluded that body condition at parturition was the determining factor related to re-initiation of postpartum estrous cycles in the beef cow. However, in dairy cows, it has been shown that a further loss of body condition during lactation may be even more closely related to reproductive failure than body condition at parturition (Oldick and Firkins, 1996). Increased loss of bodyweight following parturition has been shown to decrease ovarian activity (Staples et al, 1990) and increase the number of days to conception (Heinonen et al., 1988).

The consumption of diets very high in crude protein during lactation has been suggested to influence reproductive performance. Probably more correctly, when the amount of energy available to rumen microbes is insufficient and excess ammonia is present, decreased fertility may occur. These problems can be partially alleviated by feeding protein that is less degradable in the rumen or by feeding less dietary protein.

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The level of milk production will also influence the quantity of absorbed protein excreted in the milk and may indirectly influence the amount of urea produced and subsequent fertility (Oldick and Firkins, 1996). Staples et al. (1992) suggested that dairy cows which experienced stress (high milk production, increased negative energy status, lower immune function and reproductive health problems) may be more likely to respond in a negative manner to high dietary crude protein or degradable intake protein.

Moore and Kunkle (2000) summarized the requirements for crude protein and total digestible nutrients (TDN) for different production classes of beef cattle (Table 1). Using requirements for crude protein and TDN, the ratio of these nutrients should be between approximately 6 and 8. For example, lactating cows grazing native range with a protein content of 5% and a TDN content of 45% would have a ratio of 9, which would suggest supplemental protein would be necessary.

Table 1 . Requirements for Crude Protein (CP) and Total Digestible Nutrients (TDN), and the Resulting TDN:CP Ratio for Beef Cattle (from Moore and Kunkle, Univ. of FL 2000).

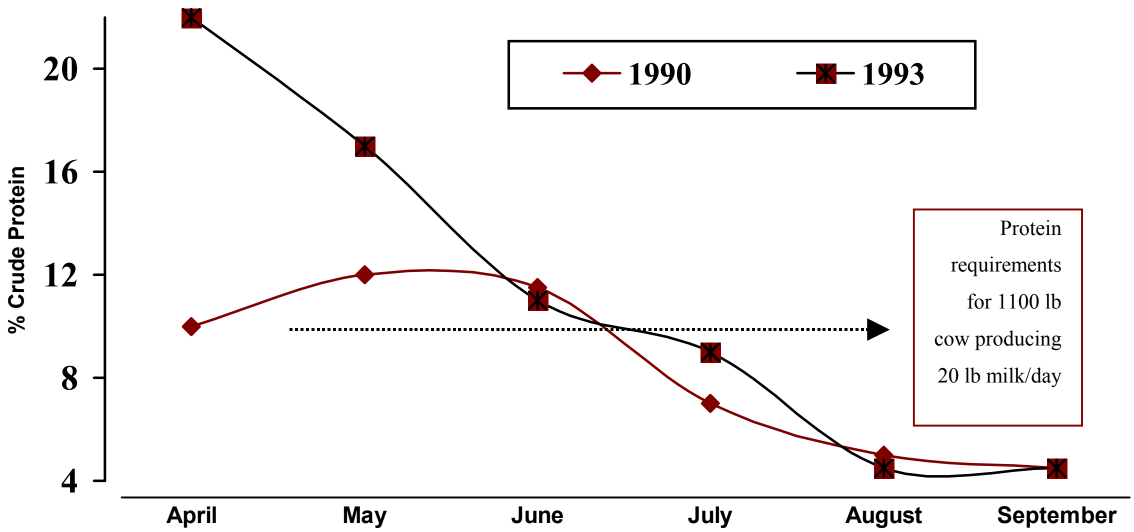
Animal	**Requirement (% of DM)**		**TDN:CP Ratio**
	CP	**TDN**	
Heifer, 800 lb body weight (BW):			
Non-Pregnant, 0 lb gain/day	7	54	7.7
Pregnant, 1.0 lb gain/day	8	55	6.9
Heifer, 600 lb BW, 1.25 lb gain/day	9	59	6.6
Lactating Cow, 1000 lb BW, 15 lb milk/day	11	62	5.6

