Relationship Between Nutrition and Reproduction in Beef Cows

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Introduction

Since 50 to 70% of input costs are associated with feed, manipulating nutrition can make operations more profitable, BUT manipulation must be done strategically not to affect future cattle performance. Knowing when to supplement cows and what form of supplement will work in a given operation at a given time is often clouded by what feedstuffs a producer has available. In essence, understanding the production cycle of the cow (Figure 1), the cow's nutritional needs, and how to manipulate the diet may save producers financially and will prevent future reproductive failures.

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. For producers with shorter calving intervals with cows in good condition, the probability of a pregnancy is generally very good. But in herds that utilize calving seasons of greater than 60 days, maintaining a 365 day calving interval becomes increasingly more difficult (Figure 2; Short et al., 1990)

Body Condition Scores

Body condition scoring (BCS) is a reliable method to assess the nutritional status of a cow herd (Table 1). 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 an 80-lb weight change is associated with each unit change in BCS.

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In spite of the advantages of body condition scoring, less than 25% of cattlemen throughout the United States utilize this simple, effective method of analyzing the nutritional status of a cow herd (Figure 3; NAHMS, 1997). In some cases producers create their own systems for monitoring condition in their herd. Regardless of the scoring system or monitoring system, it is important to understand when cows can be maintained on a decreasing plane of nutrition, when they should be maintained on an increasing plane of nutrition, or when cows can be kept on a maintenance diet. Understanding the production cycle of the cow and how to manipulate the diet will improve reproductive performance, but may also reduce feed input costs and increase economic efficiency of the operation.

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.

In a recent unpublished study (Figure 4), Stevenson et al. collected blood samples from suckled beef cows at the initiation of the breeding season. Of the 1702 cows in this study only 47.2% of the cows were cycling at the onset of the breeding season. However, as BCS increased the percentage of cows that were cycling also increased. It is important to note that by the inititiation of the breeding season, when cows had a body condition of less than 4 only 33.9% percent of those cows had resumed their estrous cycles!

Cows in moderate BCS at calving also tend to have healthier calves. Calves nursing cows in a condition of 3 or 4 had lower serum immunoglobulin (a measure of potential disease resistance) concentrations than calves nursing dams in BCS 5 or 6 (Table 2). Thin cows and those that have been fed poorly tend to produce less colostrum (which contains immunoglobulins), which results in weaker calves that are more susceptible to disease.

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 3 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 4 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. In this

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 5; 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.

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.

What Can A Producer Do To Manage Nutrition To Ensure Reproductive Performance In Beef Cattle?

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.

In heifers, remember that age and weight dictate the pubertal status of the replacement heifer. Ensure that replacements are approximately 60 to 65% of their mature weight at the initiation of the breeding season. Table 6 gives and approximation of weights and potential cycling status at various weights for different breeds for small to moderate framed females. Producers can make the necessary adjustment for their herds if the average cow size is larger. An alternative to solely using weight and breed to make management decisions is using frame size (Table 7). Larger framed females require more feed and average daily gains to achieve similar reproductive performance. As mentioned previously in this report, overfeeding has detrimental effects on subsequent milk production and calving ease. By monitoring average daily gains until a females reaches maturity can improve the long term productivity of a cow.

Strategic feeding to obtain ideal condition scores can be achieved by understanding the production cycle of the cow. Shortly after weaning, beef cows should be in mid gestation. This is the period at which producers can manipulate the diet to either increase or decrease a cows condition. At this point, cows require very little in terms of nutrients to maintain their metabolism. If cows are in poor condition there is no better stage to adjust a cows feed regimen to increase her condition. During stage two of the cows production cycle, the fetus begins to grow rapidly (up to a pound of gain a day shortly before parturition). In addition, cows also require several other physiological mechanisms to occur to prepare a cow for lactation. Therefore, adjusting a cow's condition requires more feed and very often occurs during the worst part of winter when feed quality tends to be poor and supplementation becomes expensive.

