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IMPORTANCE OF EARLY CONCEPTION AND FACTORS INFLUENCING IT

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Introduction

Direct reproductive traits as they are currently measured tend to be low in heritability, making the beef female's environment key to reproductive success. Management and nutrition are factors that can be easily affected and yield significant results. Decisions in crossbreeding, cow size, and calving season can have dramatic impacts on pregnancy rates. Body condition score, adequate energy and protein supplementation, and vitamin and mineral balance also play important roles in insuring reproductive efficiency is optimized. Consideration must be made to total cowherd management and proper nutrition to attain the goal of optimum pregnancy rates.

Management

Importance of Early Conception

Calving date for first calf heifers may impact cow longevity and productivity. Calving late in yr 1 increases the proportion of cows that either calve later next year or do not conceive (Burris and Priode, 1958). Research has indicated heifers having their first calf earlier in the calving season remained in the herd longer compared with heifers that calved later in the calving season (Cushman et al., 2013). Therefore, heifers calving earlier in the calving season have greater potential for longevity and lifetime productivity.

Decreasing the calving period has far reaching implications across the cow-calf enterprise and beyond. Calf age is the single most important factor impacting weaning weight in cow-calf operations so herds with more concentrated calving distributions are expected to have heavier weaning weights compared with herds that do not. Effects of calving early in the calving season potentially extend much further into beef systems, including improved pregnancy percentages and subsequent calving distributions the next calving season, increased cow longevity, lower replacement rate, positive influences on carcass quality and value, reduced labor requirements, increased returns on feed inputs and improved overall sustainability.

Advantage of Crossbreeding

Traits of low heritability, such as reproduction, have the greatest response to heterosis (crossbreeding). It was determined from research at Montana State University (Davis et al., 1994) that crossbred cows have a substantial economic advantage over straight bred animals, primarily through increased longevity and calf weaning weight per cow exposed, which takes into account calf weight as well as cow reproductive performance (Table 1).

Table 1. Advantage of crossbred cows (maternal heterosis) over straight bred cows for economic traits (Davis et al., 1994)

Trait	Maternal heterosis
Longevity	1.2 years (44%)
Calf weight weaned per cow exposed	74 lb (25%)
Net profit per cow exposed	$70

Match Cow Type to Forage Base

Large cow size and high milk production translate into increased nutrient requirements for the cow. Increased milk production and cow size increase both energy and crude protein requirements. Excess milk production and cow size can significantly limit the carrying capacity of any ranch operation or reproduction will be compromised.

Herd Health

A sound herd health program is an essential part of any reproductive management system. Cattle are susceptible to a variety of diseases detrimental to reproduction. All herd health programs should be implemented under the supervision of a qualified, licensed veterinarian. A relationship exists between poor nutrition and increased incidence of herd health problems. Several vitamins and minerals are necessary for immune system function and nutrient deficiencies in these areas can result in an increased susceptibility to disease.

Minimize the Postpartum Interval

Rebreeding performance of the first calf heifer has major economic consequences. This classification of breeding animal is often the most challenging to manage for reproductive efficiency, primarily because this animal is not only subject to the stresses of calving and lactation for the first time, but she is also still growing. Failure to rebreed after birth of the first calf is one of the primary reasons for culling in a beef cattle operation. There is a considerable amount of money invested in this animal and high replacement rates can greatly decrease the profitability of a beef cattle operation. The period from calving until the cow conceives is a very critical period in a cow’s production cycle, minimizing this time period is critical for maximizing reproductive and economic efficiency of a beef cattle operation. Cows cycling early in the breeding season have more opportunities to become pregnant during a limited breeding season. Breeding season length will influence uniformity of calves and their value at weaning. In order to have a successful, short breeding season, it is vital that cattle cycle and conceive early in the breeding season. Minimizing the postpartum interval is limited by uterine involution, which is the time needed for repair of the reproductive tract so another pregnancy can be established. Uterine involution generally occurs within 30 days postpartum and does not generally limit cyclicity; however, factors such as malnutrition, disease and calving difficulty will delay normal involution.