Matching Forage Quality with the Nutrient Requirements of the Range Cow

Much of the land area in the western states fits the general classification of "rangeland" and is not suitable for tillage because of arid conditions, shallow and rocky soils, and a short growing season (Del Curto et al. 2000). Year to year precipitation influences forage quality. Figure 1, illustrates how the crude protein content of diets selected by cattle in the northern Great Basin differed across years and seasons. The average rainfall in 1990 was approximately six inches compared to 1993, which received approximately 21 inches of rainfall. These authors also estimated when the forage crude protein content would not support the requirements for a lactating cow producing 20 lbs of milk/d. If a cow produced 20 lbs of milk/d then crude protein content would be below requirements after June of 1993. However, if the cow only produced 10 lbs of milk/d, then protein requirements would be met through July (data not shown).

Short and Adams (1988) prioritized the metabolic use of available energy in ruminants ranking each physiological state in order of importance, as follows: 1) basal metabolism; 2) activity' 3) growth; 4) energy reserves; 5) pregnancy; 6) lactation; 7) additional energy reserves; 8 estrous cycles and initiation of pregnancy and 9) escess energy reserves. Superior milking beef cows require diets that contain more energy, protein, calcium and phosphorus (and probably trace minerals) than average milking beef cows if they are expected to rebreed and produce a calf every year. First calf heifers, regardless of milking ability, must be fed to gain weight during the first three months of lactation in order to rebreed (Rasby and Rush, 1996). Body size, milk production, pregnancy and grazing activity are the primary influencers of nutrient requirements of range cattle (NRC, 1996).

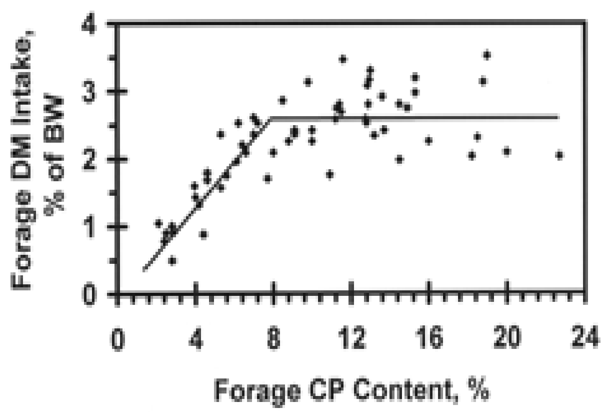
Figure 1. Crude Protein Content of Diets Selected by Cattle Grazing Northern Great Basin Native Rangelands Over Three Years (Delcurto et al., 2000)



Matching the nutrient requirements of the cow with the nutrients available in forages has been recommended as a means to efficiently utilize grazed forages (Vallintine, 1990; Vavra and Raleigh, 1976 and Adams et al., 1996). Two general factors which determine how well the range cow and range forage are complimentary with each other are: 1) genetic potential for milk production by the cow and 2) the synchrony between the cow's nutrient requirements during lactation and the highest nutrient content of the forage (Adams et al., 1996). When the cow's requirements and forage nutrient content are well matched, the cow should receive most of her dietary nutrients from the forage and the need to supply supplementary nutrients from supplements would be reduced. Reducing the need for feeding supplemental hay during the winter months has been shown to result in lower production costs and greater net returns (Adams, 1997).

Daily energy intake is a primary cause of reduced cattle performance on forage diets. In many instances with warm-season perennial forages (and possibly with cool-season perennial forages at advanced stages of maturity), there is an inadequate supply of crude protein, which will limit energy intake (Mathis, 2000). An example of the relationship between crude protein content of forages and forage intake is presented in Figure 2. Dry matter intake declined rapidly as forage crude protein fell below about 7 percent, a result attributed to a deficiency of nitrogen (protein) in the rumen, which hampered microbial activity. If the forage contained less than about seven percent crude protein, feeding a protein supplement generally improved the energy and protein status of cattle by improving their forage intake and digestibility. For example, with a crude protein content of 5 percent, forage intake was about 1.6 percent of body weight, while at 7 percent crude protein, forage intake was 44 percent higher and consumed at 2.3 percent of body weight.

