Nutritional Factors Affecting Reproduction in Young Beef Cows

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Introduction

For cattle producers, heifers that have just given birth to their first calf (first-calf heifers) are the toughest group of females to manage. Giving birth for the first time is a shocking experience for a heifer, but stress associated with the first birth also is confounded with numerous other management related issues. After birth, the first-calf heifer is required to nurse a young calf, her reproductive tract needs to undergo repair (uterine involution) to prepare for the next pregnancy, and she is required to maintain her own condition in order to become pregnant during the subsequent breeding season. All of these factors are new to a heifer and she is required to do this at a time when she is introduced to the mature cow herd. In other words, a heifer that has just given birth needs to compete with older, more aggressive cows for feed and yet continue to grow to a mature weight and become pregnant to calve during the following calving season.

In most herds, 15 to 20% of the cow herd is replaced annually by replacement females. These replacement females represent the future genetics of the operation and could dictate the ultimate profitability of the operation. Sound selection for females that will produce offspring on a yearly basis, nurture their offspring until weaning with a minimum of disease or sickness, and wean their offspring with acceptable weaning weights is paramount to a successful operation.

Replacement, virgin beef heifers require little input from a producer. After weaning, heifers selected as replacements usually are forgotten or neglected until shortly before the breeding season. However, the management decisions on how we treat our replacement heifers, usually affects their performance for a period of time following the birth of their first calf. In fact, when one considers that a replacement heifer remains in the herd for almost three years before she makes a financial contribution to the producer, it is imperative that we pay close attention to our genetic selection and management of our future “bread winners”.

The ultimate goal for cow/calf producers is to obtain one live calf from each cow, every year. Unfortunately most beef cattle operations fail to achieve an annual 100% calving rate. For a producer to ensure that each cow calves on a yearly basis, cows are required to conceive within 83 days after calving. Many beef cattle have not even resumed their estrous cycles by this point, especially cows that have given birth to their first calf! Several factors contribute to delaying the onset of estrous cycles in postpartum cows; however, nutrition and suckling are the two critical factors that tend to dictate when cows begin to cycle. Because most beef cows are suckled within the first few months after calving, nutrition becomes the major component that can be managed to enhance productivity of beef cows. Yet, we must keep in mind that the goal of sound nutritional management, in a beef production setting, is to satisfy the cows reproductive needs.

Insufficient intake of energy, protein, vitamins, and micro- and macrominerals have all been associated with suboptimal reproductive performance. Of these nutritional effects on reproduction, energy balance is probably the single most important nutritional factor related to poor reproductive function in cows. 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) excess energy reserves. Based on this list of metabolic priorities for energy, reproductive function is compromised because available energy is directed towards meeting minimum energy reserves and milk production.

Generally, beef cows do not experience a period of negative energy balance because they fail to produce the quantity of milk that dairy cows produce; however, beef cows need to be in good enough condition to resume estrous cycles after parturition and overcome general infertility, anestrus, short estrous cycles, and uterine involution just to maintain a yearly calving interval. Why, then, are first-calf heifers a nemesis to our beef cattle operations? Firstly, these young cows need additional nutrients, because even though they are cows, they are still growing themselves; therefore, not only do they need nutrients for their calves, but they need nutrients for further growth. Secondly, from a physiological standpoint, these cows have never experienced a birth. They generally have smaller pelvic areas than mature cows, which increases the incidence of dystocia; they have to struggle with the stress of calving for the first time; they are required to raise a calf; and, they must reinitiate estrous cycles to become pregnant during the subsequent breeding season. Even in an ideal setting, we require these young cows to perform at unrealistic levels. Nonetheless, with a little foresight we can set the stage to allow these cows to have an opportunity to become productive mature cows.

Factors Affecting Reproduction

Ultimately, the primary hurdle for a first-calf heifer to overcome is to become pregnant during her second breeding season. In most cattle operations, cows that do not calve once a year are culled because they become an economical liability. If we can ensure that our first-calf heifers are pregnant by the end of the second breeding season most of our goals regarding first-calf heifer management will have been achieved.

For producers using a short breeding season, estrus expression is important for either AI technicians or a bull. First-calf heifers with greater incidences of dystocia tend to have poorer fertility responses (Table 1). Detection of estrus, conception rates, and overall pregnancy rates are all factors negatively affected by dystocia. In addition, as cows become more comfortable with each additional birth the incidence of dystocia decreases and fertility traits increase.

