Supplementation and Management Strategies to Optimize Reproductive Performance

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Females failing to conceive during the breeding season are still the principal reproductive loss in the beef cattle operation (Ringwall and Helmuth, 1999). Longevity of a cow and the number of calves she produces are critical factors affecting sustainability and profitability of a commercial beef operation (Hughes, 1999). Failure to rebreed is the primary reason for culling young cows, and removal of cows from the herd at an early age results in considerable economic and genetic loss.

An animal's nutritional status can have profound effects on reproductive efficiency. For the past 40 years, considerable research has focused on nutritional management to increase reproduction. The challenge for the manager and the researcher is the myriad of environments and nutritional options in beef production. To further complicate the situation, rapid progress or changes in genetic selection often results in published nutritional research and nutrient requirements lagging behind current animal type.

Fortunately, there are several factors in the manager's favor. First, cow nutrition and supplementation can be controlled by the producer. Next our systems that predict nutrient requirements are dynamic and can account for factors such as changes in cow size, milk production, and weather (NRC, 1996; NRC 2000). Finally, although cows and environments may change, the basic nutrition-reproduction interaction concepts presented by Dr. Funston remain true across all situations.

The principal management tools are increasing nutrient availability (supplementation) and decreasing nutrient demand (weaning). Nutritional maximization of reproduction is simple if capital for supplements, and weaning labor and facilities are not limited. The goal of nutritional optimization of reproduction is to maximize reproductive success while controlling feed and labor costs. The focus of this paper will be current concepts in the use of supplements, weaning, and other management strategies to enhance reproduction.

Analysis of nutritional status

The first step in developing a nutritional strategy is to analyze the current nutritional status of cows and heifers as well as available feed resources (Figure 1). While conducting this analysis seems intuitive, and most managers have a similar process, it is surprising the number of producers that begin an AI program with cattle in less than optimal nutritional status.

Nutrient needs of the cow can be calculated from the Nutrient Requirements of Beef Cattle (NRC, 1996; NRC, 2000). This program accounts for stage of production, cow body size, estimated milking ability and environmental factors when calculating nutrient needs. The cow production year can be divided into four nutritional periods: Precalving, Lactating & Breeding, Lactating & Pregnant, Gestation. Nutrient needs of the cow are highest during the Lactating & Breeding period and lowest during Gestation. Precalving is a critical nutritional period as well.

Figure 1. Animal status and resource analysis

Cows

- **Cow BCS**
- **Cow age**
- **Days/months before breeding season**
- **Location – Range/pasture**
- **Forage base**
  - Cool season forage
  - Warm season forage
- **Expected forage availability and quality**
  - Prepartum, postpartum, breeding seaon
- **Available energy and protein supplements**

Replacement Heifers

- **Current heifer body weight**
- **Desired target weight**
- **Days/months before breeding season**
- **Location –**
  - **Range/pasture/Drylot**
- **Forage base**
  - **Cool season forage**
  - **Warm season forage**
- **Expected forage availability and quality**
- **Prepartum, postpartum, breeding seaon**
- **Available energy and protein supplements**

The changes in nutrient requirements of beef cows by different stages of production and varying levels of milk production are illustrated in Table 1. Energy and protein requirements increase by 1/3 between weaning and 1 month before calving, and nutrient requirements almost double from weaning to peak lactation. Note that the greatest nutrient demand is two months after calving which coincides with peak lactation as well as the beginning of the breeding season. Cows in early lactation and young growing cows will often need supplementation. Similarly, cows in late gestation may need supplementation if this period occurs when cows are grazing dormant forage or consuming hay. Cows with greater milking ability also have higher maintenance costs due to differences in basal metabolism (NRC, 1996). Therefore, even when they are not lactating, it takes more energy to maintain these high milking cows. For efficient production and reproductive success, animals need to be matched to the environment in terms of animal type and calving season (Adams et al., 1996).

The minimum required nutrient density of the diet needed to meet animal requirements is also listed in Table 1. Total digestible nutrients (TDN) and crude protein (CP) are older and less accurate measures of energy and protein than net energy – maintenance (NEm) and metabolizable protein (MP). However, they are included in the table because they are commonly reported measures on forage analyses.

Current nutritional status of animals can be assessed easily by use of body condition scores (BCS) for cows, and body weights and BCS for heifers. Cows should be in BCS 5 to 6 (1 = emaciated to 9 obese) at calving and maintain body condition through breeding. Ideally, BCS assessments should be made at weaning, 90 days before calving, at calving, and the beginning of the breeding season. Heifers should reach 65 % (55%?) of their mature weight about one month before the breeding season with a BCS of 5 to 7. A review of body condition scoring is beyond the scope of this paper, but it is a critical management practice; therefore, BCS resources are included at the end of this paper.

Table 1. Protein and energy requirements of cows and minimum nutrient content of diets for 1250 cows with producing 18 or 25 lbs milk at peak lactation.

