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STRATEGIES FOR BREEDING HIGH RISK BEEF FEMALES

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Introduction

Managing replacement heifers after breeding is equally as important as pre-breeding management. After breeding, nutrient demands of the growing heifer increase to include advancing fetal growth, overcoming stress from calving, and first lactation. Failure to become pregnant after the birth of the first calf is a primary reason for culling in a beef cattle operation. The economic consequences of non-pregnant two-year-old cows can be very costly. Nutrition is the primary management factor that influences the postpartum interval (PPI) and subsequent pregnancy rates. Feed also represents the single largest expense in a cow-calf operation. Finding the optimum reproductive rate for a given production environment can be a fine balance, particularly with the first calf heifer. This review discusses management strategies to optimize second calf pregnancy rates in primiparous heifers.

Concepts

Postpartum interval

From calving until the cow conceives is a critical time in her production cycle. Minimizing this period maximizes reproductive and economic efficiency of a beef cattle operation. Factors affecting the postpartum interval (PPI) have been reviewed (Casida, 1971; Inskeep and Lishman, 1979; Short et al., 1990; Yavas and Wallon, 2005) and include nutrition, suckling, parity, season, breed, dystocia, disease, and presence of a bull. Postpartum interval is longer in primiparous than multiparous cows (Dunn and Kaltenbach, 1980)and even if calving occurs before the mature cow herd, fewer primiparous cows resume estrus by the beginning of the breeding season than mature cows (Stevenson et al., 2003).

Cows in estrus early in the breeding season have more opportunities to become pregnant during a limited time. A short breeding season for replacement heifers allows the last heifers to calve with more days to achieve a positive energy balance before the first day of their second breeding season. An extended breeding season for replacements may set up a heifer to not have calved before the next breeding season begins. A shorter breeding season makes for a shortened calving season, creating a more uniform calf crop that is more valuable at weaning. To have a successful, short breeding season, cattle must conceive early in the breeding season.

Minimizing the PPI is limited by uterine involution, which is the time needed for reproductive tract repair so another pregnancy can be established. However, uterine involution is generally completed by the time the inhibitory effects of suckling and negative energy balance allow for the first postpartum ovulation. Size differences between the previously pregnant and non-pregnant uterine horn can still be distinguished up to 4 weeks postpartum (Sheldon, 1994), but size may not reflect when cellular changes occur. Prior to day 20 postpartum, fertilization rates and pregnancy rates are very low, but not zero, and sperm transport may be a barrier to fertilization (Short et al., 1990). Malnutrition, disease, and calving difficulty can delay uterine involution in beef cows.

Body condition score (BCS)

Body condition can greatly affect net income on a cow-calf operation because it correlates to several reproductive events such as PPI, services per conception, calving interval, milk production, weaning weight, calving difficulty, and calf survival (Kunkle et al., 1994; Table 1). Body condition score (1=emaciated to 9=obese) generally reflects nutritional management; however, disease and parasitism can contribute to decreased BCS even if nutrient requirements are met.

Table 1. 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, $/cwt	$/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 × pregnancy rate.
Data from Kunkle et al. (1994).

Nutritional management

The relationship of nutrition to successful beef cattle reproduction has been reviewed (Wetteman et al., 2003; Randel, 1990; Hess et al., 2005). Hess and coworkers (2005) summarized the following key findings:

1. Prepartum, more than postpartum, nutrition determines postpartum anestrus length.
2. Inadequate dietary energy during late pregnancy lowers reproduction even if dietary energy is sufficient during lactation.
3. A BCS ≥ 5 will ensure adequate body reserves for postpartum reproduction.
4. Reproduction declines further when lactating cows are in a negative energy balance.

Nutrient demands during late gestation include both heifer and fetal growth. Fetal birth weight increases 60% during the last 70 days of gestation (Bauman and Currie, 1980). Providing adequate dietary energy and protein to meet this demand is a key step to adequate body condition at calving. The importance of prepartum protein and energy on reproductive performance has been consistently demonstrated (Table 2; Randel, 1990). Reproduction has low priority among partitioning of nutrients and consequently, cows in thin BCS often don’t rebreed.

In addition to impacting subsequent cow reproduction, nutrient intake during gestation impacts dystocia, calf health, and calf survival (Table 3; Bellows, 1995). Dams receiving inadequate protein and energy produce calves more susceptible to cold stress, weak, and slow to suckle, increasing the risk for passive transfer failure (Sanderson and Chenoweth, 2001).