The period of greatest nutritional need is stage three, shortly after calving. A cow is required to produce milk for a growing calf, she must regain any weight lost shortly before and after parturition and finally repair her reproductive tract in order to become pregnant within three months after birth. During this stage a cow usually is consuming as much feed as she can to support herself. Adjusting condition at this stage often is futile. Cows usually are grazing and tend to consume their full protein, vitamin and mineral requirements; however, the grass is often lush with a high percentage of moisture which occasionally can cause a deficiency in energy. During stage four of a cow's production cycle, lactation requires the majority of nutrients, but condition can be manipulated here with some innovative feeding practices.

Finally, BCS should be an essential management tool in every cattlemen's philosophy. This is a simple procedure which, if used correctly, can ensure the management of a successful beef cow-calf operation. However, manipulating the diet is pointless if the diet composition is unknown. Producers should request feed analyses from their feed companies and analyze their own forage stores. Without knowing diet composition adjusting BCS is not as simple.

Tables 8 and 9 demonstrate scenarios of adjusting BCS prior to calving and between calving and breeding. Obtaining daily gains in cows of 4 lbs/day are virtually impossible in cows; therefore, preparation by cattlemen at weaning or prior to weaning can reduce the daily gains required prior to calving to obtain condition scores of 5 at calving. Use these tables to understand the demands required in your herd!

Conclusion

Our primary objective, as beef cattle producers, is to produce one live calf from every cow once a year. Many factors account for the failure of cows to maintain that yearly calving interval. The nutrition/reproduction interaction is a complex system involving many interactions between nutritional components and physiological signals, but is still the most responsible interaction for the equilibrium between feeding cows sufficiently to conceive and maintaining that pregnancy until term without utilizing excess resources that eliminate potential profits. Every producer experiences different challenges in an attempt to optimize profitability of their herds, yet without a full appreciation of the delicate balance between nutrition and reproduction many operations fail to achieve optimal production from their cows.

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Table 1. Body condition scores and animal appearance at each condition score (Whitman et al., 1975)

BCS	Condition	Appearance
1	Emaciated	Shoulder, ribs and back are visible
2	Very thin	Some muscle, no fat deposits
3	Thin	Some fat deposits, ribs visible
4	Borderline	Foreribs not noticable
5	Moderate	12th and 13th ribs not visible
6	Good	Ribs covered, sponginess to tailhead
7	Very good	Abundant fat on tailhead
8	Fat	Fat cover thick and spongy
9	Obese	Extremely fat throughout

Table 2. Effect of cow condition at calving on calf serum immunoglobulin concentration (Adapted from Odde, 1997)

	Cow body condition score			
Item	3	4	5	6
IgM[a], mg/dL	146	157	193	304
IgG[b], mg/dL	1998	2179	2310	2349

[a] Immunoglobulin M.
[b] Immunoglobulin G.

Table 3. Effect of body condition score and postpartum weight gain on birth weight, dystocia score and weaning weights (Adapted from Spitzer et al., 1995)

Item	Body weight at parturition, lbs	Birth weight, lbs	Dystocia score[a]	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] 1 = unassisted and 5 = caesarian section.
[x,y,z] Means within column, within item, lacking a common superscript differ ($P < 0.05$).

Table 4. Effect of body condition score and postpartum weight gain on cyclicity (Adapted from Spitzer et al., 1995)

	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}

[x,y,z] Means within column, within item, lacking a common superscript differ ($P < 0.05$).

Table 5. 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 (Adapted from Lalman et al., 1997)

	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

Table 6. Average puberty weight (pounds) for small to moderate frame heifers by breed (Accessed from http://www.ansi.okstate.edu/exten/cc-corner/checkheiferwts.html, Jan. 2002)

Breed	Weight at 50% cycling	Weight at 90% cycling	Estimated mature weight
Angus	550	650	1000
Brangus	600	700	1075
Charolais	700	775	1190
Hereford	600	700	1075
Shorthorn	500	600	925
British×British	575	675	1040
Charolais×British	675	775	1190
Jersey×British	500	600	925
Limousin×British	650	775	1190
Simmental×British	625	750	1150
Brahman	700	750	1150