Table 1. Effect of calving difficulty on detection of estrus, conception rates, and pregnancy rates[a]

Group			During AI period		
Dystocia class	Cow age	No. of cows	Detected in estrus, %	Conception rates, %	Overall Pregnancy rate, %
No dystocia	2	584	68.3[x]	66.0[x]	79.6[x]
Dystocia	2	366	59.3[y]	50.6[y]	71.4[y]
No dystocia	3	451	71.8[x]	63.6[x]	86.6[x]
Dystocia	3	69	55.1[y]	46.0[y]	72.6[y]
No dystocia	4	388	86.1[x]	77.9[x]	89.7[x]
Dystocia	4	31	77.4[y]	64.1[y]	64.1[y]

[a] Adapted from Laster et al., 1973.
[x,y,z] Within a cow age group and column, means with uncommon superscripts differ ($P < .01$).

A recent study (Table 2; Stevenson et al., 1997) determined the incidence of cyclicity in beef cows at the initiation of the breeding season. As expected, a majority (87.7%) of the virgin heifers had reached puberty by the beginning of the breeding season. In the two suckled beef cow groups multiparous cows had a greater ($P < .05$) incidence of cyclicity than primiparous cows (74.1 vs 53.4%, respectively). This experiment provides further evidence that first-calf heifers tend to have greater difficulty resuming their estrous cycles after calving than mature cows. Therefore, it is imperative to ensure that precalving management allows first-calf heifers sufficient resources to recover following calving, and yield acceptable fertility results.

Table 2. Cycling status of beef females before the beginning of the breeding season[a]

Category	No. of females	Percent cycling, %
Virgin heifers	73	87.7
Primiparous cows	101	53.4
Multiparous cows	178	74.1

[a] Adapted from Stevenson et al., 1997.

The Nutrition/Reproduction Interaction

Body condition scoring (BCS) is a reliable method to assess the nutritional status of a cow herd, but is especially important in first-calf heifers. A visual body condition scoring system developed for beef cattle uses a scale from 1 to 9, with 1 representing emaciated and 9 obese cattle (Whitman, 1975). A linear relationship exists between body weight change and body condition score (using a 1 to 9 scale), where approximately a 90-lb weight change is associated with each unit change in BCS.

Live weight at calving has no effect on reproductive performance, whereas calving condition score is a better indicator than prepartum change in either weight or condition score on the duration of postpartum anestrus (Whitman, 1975; Lalman et al., 1997). When cows are thin at calving or have BCS of 4 or less, increased postpartum level of energy increases percentages of females exhibiting estrus during the breeding season. Likewise, heifers that calve with a BCS of 4, and are fed to maintain weight after parturition, have a reduction in ovarian activity and lower pregnancy rates than to heifers that calve at a similar body condition and gain weight after parturition (Wetteman et al., 1986). Body condition score at parturition and breeding are the dominant factors influencing pregnancy success, although body weight changes during late gestation modulated this effect.

The general belief is that cows maintained on an increasing plane of nutrition prior to parturition usually have a shorter postpartum interval to their first ovulation than cows on a decreasing plane of nutrition. Energy restriction during the prepartum period results in thin body condition at calving, prolonged postpartum anestrus, and a decrease in the percentage of cows exhibiting estrus during the breeding season. Pregnancy rates and intervals from parturition to pregnancy also are affected by level of prepartum energy.

Some experts have suggested that when prepartum nutrient restriction is followed by increased postpartum nutrient intake, the negative effect of prepartum nutrient restriction may be overcome partially. However, the effectiveness of elevated postpartum nutrient intake may depend on the severity of prepartum nutrient restriction (Lalman et al., 1997). This conclusion concurred with that of Perry et al. (1991) in which prepartum nutrient restriction resulted in 1.8 units loss in BCS during a 90-d prepartum period. Enhanced energy in the postpartum diet reduced, but did not completely abolish, the negative effects of prepartum energy restriction on postpartum anestrus.

Table 3 demonstrates the importance of prepartum nutrition on return to estrous cycles in suckled beef cows. Cows calving in poor condition (i.e BCS of 3 or 4) had longer intervals before resuming their estrous cycles than cows calving in good condition (i.e. BCS 5 or greater). Remember, for cows to calve on a yearly interval they are to conceive within 83 days after calving; therefore, if cows only reinitiate there estrous cycles at 70 to 90 days postcalving the possibility of a yearly calving interval is vastly reduced.