Figure 2. Effect of Forage Crude Protein on Dry Matter Intake (from Mathis, 2000)



Improved forage intake boosts total dietary energy intake, and explains why correcting a protein deficiency is usually the first step in formulating a supplementation program. As suggested, when the crude protein content of forages drops below about 5 percent, forage intake declines. However, intake of other forages may decline when forage crude protein drops below 10 percent. Part of the variation can be attributed to differences in nutrient requirements of the cattle, with the remainder of the variation attributed to inherent differences among forages that present different proportions of nutrients to rumen microbes. Response of intake to a single nutrient such as crude protein should not be expected to be similar among all forages.

How Does Nutrition Influence Reproduction of the Range Cow?

Bearden and Fuquay (1992) summarized the effects of inadequate and excessive nutrients on reproductive efficiency (Table 2).

Table 2. Influence of Inadequate and Excessive Dietary Nutrient Intake on Reproduction in Beef Cattle (Bearden and Fuquay, 1992)

Nutrient Consumption	Reproductive Consequence
• Excessive Energy Intake	• Low conception, abortion, dystocia, retained placentae, reduced libido
• Inadequate Energy Intake	• Delayed puberty, suppressed estrus and ovulation, suppressed libido and spermatozoa production
• Excessive protein intake	• Low conception rate
• Inadequate protein intake	• Suppressed estrus, low conception, fetal resorption, premature parturition, weak offspring
• Vitamin A deficiency	• Impaired spermatogenesis, anestrus, low conception, abortion, weak offspring, retained placentae
• Phosphorus deficiency	• Anestrus, irregular estrus
• Selenium deficiency	• Retained placenta
• Copper deficiency	• Depressed reproduction, impaired immune system, impaired ovarian function
• Zinc deficiency	• Reduced spermatogenesis

This summary shows that excessive protein and energy can both have negative effects on reproduction. Recent research has also shown that in inadequate consumption of certain trace elements combined with antagonistic effects of other elements can reduce reproductive efficiency (Paterson et al., 2000).

Often, there are questions by livestock producers who are concerned that excessive dietary nutrients during the last trimester of pregnancy may negatively influence calf birth weights and dystocia. Selk (2000) summarized the effects of providing either adequate or inadequate amounts of dietary energy and protein on calving difficulty, reproductive performance and calf growth. These summaries are presented in the following two tables.

Table 3. Summary of Studies on Supplemental Prepartum Energy Intake on Calving Difficulty, Subsequent Reproductive Performance and Calf Growth (Selk, 2000)

Researcher	Supplementation[a]	Summary of Effects
Christenson et al., 1967	HE vs. LE for 140 d Prepartum	HE increased birth wt.,dystocia, milk & estrus activity
Dunn et al. 1969	ME vs LE for 120 d prepartum	ME increased birth wt. and dystocia
Bellows et al. 1972	HE VS LE for 82 d prepartum	HE increased birth wt but had no effect on dystocia or weaning wt.
Laster & Gregory, 1973	HE vs ME vs LE for 90 d prepartum	HE increased birth wt but had no effect on dystocia
Laster, 1974	HE vs ME vs LE for 90 d prepartum	HE increased birth wt. but had no effect on dystocia
Corah et al. 1975	ME vs LE for 100 d prepartum	ME increased birth wt., estrus activity, calf vigor and weaning wt. but had no effect on dystocia
Bellows and Short, 1978	HE vs LE for 90 d prepartum	HE increased birth wt., estrus activity, pregnancy rate and decreased post partum interval but had no effect on dystocia
Anderson, et al. 1981	HE vs LE for 90 d prepartum	HE had no effect on birth wt., milk or weaning wt.
Houghton et al., 1986	ME vs. LE for 100 d prepartum	ME increased birth wt. & weaning wt. but had no effect on dystocia