Calving Difficulty and Time of Intervention

Bellows (1995) indicated cows that experience calving difficulty will take longer to cycle than cows not experiencing calving difficulty, therefore, it is important to minimize calving difficulty in your breeding herd. Time of intervention, when obstetrical assistance is needed, also affects cyclicity. Dams given early assistance had a reduction in postpartum interval, a higher percentage in heat by the beginning of the breeding season, a trend toward fewer services per conception, an increase in pregnancy rate, and heavier calves at weaning (Table 2). Therefore, early assistance, when needed, is important to assure heifers return to estrus as soon as possible.

Table 2. Effect of time of calving assistance on dam breeding and calf performance

	Time of Assistance	
Item	Early	Late
Postpartum interval, (d)	49	51
In heat at beginning of breeding season (%)	91	82
Services/conception	1.15	1.24
Pregnancy (%)	92	78
Calf average daily gain (lb)	1.74	1.63
Calf weaning weight (lb)	422	387

Calf Effects

Suckling stimulus from the calf has a negative effect on cyclic activity during the postpartum period; however, animals in a positive energy balance and in adequate body condition generally overcome this negative stimulus prior to the breeding season. Calf removal, either temporary or permanent, can increase the number of cows that return to estrus during the breeding season (Williams, 1990). A common practice in some synchronization programs is 48 hr calf removal, which has been shown to induce cyclicity in postpartum cows and first calf heifers. It is important to provide a clean, dry pen with grass hay and water and make sure that pairs mother up before going to pasture.

Induction of Estrus with Hormones

Progestin containing products such as MGA (melengesterol acetate) or CIDR can shorten the postpartum interval provided nutrition and body condition are adequate. Gonadotropin releasing hormone (GnRH) is another hormone used in synchronization programs to induce estrus in some heifers. None of these products are substitutes for good management and heifers need to be at least 40 days postpartum before they will induce cyclicity.

Bull Effects

Bull presence from 30 days after calving to the start of the breeding season has been shown to cause heifers to cycle earlier. Bull exposure requires exposing heifers to surgically altered bulls not capable of breeding. Approximately 1 bull per 20 heifers is required and limited data suggests exposure to androgenized steers or cows will produce similar results.

Nutrition

Body Condition Score

Body condition score (BCS) is correlated with several reproductive events such as postpartum interval, services per conception, calving interval, milk production, weaning weight, calving difficulty, and calf survival; which greatly affect net income in a cow-calf operation (Table 3; Kunkle et al., 1994). The most important factor influencing pregnancy rate in beef cattle is body energy reserves at calving (Wettemann et al., 2003). Body condition at calving is the single most important factor determining when beef heifers and cows will resume cycling after calving. Body condition score at calving also influences response to postpartum nutrient intake. Spitzer et al. (1995) fed primiparous cows differing in body condition (BCS 6 vs. 4; 1 = emaciated, 9 = obese) to gain either 1.87 or .97 lb/d. The percentage of BCS 6 cows in estrus during the first 20 days postpartum increased from 40 to 85% when fed to the higher rate of gain, the cows in BCS 4 only increased estrous response from 33 to 50% during the first 20 d postpartum when fed to gain at the higher rate. Cattle should have an optimum BCS of 5 to 6 at calving through breeding to assure optimal reproductive performance. Body condition score is generally a reflection of nutritional management; however, disease and parasitism can contribute to lower BCS even if apparent nutrient requirements are met.

Table 3. Relationship of body condition score (BCS) to beef cow performance and income

BCS	Pregnancy rate, %	Calving interval, d	Calf ADG, lb	Calf WW, lb	Calf Price, $/100 lb	$/cow Exposed[a]
3	43	414	1.60	374	96	154
4	61	381	1.75	460	86	241
5	86	364	1.85	514	81	358
6	93	364	1.85	514	81	387

[a] Income per calf x pregnancy rate.