	Lactation/Breeding			***Lactation & Pregnant***				***Gestation***			***Precalving***	
	Months since Calving											
	1	2	3	4	5	6	7	8	9	10	11	12
18 lbs peak milk production (British cross)												
Milk lb/day	15.0	18.0	16.2	13.0	9.7	7.0	3.0	0	0	0	0	0
Met-Protein[a] g/day	798	869	827	751	675	614	571	466	487	522	579	669
NEm[b] Mcal/day	15.6	16.6	16.0	15.0	14.0	13.1	12.6	9.5	10.0	10.8	12.1	13.8
%TDN[c] needed	*60*	*60*	*60*	*56*	*56*	*55*	*55*	*49*	*49*	*50*	*53*	*56*
% CP[d] needed	*10*	*10.5*	*10*	*9*	*9*	*8.5*	*8.5*	*7*	*7*	*7*	*8*	*9*
25 lbs peak milk production (Continental cross)												
Milk lb/day	20.8	25.0	22.5	18.0	13.5	9.7	4.5	0	0	0	0	0
M-Protein g/day	936	1035	976	870	765	679	616	466	487	522	579	669
NEm Mcal/day	19.67	21.0	20.2	18.8	17.3	16.2	15.4	11.3	11.8	12.6	13.8	15.6
%TDN needed	*63*	*63*	*63*	*60*	*60*	*58*	*58*	*51*	*51*	*56*	*58*	*59*
% CP needed	*11*	*11*	*11*	*10*	*10*	*9*	*9*	*7.5*	*7.5*	*8*	*8*	*8*

a Metabolizable protein
b Net Energy for mantainence
c Percent Total Digestible Nutrients, a measure of energy typically reported on forage tests
d Percent Crude Protein, a measure of protein less accurate than metabolizable protein but commonly reported on forage analysis.

Understanding the ranch forage resource (grazing and stored) is critical to strategic planning. Too often nutritional strategies are presented to ranchers by advisors or the media without regard to regional differences in forage type, quality, and availability. For example, protein supplementation is often mentioned as a strategy to enhance digestibility of forage and increase cow body condition. While this is an appropriate supplement for dormant range, it is virtually useless and may be detrimental as a supplement for eastern cool season hay. It is essential that managers understand the advantages and deficiencies of the resource in order to supplement the appropriate nutrients. Over-supplementing a nutrient that is not needed may be as detrimental as deficiencies.

Range and pasture forages in the growing vegetative state are highly digestible (65% -70%+) and contain sufficient to excess protein (10% - 20% CP; Adams and Short, 1988; Hall et al., 2004). Properly stockpiled fescue, brome, and orchardgrass exceed 60% digestibility and 10% crude protein as fall and winter grazing (Blaser et al., 1986; Kilgore and Brazle, 1994; Hall et al., 2004). At this stage, plants usually meet the nutrient requirements of lactating cows. In contrast, dormant range forage and over-mature pasture are lowly digestible (< 50%) and a poor source of protein (< 6% CP; Kilgore and Brazle, 1994; Lardy et al., 1997). These forages may require supplementation even to meet requirements of cows in the gestation period (mid-pregnancy).

Tremendous differences exist in forage quality and availability within the Midwest and Great Plains regions. The extremes in nutrient availability are represented in Figures 2 and 3. Native western range forages vary greatly in protein content with maturity (Figure 2.) and may not contain sufficient protein for proper rumen function resulting in a decrease in digestibility of dormant range. Much of the year range forage contains sufficient energy to meet mature cow needs but lacks protein. Supplementation of dormant range with protein increases digestibility and cow performance (DelCurto et al., 1990). In contrast, eastern cool season forages harvested through managed intensive grazing (Figure 3) may meet or exceed the nutrient needs of lactating cows during the summer and early fall (White, 2000). However, first cutting hays from eastern cool season forages usually lack quality as harvest is often delayed due to rainy weather. These over-mature hays are marginal in protein content, but are severely lacking in energy and digestibility (Blaser et al., 1986; Kilgore and Brazle, 1994). Energy is the primary limiting nutrient in mature eastern cool season pastures

Figure 2. Seasonal variation in protein content of western range compared to cow requirements