Table 2. Effect of pre- or postpartum dietary energy or protein on pregnancy rates in cows and heifers

Nutrient and time	Adequate	Inadequate
	Percent Pregnant	
Energy level precalving[a]	73	60
Energy level postcalving[b]	92	66
Protein level precalving[c]	80	55
Protein level postcalving[d]	90	69

[abcd] Combined data from 2, 4, 9 and 8 studies, respectively.
Adapted from Randel (1990)

Table 3. Effects of feed level during gestation on calving and subsequent reproduction[a]

Item	Gestation diet of dam: Low	High[b]
Calf birth weight (lb)	63	69
Dystocia (%)	35	28
Calf Survival (%)		
At Birth	93	91
Weaning	58	85
Scours (%)		
Incidence	52	33
Mortality	19	0
Dam Traits		
Estrus (prior to breeding season (%))	48	69
Pregnancy (%)	65	75

[a]Average of seven studies; cows and heifers combined.
[b]Diet level fed from up to 150 days precalving; low and high, animals lost or gained weight precalving, respectively.
Reprinted from Bellows (1995).

If heifers are thin at calving, achieving a positive energy balance postpartum is essential for timely return to estrus and pregnancy. Lalman et al. (1997) provided increasing amounts of energy to thin (BCS 4), primiparous heifers postpartum, decreasing PPI as dietary energy increased (Table 4). Body condition at calving also influences response to postpartum nutrient intake. Primiparous cows fed to achieve BCS 4, 5 or 6 at calving were targeted to gain either 0.9 or 0.45 kg/d postpartum (Spitzer et al., 1995). Thinner cows had a greater response to energy level on initiating estrous cycles early in the breeding season than cows with greater BCS. However, even with increased postpartum energy, the pregnancy rates of thin, primiparous cows may not be acceptable.

Table 4. Influence of postpartum diet on weight change, body condition score (BCS) change, and postpartum interval (PPI)

	Diet			
Item	Low	Maintenance	Maint./ High	High
Calving Weight, lb	835	822	826	821
Calving BCS	4.27	4.26	4.18	4.10
PPI[a], d	134	120	115	114
PPI Wt. Change[a], lb	12	40	70	77
PPI BCS Change[a]	-.32	.37	1.24	1.50

[a]Linear effect, $P < 0.01$
Adapted from Lalman et al. (1997).

Fat

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

Supplemental fats may also have direct positive effects on beef cattle reproduction independent of energy contribution. Fat 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. Lactating dairy cows commonly receive fat supplements, primarily to increase diet energy density. Associated positive and negative effects on reproduction have been reported (Grummer and Carroll, 1991; Staples et al., 1998). The effects of fat supplementation on beef reproduction have been reviewed (Funston, 2004) and are summarized below.

Fat supplementation prepartum. Results from feeding supplemental fat prepartum are inconclusive. However, supplementation response appears to depend on postpartum diet. Beef animals apparently have the ability to store certain fatty acids, supported by studies in which fat supplementation discontinued at calving resulted in a positive effect on reproduction. Postpartum diets containing adequate levels of fatty acids may mask any beneficial effect of fat supplementation. There appears to be no benefit, and in some cases, feeding supplemental fat postpartum can have a negative effect, 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 and coworkers (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 reviewed by Funston (2004). Many of the studies reported approximately 5% total fat in the experimental diet, so 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, the amount of fat supplemented might affect which response is elicited. First service conception rates decreased from 50% in controls to 29% in young beef cows fed high linoleate safflower seeds (5% DMI as fat) postpartum (Hess et al., 2005). The same laboratory also reported (Grant et al., 2002) an increase in $PGF_{2\alpha}$ metabolite when high linoleate safflower seeds are fed postpartum and a decrease in several hormones important for normal reproductive function (Scholljegerdes et al., 2003; Scholljegerdes et al., 2004).

Summary of fat supplementation. Currently, research is inconclusive on how to supplement fat to improve reproductive performance beyond energy contribution. Most studies have attempted to achieve isocaloric and isonitrogenous diets. Several studies had only sufficient animal numbers to detect very large differences in reproductive parameters such as conception and pregnancy rate. Research on supplementing fat has resulted in varied (positive, negative, no effect) and inconsistent reproductive results. Postpartum fat supplementation appears to be of limited benefit and adding a fat source high in linoleic acid postpartum may actually affect reproduction negatively.

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 relationships are better understood, producers are advised to strive for low cost and balanced rations. If a supplemental fat source can be added with little or no change in the ration cost, producers are advised to do so.