Specific Nutrients and Reproduction

Feeding a balanced diet to beef females in the last trimester of pregnancy through the breeding season is critical. Nutritional demands increase greatly in late gestation and even more in early lactation. Reproduction has low priority among partitioning of nutrients and consequently, cows in thin body condition often don't rebreed. Plane of nutrition the last 50 to 60 days before calving has a profound effect on postpartum interval (Table 4; Randel, 1990). The importance of pre- and postpartum protein and energy level on reproductive performance has been consistently demonstrated (Table 4). Positive energy balance postpartum is essential for prompt rebreeding of heifers calving in thin condition (Table 5; Lalman et al., 1997).

Table 4. Effect of pre- or postpartum dietary energy or protein on pregnancy rates in cows and heifers

Nutrient and time	Pregnant, %		Difference, %
	Adequate	Inadequate	
Energy level pre-calving[a]	73	60	13
Energy level post-calving[b]	92	66	26
Protein level pre-calving[c]	80	55	25
Protein level post-calving[d]	90	69	21

[abcd] Combined data from 2, 4, 9 and 10 studies, respectively.

Table 5. Influence of postpartum diet on weight change, body condition score (BCS) change and postpartum interval (PPI)

	Diet			
Item	Low	Maintenance	Maint./ High	High
Post-calving weight, lb	835	822	826	821
BCS at calving	4.27	4.26	4.18	4.10
PPI, d	134	120	115	114
PPI wt. change, lb	12	40	70	77
PPI BCS change	-.32	.37	1.24	1.50

Bearden and Fuquay (1992) summarized the effects of inadequate and excessive nutrients on reproductive efficiency (Table 6).

Table 6. Influence of inadequate and excessive dietary nutrient intake on reproduction in beef cattle

Nutrient Consumption	Reproductive Consequence
Excessive energy intake	Low conception, abortion, dystocia, retained placenta, 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 reabsorption, premature parturition, weak offspring
Vitamin A deficiency	Impaired spermatogenesis, anestrus, low conception, abortion, weak offspring, retained placenta
Phosphorus deficiency	Anestrus, irregular estrus
Selenium deficiency	Retained placenta
Copper deficiency	Depressed reproduction, impaired immune system, impaired ovarian function
Zinc deficiency	Reduced spermatogenesis

Protein and Energy

Inadequate 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; Paterson et al., 2001). An example of the relationship between crude protein content of forages and forage intake is presented in Figure 1. Dry matter intake declined rapidly as forage crude protein fell below 7%, a result attributed to a deficiency of nitrogen (protein) in the rumen, which decreased microbial activity. If forage contains less than approximately 7% crude protein, feeding a protein supplement generally improves the energy and protein status of cattle by improving forage intake and digestibility. For example (Figure 1), forage intake was about 1.6% of body weight when crude protein was 5%, while at 7% crude protein, forage intake was 44% higher and consumption was 2.3% of body weight.

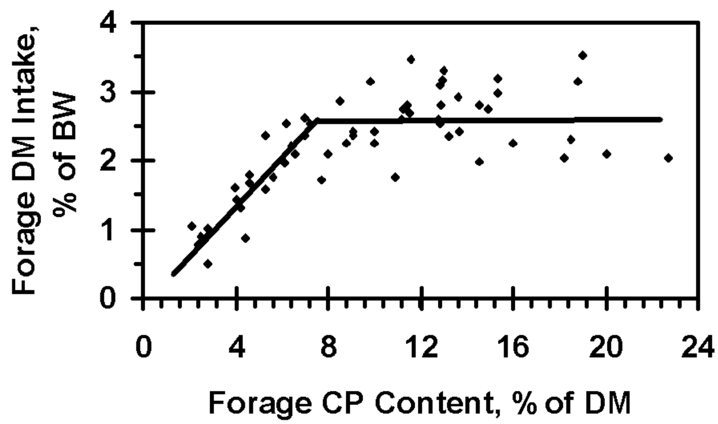

Figure 1. Effect of forage crude protein (CP) on dry matter (DM) intake (Mathis, 2000)