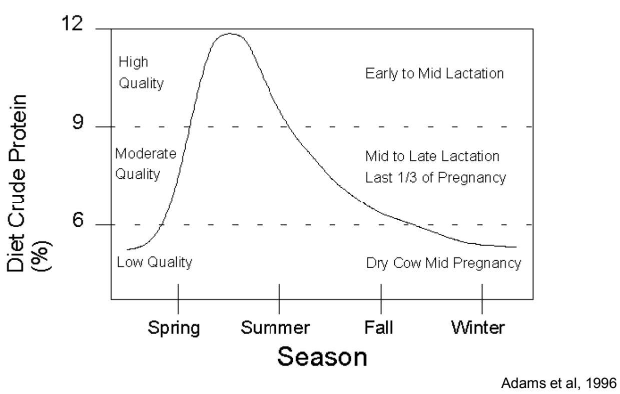
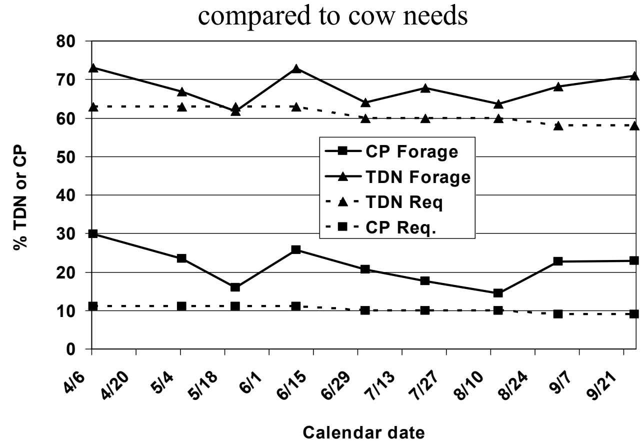


Figure 3. Forage protein and energy content in managed intensively grazed cool season grass/legume pastures compared to cow needs



and hays (Rayburn et al., 1986). Supplementation of these hays with protein does little to improve digestibility or cow performance; however, supplementation of energy will enhance cow performance or reduce body weight loss.

Composition of the supplement can impact forage digestibility. Starch-based energy supplements such as corn, barley, or wheat can decrease the ability of cattle to digest forage if supplementation levels exceed 0.5 % of body weight (about 6 lbs for a mature cow) per day. High levels of starch shift the population of rumen microbes toward starch digesters. The resulting decrease in fiber digesting microbes impairs forage digestion. Fiber-based energy supplements such as soyhulls, wheat mids, and corn gluten feed do not suppress digestion of forage. Forages that are low in protein require supplementation with degradable intake protein (DIP) to enhance function and reproduction of rumen microbes. When forages are extremely low in protein, non-protein nitrogen sources of DIP such as urea may not be effective. In these situations, insufficient amount of amino acids are available to allow rumen microbes to utilize the non-protein nitrogen effectively.

Forage intake by cattle also affects nutrient availability. Typically, cattle consume approximately 2% of their body weight in dry matter per day. Forage intake is influenced by fiber content, available forage, and weather (NRC, 1996). Highly digestible pasture has a high passage rate through the digestive tract; thereby producing dry matter intake of 2.3 to 2.5 % of body weight (Gerrish et al., 1998). In contrast, cows may only be able to eat 1.5 to 1.7 % of their body weight in highly fibrous mature grasses (Kilgore and Brazle, 1994). Cows can easily eat enough high quality forage (CP ≥ 10 %; TDN > 65%) to meet their nutrient needs. However, cows many not be able to consume sufficient amounts of fibrous, mature, low quality forage to meet their nutritional needs. For example, a 1000 lb cow producing 20 lbs of milk per day would need to eat 50 lbs of 5.0 % CP range grass to meet her protein needs (Adams et al., 1986). Considering, her maximum intake would be 25 lbs or less of forage, the cow will be full but nutritionally starved.

Nutritional and management strategies for replacement heifers

Nutritional management of replacement heifers begins at or before weaning and continues through mid-gestation. The goal during this period is to optimize reproductive performance and heifer development costs. Results from current research indicate that some flexibility exists for heifer development programs.

Target weight. One of the most critical factors affecting the success of reproduction in replacement heifers is postweaning nutrition. Considerable research has investigated the role of nutrition and specific nutrients on puberty onset and reproduction in heifers (Schillo et al., 1992; Patterson et al., 1992). From a management perspective, the most important consideration is that heifers reach a critical or “target” body weight before the breeding season (Lamond, 1970).

Achieving the target weight before breeding insures that breeding success will not be limited by nutrition. For many years, the target weight for heifers suggested by research and experience has been set at 65% of mature weight (Patterson et al., 1992). In addition, heifers developed to 65% of mature weight by breeding had less calving difficulty than heifers developed to 55% of mature weight. The 65% level appears to be effective across a wide range of cattle biological types and nutritional environments. If supplementation of heifers can be achieved economically or if heifer value or pasture costs are high, raising heifer to 60% to 65% of mature weight is advantageous.

Recently, several articles focused on advantages and disadvantages to developing heifers to 53% compared to 58% of mature weight (MW) by the breeding season. These researchers found that developing spring calving heifers to 53 % of mature weight reduced heifer development costs without any impacts on initial pregnancy rates, dystocia, rebreeding rates or calf production traits (Funston and Deutscher, 2004). It should be noted that these were crossbred heifers which tended to reach puberty early as evidenced by 74 % of the 53% MW heifers and 85 % of 58 % MW heifers cycling by the start of the breeding season. A follow-up study (Creighton et al., 2005) indicated that developing heifers to 50 % MW compared to 55 % MW resulted in similar overall pregnancy rates, but decreased calf weaning weight from 2-yr old cows and delayed calving in 3-yr old cows. The decrease in calf value offset any gain by reducing heifer development costs. Ranches adopting a lower target weight strategy reduce heifer development costs, but may realize an increase in dystocia and slight reduction in numbers of pregnant heifers. Furthermore, ranches which can retain ownership and feedout open heifers may be able to better offset production losses than smaller operations.