[a]HE = high energy (over 100% NRC or National Research Council's recommended dietary need); ME = moderate energy (approximately 100% NRC); LE = low energy (under 100% NRC)

Research has been consistent in suggesting that reducing protein or energy prepartum had virtually no effect on dystocia rates, even though birth weights were altered in some experiments. Of the nine trials summarized, seven showed that increased energy intakes during the last trimester of gestation did not increase calving difficulty.

In addition, producers have commented that supplemental crude protein increases calf birth weight. Table 4 summarizes studies that have been done to specifically measure effects of varying protein intake to the prepartum beef female on calving difficulty.

Table 4. Summary of Studies on Feeding Supplemental Protein During Gestation on Calving Difficulty, Subsequent Reproductive Performance and Calf Growth (Selk, 2000).

Researcher	Supplementationa	Summary of Effects
Wallace & Raleigh, 1967	HP[a] vs LP for 104 - 137 d prepartum	HP increased cow wt., birth wt. and conception rate but decreased dystocia
Bond & Wiltbank, 1970	HP vs MP throughout gestation	HP had no effect on birth wt or calf survivability
Bellows et al. 1978	HP vs LP for 82 d prepartum	HP increased cow wt., cow ADG, birth wt., dystocia, weaning wt. and decreased conception rate
Anthony, et al. 1982	HP vs LP for 67 d prepartum	HP had no effect on birth wt., dystocia or postpartum interval
Bolze, et al.1985	HP vs MP vs LP for 112 d prepartum	HP had no effect on birth wt., dystocia, weaning wt., milk or conception rate but decreased the postpartum interval

[a]HP = high protein (over 100% NRC); MP = moderate protein (approximately 100% NRC); LP = low protein (under 100% NRC)

Using Forage Analyses to Predict Animal Productivity; One Example

Montana State University researchers (Blunt and Cash) have recently completed a three-year study to determine how forage nutrient profiles change both during the growing season and across years at various locations in Montana. Figure 3 shows how crude protein content of Hycrest Crested Wheat grass and Slender Wheat grass changed over three years while Figure 4 shows how the in vitro dry matter digestibility of these forages changed. For the following assumptions, in vitro values were assumed to be approximately equal to TDN and these values were converted to net energy values for maintenance and gain.

Figure 3. Changes in the Crude Protein Content of Crested Wheat Grass and Slender Wheat Grass (Blunt and Cash, unpublished data, 2000).