Improved forage intake increases total dietary energy intake, and explains why a protein deficiency is usually corrected first when formulating a supplementation program for animals grazing poor quality forage. As suggested, when the crude protein content of forages drops below about 7%, forage intake declines. However, intake of other forages may decline when forage crude protein drops below 10%. Part of the variation is attributed to differences in nutrient requirements of the cattle, with the remainder of the variation attributed to inherent differences among forages presenting different proportions of nutrients to rumen microbes. Intake response to a single nutrient such as crude protein is not expected to be similar among all forages (Mathis, 2000).

Livestock producers are often concerned 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 on calving difficulty, reproductive performance, and calf growth. This summary is presented in Table 7.

Reducing energy pre-partum had virtually no effect on dystocia rates, even though birth weights were altered in some experiments. Of the 9 trials summarized, 7 indicated increased energy intakes during the last trimester of gestation did not increase calving difficulty.

Table 7. Summary of studies on supplemental prepartum energy intake on calving difficulty, subsequent reproductive performance and calf growth

Researcher	Supplementation[a]	Summary of Effects
Christenson et al., 1967	HE vs. LE for 140 d prepartum	HE increased birth wt., dystocia, milk and 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 and 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. and 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)

In addition, producers are often concerned with levels of crude protein and possible effects on calf birth weight. Selk (2000) summarized studies conducted to specifically measure effects of varying protein intake to the prepartum beef female on calving difficulty (Table 8). Reducing dietary crude protein prepartum does not decrease calving difficulty and may compromise calf health and cow reproductive performance.

Table 8. Summary of studies on feeding supplemental protein during gestation on calving difficulty, subsequent reproductive performance and calf growth

Researcher	Supplementation[a]	Summary of Effects
Wallace and Raleigh, 1967	HP[a] vs. LP for 104 - 137 d prepartum	HP increased cow wt., birth wt. and conception rate but decreased dystocia
Bond and 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)

Excess Protein and Energy

Caution should be used with feeding excessive amounts of nutrients before or after calving. Not only is it costly, but animals with BCS >7 have lower reproductive performance and more calving difficulty than animals in moderate BCS 5 to 6. Excessive protein and energy can both have negative effects on reproduction. Overfeeding protein during the breeding season and early gestation, particularly if the rumen receives an inadequate supply of energy, may be associated with decreased fertility (Elrod and Butler, 1993). This decrease in fertility may result from decreased uterine pH during the luteal phase of the estrous cycle in cattle fed high levels of degradable protein. The combination of high levels of degradable protein and low energy concentrations in early-season grasses may contribute to lower fertility rates in females placed on such pastures near the time of breeding. Negative effects of excess rumen degradable intake protein on reproduction are well documented in dairy literature (Ferguson, 2001).

Effects of supplementing feedstuffs high in undegradable intake protein (UIP) on reproduction are inconclusive and appear to be dependent on energy density of the diet (Hawkins et al., 2000). Research by Kane and others (2004) demonstrated negative effects on reproductive hormones when high (.71 lb/d) levels of UIP were supplemented, but not at low (.25 lb/d) or moderate (.48 lb/d) levels. Heifers fed additional UIP (.55 lb/d) during development reached puberty at a later age and heavier weight and fewer were serviced in the first 21 d of the breeding season. Pregnancy rate was not affected (Lalman et al., 1993). Further research is needed to elucidate potential mechanisms UIP may stimulate or inhibit reproductive processes and under what conditions.

Distillers grains are a co-product from the ethanol industry being utilized in beef cattle diets and are also high (65% of CP content) in UIP.