Beef producers need to consider heifer biological type, breeding (purebred vs crossbred), development costs, and marketing options before selecting a target weight (percentage mature weight) goal. Reducing development costs for replacement heifers by lowering target weights are not without risks.

Pattern of gain and feeding management. Once a target weight is determined, mangers can focus on the mechanics of heifer development. The route (pattern of gain) towards the target weight may not be as important as attaining the target weight by the breeding season (Table 2). Heifers managed to meet target weight by three different methods: 1) rapid gain followed by slow gain, 2) steady gain, or 3) slow gain then rapid gain had similar pregnancy rates (Clanton et al., 1983). Similarly, spring-born heifers that were roughed through the winter then pushed to gain a majority of their target weight during the last 60 days before the breeding season had pregnancy rates equal to (Lynch et al, 1997) or less than (Hall et al., 1997) heifers on a steady rate of gain. Heifers developed on stair step gain (fast-slow-fast) had enhanced or equal pregnancy rates to heifers on a steady gain system (Poland et al., 1998; Grings et al., 1999). Therefore, managers can design feeding programs to maximize gain during times of abundant forage or cheap feed supplies.

Table 2. Impact of pattern of gain on pregnancy rates in replacement beef heifers.

	Pattern of Gain				
Study	**No. of heifers**	**Even gain**	**Slow - Fast**	**Fast - Slow**	**Fast-Slow-Fast**
Clanton et al., 1983	180	82.0 %	75.0 %	73.0 %	--
Lynch et al., 1997	160	87.4 %	87.2 %	--	--
Poland et al., 1998	96	75.0 %	--	--	89.6 %
Grings et al., 1999	210	81.8 %	--	--	86.6 %

Sorting heifers into feeding groups by body weight at weaning decreases feed costs and improves reproductive performance (Varner et al., 1977; Bellows and Hall, 1994). Light weight heifers at weaning benefited from separate feeding as indicated by increased body weights at breeding and enhance pregnancy rates. Feed costs are reduced because heavier heifers can be grown at a slower rate on less expensive feedstuffs.

Producers are often concerned about pattern of gain affecting subsequent productivity in heifers. Heifers that receive creep feed pre-weaning reach puberty earlier, but they have suppressed milk production as primiparous cows compared to non-creep fed heifers (Hixon et al., 1982; Buskirk et al., 1996). Even though, milk production is reduced calf weaning weight may not be affected as calves may substitute forage for milk if forage quality is high (Buskirk et al., 1996; Sexton et al., 2004). Stair-step feeding regimes for replacement dairy heifers result in substantial increases in milk production. Studies in beef heifers have reported a 0 % to 6 % increase in milk production in response to stair-step development (Park et al., 1998; Grings et al., 1999). The variation in response appears to be related to breed and/or timing of different growth rates. Overall, although measurable changes in milk production can occur in response to feeding patterns of replacement heifers, lifetime productivity may not be altered as long as target pre-breeding weight are achieved.

Specific nutrients.

Metabolizable protein. In one study, feeding 250 g of UIP to heifers delayed puberty compared to heifers fed monensin (Rumensin), but did not hurt over all conception rates (Lalman et al., 1993). In contrast, feeding 100 g of UIP decreased age at puberty and increased pelvic areas (Graham, 1998; Table 3). In addition, UIP supplemented at 216 g or 115 g per heifer per day increased FSH production and/or secretion (Kane et al., 2004). The effect of UIP on replacement heifers appears to depend on the amount of UIP supplied as well as UIP in the base diet.

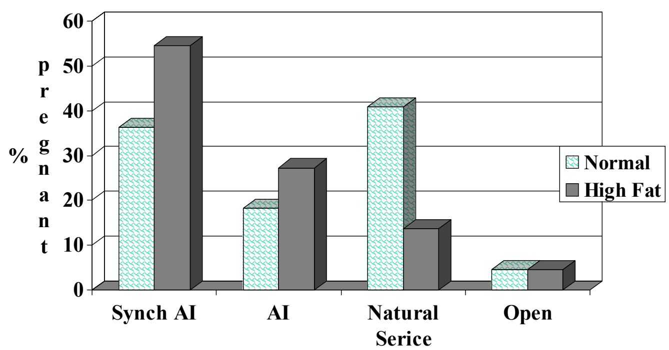
Table 3. Effect of UIP on developing replacement heifers

