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# SUPPLEMENTING FAT TO THE COW HERD

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## INTRODUCTION

Range livestock operations are continually challenged with the need to maintain sustainable production systems. Improvements in the herd's biological efficiency are important considerations for the sustainability of beef cattle production. In a broad sense there are two levels at which improvements can be made, the cow and the calf. Considering that the majority of income for the typical cow-calf operation comes from the sale of the calf being produced, the calf would be a logical production unit to target for improvement. However, the key factor influencing total calf production is reproductive efficiency of the cow herd. Sound nutritional programs are pivotal to achieving the highest reproductive rates and increasing efficiency of beef cattle production. Strategic nutritional inputs may afford beef cattle managers the opportunity to produce beef cattle more efficiently and become more sustainable. In this regard, provision of supplemental fat to reproducing beef cows has been purported to improve production traits of the cow-calf unit. The purpose of this paper is to summarize expected responses of the cow and calf to dietary fat by compiling data available in the refereed (peer-reviewed) literature and from experiments conducted at the University of Wyoming. The goal will be to develop recommendations that will assist beef cattle managers determine whether or not supplementing fat to the cow herd has potential to improve biological efficiencies, and thus, improve sustainability of their beef cattle operations.

The most important factor affecting profit in a cow-calf enterprise is reproduction. In reviewing several sources of information, Bellows et al. (2002) estimated that reproductive diseases and conditions cost beef cattle producers $441 to $502 million in lost income yearly. Seventy-five percent of these costs were attributed to female infertility and dystocia and the failure to produce a healthy, viable neonatal calf. Therefore, the focus of this paper will be on supplementing fat to the beef cow during the most critical points of her annual production cycle (i.e. late gestation and early lactation). The initial discussion will focus on supplementing fat as a strategy to increase the probability of conception. The subsequent discussion will concentrate on how supplementing fat to the cow affects the calf. Researchers conducting the studies reviewed in the following discussion formulated the high-fat diets to provide equal energy and protein to that of the control diets so that responses could be directly attributed to the fat supplement.

## FEEDING FAT POSTPARTUM AFFECTS OVARIAN FOLLICULAR DEVELOPMENT

The largest reproductive loss experienced by the beef herd is failure of cows to exhibit regular estrus and conceive by the end of a restricted breeding season (Bellows and Short, 1994). It is well accepted that nutrition has dramatic effects on reproductive processes in the beef cow. In a review of the literature summarizing results of 19 experiments conducted to elucidate potential reproductive responses of postpartum beef cows to supplemental fat, Hess et al. (2002) concluded that one would expect increased numbers of ovarian follicles in the larger classification groups with provision of supplemental fat to reproducing beef cows. However, the question is whether or not supplementing fat contributes to postpartum recovery of biological events leading to reproductive success. Reproductive success in beef cows is a function of interval from parturition to first ovulatory estrus (postpartum interval) and conception rates in estrous cycling cows.

## EFFECTS OF FEEDING FAT ON BEEF COW REPRODUCTION

Duration of postpartum anestrus has been identified as one of the main factors influencing reproductive efficiency of beef cows because pregnancy rates during a restricted breeding season may be improved by shortening this postpartum period. Therefore, studies in which researchers reported luteal activity and (or) postpartum interval of beef cows in response to consumption of fat are summarized in Table 1. Levels of circulating progesterone were often used to determine luteal activity. Luteal activity was only reported in studies conducted with cows fed fat after calving. Both primi- and multiparous cows were included in the present Chi-square analysis. Supplementing fat significantly improved ($P < 0.0001$) luteal activity. Of the 181 control cows, 50.8% demonstrated luteal activity whereas 73.6% of the 216 cows fed fat postpartum exhibited luteal activity. Postpartum interval was not affected (average = 66 days) in the only experiment that evaluated fat supplementation prepartum (Alexander et al., 2002). For cows supplemented with fat postpartum, treatment (control versus fat supplement) means from the eight studies that reported postpartum interval were analyzed as a randomized complete block design with experiment as the block. Once more, postpartum interval was not influenced ($P = 0.47$) by supplementing fat (control = 75 days, fat-supplemented = 73 days). Thus, supplementing fat may increase the percentage of cows exhibiting luteal activity but this nutritional strategy does not affect the interval from parturition to first ovulatory estrus.