A 2 yr study was conducted at 2 locations to determine if supplementing beef heifers with dried distillers grains (DDG) as an energy source affected growth or reproduction (Martin et al., 2007a). Spring-born crossbred heifers (n = 316) were blocked by age or sire and age and assigned randomly to DDG or control (dried corn gluten feed, whole corn germ, urea) supplement. Heifers received prairie hay in amounts sufficient for ad libitum intake and 0.59% of BW DDG or 0.78% of BW control supplement (DM basis). Supplements were formulated to be isocaloric, but protein degradability differed. Final BW, ADG, and final BCS were not affected by supplementation. Estimated age and BW at puberty did not differ between treatments, and the proportions of pubertal heifers did not differ at the initiation of the experiment, at the beginning of the 10-d sampling intervals, or before synchronization. Estrus synchronization rate (75.9%), time of estrus, and overall pregnancy rate (89.5%) were not affected by treatment. However, a greater proportion of DDG than control heifers conceived to AI (75.0 vs. 52.9%), resulting in greater AI pregnancy rates for DDG heifers (57.0 vs. 40.1%). Body weight or BCS at pregnancy diagnosis did not differ between DDG and control heifers. Supplementing beef heifers with DDG during development did not affect age at puberty but improved AI conception and pregnancy rates compared with an isocaloric control supplement.

Minerals

Minerals are important for all physiological processes in the beef animal including reproduction, so it is simply a matter of determining when they have to be supplemented in the basal diet.

Salt (NaCl) is the most important mineral a beef animal needs. Normally, sodium and chloride do not appear in feedstuffs in adequate amounts to meet animal requirements and should be provided free choice at all times.

Calcium is generally adequate in forage-based diets, but is often included in commercially available mineral supplements because many phosphorus sources also contain calcium. Much debate and research has been conducted on the effects of phosphorus supplementation on reproductive function. Phosphorus and crude protein content generally parallel each other in pasture or rangeland. Mature forages are generally deficient in phosphorus and impaired reproductive function has been associated with phosphorus deficient diets (Dunn and Moss, 1992; Lemenager et al., 1991). Diets should be evaluated for phosphorus content and supplemented accordingly. Caution should be used to not overfeed phosphorus -- it is costly, of potential environmental concern, and does not positively influence reproduction in beef (Dunn and Moss, 1992) or dairy (Lopez et al., 2004) cattle.

Other macro minerals include magnesium, potassium, chlorine, and sulfur. Need for supplementation, as with the previously mentioned minerals, is dependent on content in the basal diet and water. Both deficiencies and excesses can contribute to suboptimal reproductive function.

Micro or trace minerals include copper, cobalt, iodine, iron, manganese, and zinc. Inadequate consumption of certain trace elements combined with antagonistic effects of other elements can reduce reproductive efficiency (Greene et al., 1998).

Vitamins

Most of the vitamins (C, D, E, and B complex) are either synthesized by rumen microorganisms, synthesized by the body (vitamin C) or are available in common feeds and are not of concern under normal conditions. Vitamin A deficiency, however, does occur naturally in cattle grazing dry winter range or consuming low quality crop residues and forages (Lemenager et al., 1991). The role of vitamin A in reproduction and embryo development has been reviewed by Clagett-Dame and Deluca (2002). Supplementation before and after calving can increase conception rates (Hess, 2000).

Water

Water is more essential to life than any other nutrient. Feed intake is directly related to water intake. Water may also contribute significant macro and micronutrients that may benefit or impair production and reproduction. Contribution of these nutrients from water sources must be considered to accurately design a supplementation program.

Ionophores

Bovatec® and Rumensin® have been shown to influence reproductive performance during the postpartum period. Cows and heifers fed an ionophore exhibit a shorter postpartum interval provided adequate energy is supplied in the diet (Table 9; Randel, 1990). This effect appears to be more evident in less intensely managed herds with a moderate (60 to 85 d) or longer postpartum interval. Scientists have also demonstrated heifers fed an ionophore reach puberty at an earlier age and a lighter weight (Patterson et al., 1992).