	UIP (grams per day)	
	0	100
Average Daily Gain	1.86	2.1
Pelvic area (sq. cm)	150.6	162.8
Cycling %	54.0	77.0

Graham, 1998

Increasing dietary fat. The research on developing heifers is less extensive than studies on postpartum cows and heifers. Lammoglia and co-workers reported a high-fat diet increased pregnancy rates and cyclicity in heifers of a double muscled breed, but it had little effect or a negative effect in other breeds. In contrast, we have preliminary data that indicates an advantage to feeding whole cottonseed (5 % fat diet) to developing beef heifers (Figure 4). The difference between the two studies may be related to the length of time the high fat diet was fed before breeding. Our heifers were fed the high fat diet for 75 days before breeding compared to 162 in the other study. We are continuing further research to determine if short-term feeding of high fat diets, perhaps during synchronization, will improve reproduction in heifers.

Figure 4. Effect of High Fat Diet During the Peripuberal Period in Beef Heifers



Cuddy, 2000

Ionophores

Rumensin and Bovatec act by altering the types of microbes in the rumen, thereby enhancing digestion and growth rate. Addition of ionophores to replacement heifer diets can reduce age at puberty by 15 to 30 days while increasing growth rate (Mosley et al., 1982). Although some of the reproductive effect may be due to ionophores action in the rumen, evidence indicates there may be systemic actions as well. Response to ionophores appears to be less dramatic in light-weight or poorly fed heifers.

Early weaning. Control of replacement heifer nutrition by managers usually begins at weaning. Drought conditions or management strategies to improve reproduction in young cows (see next section) may result in potential replacements being weaned at 60 to 120 day of age rather than the traditional 7 to 8 months. Considerable research has focused on performance of early weaned calves in the feedlot, but few studies address reproductive impacts. Proper nutritional management of these early weaned heifers resulted in heifers that were lighter at breeding, but had improved conception rates compared to normal weaned heifers (Sexten et al., 2004).

Nutritional and management strategies for two- and three-year old cows

Young cows represent the greatest management challenge in the herd. The combination of lactation and continued growth creates a significant nutritional strain on young cows. This nutritional stress combined with the effects of suckling and presence of the calf results in prolonged intervals of postpartum anestrous (Short et al, 1990). Prolonged anestrous decreases the probability that young cows will conceive during the breeding season. In addition, primiparous cows have higher incidence of dystocia and retained placenta; conditions which result in decreased rebreeding success. Ranch and IRM data indicate that only 50 % to 60 % of the heifers that calve as 2-year-olds are on the ranch to calve at 4 years of age (Meeks et al., 1999; Hughes, 1999). Management strategies should focus on reducing or managing postpartum anestrous. Economic analysis by Meeks and co-workers (1999) indicated that investing money in heifers at this stage of production was more profitable than increasing costs on heifer development.

Body condition and weight at calving. Primiparous cows calving in body condition score 6 or 7 have reduced postpartum intervals and higher rebreeding rates than heifers calving in body condition score 5 or less (Spitzer et al., 1995). Similarly, three year old cows calving for the second time need to be in BCS 5 or 6. Management of heifers to reach 85-90 % of their mature weight by calving may reduce dystocia (Corah et al., 1975). Pattern of gain during the precalving period does not appear to be as important as the final body condition score at calving. However, there is limited evidence that heifers gaining weight during the precalving period may have improved reproductive rates during the breeding season.

Precalving supplementation. Numerous studies investigated the impact of different precalving nutritional strategies on cow performance and rebreeding success of young cows (Randel, 1990; Whittier et al., 2005). Overwhelmingly, these studies indicate that when supplementation provides sufficient nutrients so body condition scores are optimized at calving, there is limited impact on subsequent reproductive performance. The only exception may be diets balanced for metabolizable protein. Limited effects of supplement type have been reported on precalving weight gain and body condition. Alfalfa hay, soybean meal, cottonseed meal, sunflower meal, safflower meal, and feather meal are supplements that can provide sufficient protein to pregnant heifers grazing winter range. Soy hulls, corn gluten feed, wheat mids, corn, barley, and dried brewers grains are appropriate energy supplements for pregnant heifers consuming grass hay.

Balancing diets for pregnant heifers to meet metabolizable protein (MP) requirements rather than crude protein (CP) requirements may result in improved rebreeding performance on heifers provided native range and meadow hay (Table 4.; Patterson et al., 2003). Patterson concluded that spending an additional $ 1.81 per heifer for the MP based supplement increase value of the 2-year old heifer by $13.61. However, providing UIP to replace or in addition to CP did not improve reproduction in heifers grazing fescue (Strauch et al., 2001).

Table 4. Pregnancy rates in two-year-old cows, across two years and two locations, that were supplemented the previous winter to meet metabolizable protein (MP) or crude protein (CP) requirements while grazing sandhills range and consuming meadow hay[a,b]

	Location A		*Location B*	
Year	MP req.	CP req.	MP req.	CP req.
1997-98[c]	95	95	84	75
1998-99[d]	95	88	89	85

[a] Patterson et al., 2003. [b] Treatment × Year × Location interaction (P = .07).