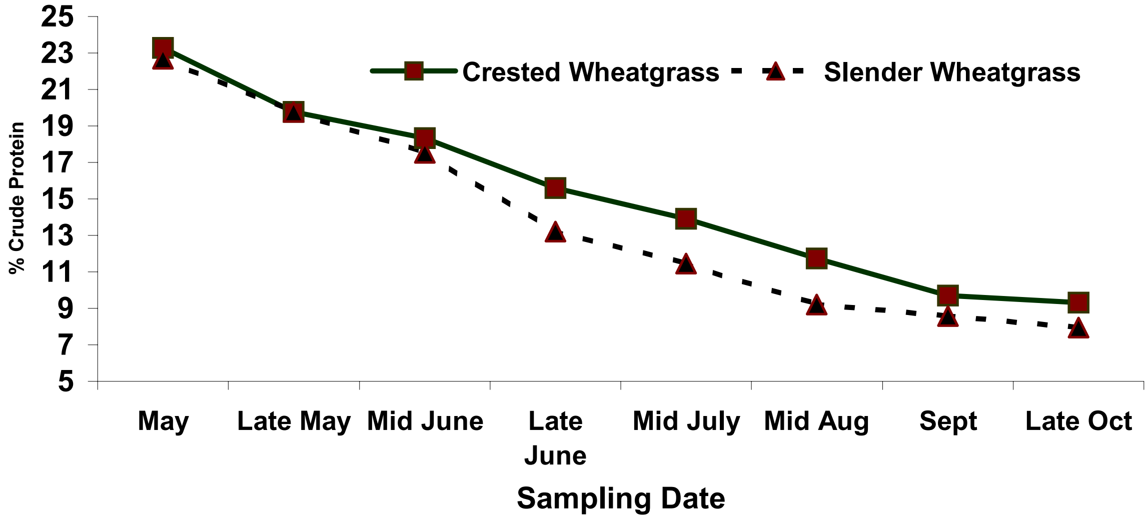
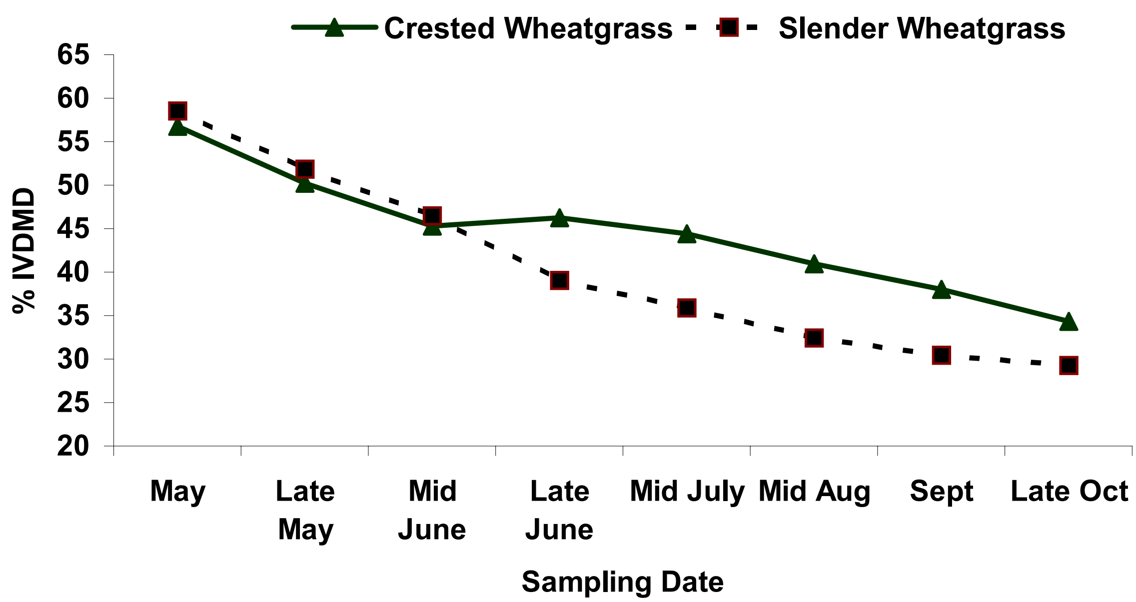


Figure 4. Changes in the In Vitro DM Digestibility of Crested Wheat Grass and Slender Wheat Grass (Blunt and Cash, unpublished, 2000)