Table 9. Effect of ionophore feeding on postpartum interval (PPI) in beef cows and heifers

Study	Ionophore (PPI, d)	Control (PPI, d)	Difference (d)
1	30	42	-12
2	59	69	-10
3	67	72	-5
4	65	86	-21
5	92	138	-46

Fat Supplementation

Inadequate dietary energy intake and poor body condition can negatively affect reproductive function. Supplemental lipids have been used to increase the energy density of the diet and avoid negative associative effects (Coppock and Wilks, 1991) sometimes experienced with cereal grains (Bowman and Sanson, 1996) in high roughage diets.

Supplemental lipids may also have direct positive effects on beef cattle reproduction independent of the energy contribution. Lipid supplementation has been shown to positively affect reproductive function in several important tissues including the hypothalamus, anterior pituitary, ovary, and uterus. The target tissue and reproductive response appears to be dependent upon the types of fatty acids contained in the fat source. Fat supplementation is a common practice in dairy cattle production, primarily to increase the energy density of the diet. Associated positive and negative effects on reproduction have been reported (Grummer and Carroll, 1991; Staples et al., 1998).

Research with supplemental fat has been conducted on cows and replacement heifers. Fats have been fed before and after calving and during the breeding season. Several response variables have been examined, including body weight and BCS, age at puberty, postpartum interval, first service conception rates, pregnancy rates, calving interval, calving difficulty, and calf birth and weaning weight. To determine potential mechanisms of action, scientists have investigated changes in follicular and uterine development, hormonal profiles and changes, brain function, and embryonic development.

The effects of fat supplementation on reproduction in beef heifers and cows has been reviewed (Funston, 2004) and is summarized below.

Fat Supplementation to Replacement Heifers. Studies are limited on the use of fat supplements in replacement heifer diets. In general, heifers in the studies cited were on a positive plane of nutrition and developed to optimum weight and age at breeding. There may have been a positive response to fat supplementation had heifers been nutritionally challenged. It appears from the studies cited, there is limited benefit of fat supplementation in well-developed replacement females and is probably only warranted when supplements are priced comparable to other protein and energy sources.

Fat Supplementation Prepartum. Results from feeding supplemental fat prepartum are inconclusive. However, response to supplementation appears to be dependent on postpartum diet. Beef animals apparently have the ability to store certain fatty acids, supported by studies in which fat supplementation was discontinued at calving but resulted in a positive effect on reproduction. Postpartum diets containing significant levels of fatty acids may mask any beneficial effect of fat supplementation. There appears to be no benefit and in some cases, a negative effect of feeding supplemental fat postpartum, particularly when supplemental fat was also fed prepartum. Fat supplementation has been reported to both suppress and increase $PGF_{2\alpha}$ synthesis. When dietary fat is fed at high levels for extended periods of time, $PGF_{2\alpha}$ synthesis may be increased and compromise early embryo survival. Hess et al. (2005) summarized research on supplementing fat during late gestation and concluded feeding fat to beef cows for approximately 60 d before calving may result in a 6.4% improvement in pregnancy rate in the upcoming breeding season.

Fat Supplementation Postpartum. Supplementing fat postpartum appears to be of limited benefit from studies reported here. Many of the studies reported approximately 5% fat in the diet supplemented with fat. It is not known if more or less fat would have elicited a different response (either positive or negative). If supplementing fat can either increase or decrease $PGF_{2\alpha}$ production, it seems reasonable the amount of fat supplemented might affect which response is elicited. Recent research (Hess et al., 2005) demonstrated a decrease in first service conception rates (50 vs. 29%) when young beef cows were fed high linoleate safflower seeds (5% DMI) postpartum. The same laboratory has also reported (Grant et al., 2002) an increase in $PGF_{2\alpha}$ metabolite (PGFM) when high linoleate safflower seeds are fed postpartum and a decrease in several hormones important for normal reproductive function (Scholljegerdes et al., 2003 and 2004).