Table 3. Influence of body condition on return to estrous cycles in beef cows[a]

BCS	Postpartum interval, days
3	88.5
4	69.7
5	59.4
6	51.7
7	30.6

[a] Adapted from Houghton et al., 1990.

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) excess energy reserves. Based on this list of metabolic priorities for energy, reproductive function is often compromised in first–calf heifers because even though they are nursing a calf they are still growing; therefore, they are required to consume nutrients for growth, milk production, and energy reserves before pregnancy can be established. In contrast, mature cows have quit growing and, thus, can concentrate there nutrient intake on nursing a calf and then establishment of pregnancy.

Nutrition and Heifer Development

To even have a chance of managing a first-calf heifer, it is important to ensure that replacement heifers are managed correctly to obtain as many heifers pregnant at the initiation of the breeding season as possible. Age and weight are the two primary factors that determine when a heifer reaches puberty (Lynch et al., 1997). A greater percentage of heavy weight heifers attain puberty prior to the onset of breeding season compared to light-weight heifers. Although age may be unknown in many management settings heavier heifers tend to have attained puberty, whereas lighter-weight heifers tended to have underdeveloped reproductive tracts. At several stages of heifer development we have determined that weight is correlated to artificial insemination pregnancy rates, overall pregnancy rates, reproductive tract scores (RTS), and pelvic areas (Table 4). We have also determined that for every one-unit increase in RTS, heifer weight increased 41 pounds.

Table 4. Pearson correlations between pregnancy rates (PR), reproductive tract scores (RTS), and pelvic area to body weight

	Correlation coefficients[a]			
Weight[b]	Synchronized PR	Overall PR	RTS	Pelvic area
Prebreeding	0.167	0.208	0.461	0.734
Breeding	0.178	0.229	0.507	0.716
Postbreeding	0.167	0.218	0.438	0.682
Final weight	0.294	0.244	0.374	0.697

[a] P < .001.
[b] Weights were taken on d -67 or -64 (Prebreeding), d -17 or -18 (Breeding), d +36 or +34 (Postbreeding), and d +133 or +131 (Final) relative to initiation of the breeding season for MH and SS heifers, respectively.

When heifers are restricted of energy intake their estrous cycles cease. Obviously heifers that are severely energy restricted stop cycling faster than heifers that are mildly energy restricted (Cassady, unpublished data). However, the condition in which cows are prior to energy restriction dictates how fast they become anestrus. Estrous cyclicity ceased for well conditioned heifers (FAT; BCS = ± 7) or moderately conditioned heifers (MOD; BCS = ± 5) after 156 d or 66 d of energy restriction (Table 5). The BCS when these heifers became anestrus was approximately 3.

Table 5. Body weight, body condition score, and days to onset of anestrus and estrous for heifers in fat (FAT) or moderate (MOD) condition in response to energy restriction and repletion at various stages

	BW, lbs		BCS		Days	
Determination	FAT	MOD	FAT	MOD	FAT	MOD
Preliminary weight	1001^{y}	950^{y}				
Restriction phase						
Initiation of restriction	1133^{y}	935^{z}	7.1^{y}	5.0^{z}		
Onset of anestrus	836^{y}	779^{y}	3.3^{y}	3.1^{y}	156^{y}	67^{z}
Repletion phase						
Initiation of repletion	836^{y}	770^{y}	3.0^{y}	3.2^{y}		
Onset of estrus	1129^{y}	1001^{z}	6.0^{y}	5.2^{z}	79^{y}	68^{y}

[y,z]Within a row, means lacking a common superscript differ (P < .05).

Although well conditioned heifers took longer to achieve anestrus after energy restriction, a disadvantage was after adjusting the diets to reinitiate estrous cycles again. Well conditioned heifers were required to be in greater condition after calving. Therefore, the perception of these heifers was to have a "normal" condition at greater condition than those heifers maintained at a BCS of 5. Other disadvantages of feeding heifers to have excess fat are that they have a decrease in subsequent milk production, a potential for increased calving difficulty and pregnancy rates do tend to decline. Therefore, for producers who remove heifers from feedlots to utilize as replacements need to realize the long-term effects of excessive feed on reproductive efficiency.