[c] Treatments differ at Location B (P = .01).

[d] Treatments differ at Location A (P = .01) and Location B (P = .15)

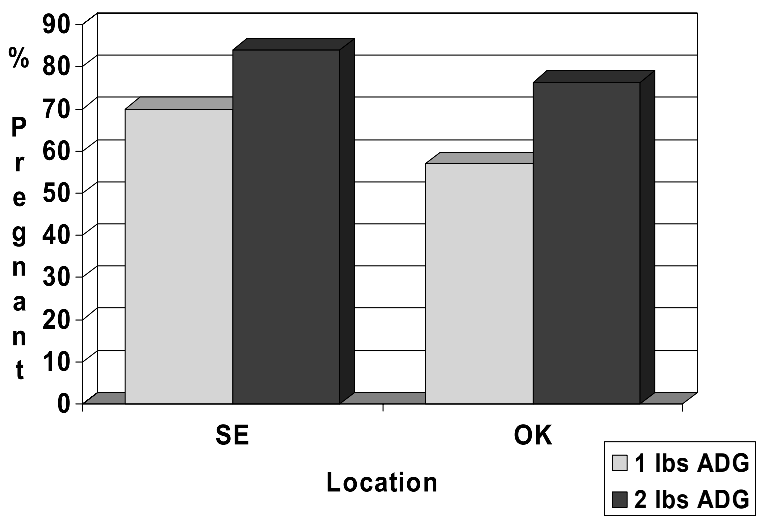
Addition of high fat supplements to gestating heifer diets or both pre- and postcalving has varying impacts on postpartum reproduction. In a review by Funston (2004), he determined that the impact of prepartum high fat feeding on subsequent reproduction was inconclusive. In fact more studies noted no effect or a negative effect of high fat feeding on subsequent reproduction in young cows than a benefit. Positive effects of prepartum high fat supplementation appear to be dependent on pre- and postpartum forage availability (Bellows et al., 2001). Feeding high fat diets during gestation increases calf vigor and survivability in cold (Lammoglia et al, 1997; Geary et al., 2002), but not temperate (Dietz et al., 2004) calving seasons.

In practice, high fat supplements are usually whole or cracked oilseeds such as sunflower, safflower, soybean, or cottonseed, but other forms of fat or rumen protected fats can be fed as well. These supplements are fed at a rate of 1 to 5 lbs per animal depending on the fat content of the supplement. Overall, the diet should not exceed 5% dietary fat or rumen function may be impaired.

Choice of supplements for heifers in late gestation should be based on the most cost effective supplement that provides the missing nutrients. When protein is the limiting nutrient, there appears to be an advantage to balancing diets for metabolizable protein with a UIP protein source. High fat supplementation prepartum may be an advantage in cold climates if high fat supplements are approximately the same cost as normal supplements.

Postcalving supplementation. Although body condition at calving has the greatest impact on rebreeding success in young cows, postpartum nutrition can enhance or impair the effects of body condition. Young cows that lose weight postcalving have prolonged anestrous periods and poor rebreeding performance (Dunn et al., 1969). In contrast, young cows that gain weight rebreed earlier and have greater pregnancy rates than cows that maintain their weight (Figure 5; Spitzer et al., 1995; Ciccioli et al., 2003). Therefore, young cows must gain weight during the postpartum period to successfully rebreed. In most cases, energy supplementation will be required during early lactation (Table 5).

Figure 5. Effect of average daily gain from calving to breeding on pregnancy rates in 1st calf heifers



Most studies indicate little advantage to feeding young lactating cows specific forms of energy or protein as well as feeding nutrients in excess of requirements. Feeding high fat diets during the postpartum period influenced milk production, but did not affect pregnancy rates (Bottger et al., 2002; Lake et al., 2005). Added UIP or substituting UIP for DIP in diets for lactating young cows did not enhance reproduction in well fed cows (Alderton et al., 2000; Strauch et al., 2001). Increasing CP or MP in the diet above requirements does not significantly improve cow reproductive performance (Rusche et al., 1993; Waterman et al., 2006).

Supplementation and management strategies should include calving heifers before the cow herd, timing of calving relative to forage availability, and supplementation to provide a high rate of gain for lactating heifers. The extended postpartum interval in young cows, combined with high probabilities of dystocia and calf mortality in young dams, warrants calving heifers ahead of the cow herd.

