REPRODUCTION AND BREEDING

How Can Cattlemen Manipulate Their Operations for Optimum Reproductive Performance

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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

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).

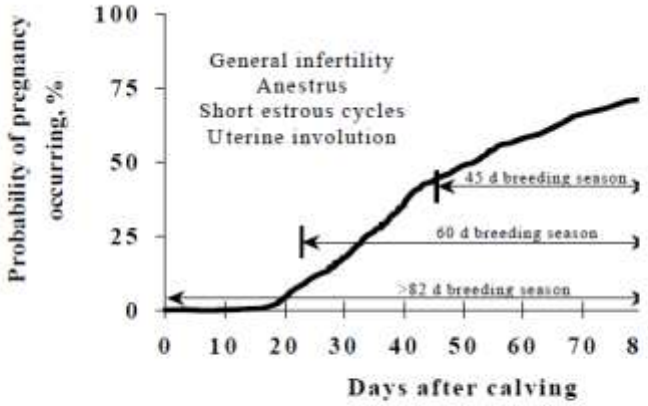

Figure 2. Relationship of length of breeding season to fertility during the postpartum period (Short et al., 1990)

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.

Table 1. Body condition scores and animal appearance at each condition score

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

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). In a statewide survey of Minnesota we noted that 41% of producers utilize BCS to monitor the status of their herds. In 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.

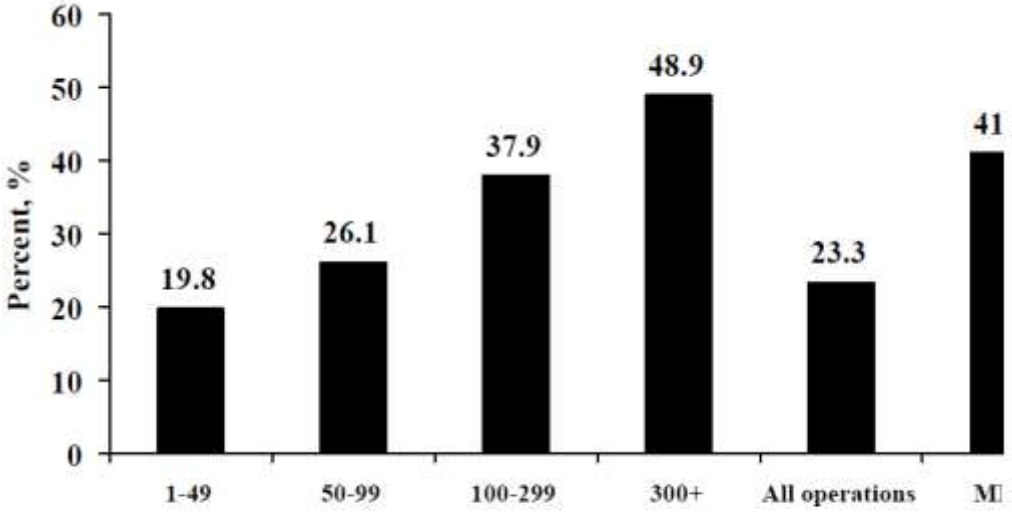

Figure 3. Percentage of herds that use body condition scores in management decisions (NAHMS, 1997). * Determined in a statewide survey of Minnesota in 2001.

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 an 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 initiation 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!

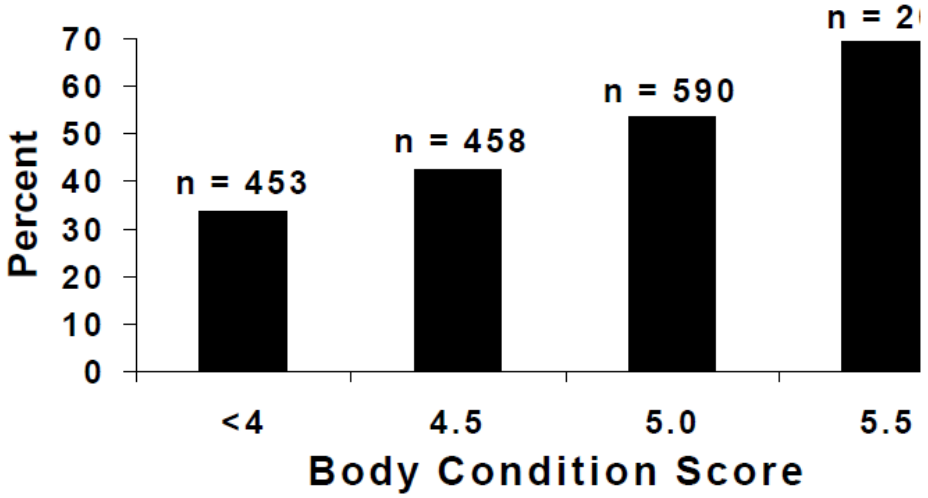

Figure 4. Percentage of cows cycling at various body condition scores (Stevenson et al., unpublished)

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) levels 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.