Table 7. Optimum growth rate for replacement females (Adapted from Fox et al., 1988)

Factor	Frame size 1	3	5	7	9
Optimum weight at first estrus, lbs	581	653	728	803	880
Mature weight, lbs	880	1027	1173	1320	1467
Age	----------------------- Daily gain, lbs/d[a] ------------------------				
7 months	1.36	1.50	1.67	1.85	2.03
12 months	0.88	1.03	1.16	1.30	1.44
18 months	0.56	0.66	0.77	0.87	0.97
24 months	0.35	0.43	0.51	0.58	0.66
30 months	0.22	0.28	0.33	0.39	0.44
36 months	0.14	0.18	0.22	0.26	0.30
42 months	0.09	0.12	0.15	0.17	0.20
48 months	0.06	0.08	0.10	0.12	0.14
54 months	0.04	0.05	0.06	0.08	0.09
60 months	0.02	0.03	0.04	0.05	0.06

[a] Daily gain that will result in optimum weight to first estrus at 426 d and mature weight at 60 months of age.

Table 8. Body weight gains required in pregnant cows in varying body condition scores from 100 to 200 days prior to calving to achieve optimum calving body condition (Adapted from Corah et al., 1991)

BCS at weaning	BCS needed at calving	Calf and placenta weight, lbs	Body weight gain, lbs	Total gain, lbs	Days to calving	Average daily gain, lbs/d
3	5	100	160	260	120	2.2
4	5	100	80	180	120	1.5
5	5	100	0	100	120	0.8
3	5	100	160	260	200	1.3
3	5	100	160	260	100	2.6

Table 9. Predicting body weight gains in nursing cows in different body conditions (Adapted from Corah et al., 1991)

BCS		Body weight gain needed for breeding, lbs		
At calving	Needed at breeding	Total pounds needed, lbs	Days to breeding	Average daily gain, lbs/d
3	5	160	80	2.0
4	5	80	80	1.0
5	5	0	80	0
3	5	160	60	2.7
3	5	160	40	4.0

Production Cycle of the Cow

Weaning ↙

I	II	III	IV
Mid gestation	60-90 days precalving	Calving to rebreeding	Breeding to weaning
Maint.	Maint.	Maint.	Maint.
	Rapid fetal growth	Lactation	Lactation
	Prepare for lactation	Regain wt loss	
		Repair Repro. tract	

Figure 1. Production cycle of a beef cow emphasizing important nutritional and reproductive requirements

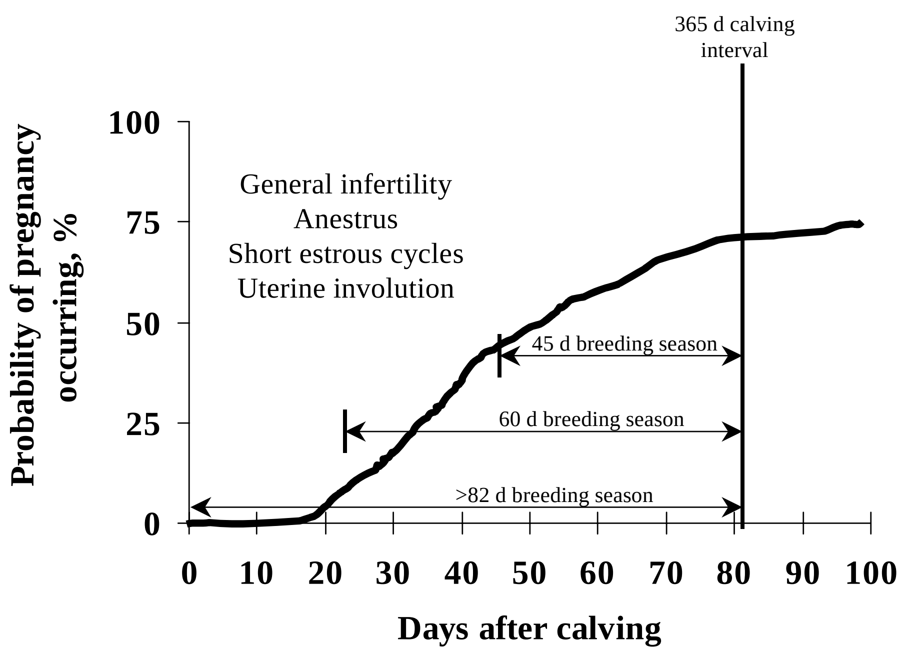

Figure 2. Relationship of length of breeding season to fertility during the postpartum period (Short et al., 1990)