Minerals and vitamins

Minerals and vitamins are important for all physiological processes in the beef animal, including reproduction. Both deficiencies and excesses can contribute to suboptimal reproduction. Management guidelines for mineral supplementation in cow-calf operations have been provided (Olson, 2007). The increased use of grain by-products in cattle rations require traditional mineral programs be re-evaluated, making allowances for high phosphorus and sulfur contents and altered calcium to phosphorus ratios found in grain by-products. Over feeding phosphorus is costly, of potential environmental concern, and does not positively influence reproduction in beef (Dunn and Moss, 1992) or dairy cattle (Lopez et al., 2004). Inadequate consumption of certain trace elements combined with antagonistic interactions of other elements can reduce reproductive efficiency (Greene et al., 1998).

Most 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 not of concern under normal growing conditions. Vitamin A deficiency, however, does occur naturally in cattle grazing winter range or consuming low quality crop residues and forages (Lemenager et al., 1991). Drought can extend periods when low quality forages are fed and increase the need for vitamin A supplementation. The role of vitamin A in reproduction and embryo development has been reviewed by Clagett-Dame and Deluca (2002). Vitamin A supplementation before and after calving has been demonstrated to improve pregnancy rates (Bradfield and Behrens, 1968; Meacham et al., 1970).

Nutrition and calving difficulty

Feeding a balanced diet the last trimester of pregnancy decreases calving difficulty. Heifers fed diets deficient in energy or protein the last trimester experience more calving difficulty; conceive later in the breeding season; and have increased sickness, death, and lighter calf weaning weights (Table 3).

Beef producers may be concerned excessive dietary nutrients during the last trimester of pregnancy will negatively influence calf birth weight and dystocia. Providing either adequate or inadequate amounts of dietary energy and protein and their effects on calving difficulty, reproductive performance, and calf growth have been reviewed (Houghton and Corah, 1987) and are summarized in Tables 5 and 6. Reducing energy pre-partum does not affect dystocia rates, even though birth weights were altered in some experiments. Of the 9 trials summarized, 6 demonstrated increased energy intake during the last trimester did not increase calving difficulty.

In addition, beef producers may be concerned crude protein levels will influence calf birth weight and subsequent calving difficulty. Houghton and Corah (Houghton and Corah, 1987) summarized studies investigating the effects of prepartum protein intake on calving difficulty (Table 6). Reducing prepartum dietary crude protein does not decrease calving difficulty, but it may compromise calf health and cow reproductive performance.

Table 5. Summary of supplemental prepartum energy effects on calving difficulty, subsequent reproductive performance and calf growth

Study	Prepartum Supplementation[a]	Effect	Birth Wt[b]	Dystocia[b]	Other[b]
Christenson et al., 1967	HE vs LE 140 d	HE	+	+	+ Milk, + estrus activity
Dunn et al., 1969	ME vs LE 120 d	ME	+	+	
Bellows et al., 1972	HE vs LE 82 d	HE	+	nc	nc weaning weight
Laster and Gregory, 1973	HE vs ME vs LE 90 d	HE	+	nc	
Laster, 1974	HE vs ME vs LE 90 d	HE	+	nc	
Corah et al., 1975	ME vs LE 100 d	ME	+	nc	+ estrus activity,+ calf vigor, + weaning weight
Bellows and Short, 1978	HE vs LE 90 d	HE	+	nc	+ estrus activity, + pregnancy rate, - postpartum interval
Anderson et al., 1981	HE vs LE 90 d	HE	nc		nc milk, nc weaning weight
Houghton et al., 1986	ME vs LE 100 d	ME	+	nc	+ weaning weight

[a]HE = high energy (> 100 % NRC); ME = moderate energy (approximately 100 % NRC); LE = low energy (< 100 % NRC)
[b] + = increased response; nc = no change
Adapted from Houghton and Corah (1987)

Table 6. Summary of studies on feeding supplemental protein during gestation on calving difficulty, subsequent reproductive performance and calf growth

Study	Supplementation[a]	Effect	Birth Wt[b]	Dystocia [b]	Other[b]
Wallace & Raleight, 1967	HP vs LP for 104-137 d Prepartum	HP	+	DEC	+ cow weight, + conception rates
Bond & Wiltbank, 1970	HP vs MP throughout Gestation	HP	nc		nc calf survivability
Bellows et al., 1978	HP vs LP for 82 d Prepartum	HP	+	+	+ cow weight, + cow gain, + weaning wt, DEC conception rate
Anthony et al., 1982	HP vs LP for 67 d Prepartum	HP	nc	nc	nc postpartum interval
Bolze, 1985	HP vs MP vs LP for 112 d Prepartum	HP	nc	nc	nc weaning weight, nc milk, nc conception rate, DEC postpartum interval