Table 2. Effect of cow condition at calving on calf serum immunoglobulin level[a]

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

[a] Adapted from Odde, 1997.
[b] Immunoglobulin M
[c] Immunoglobulin G

NUTRITION AND HEIFER DEVELOPMENT

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 3). We have also determined that for every one-unit increase in RTS, heifer weight increased 41 pounds.

Table 3. 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.

Table 4. Description of reproductive tract scores (RTS)[a]

RTS	Uterine horns	Ovarian length (mm)	Ovarian height (mm)	Ovarian Width (mm)	Ovarian structure
1	Immature, < 20 mm diameter no tone	15	10	8	No palpable follicles
2	20-25 mm diameter, no tone	18	12	10	8 mm follicles
3	25-30 mm diameter, slight tone	22	15	10	8 to 10 mm follicles
4	30 mm diameter, good tone	30	16	12	> 10 mm follicles, CL possible
5	> 30mm diameter, good tone, erect	> 32	20	15	> 10 mm follicles, CL present

[a]Adapted from Anderson et al., 1991

Reproductive tract scores can be used to predict the cycling status of the herd. Developed by Anderson et al. (1991), heifers are assigned a score of 1 to 5 based on the diameter of the uterine horns at the external bifurcation and structures present on the ovaries (Table 4). A score of 1 is equivalent to an infantile tract, and a score of 5 is indicative of both a uterus with a large diameter (> 25 mm) and an ovary containing a CL. Because heifers with a RTS of 4 and 5 are cycling, synchronized pregnancy rates and estrous response from these heifers are greater than their non-cycling (RTS 1 to 3) contemporaries (Anderson et al, 1991; Patterson et al., 2000). A reliable benchmark to achieve acceptable pregnancy rates at the beginning of the breeding season is for 50% of the heifers to have a RTS of 4 or 5 at the initiation of the breeding season (Patterson et al., 2000).

Replacement heifers are often neglected or fed maintenance diets throughout the development period resulting in a vast majority of heifers that are not cycling at the initiation of the breeding season, especially when estrous synchronization is used. Table 5 demonstrates the importance of knowing the RTS of heifers at least 45 days prior to the breeding season. That way nutrition can be manipulated to ensure that heifers are cycling prior to the breeding season. Adjusting the feeding regimen will result in an increased pregnancy rate and a greater majority of heifers pregnant at the beginning of the breeding season.

Table 5. Synchronized pregnancy rates and reproductive tract scores in heifers synchronized with Prostaglandin F_{2a} and GnRH

	Treatment			
Item	Control	GPG	GGPG	Overall
No. of heifers	173	172	169	514
	no. (%)			
RTS				
2	0/53 (0.0)	6/55 (10.9)	9/53 (17.0)	15/161 (9.3)[x]
3	12/72 (16.7)	12/71 (16.9)	21/73 (28.8)	45/216 (20.8)[y]
4	6/38 (15.8)	17/38 (44.7)	12/35 (34.3)	35/111 (31.5)[z]
5	4/10 (40.0)	3/8 (37.5)	1/8 (12.5)	8/26 (30.8)[yz]

[x,y,z] Percentages within a column lacking a common superscript differ ($P < 0.01$).

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 6). The BCS when these heifers became anestrus was approximately 3.

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.

Table 6. 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 ($P < .05$).

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 7 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 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 8 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.

Table 8. 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 ($P < 0.05$).

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 9; 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 9. 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 toensure 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 10 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 11). 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.

Table 10. Average puberty weight for small to moderate frame heifers by breed[a]

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

[a] Accessed from http://www.ansi.okstate.edu/exten/cc-corner/checkheiferwts.html, Jan. 2002.
[x,y,z] Means within column, within item, lacking a common superscript differ ($P < 0.05$).

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 cows condition requires more feed and very often occurs during the worst part of winter when feed quality tends to be poorer and supplementation becomes expensive.

Table 11. Optimum growth rate for replacement females[a]

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[b]				
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] Adapted from Fox et al., 1988.
[b] Daily gain that will result in optimum weight to first estrus at 426 d and mature weight at 60 months of age.

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 cowcalf 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 12 and 13 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 tounderstand the demands required in your herd!

Table 12. 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[a]

BCS at weaning	BCS needed at calving	Calf and placenta weight	Body weight gain	Total gain	Days to calving	Average daily gain
3	5	100	160	260	120	2.0
4	5	100	80	180	120	1.0
5	5	100	0	100	120	0
3	5	100	160	260	200	2.7
3	5	100	160	260	100	4.0

[a] Adapted from Corah et al., 1991.

Table 13. Predicting body weight gains in nursing cows in different body conditions[a]

BCS		Body weight gain needed for breeding, lbs		
At calving	Needed at breeding	Total pounds needed	Days to breeding	Average daily gain
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

[a] Adapted from Corah et al., 1991.

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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