Although the length of postpartum anestrus has been identified as one of the most critical factors influencing reproductive efficiency, cows will only conceive if they exhibit normal estrus. To assess the influence of supplementing fat to beef cows on detection of normal estrus, results were pooled across several experiments for Chi-square analysis. The prepartum fat-feeding evaluation included 129 control cows and 212 cows fed fat; the postpartum fat-feeding evaluation included 99 control cows and 143 cows fed fat. Feeding fat prepartum or postpartum did not influence ($P = 0.49$ or 0.53, respectively) the percentage of cows detected to have normal estrous cycles (Table 1).

Table 1. Reproductive responses by beef cows to provision of dietary fat[a]

| | Pre-partum | | | Post-partum | | |
|---|---|---|---|---|---|---|
| Response | Control | Fat | *P* | Control | Fat | *P* |
| Exhibited luteal activity | Not evaluated | | | 50.8% | 73.6% | 0.0001 |
| Estrus detected | 84.5% | 81.6% | 0.49 | 69.7% | 73.4% | 0.53 |
| Postpartum interval | Average = 66 ± 5 d | | 0.25 | 74.8 d | 73.2 d | 0.47 |
| 1st service conception rate | 64.3% | 67.0% | 0.60 | 65.1% | 58.4% | 0.22 |
| Overall conception rate | 86.3% | 91.8% | 0.05 | 84.5% | 84.2% | 0.94 |

[a]Data presented in the Table were from refereed literature reports reviewed by Hess et al. (2002), in addition to experiments conducted by Burns et al. (2002), Sanson and Coombs (2003), Grant et al. (2003), Small et al. (2003), and Lake et al. (unpublished data from the University of Wyoming). The length of the prepartum fat supplementation period ranged from 56 days to 68 days. The length of the postpartum fat supplementation period ranged from 28 days to 100 days. There were 181 control cows and 216 fat-supplemented cows in the data set evaluating luteal activity. Data for percentage of cows detected in estrus included 129 controls and 212 fat-supplemented prepartum and 99 controls plus 143 cows fed fat postpartum. Postpartum interval for cows fed fat prepartum was only reported by Alexander et al. (2002), but treatment means from eight separate experiments were included in the postpartum data set. The number of cows used to assess first service conception rate included 140 controls and 194 fat-supplemented prepartum and 146 controls and 173 fat-supplemented postpartum. Overall conception rate was evaluated using 197 controls and 281 fat-supplemented cows in the prepartum data set, while postpartum fat supplementation was evaluated with 197 controls and 281 fat-supplemented cows.

Cows that conceive early in the breeding season are likely to be more profitable because of the potential to produce heavier calves at weaning. First service conception rates of beef cows fed fat prepartum was determined in three experiments conducted at the University of Wyoming. Although results of individual investigations did not demonstrate an effect of feeding fat during late gestation on first service conception rates, results from these experiments were pooled to increase total number of observations for Chi-square analysis. Sixty-seven percent of the fat-supplemented cows conceived on first service compared to 64.3% first service conception rate for the control cows ($P = 0.60$). Data from five separate experiments were pooled to evaluate feeding fat to postpartum beef cows. This data set included 99 control-fed cows and 143 fat-supplemented cows. Although results of the Chi-square analysis revealed that supplementing fat to postpartum beef cows did not affect ($P = 0.22$) first service conception rates, there was a bit of disparity among the different studies. The results of the analysis presented herein were consistent with those of both Webb et al. (2001) and Lloyd et al. (2002). First service conception rates approached significance ($P = 0.12$) and tended to be greater for cows fed diets supplemented with fishmeal in the experiment conducted by Burns et al. (2002). However, supplementing fat to postpartum cows in the University of Wyoming herd resulted in decreased first service conception rates (Table 2).