Feeding Considerations. The amount of supplemental fat needed to elicit a positive or, in some cases, a negative effect on reproductive function is largely unknown and titration studies are needed in all situations in which supplemental fat has been fed. Dose response studies indicate the amount of added plant oil necessary to maximize positive ovarian effects is not less than 4% (Stanko et al., 1997; Thomas et al., 1997). Staples et al. (1998) indicated 3% added dietary fat (DM basis) has often positively influenced the reproductive status of the dairy cow.

Lower levels of added dietary fat (2%) have also been shown to elicit a positive reproductive response (Bellows et al., 2001) and studies with fishmeal, less than 1% added fat (Burns et al., 2002) produced a positive reproductive response. This indicates both amount and types of fatty acids are important. Feeding of large quantities of fat (> 5% of total DMI) has not been recommended due to potential negative effects on fiber digestibility and reduction in DMI (Coppock and Wilks, 1991). The duration and time (pre or postpartum) of supplement feeding needed to elicit a positive response is not precisely known, many of the studies have supplemented fat at least 30 d. The period of supplementation has varied from different times before breeding in heifer development, pre-calving, post-calving, and/or pre-breeding periods. The young, growing cow appears to be the most likely to respond to supplemental nutrients. An appropriate situation for fat supplementation may be when pasture or range conditions are limiting or are likely to be limiting before and during the breeding season. Feeding supplemental fat to well-developed heifers or cows in adequate body condition on adequate pasture or range resources may not provide any benefit beyond energy contribution to the diet.

Summary of Fat Supplementation. Currently, research is inconclusive on exactly how to supplement fat to improve reproductive performance beyond energy contribution. Most studies have tried to achieve isocaloric and isonitrogenous diets. However, this can be challenging. Some studies only have sufficient animal numbers to detect very large differences in reproductive parameters such as conception and pregnancy rate. Research on feeding supplemental fat has resulted in varied and inconsistent results as it relates to reproductive efficiency including positive, negative, and no apparent effect.

Elucidating mechanisms of action of how supplemental fat can influence reproductive function has been a difficult process. Animal response appears to be dependent on body condition score, age (parity), nutrients available in the basal diet, and type of fat supplement. The complexity of the reproductive system and makeup of fat supplements are often confounded by management conditions and forage quality both in research and in commercial feeding situations. This has contributed to inconsistencies in research findings.

Improvements in reproduction reported in some studies may be a result of added energy in the diet or direct effects of specific fatty acids on reproductive processes. As is the case for any technology or management strategy that improves specific aspects of ovarian physiology and cyclic activity; actual improvements in pregnancy rates, weaned calf crop, or total weight of calf produced are dependent on an array of interactive management practices and environmental conditions. Until these interrelationships are better understood, producers are advised to strive for low cost and balanced rations. If a source of supplemental fat can be added with little or no change in the ration cost, producers would be advised to do so. Research investigating the role of fat supplementation on reproductive responses has been variable. Therefore, adding fat when significantly increasing ration cost would be advised when the risk of low reproduction is greatest. Postpartum fat supplementation appears to be of limited benefit and adding a fat source high in linoleic acid postpartum may actually have a negative effect on reproduction.

Maternal Nutrition and Postnatal Development

Fetal programming is the concept maternal stimuli during fetal development influence the physiology of the fetus and postnatal growth and health (Barker et al., 1993). Limited data exists concerning the influence of late-gestation nutrition of ruminants on reproductive performance of their female progeny. Primiparous heifers restricted to 65% of the NRC recommended energy intake during the final 100 d of pregnancy had calves with lighter birth weights and a reduced weaning percentage compared with heifers fed at NRC recommendations. Age at puberty of heifer calves from energy restricted primiparous dams was increased by 19 d, but pregnancy rate of the heifer calves was not measured (Corah et al., 1975). Energy restriction of ewes for 10 d during late gestation resulted in altered adrenal steroid production in adult female progeny (Bloomfield et al., 2003).