Prepartum Nutrition

Several studies have reported the relationship between nutritional status and reproductive performance in cattle. The general belief is that cows maintained on an increasing plane of nutrition prior to parturition usually have a shorter postpartum interval to their first ovulation than cows on a decreasing plane of nutrition. Energy restriction during the prepartum period results in thin body condition at calving, prolonged postpartum anestrus, and a decrease in the percentage of cows exhibiting estrus during the breeding season. Pregnancy rates and intervals from parturition to pregnancy also are affected by level of prepartum energy.

Some experts have suggested that when prepartum nutrient restriction is followed by increased postpartum nutrient intake, the negative effect of prepartum nutrient restriction may be overcome partially. However, the effectiveness of elevated postpartum nutrient intake may depend on the severity of prepartum nutrient restriction (Lalman et al., 1997). This conclusion concurred with that of Perry et al. (1991) in which prepartum nutrient restriction resulted in 1.8 units loss in BCS during a 90-d prepartum period. Enhanced energy in the postpartum diet reduced, but did not completely abolish, the negative effects of prepartum energy restriction on postpartum anestrus.

Table 6. Effect of body condition score and postpartum weight gain on birth weight, dystocia score and weaning weights[a]

Item	Body weight at parturition, lbs	Birth weight, lbs	Dystocia score[b]	205-day weaning weight, lbs
BCS				
4	743^{x}	64^{x}	1.2	411^{x}
5	825^{y}	67^{y}	1.2	$425^{x,y}$
6	933^{z}	71^{z}	1.2	436^{y}
PP weight gain				
Moderate	-	-	-	414^{x}
High	-	-	-	433^{y}

[a] Adapted from Spitzer et al., 1995.
[b] 1 = unassisted and 5 = caesarian section.
[x,y,z] Means within column, within item, lacking a common superscript differ ($P < 0.05$).

Table 6 demonstrates the effect of BCS on calf birth weight and weaning weight of first calf heifers. After cows were fed to achieve BCS of 4, 5, or 6 prior to calving their body weights were greater (as expected), but calf birth weights (with similar genetics), and weaning weights also were greater. In spite of the greater birth weights there was no difference in calving difficulty. An added advantage is the potential for increased weaning weights in cows calving in good condition.

Table 7. Effect of body condition score and postpartum weight gain on cyclicity[a]

	Percent cycling by indicated days of the breeding season			
Item	0	20	40	60
BCS				
4	32	42	56[x]	74[x]
5	42	54	80[y]	90[y]
6	49	63	98[z]	98[y]
PP weight gain				
Moderate	34[x]	41[x]	69[x]	79[x]
High	48[y]	65[y]	86[y]	96[y]

[a] Adapted from Spitzer et al., 1995.
[x,y,z] Means within column, within item, lacking a common superscript differ ($P < 0.05$).

Table 7 demonstrates the importance of prepartum nutrition on return to estrous cycles in suckled beef cows. At the initiation of the breeding season cows calving in good condition had a numerical increase in the percentage cyclicity, but after a 60-day breeding season cows in good condition had greater cyclicity rates. A general rule of thumb is that cows calving in poor condition have longer intervals before resuming their estrous cycles than cows calving in good condition (i.e. BCS 5 or greater). Remember, for cows to calve on a yearly interval they are to conceive within 83 days after calving; therefore, if cows only reinitiate there estrous cycles at 70 to 90 days postcalving the possibility of a yearly calving interval is vastly reduced.

Postpartum Nutrition

Numerous studies document that increasing nutritional levels following parturition increases conception and pregnancy rates in beef cows (Wiltbank et al., 1962; Whitman, 1975). Increasing the dietary energy density increases weight and condition score, in the process decreasing the postpartum interval to first estrus (Table 8; Lalman et al., 1997). However, few cows fed a high energy diet resume normal estrous cycles by 90 d postpartum. Similarly, suckled beef cows gaining in excess of 1 kg/d while consuming an 85% concentrate diet do not resume cyclic ovarian activity before 70 d postpartum.

Table 8. Predicted number of days from calving to first heat as affected by body condition score at calving and body condition score change after calving in young beef cows[a]

	Condition score change after calving to day 90 postpartum						
BCS at calving	-1	-0.5	0	0.5	1	1.5	2
3	189	173	160	150	143	139	139
4	161	145	131	121	115	111	111
5	133	116	103	93	86	83	82
5.5	118	102	89	79	72	69	66

[a] Adapted from Lalman et al., 1997.

