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Published Version Information

Citation: Johnson, D. K., & Funston, R. N. (2013). Postbreeding heifer management. Veterinary Clinics of North America: Food Animal Practice, 29(3), 627-641.

Digital Object Identifier (DOI): doi:10.1016/j.cvfa.2013.07.002

Publisher's Link: http://www.sciencedirect.com/science/article/pii/S0749072013000546

Post Breeding Heifer Management

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The authors have nothing to disclose.

Synopsis –

Rebreeding performance of the first calf heifer has major economic consequences for cow-calf producers. Management systems that allow heifers to cost effectively achieve a body condition score of 5 to 6 at calving and maintain this through rebreeding have a higher probability of pregnancy success.

KEY POINTS –

- When a short breeding season is used on replacement heifers, the last heifer to calve has more time to resume estrous cycles and conceive as a 2-year old.
- Body energy reserves at calving and nutrient status from calving through breeding are two major factors influencing pregnancy rate in beef cattle.
- A body condition score of 5 or 6 should be achieved by calving and maintained through rebreeding.
- Reducing energy or protein in late gestation will not reduce calving difficulty but may impact calf health and survival and a heifer's ability to rebreed.
- Diet changes, new environment, transportation and other stressors may affect embryo survival.
- Early pregnancy detection provides information for increased management opportunities.
- Ionophores can conserve forage, control coccidiosis, and be beneficial to reproduction.

KEYWORDS

Primiparous, Body Condition, Nutrition, Pregnancy, Ionophore

Introduction

Post-breeding management of primiparous heifers often receives less emphasis than pre-breeding; however, it is equally important. During this time, 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 one of the primary reasons for culling in a beef cattle operation. The economic consequences of non-pregnant two-year-old cows have long been recognized and are discussed in more detail elsewhere in this series. 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 addresses management strategies to optimize second calf pregnancy rates in primiparous heifers.

CONCEPTS

Postpartum Interval

The period from calving until the cow conceives is critical in a cow's production cycle, minimizing this time period maximizes reproductive and economic efficiency of a beef cattle operation. Factors affecting the postpartum interval (PPI) have been reviewed [1, 2, 3, 4] and include impacts of nutrition, suckling, parity, season, breed, dystocia, disease, and presence of a bull. Postpartum interval is longer in primiparous than multiparous cows [5] and even if calving occurs before the mature cow herd, fewer primiparous cows have resumed estrous cycles by the beginning of the breeding season than mature cows [6].

Cows that are in estrus early in the breeding season have more opportunities to become pregnant during a limited time. A short breeding season for replacement heifers is of particular advantage to the last heifers to calve, providing more days to achieve a positive energy balance before the first day of the breeding season. With an extended breeding season for replacements, a heifer may not have calved before the breeding season begins. An additional advantage of a shorter breeding season is the 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.

The ability to minimize the PPI is limited by uterine involution, which is the time needed for repair of the reproductive tract so another pregnancy can be established. However, uterine involution does not impact the length of postpartum anestrus [7] because it 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 gravid and non-gravid horn can still be distinguished up to 4 weeks postpartum [8], 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 [3]. Malnutrition, disease, and calving difficulty can delay uterine involution in beef cows.

Body condition score

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

Nutritional management

The relationship of nutrition to successful beef cattle reproduction has been reviewed [10, 11, 12]. Hess and coworkers [12] summarized key findings as follows:

1. Prepartum nutrition is more important than postpartum nutrition in determining the length of postpartum anestrus.
2. Inadequate dietary energy during late pregnancy lowers reproduction even when dietary energy is sufficient during lactation.
3. A body condition score ≥ 5 will ensure body reserves are adequate for postpartum reproduction.

4. Further declines in reproduction occur when lactating cows are in negative energy balance.

Nutrient demands during late gestation include continuing heifer growth as well as fetal growth. Fetal birth weight increases by 60% during the last 70 days of gestation [13]. Timely provision of adequate dietary energy and protein to meet this demand is a key step to have adequate body condition at calving. The importance of prepartum protein and energy level on reproductive performance has been consistently demonstrated (Table 2) [11]. 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) [14]. Inadequate protein and energy to the dams results in calves more susceptible to cold stress, weak, and slow to suckle, increasing the risk for passive transfer failure [15].

If heifers are thin at calving, achieving a positive energy balance postpartum is essential for timely return to estrus and pregnancy. Lalman and colleagues [16] provided increasing amounts of energy to thin (BCS 4), primiparous heifers postpartum and decreased 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 [17]. The magnitude of response to energy level was greater for BCS 4 heifers than those with greater BCS on the proportion of heifers initiating estrous cycles early in the breeding season. However, even with increased postpartum energy, the pregnancy rates of thin, primiparous cows may not be acceptable.

Fat

Inadequate dietary energy intake and poor BCS can negatively affect reproductive function. Supplemental lipids have been used to increase diet energy density and avoid negative associative effects [18] sometimes experienced with cereal grains [19] in high roughage diets.