Probable causes for the difference among the studies previously mentioned include, but may not be limited to body condition of the cows as well as dietary level and source of fat used in the various studies. Body condition scores ranged from 5 to 7 (9-point scale) for

Table 2. Comparison of first service conception rates between postpartum beef cows fed control diets and diets containing fat

| Source of data | Control | Fat | *P* |
|---|---|---|---|
| Literature[a] | 70.0% | 73.7% | 0.54 |
| University of Wyoming[b] | 50.0% | 28.8% | 0.04 |

[a]The data set included results reported by Webb et al. (2001), Burns et al. (2002), and Lloyd et al. (2002). Only Burns et al. (2002) reported a trend ($P = 0.12$) for increased first service conception rates in cows receiving fat (fishmeal).
[b]Data from the University of Wyoming included those of Grant et al. (2003) and unpublished data of Lake et al. In the latter experiment, cows were maintained to calve at a body condition score of either 4 or 6.

all of the studies except for the study of conducted at the University of Wyoming (Lake et al., unpublished data). The cows in the study of Lake et al. were managed to calve at a body condition score of either 4 or 6. A body condition score x dietary treatment interaction was not detected in this study, suggesting that response to supplemental fat was similar among cows in each of the body condition score groups. Likewise, Ryan et al. (1994) reported that ovarian follicular responses to supplemental fat by cows with a body condition score of 4 were similar to cows with body condition scores of 6 or 8. Thus, differences in body condition score of cows used in the various experiments does not appear to be contributing to the differences noted in first service conception rates. Level of supplementary fat provided to the cows ranged from as low as 56 grams from fishmeal (Burns et al., 2002), 113 grams of calcium-fatty acids soaps (Lloyd et al., 2001), 149 grams of fat from rice bran (Webb et al., 2001), to highs of 420 grams (averaged across the University of Wyoming studies) from either high-linoleate or high-oleate safflower seeds. Although it would seem that the level of fat provided to cows in the University of Wyoming studies was extraordinarily high, it is important to note that Webb et al. (2001) included other dietary ingredients (such as corn) that contributed substantially to total dietary fat intake (total fat intake was approximately 470 grams per day). Nevertheless, the level of fat in the diet of the cows appears to have been a factor in determining the response to supplemental fat. There were too few experiments in the present review to definitively conclude that level of fat was the major factor contributing to the response, and a confounding factor that cannot be ruled out as a contributor to the response is fatty acid composition of the fat source fed to the cows. Burns et al. (2002) attributed a trend for increased first service conception rates of cows fed fishmeal to increased status of ω-3 fatty acids, whereas Hess et al. (2002) argued that feeding vegetable fats containing high levels of linoleic acid may elicit a different response. Thus, while level of dietary fat cannot be ruled out, there is evidence to suggest that fatty acid composition of the fat source also influences the first service conception response.