[a]HP = high protein (over 100% NRC); MP = moderate protein (approximately 100% NRC); LP = low protein (under 100% NRC)
[b] + = increase, nc = no change, DEC = decrease
Adapted from Houghton and Corah (1987)

Excess protein and energy

Caution should be used with feeding excess nutrients before or after calving. Not only is it costly, but cows and heifers with BCS > 7 have lower pregnancy rates and more calving difficulty than beef females with BCS 5 to 6. Excess protein and energy can negatively impact pregnancy rates. Overfeeding protein during the breeding season and early gestation, particularly if energy is limiting, may be associated with decreased pregnancy rates (Elrod and Butler, 1993). This decrease in fertility may result from decreased uterine pH during the luteal phase of the estrous cycle in cattle receiving high levels of degradable protein. The combination of high levels of degradable protein and low dietary energy in early-season grasses may contribute to lower conception rates. Negative effects of excess rumen degradable protein on reproduction are well documented in dairy literature (Ferguson, 2001).

Effects of supplementing feedstuffs high in undegradable intake protein (UIP) during late gestation and/or early postpartum have improved reproduction in cows grazing low quality forages (Hawkins et al., 2000; Mulliniks et al., 2011); however, when considering the broader set of data, results are inconclusive and may be dependent on the UIP level (Kane et al., 2004) and energy density of the diet (Martin et al., 2007). Further research is needed to understand how UIP stimulates or inhibits reproductive processes and under what conditions.

A recent study (Mulliniks et al., 2012) challenges dogma regarding BCS required at calving for successful conception rates. Retrospectively, 2 and 3-yr old cows were grouped by BCS 30 days before calving into 3 groups whose average BCS were 4.3 (n=186), 5.0 (n=108) and 5.8 (n=57). Days to lowest body weight, days to first postpartum ovulation, and pregnancy rate were similar among BCS groups. Cows studied by Mulliniks and colleagues (2001) were managed as one group before and after calving so BCS manipulation before calving did not impact the results. In contrast, other studies (Spitzer et al., 1995; Ciccioli et al., 2003) used prepartum ration changes to achieve desired BCS differences at calving.

Interpretation of this study (Mulliniks et al., 2012) must be tempered with the knowledge that dams of these heifers were successfully managed in the same production system for 10 years. Cows had access to sufficient grazing resources demonstrated by similar body weight changes even in years when precipitation was limiting. Implications of this observation across a wide variety of management systems is unknown; however, when considered with recent demonstrations of successful moderate heifer development systems (Funston and Larson, 2011; Roberts et al., 2009) it does question the common solution of providing more feed (and cost) to correct all young cow reproductive deficiencies.

Management Considerations

Breeding to pregnancy diagnosis

Many heifer development systems for spring calving herds rely on drylot development before shifting to pasture grazing. The transition from a drylot diet to grazing may come at the end of an AI program, the same time as early embryonic development. Stress during this transition may impact embryonic mortality.

If heifers must be moved after AI, consideration should be given to when the move occurs. Transportation stress impacts pregnancy rates. Mean conception date was earlier when heifers were transported 300 miles 1 to 4 days after AI compared with 8 to 12 or 29 to 33 days after AI (Harrington et al., 1995). Additional studies in heifers (Yavas et al., 1996) and cows (Merrill et al., 2007) investigated transportation one hour before or after AI and 14 days after AI. Concentrations of cortisol increased with AI and with transportation 14 days after AI, but pregnancy rates were not affected.

Nutritional stress can also reduce embryo quality and survival. Changing from a gaining or maintenance diet pre-insemination to 80% of maintenance for 6 days to 2 weeks post insemination produced developmentally delayed embryos (Bridges et al., 2012) and lower embryo survival and pregnancy rates (Dunne et al., 1999) occurred. Embryonic loss is greatest during early gestation with most losses occurring from day 8 to 16 corresponding with the time period between when the embryo reaches the uterus and maternal recognition of pregnancy (Diskin et al., 2012). Pregnancy rate to AI through the second service was higher in heifers gaining weight for 21 days after AI compared with heifers either maintaining or losing weight (Arias et al., 2012). Heifers maintaining or losing weight post AI had similar pregnancy rates.