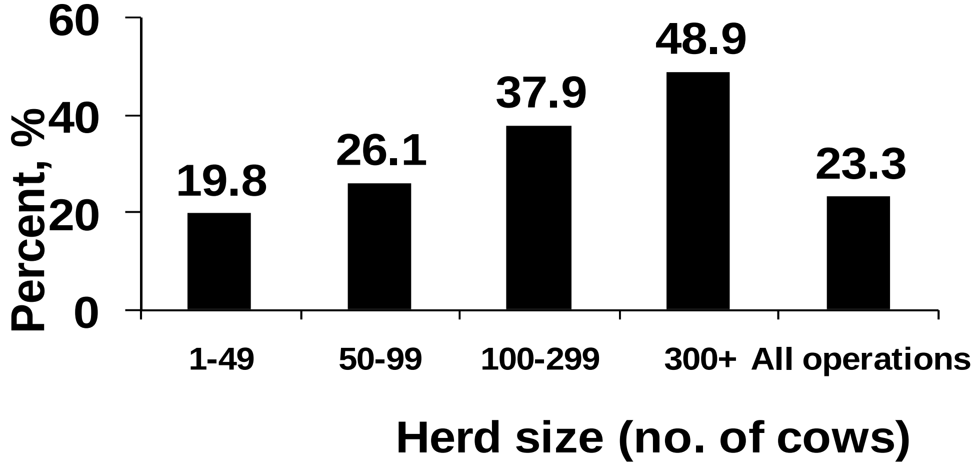

Figure 3. Percentage of herds that use body condition scores in management decisions (NAHMS, 1997)

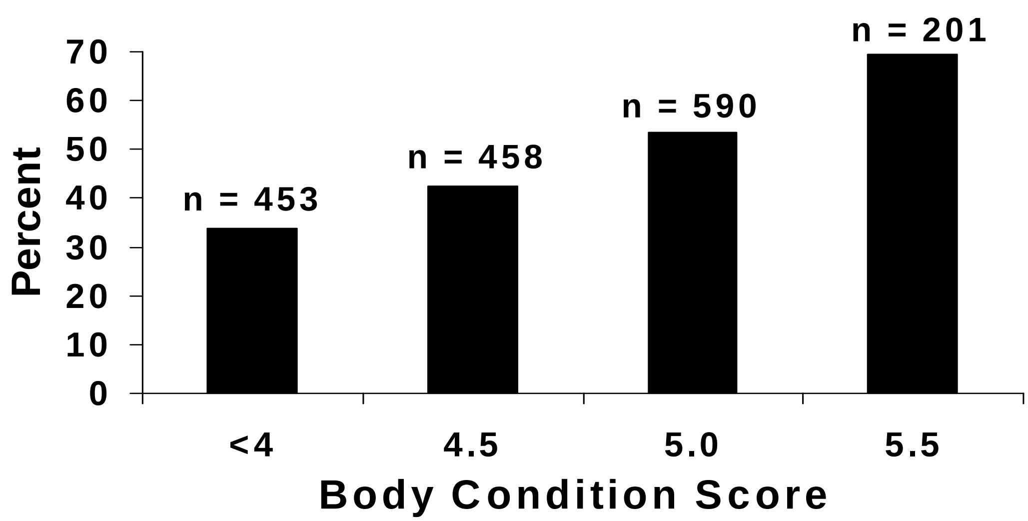

Figure 4. Percentage of cows cycling at various body condition scores (Stevenson et al., unpublished)

SESSION NOTES