The affects of supplying specific dietary fatty acids to reproducing beef cows has received much attention by researchers working in the area. The focus on this area of research has been prompted by the observation that the percentage of cows experiencing abnormal estrous cycles could be altered through manipulation of dietary fatty acids. Knowing that cows experiencing estrous cycles with abbreviated luteal phases are less likely to conceive than cows with normal estrous cycles, researchers have concentrated on identifying how provision of specific fatty acids affects processes involved with short estrous cycles. A hormone produced by the uterus, prostaglandin $F_2$ ($PGF_2$), plays a role in the short-lived corpora lutea associated with short estrous cycles. Burns et al.'s (2002) explanation for increased first service conception rates comes from the observation that □-fatty acids attenuate $PGF_2$ synthesis by the cells of the uterus (Mattos et al., 2001). Plasma or serum concentrations of a metabolite produced when the lungs and uterus metabolize $PGF_2$ (13, 14-dihydro-15-keto$PGF_2$ metabolite; PGFM) have also been used to assess the role of $PGF_2$ in reproductive processes. Interestingly, Webb et al. (2001) reported that a greater percentage of cows receiving the control diet exhibit normal estrous cycles than cows supplemented with fat (33.7% linoleic acid). Although Webb et al. (2001) did not observed an effect of feeding fat on plasma PGFM, these authors only evaluated PGFM for the first 7 days after calving. However, in a study using the same diets as Webb et al. (2001), Lammoglia et al. (1997) observed that peak concentrations of PGFM in plasma tended to increase in cows fed fat from day 1 of the first estrous cycle until emergence of the dominant follicle of the second estrous cycle. Grant et al. (2003) did not have enough cows in their study to demonstrate (statistically) a greater percentage of short cycles in cows fed fat, but serum PGFM in two separate experiments was greater in cows fed high-linoleate (76% 18:2) safflower seeds than cows fed the control supplement (Grant et al., 2002). Thus, it is highly probable that feeding fat high in □-3 fatty acids will lead to decreased PGFM whereas feeding fat with high levels of linoleic acid will have the opposite effect. The net result would be less chance of short cycles and potentially higher first service conception rates with feeding □-3 fatty acids and increased chance of short cycles and lower first service conception rates with feeding diets high in linoleic acid.

The inability of cows to become pregnant in a defined period may have the single greatest effect upon reproduction cost and efficiency (Bellows et al., 2002). Overall pregnancy rate was not affected ($P = 0.94$) by supplementing fat to postpartum beef cows (average = 84.3%); however, supplementing fat to cows during late gestation increased ($P = 0.05$) overall pregnancy rate from 86.3% to 91.8% (Table 1). Therefore, it would seem reasonable to suggest that feeding fat to beef cows for approximately 60 days before calving may result in a 6.4% improvement in pregnancy rates in the upcoming breeding season. However, results of individual investigations have been inconsistent. As suggested by Bellows et al. (2001), dietary factors during the supplementation period as well as following supplementation may impact the influence prepartum fat supplementation has on pregnancy rates in the subsequent breeding season.

## CALF RESPONSES TO FEEDING THE COW FAT

In addition to improving the probability of conception, Bellows et al. (2002) urged researchers to focus on strategies to improve the production of healthy calves that experience minimal dystocia and survive beyond the first 24 hours of birth. Birth weight has been identified as the most important factor affecting calving difficulty. Thus, birth weights of calves born to cows fed fat during gestation can be used as an indicator of the potential for this nutritional strategy to influence dystocia. Results of literature published in refereed journals on birth weights of calves from dams that received supplemental fat during late gestation have been inconsistent. Three of the 18 prepartum dietary fat treatments increased calf birth weight, two decreased calf birth weight, and calf birth weight was not affected by

12 of the prepartum fat supplementation programs. Nonetheless, based on the information in Table 3, it is concluded that supplementing fat to beef cows during late gestation does not affect calf birth weight. Therefore, prevalence of calving difficulty is expected to be similar between fat-supplemented cows and cows not supplemented with fat during late gestation.

Table 3. Calf responses to supplementing cows with fat during late gestation[a]

| Response | Control | Fat | *P* |
|---|---|---|---|
| Birth weight[b] | 76.3 lbs | 76.8 lbs | 0.84 |
| Vigor score[c] | 1.2 | 1.1 | 0.48 |

[a]Data presented in the Table were from refereed literature reports reviewed by Hess et al. (2002), in addition to experiments conducted by Dietz et al. (2003), Vann et al. (2003), and Small et al. (2003).
[b]Birth weights represent pooled means of the original treatment means reported for 11 separate experiments.
[c]Vigor scores represent pooled means of the original treatments reported in four separate experiments; 1 = alert vigorous, active, 2 = alert, able to stand, 3 = lethargic, unable to stand, 4 = dead at birth.