Grazing is a learned behavior and it has been suggested grazing experience during development may improve yearling heifer performance (Olson et al., 1992). Increased energy required for grazing and the novelty of new surroundings and feedstuffs could combine to create a short term energy deficit for heifers transitioning from drylot to pasture. Weight loss was 1.6 ± 0.08 kg/day the first week on spring pasture for drylot-developed heifers (Salverson et al., 2005). Pregnancy rate was similar compared with range-developed heifers; however the breeding season did not begin until after an adaption period. A heifer development system that included a post-weaning grazing period reduced the number of steps taken on the first day of turnout compared with heifers developed in a dry lot (Perry et al., 2012). Drylot-developed heifers receiving supplementation the first month of grazing following AI had higher pregnancy rates than non-supplemented heifers (Perry et al., 2012). Supplementation on pasture did not increase AI pregnancy rates when heifers were developed on range compared with heifers receiving no supplement or drylot-developed (Perry et al., 2012). Improving heifer ADG on summer pasture has traditionally received minimal consideration in heifer development systems. Heifers with less gain (little to no supplement) during winter development had greater gains on summer pasture compared with heifers with higher gain (or supplemented) during winter development (Funston and Larson, 2011; Lemenager et al., 1980; Short and Bellows, 1971).

Pregnancy detection

Early pregnancy detection should not be overlooked as a management tool for producers. In addition to traditional palpation, increasing availability of ultrasound and commercial serum pregnancy tests provide more options for producers and veterinarians (Lucy, 2012). Pregnancy can be accurately detected with ultrasound as early as 25 days post breeding, but speed and accuracy will be improved by waiting until day 30 or later (Fricke and Lamb, 2005). Heifers conceiving early in the breeding period will have greater lifetime productivity (Lesmeister et al., 1973) in the herd and should be a priority to keep if drought or market conditions require herd reduction.

Pregnancy diagnosis to calving

Continued gain is needed through calving for heifer and fetal growth, particularly for more moderate development systems. Body weight and BCS at pregnancy diagnosis and 90 days pre-calving should be used to monitor development. Forage intake in pregnant heifers decreases as gestation advances (Patterson et al., 2003), which could impact gain and energy intake during the third trimester. Recommendations have been made for heifers to achieve 85% of mature weight and a BCS 5 to 6 by calving (Bolze and Corah, 1993). However, heifers developed to 53% of mature body weight at breeding that reached 77% of mature body weight at calving had pregnancy rates through 4 calving seasons ranging from 92 to 96 % (Funston and Deutscher, 2004). While dietary restriction during early heifer development may reduce cost and capitalize on compensatory gain, continued restriction during subsequent winter (gestation) periods will increase the proportion of non-pregnant heifers and reduce herd retention rate (Roberts et al., 2009; Endecott et al., 2012). Two-year old heifers failing to rebreed weighed less at calving and breeding than those that became pregnant the second time (Endecott et al., 2012).

Calving difficulty

First-calf heifers experience more calving difficulty compared with the mature cow. Bellows (1995) indicated cows experiencing calving difficulty will take longer to resume estrus than cows not experiencing calving difficulty.

Time of intervention, or when obstetrical assistance is needed, also affects resumption of estrus. Dams provided early assistance had a higher percentage in estrus by the beginning of the breeding season, increased fall pregnancy rate and improved calf gains compared to late assistance dams (Table 7; Bellows et al., 1988; Doornbos et al., 1984) as soon as possible.

Table 7. Effect of time of calving assistance[a] or duration of labor[b] on dam breeding and calf performance

Item	Time of Assistance/Duration of Labor	
	Early/Short	Late/Prolonged
Postpartum interval, (d)[a,b]	49	51
In estrus at beginning of breeding season	91[c]	82[d]
Services/conception[a,b]	1.15	1.24
Fall pregnancy (%)[a,b]	92[e]	78[f]
Calf average daily gain (lb)[a]	1.74[c]	1.63[d]
Calf weaning weight (lb)[a]	422	387

Adapted from [a]Bellows et al. (1988) and [b]Doornbos et al. (1984)
[c,d] Means differ $P < 0.10$.
[e,f] Means differ $P < 0.05$.