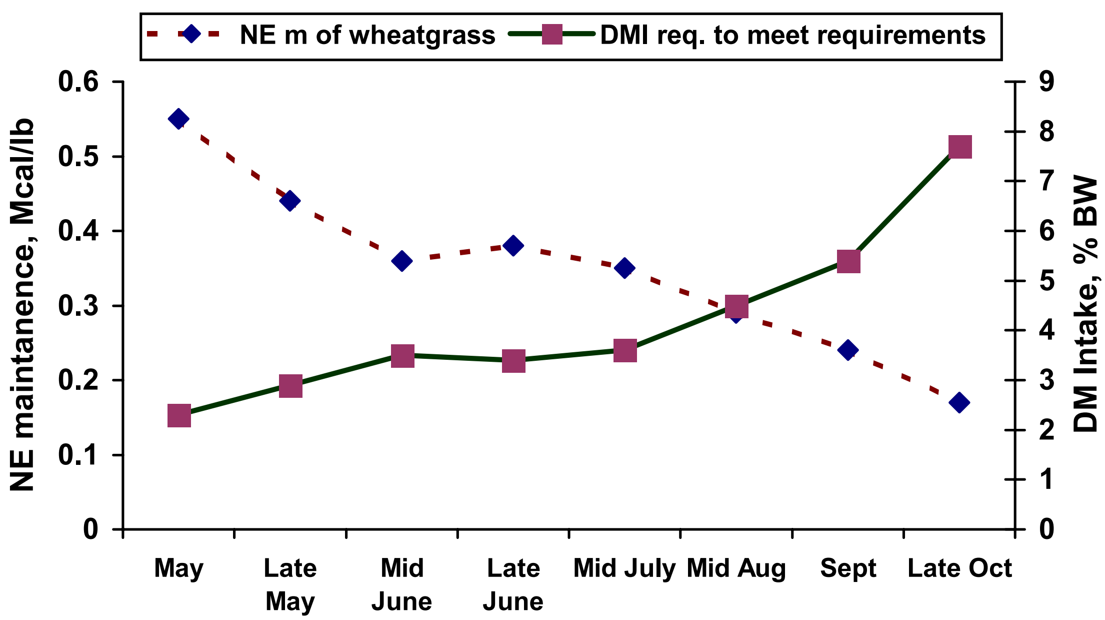
The crude protein content of the crested wheat grass dropped from more than 20% in early May to less than nine percent by October. Similarly, IVDMD of crested wheat grass dropped from more than 55% in May to less than 35% in October. Using these changes, the amount of dry matter required to meet the requirements of a 1200 lb lactating beef cow producing 20 lb milk/day with a body condition score of 5 was estimated. The following table shows how a decline in forage protein and TDN increased the amount of dry matter intake required to meet energy requirements of the cow.

Table 5. Theoretical Amounts of Dry Matter Intake Required to Meet the Energy (TDN) Requirements of a 1200 lb Lactating Beef Cow Producing 20 lb Milk Per Day When Grazing Crested Wheat grass with Different Protein and Energy Concentrations

Date of Sampling	Avg. Crude Protein, %	Avg. IVDMD, %	Dry matter intake required to meet TDN requirements for a 1200 lb lactating cow, %BW
May	23.27	56.77	2.3
Late May	19.77	50.20	2.9
Mid June	18.33	45.30	3.5
Late June	15.60	46.23	3.4
Mid July	13.90	44.43	3.6
Mid Aug	11.73	40.97	4.5
Sept	9.70	38.00	5.4
Late Oct	9.30	34.33	7.7

These same data are also presented graphically in Figure 5.

Figure 5. Theoretical Changes in DM Intake to Meet Requirements of a 1200 lb Lactating Beef Cow Consuming Crested Wheat grass with Decreasing Net Energy Concentration



Based on these calculations, a cow grazing wheat grass during May and July would have to consume between 2.3 and 3.6% of her body weight to meet requirements for lactation. After July and until October, DM intake requirements would rise until she would have to consume over 7% of her body weight each day as crested wheat grass; unlikely to occur.

Summary

The challenge for the cow calf producer is to match forage nutrients with animal requirements. Often, because there are not synchrony between these two, supplemental feedstuffs are required to maintain productivity (lactation, body condition, growth of the calf). Research suggests that when forage crude protein content falls below approximately 6-7%, dry matter intake also declines. At levels below this, it may be difficult for the cow to consume enough forage to meet energy requirements. In addition it has been shown that diets low in protein have resulted in weak calves at parturition. However, recent data suggests that exceeding protein intake prior to parturition (e.g. high quality alfalfa hay) did not negatively influence calf birth weight or the incidence of dystocia. After the drought of 2000 in many parts of the western states, a forage analysis is critical in determining how well the forage resource will meet the nutrient requirements of the gestating cow during the winter of 2001.

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