Supplemental lipids may also have direct positive effects on beef cattle reproduction independent of energy contribution. Lipid supplementation has been shown to positively affect reproductive function in several important tissues including the hypothalamus, anterior pituitary, ovary, and uterus. The target tissue and reproductive response appears to be dependent upon the types of fatty acids contained in the fat source. Lactating dairy cows commonly receive fat supplements, primarily to increase diet energy density. Associated positive and negative effects on reproduction have been reported [20, 21]. The effects of fat supplementation on beef reproduction have been reviewed [22] and are summarized below.

Fat Supplementation Prepartum. Results from feeding supplemental fat prepartum are inconclusive. However, supplementation response appears to be dependent on postpartum diet. Beef animals apparently have the ability to store certain fatty acids, supported by studies in which fat supplementation 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 [12] 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 [22]. 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 [13]. The same laboratory has also reported [23] an increase in $PGF_{2\alpha}$ metabolite (PGFM) when high linoleate safflower seeds are fed postpartum and a decrease in several hormones important for normal reproductive function [24, 25].

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 feeding supplemental 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 have a negative effect on reproduction.

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 [26]. 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 [27] or dairy cattle [28]. Inadequate consumption of certain trace elements combined with antagonistic interactions of other elements can reduce reproductive efficiency [29].

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 [30]. 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 [31]. Vitamin A supplementation before and after calving has been demonstrated to improve pregnancy rates [32, 33].

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 lower weaning weights in their calves (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 [34] 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 nine trials summarized, six 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 [34] 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.

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 [35]. 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 [36].

Effects of supplementing feedstuffs high in undegradable intake protein (UIP) during late gestation and/or early postpartum have shown positive reproductive responses in cows grazing low quality forages [37, 38]; however, when considering the broader set of data, results are inconclusive and may be dependent on the UIP level [39] and energy density of the diet [40]. Further research is needed to understand how UIP stimulates or inhibits reproductive processes and under what conditions.

A recent study [41] 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 three groups whose average BCS were 4.3 (n=186), 5.0 (n=108) and 5.8 (n=57). Days to body weight nadir, days to first postpartum ovulation, and pregnancy rate were similar among BCS groups. Cows studied by Mulliniks and colleagues [41] were managed as one group before and after calving so body condition manipulation before calving did not impact the results. In contrast, other studies [17, 42] used prepartum ration changes to achieve desired BCS differences at calving.

Interpretation of this study [41] must be tempered with the knowledge that dams of these heifers were successfully managed in the same production system for ten 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 [43,44] 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 a period of 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 as transportation stress can impact 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 [45]. Additional studies in heifers [46] and cows [47] 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 [48] and lower embryo survival and pregnancy rates [49] 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 [50]. 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 [51]. 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 [52]. 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 [53]. 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 [54]. Drylot-developed heifers receiving supplementation the first month of grazing following AI had higher pregnancy rates than non-supplemented heifers [54]. Supplementation on pasture did not increase pregnancy rates to AI when heifers were developed on range compared with heifers receiving no supplement or drylot-developed [54]. Improving heifer ADG on summer pasture has traditionally received minimal consideration in discussions of 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 [43, 55, 56].

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 [57]. 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 [58]. Heifers conceiving early in the breeding period will have greater lifetime productivity [59] (and see Perry this series) in the herd and should be favored in selection 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 weights 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 [60], 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 condition score of 5 to 6 by calving [61]. However, heifers developed to 53% of mature body weight at breeding that reached 77% of mature body weight at calving had pregnancy rates through four calving seasons ranging from 92 to 96 % [62]. 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 [44, 63]. Two-year old heifers failing to rebreed weighed less at calving and breeding than those that successfully became pregnant the second time [63].

Calving to Rebreeding

Calving difficulty

First-calf heifers experience more calving difficulty compared with the mature cow. Bellows [14] indicated cows experiencing calving difficulty will take longer to resume estrus than cows not experiencing calving difficulty. Sire selection and genetic components of dystocia are reviewed elsewhere in this series.

Time of intervention, when obstetrical assistance is needed, also affects resumption of estrous cycles. 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) [65,66]. Therefore, early assistance, when needed, is important to assure heifers return to estrus as soon as possible.

Stimulating estrus

Ionophores

Ionophores can influence reproductive performance during the postpartum period [64]. Cows and heifers fed an ionophore exhibit a shorter PPI provided adequate energy is provided in the diet (Table 8) [11]. This effect is more evident in less intensely managed herds with a moderate (60 to 85 days) to longer PPI. Pregnancy rates, if measured, generally were not different in the studies summarized by Randel and colleagues [11], however, in most cases the number of observations was relatively low. In a more recent study replicated over two 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 [67]. 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 [64].

Calf removal

Suckling stimulus has a negative effect on 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 [11, 68]. Some synchronization programs remove calves for 48 hours [69], 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 and to make sure calves have found their mothers before going to pasture.