Stimulating Estrus

Ionophores

Ionophores can influence reproductive performance during the postpartum period (Sprott et al., 1988). Cows and heifers fed an ionophore exhibit a shorter PPI provided adequate energy is provided in the diet (Table 8; Randel, 1990). This effect is more evident in less intensely managed herds with a 60 to 85 day PPI. Pregnancy rates, if measured, generally were not different in the studies summarized by Randel (1990); however, in most cases the number of observations was relatively low. In a more recent study replicated over 2 years and 12 pastures, monensin was provided to crossbred cows early postpartum reducing days to conception and increasing calving percentage compared with cows not receiving monensin (Bailey et al., 2008). Adding an ionophore may also reduce feed costs through reduced intake and improved feed efficiency on lower quality forages and improved rate of gain with higher quality feedstuffs offered ad libitum (Sprott et al., 1988).

Table 8. 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

Adapted from Randel (1990)

Calf removal

Suckling stimulus negatively affects estrous activity during the postpartum period; however, animals in a positive energy balance and adequate BCS generally overcome this negative stimulus prior to the breeding season. Calf removal, either temporary or permanent, can increase the number of cows returning to estrus during the breeding season (Randel, 1990; Williams, 1990). Some synchronization programs remove calves for 48 hours (Smith et al., 1979), which can induce estrus in postpartum cows and first calf heifers. It is important to provide the calves a clean, dry pen with grass hay and water during this separation.

Induction of estrus with hormones

An intravaginal insert (CIDR), containing progesterone, can shorten the PPI provided nutrition and BCS are adequate (Day, 2004; Perry et al., 2004). A number of protocols for synchronization of estrus and ovulation incorporate a progestin and have resulted in pregnancies in previously non-cycling females (Stevenson et al., 2003b). Ovulation induction with gonadotropin releasing hormone was limited in primiparous cows until BCS were ≥ 5 (Stevenson et al., 2003a).

Bull Exposure

Bull exposure requires exposing cows to surgically altered bulls not capable of a fertile mating. Reproductive performance of postpartum cows in response to bull exposure has been reviewed (Fiol and Ungerfeld, 2012) and is summarized in Table 9. Exposure length, proximity, timing of exposure, and nutritional status have impacted response. Primiparous cows exposed to bulls at 15, 35 or 55 days postpartum had shorter PPI than non-exposed cows, but PPI was similar regardless of the date exposure began (Berardinelli and Joshi, 2005). The PPI was reduced in cows exposed to as many as 1 bull per 29 females (Burns and Spitzer, 1992). Exposure to androgenized steers (Ungerfeld, 2009) or cows (Burns and Spitzer, 1992) will produce similar results.

Table 9. Summary of studies evaluating reproductive performance (resumption of cyclic activity and pregnancy rates) in postpartum cows exposed to males (EXP) or isolated from males (ISO)

Exposure type[a] and length (d)	Cyclic activity (%)		Pregnancy (%)		Reference
	EXP	ISO	EXP	ISO	
ASE/DPC (20 d)	---	---	58.5	50.0	Ungerfeld, 2010
BE/DPC (60 d)	81[b]	41[c]	67	63	Berardinelli *et al.*, 2001
BE/DPC-EPB (63 d)	87[b]	19[c]	87[b]	56[c]	Anderson *et al.*, 2002
BE/DPC-EPB (60 d)	85.1[b]	31.3[c]	66.3[b]	51.5[c]	Berardinelli *et al.*, 2007
BE/DPC (35 d)	100[b]	70.4[c]	85[b]	60[c]	Tauck and Berardinelli, 2007
BE/DPC (50 d)	82[b]	38.5[c]	54.5[b]	15.4[c]	Gokuldas *et al.*, 2010
BE/FCB (42 d)	86[b]	76[c]	58	77	Tauck and Berardinelli, 2007
TBU (64 d)	15	33	89.5[b]	55[c]	Tauck and Berardinelli, 2007

[a]ASE: androgenized steers exposure; BE: bull exposure; DPC: direct physical contact; EPB: excretory products of bulls; FCB: fence-line contact with bulls; TBU: treatment with bull urine.
[b,c] Different letters in the same row and for each experiment differ, $P<0.05$.
From Fiol and Ungerfeld (1997)

Summary

The interaction of nutrition and reproduction in young beef cows has been studied extensively. Diets that meet the high nutrient demands of late gestation and early lactation require attention and monitoring. Adequate nutrition will limit calving difficulty, increase calf health and vigor, and allow for a timely second pregnancy. Heifers that conceive in a short breeding season will have more time to achieve positive energy balance before the second breeding season. A BCS of 5 or 6 should be achieved by calving and maintained through the breeding season to minimize PPI. Several interventions can assist in shortening the PPI but none take the place of timely nutritional management. Advances in our understanding of nutrition and reproduction interactions may provide opportunities for strategic supplementation to optimize reproduction for a given production system.

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