Recently, there has been considerable interest in shifting calving seasons so maximum nutrient needs of the cow with maximum forage growth and quality. In studies in Montana and Nebraska, calving cows in June resulted in decreased cow costs and improved rebreeding rates (Adams et al., 1996; Grings et al., 2005). However, shifting to summer or late spring calving is not without risks or tradeoffs. In the Northern Plains, summer calving results in decreased forage quality coinciding with increased calf nutrient needs and forage intake. Producers either accept lower returns for lighter weight calves or must spend money on supplementing early weaned calves. In turn, these calf costs somewhat offset the savings in cow costs. In the Southern Plains or Midwest, late spring or early summer calving moves the breeding season to the hottest, most humid part of the year. Heat stress reduces fertility in cows and bulls resulting in reduced calf crop (Selk, 2001).

Fall calving is a viable option from eastern Texas and Oklahoma to southern Iowa and eastern Kansas. Fall calving cows in these regions enter the calving season in greater body condition than spring calving cows. In addition, cool season perennial grasses produce a fall flush of growth that coincides with high nutrient needs of the cow. Finally, the breeding season takes place during November and December before severe winter weather hits.

Table 5. Example diets (as-fed) for lactating primiparous cows gaining 1.5 lbs/day[a]

	Feed Ingredients (lbs./hd/day)								
Diet	Barley	Corn	Soyhulls	Corn Gluten Feed	Range, June	Pasture, Spring	Meadow Hay	Fescue Hay	Cost/hd/day $
1	----	5.5	----	5.5	-----	-----	----	18	1.10
2	----	----	----	----	----	122*	----	----	0.84
3	3.5	----	8.5	----	----	----	19	----	0.95
4	----	-----	----	----	135*	----	----	----	0.88

[a] Based on NRC level 1 calculations for 1080 lb lactating 1st calf heifers and estimated feed prices based on 7/21/06 national feedstuff prices plus transportation.
* High rate of passage of these diets may reduce animal performance; therefore, energy or fiber supplementation may be needed.

Weaning – early or temporary. One of the most powerful tools to improve reproductive rate in two- and three-year-old cows is weaning. The tremendous reduction in nutrient demands as well as removal of influence of the calf results in positive effects on reproduction and body weight. Early weaning falls into two categories breeding season weaning or post/during-breeding weaning. Temporary weaning or calf removal is separation of the calf and dam for 48 hours at the beginning of the breeding season or during estrus synchronization.

Weaning calves at 60 to 90 days (breeding season weaning) reduces days to first estrus, increases pregnancy rates, and body condition of 2-year-old cows (Lusby et al., 1981; Thrift & Thrift, 2004; Waterman et al., 2006). Reported enhancement of pregnancy rates are between 15% and 38%. Early weaning was even beneficial when cows were synchronized with CIDR-based synchronization system which induces cycles in anestrous cows (Waterman et al., 2006). Early weaned heifers weigh between 100 lbs. and 150 lbs. more than their normal weaned counter-parts at time of normal weaning.

Weaning post-breeding (120 to 170 days of age) does not impact pregnancy rates in 2-year-old cows, but increases body weight gain and body condition of cows preparing for their second lactation (Basarab et al., 1986; Meyers et al., 1999). Increased weight gains for cows weaned after/during breeding ranged from 0.4 lbs to 1.2 lbs/day compared to cows weaning calves at 200 to 233 days (Thrift & Thrift, 2004). The resulting increase in body condition of young cows was positively correlated with pregnancy rate and percentage of live calves the following year despite a slight increase in calving difficulty (Richardson et al., 1978).

Temporary weaning or 48 hour calf removal improved (Kiser et al., 1980, Yelich et al., 1995; Geary et al., 2001) or had no effect (Fanning et al., 1995; Whittier et al., 1999) on conception and/or pregnancy rates to various synchronization protocols. The enhancement of response to synchronization by calf removal may depend on age of cow, synchronization system, or cow body condition (Warren et al., 1988). In general, multiparous cows in good body condition do not benefit from 48 hour calf removal as much as younger or thinner cows. However, cows that are deep in anestrous do not respond to temporary calf removal.

Biostimulation. Exposure of postpartum cows to bulls or testosterone treated cows reduces postpartum interval and increase the number of cows cycling at the beginning of the breeding season (Zalesky et al., 1984; Custer et al., 1990; Burns and Spitzer, 1992). Sterile bulls, bull urine, fenceline exposure to bulls, and exposure to testosterone treated cows are effective biostimulents (Fike et al., 1996; Berardinelli and Joshi, 2005). Impacts of biostimulation are greatest in primiparous cows resulting in a reduction in postpartum interval of 12 to 20 days compared to non-exposed cows. Cows appear to need approximately 30 to 60 days of exposure to the biostimulation to maximize the response. Biostimulation increased (Tauck, 2005) or had no effect (Fike et al., 1996) on pregnancy rates to synchronized AI (Table 6).

Nutritional and management strategies for mature cows

Multiparous cows are at reduced risk for reproductive failure due to lower nutrient demands, shorter postpartum intervals, and lower incidence of reproductive complications than younger cows. This group of cows represents the largest segment of the herd, and the greatest opportunity for flexibility in management. If cow genetics and calving season are matched to the forage supply and environment then only limited supplementation of mature cows should be required.