A 3 year study was conducted with heifers (n = 170) whose dams were used in a 2 × 2 factorial arrangement of treatments to determine the effects of late gestation (LG) or early lactation (EL) dam nutrition on subsequent heifer growth and reproduction (Martin et al., 2007b). In LG, cows received 1 lb/d of a 42% CP supplement (PS) or no supplement (NS) while grazing dormant Sandhills range. During EL, cows from each late gestational treatment were fed cool-season grass hay or grazed subirrigated meadow. Cows were managed as a single herd for the remainder of the year. Birth date and birth weight of heifer calves were not affected by dam nutrition. Meadow grazing and PS increased heifer 205-d BW vs. feeding hay and NS, respectively. Weight at prebreeding and pregnancy diagnosis were greater for heifers from PS dams but were unaffected by EL nutrition. There was no effect of LG or EL dam nutrition on age at puberty or the percentage of heifers cycling before breeding. There was no difference in pregnancy rates due to EL treatment. Pregnancy rates were greater for heifers from PS dams, and a greater proportion of heifers from PS dams calved in the first 21 d of the heifers' first calving season. Dam nutrition did not influence heifers' average calving date, calving difficulty, and calf birth weight during the initial calving season. Weight at the beginning of the second breeding season was greater for heifers from PS dams but was not affected by maternal nutrition during EL. Dam nutrition did not affect heifer ADG or G:F ratio. Heifers from PS dams had greater DMI and residual feed intake than heifers from NS cows if their dams were fed hay during EL but not if their dams grazed meadows. Heifers born to PS cows were heavier at weaning, prebreeding, first pregnancy diagnosis, and before their second breeding season. Heifers from cows grazing meadows during EL were heavier at weaning but not postweaning. Despite similar ages at puberty and similar proportions of heifers cycling before the breeding season, a greater proportion of heifers from PS dams calved in the first 21 d of the heifers' first calving season, and pregnancy rates were greater compared with heifers from NS dams. Collectively, these results provide evidence of a fetal programming effect on heifer postweaning BW and fertility.

Summary

There are many considerations to take into account when striving to optimize pregnancy rates and time of conception. Because reproductive traits tend to be low in heritability, the impact of management and nutrition become paramount. Total cowherd management recommendations include:

1. A sound herd health program is essential for optimum reproductive efficiency.
2. Utilize crossbreeding (heterosis) to optimize reproductive efficiency.
3. Make sure heifers are on a balanced ration the last trimester of pregnancy through the breeding season.
4. Heifers should be in optimum body condition (BCS 5 to 6) at calving and through the breeding season.
5. Provide calving assistance in a timely manner when needed.
6. Use an ionophore for increased feed efficiency, coccidiosis control, and the positive effect on reproductive performance.
7. Progestins, GnRH, 48-hour calf removal, and bull exposure are management tools that can induce cyclicity in some heifers.

Several tools can assist in shortening the postpartum interval but none of these will take the place of good total cowherd management. Body condition, level of nutrition, age of cows, milk production, weather, disease, parasites, and other factors will affect the ability to shorten the postpartum interval. The first place to address this problem is with proper nutrition prior to calving and through the breeding season and managing for optimum body condition.

Nutrition has a profound effect on reproductive potential in all living species. Body condition is a useful indicator of nutritional status and when used in conjunction with body weight change can provide a useful method to assess reproductive potential. Energy and protein are the nutrients required in the greatest amounts and should be first priority in developing nutritional programs to optimize reproduction. Minerals and vitamins must be balanced in the diet to optimize reproductive performance. Consider water quantity and quality when balancing diets. Caution should be taken not to overfeed nutrients or reproductive processes may be adversely affected. No magic feed ingredient exists that will compensate for a diet greatly deficient in any of the mentioned nutrients or poor body condition score. Nutritional considerations and impacts on reproduction have primarily focused on postnatal development; however, prenatal nutrition appears to have potential effects on subsequent reproductive performance in beef cattle.

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