To fully appreciate the importance of a sound nutrition program before and after parturition, one must just consider that half the suckled cows in a given herd have not initiated estrous cycles at the onset of the breeding season. For example, Figure 2 represents data from 2041 suckled beef cows (Stevenson et al., unpublished data). Only 51.3% of all cows had initiated estrous cycles by the onset of the breeding season. As the postpartum interval increases, the percentage of cows resuming their estrous cycles also increases; therefore, the blame for poor conception rates during a breeding season may result more from anestrus rather than an artificial insemination technician, bull, or synchronization program. The simplest method to overcome anestrus is to ensure that cattle are maintained on a sound nutrition regimen.

Management Considerations

The first management decision that has a major impact on postpartum fertility is the length of the breeding season. Having a restricted breeding season has many advantages, such as a more uniform, older calf crop, but most importantly a reduced breeding season (60 days or less) increases the percentage of females cycling during the next breeding season. If the breeding season is shortened, then all cows have a high probability for pregnancy at the beginning of the next breeding season. Any cow that becomes pregnant after 83 days in a long breeding season will not have calved by the time the next breeding season starts.

For first-calf heifers, because they usually have a longer period of postpartum anestrus, producers should consider breeding their yearly replacement heifers to calve at least two weeks before the rest of the cow herd. This will give the first calf heifers an additional fourteen days to prepare for the breeding season.

The second management decision to consider for decreasing postpartum infertility in first-calf heifers is nutrition. As mentioned above, nutritional levels and BCS have a major impact on anestrus and potential fertility. Often it is impractical to measure body weight in many production settings, but in most situations a procedure can be developed for monitoring BCS. It is difficult and expensive to correct nutritional problems that exist at calving by increasing intake after calving. Therefore, monitoring condition, and adjusting condition before calving, is the most economical method to ensure that first-calf heifers calve at a BCS greater than 5.

The third management decision to minimize postpartum infertility is to consider options that include minimizing stress from dystocia, perhaps putting a sterile bull with cows during the early postpartum period before the breeding season starts, and using estrous synchronization treatments that initiate estrous cycles after calving and reduce the incidence of short estrous cycles (a common problem in postpartum suckled beef cows). The deleterious effects of dystocia can be minimized by careful attention to the following: selection of replacement heifers, selection of sires used on replacement heifers, providing appropriate obstetrical assistance at parturition. Putting a bull with cows during the postpartum period to reduce postpartum infertility is a new approach. However, the relative cost of using bulls is low and should be considered by producers although more information is required to discern the ideal bull:cow ratio. Estrous synchronization is potentially the most promising alternative to a production system, it can be used effectively to shorten the breeding season and take advantage of possible stimulatory effects of the synchronization products to initiate estrous cycles.

The final management alternative to consider is decreasing the suckling stimulus. This alternative should be considered a last resort, because this alternative potentially has more serious economic and management consequences, such as an increased potential for calf diseases and for reduced calf weaning weights. All the other management alternatives should be considered and dealt with before resorting to this option. The suckling stimulus can be decreased by complete weaning or weaning for a short period of time (48 hours). In some cases of limited feed supplies later in lactation, weaning can be an effective tool for managing BCS entering winter in order to minimize fertility problems during the subsequent year. The potential economic and management disadvantages should be carefully weighed against the potential advantages of increased fertility.

Keys to Young Cows Heifers Making an Economical Contribution to the Producer

1) Feed replacement heifers to achieve 65% of their mature weight by initiation of the breeding season (usually 1.5 to 2.0 lbs per day).

2) Utilize a prebreeding reproductive tract exam to eliminate heifers with under developed reproductive tracts.

3) Use pelvic measurements to identify heifers that have excessively small pelvic areas.

4) Utilize EPD’s to ensure that heifers are bred to low birth weight EPD bulls.

5) Use estrous synchronization when breeding replacement heifers – this will result in most first-calf heifers calving at the beginning of the calving season.

6) Prepare replacement heifers to calve 2 wks before the mature cow herd.

7) Heifers should calve with at least a BCS of 5 or greater.

8) Use estrous Synchronization including a progestin (Norgestomet, Intravaginal progesterone insert, or MGA) on first calf heifers to trigger postpartum estrous cycles.

9) Shorten breeding season gradually by culling late calving cows.

10) Wean calves from young cows early to allow cows to enter winter in good condition.

11) Feed young cows separately from mature cows to avoid competition for feed.

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