Induction of estrus with hormones

An intravaginal insert (CIDR), containing progesterone, can shorten the PPI provided nutrition and BCS are adequate [70, 71]. A number of protocols for synchronization of estrus and ovulation incorporate a progestin and have resulted in pregnancies in previously non-cycling females [72]. Ovulation induction with gonadotropin releasing hormone was limited in primiparous cows until BCS were ≥ 5 [6].

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 [73] 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 [74]. The PPI was reduced in cows exposed to as many as 1 bull per 29 females [75]. Exposure to androgenized steers [76] or cows [75] will produce similar results.

Summary

The interaction of nutrition and reproduction in young beef cows has been studied extensively. Diets which meet the high nutrient demands of late gestation and early lactation require attention and monitoring. Adequate nutrition will limit calving difficulty, increase health and vigor of the calf, 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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Table 1. Relationship of body condition score (BCS) to beef cow performance and income.

BCS	Pregnancy Rate, %	Calving Interval, d	Calf ADG, kg	Calf WW, kg	Calf Price, $/45.5 kg	$/Cow Exposed[a]
3	43	414	0.73	170	96	154
4	61	381	0.80	209	86	241
5	86	364	0.84	234	81	358
6	93	364	0.84	234	81	387

[a] Income per calf × pregnancy rate.

Data from Kunkle W, Sands R, Rae D. Effect of body condition on productivity in beef cattle. M. Fields and R. Sands (Ed.) Factors Affecting Calf Crop: CRC Press 1994, p174.

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

	Adequate	Inadequate
Nutrient and time	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 R. Nutrition and postpartum rebreeding in cattle. J Anim Sci 1990; 68:853-862.

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

	Gestation diet of dam	
Item	Low	High[b]
Calf birth weight (kg)	28.6	31.4
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 RA. Managing the first-calf heifer. In: Proceedings of the International Beef Symposium. Great Falls, MT: 1995, p. 74-85.

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, kg	379	374	376	373
Calving BCS	4.27	4.26	4.18	4.10
PPI[a], d	134	120	115	114
PPI Wt. Change[a], kg	5.6	18.2	31.6	35.2
PPI BCS Change[a]	-.32	.37	1.24	1.50

[a]Linear effect, P < 0.01

Adapted from Lalman D, Keisler D, Williams J, et al. Influence of postpartum weight and body condition change on duration of anestrus by undernourished suckled beef heifers. J Anim Sci 1997;75:2003-2008.

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

Researcher	Prepartum Supplementation[a]	Effect	Birth Wt[b]	Dystocia[b]	Other[b]
Christenson et al., 1967	HE vs LE for 140 d	HE	+	+	+ Milk, + estrus activity
Dunn et al., 1969	ME vs LE for 120 d	ME	+	+	
Bellows et al., 1972	HE vs LE for 82 d	HE	+	nc	nc weaning weight
Laster & Gregory, 1973	HE vs ME vs LE for 90 d	HE	+	nc	
Laster, 1974	HE vs ME vs LE for 90 d	HE	+	nc	
Corah et al., 1975	ME vs LE for 100 d	ME	+	nc	+ estrus activity,+ calf vigor and + weaning weight
Bellows and Short, 1978	HE vs LE for 90 d	HE	+	nc	+ estrus activity, + pregnancy rate decreased postpartum interval
Anderson et al., 1981	HE vs LE for 90 d	HE	nc		nc milk, nc weaning weight
Houghton et al., 1986	ME vs LE for 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 P, Corah L. A review of calving difficulty in beef cattle. Kansas State University Report of Progress 1987; 525:22-35.

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 P, Corah L. A review of calving difficulty in beef cattle. Kansas State University Report of Progress 1987; 525:22-35.

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 heat at beginning of breeding season (%)[b]	91[c]	82[d]
Services/conception[a,b]	1.15	1.24
Fall pregnancy (%)[a,b]	92[e]	78[f]
Calf average daily gain (kg)[a]	0.76[c]	0.79[d]
Calf weaning weight (kg)[a]	183	179

Adapted from [a]Bellows RA, Short RE, Staigmiller RB et al. Effects of induced parturition and early obstetrical assistance in beef cattle. J Anim Sci 1988;66:1073-1080 and [b]Doornbos D, Bellows R, Burfening P, et al. Effects of dam age, prepartum nutrition and duration of labor on productivity and postpartum reproduction in beef females. J Anim Sci 1984;59:1-10.

[c,d] Means differ $P < 0.10$.

[e,f] Means differ $P < 0.05$.

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 R. Nutrition and postpartum rebreeding in cattle. J Anim Sci 1990;68:853-862.

Table 9. Summary of studies that evaluated 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 C, Ungerfeld R. Biostimulation in cattle: Stimulation pathways and mechanisms of response. Tropical and Subtropical Agroecosystems. 2012; 15(SUP 1): S29–S45 online. Available at: http://www.veterinaria.uady.mx/ojs/index.php/TSA/article/view/1342/656. Date accessed: 15 Mar. 2013. (reprinted with permission)