Pre- and postpartum supplementation. The most critical factor for multiparous cows is for them to calve in moderate body condition (BCS 5 or 6; Randel, 1990). Calving in good condition provides some buffer against nutritional deficiencies postpartum. However, cows losing greater than 0.5 BCS from calving to breeding may have reduced pregnancy rates. Cows can lose weight after the breeding season as long as body condition is regained before calving. For spring calving herds, supplementation strategies should focus on providing sufficient nutrients to maintain or add body condition during the winter months. Fall calving herds on eastern perennial pastures may require little additional supplementation. After calving, the forage resource should meet the nutritional needs of cows unless there is a drought or cows are not matched to the ranch resource.

Most of the details of supplementation strategies and response to specific nutrients have been covered in the section on two- and three-year-old cows. In general, multiparous cows derive less benefit from MP or high fat supplementation. A majority of the studies reviewed by Funston (2004) indicated no effect or a negative effect of high fat supplementation to multiparous cows.

Biostimulation and early weaning. Biostimulation reduces postpartum interval in mature cows, but the magnitude of the reduction is small (4 to 10 days) compared to young cows. Early weaning is a strategy that should be considered in times of drought or for thin mature cows. If range or pasture conditions deteriorate greatly after breeding then weaning at 120-150 days should be considered as a method to build cow condition and reduce winter feed costs. Conversely, when fall forage is abundant there is no disadvantage to weaning later than normal (Short et al., 1996).

Table 6. Reproductive responses in primiparous suckled beef cows estrous synchronized (ES) with CO-Synch after exposure to bull or bull excretory product (BE) or no bulls or bull excretory products for 60 day before synchronization.

	Treatment			
Variable	BE	NE	X^2	*P* value
n	84	70		
% cycling before the start of ES protocol	86.3 [b]	31.3 [c]	42.0	< 0.001
% showing estrus after $PGF_{2\alpha}$	50.0 [b]	50.0 [b]	0.00	= 0.96
AI pregnancy rate (%) [d]	72.6 [b]	62.9 [b]	2.70	= 0.11
Pregnancy rate for AI 12 h after estrus	84.6 [b]	81.8 [b]	0.07	= 0.80
Pregnancy rate for TAI	59.5 [b]	37.1 [c]	3.20	= 0.07

[a,b]Percentages within rows that lack a common superscript differ.

[b]Pregnancy rates determined ultrasonographically 35 d after TAI

Berardinelli and Tauck, 2005

Management for Successful Reproduction

Based on what we have discussed today, it is apparent that there are no nutritional supplements or technologies currently available that will greatly enhance reproduction in nutritionally mismanaged cattle. Therefore, nutritional management should focus on maintaining cattle in proper nutritional status or achieving that status by critical reproductive events (i.e. calving, breeding). Other management strategies should be considered in addition to supplementation especially in young cows or thin mature cows.

Key management strategies are:

1. **Understand the grazing resource and use it to advantage**
    a. Know seasonal and yearly variations in forage nutrient content and availability
    b. Optimize calving date to forage availability and quality as well as environmental temperatures and marketing options.
    c. Design supplementation strategies to meet cow nutrient needs
2. **Ensure sufficient energy is available to support reproduction**
    a. Body condition score cows and achieve BCS 5 in cows and BCS 6 in heifers by calving (latest) or 60 days before calving (preferred).
    b. Maintain cow body condition from calving through breeding for cows in proper body condition, and increase body condition in cows that are below optimal BCS at calving.
    c. Feed thin cows and 1st calf heifers in a separate group from main herd.
    d. Consider early weaning young cows or thin mature cows.
    e. Provide energy supplementation from the most economical local source.
    f. If fats are an economical source of energy, include oil seeds or fats to increase dietary fat up to 5% of total diet dry matter.
3. **Provide optimum level of dietary protein**
    a. Balance diets on MP if possible
    b. Provide sufficient DIP for adequate rumen function
    c. Avoid over supplementation of protein
    d. Inclusion of UIP in diets may not be effective
4. **Include ionophores in diets when possible**
5. **Base mineral supplementation on forage mineral content and local deficiencies**
    a. Supplement P only when needed
    b. Pay attention to trace mineral levels especially Cu, Se, Mn, and Zn
    c. Be aware of mineral antagonisms
6. **Use other management strategies**
    a. Render calving assistance early to reduce reproductive impacts of dystocia.
    b. Consider biostimulation, especially for young cows
    c. Alter weaning times based on cow condition and available forage

Body condition scoring resources

http://www.cowbcs.info/index.html
http://www.ext.vt.edu/pubs/beef/400-795/400-795.html
http://www.ansi.okstate.edu/exten/cc-corner/archbcs1to9.html
http://www.oznet.ksu.edu/library/lvstk2/c842.pdf

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