Feeding fat prepartum may serve as an important functional link to calf survivability. Research by Lammoglia et al. (1999a,b) investigated effects of prepartum supplementation of dietary fat on cold tolerance of neonatal calves. Calves from dams that received supplemental fat during late gestation responded to cold stress by increasing rectal temperature, which was maintained for a longer period of time than calves from dams not fed supplemental fat. This calf response to cold was related to increased availability of glucose for metabolism and heat production. Additionally, Dietz et al. (2003) examined possible effects of feeding fat (2% linoleic acid) 68 days before the expected date of parturition on calves that were born below the lower critical temperature (< 43˚ F). Calves from dams fed fat tended to stand sooner and had improved vigor scores. Hence, provision of supplemental fat to beef cattle prepartum appears to be an effective nutritional management strategy to help the neonatal calf combat low ambient temperatures. Nonetheless, prevailing environmental temperatures might influence the supplemental fat induced response of the neonate. If calves were gestated in less harsh environments and exposed to milder environments after calving, prepartum fat supplementation did not affect apparent cold tolerance (Lammoglia et al., 1999b, Dietz et al., 2003). This observation may partially explain the lack of prepartum dietary fat effect on calf vigor score shortly after birth (Table 3). Thus, feeding fat to late gestational beef cows may improve the survivability of calves born in cold environments but does not appear to influence variables that may be indicative of potential survivability in milder environments.

Increasing the linoleic acid content of the prepartum diet may be an important factor influencing calf survival. Linoleic acid is an essential fatty acid that is required for many physiological processes. The linoleic acid status of the neonatal calf is less than satisfactory (Noble et al., 1978), and under normal circumstances the poor linoleic acid status is not rectified until about 10 days after birth (Shand et al., 1978). Experiments conducted with sheep showed that linoleic acid status of the neonate can be improved significantly by providing the late-gestational dam a fat supplement that greatly increased maternal plasma levels of linoleic acid (Noble et al., 1978; Shand et al., 1978). Research conducted at the University of Wyoming (Scholljegerdes et al., 2001) demonstrated that intestinal supply of linoleic acid was 2.85 times greater in cows fed high-linoleate safflower seeds than control cows. Moreover, data presented in Figure 1 illustrate that feeding fat 56 days before parturition increased cow plasma levels of linoleic acid. In a different experiment conducted at the University of Wyoming (Small et al., 2003), within 24 hours after birth, calves from cows fed fat for 61 days prepartum had 19.4% greater ($P = 0.05$) plasma linoleic acid than calves from cows consuming diets without supplemental fat. It is also possible to increase linoleic acid status of the nursing calf by supplementing the lactating beef cow fat high in linoleic acid (Lake et al., 2003). In this case, linoleic acid content of the calves' adipose tissue is highly correlated ($r = 0.91$; $P < 0.0001$) with milk linoleic acid content.

The potential benefit of enhancing the linoleic acid status of neonatal ruminant animal was recognized by Noble et al. (1978). These authors stated that "under certain circumstances, e.g., adverse environmental conditions involving exposure to pathogenic bacteria, that some practical benefit might be derived from an improvement in the essential fatty acid status of the young ruminant animal during the critical period immediately after birth." A study was conducted at the University of Wyoming to test the theory of Noble et al. (1978). Calves used in the experiment of Small et al. (2003) were weaned and given an antigen challenge of ova-albumin at approximately 90 days of age. Calves from cows fed fat for 61 days prepartum had greater ($P = 0.006$) response to the antigen (absorbance was 0.06 versus 0.09 for control and fat treatments, respectively). Likewise, serum IgG concentrations at 36 hours tended to be increased when calves were born in a cold environment to cows that were fed fat 68 days before calving (Dietz et al., 2003); however, this result was not observed in calves born during milder conditions (Dietz et al., 2003). Furthermore, supplementing cows to increase milk output of linoleic acid for the first 60 days of lactation (Lake et al., 2003) did not have a long-term effect on calves given a second antigen challenge at approximately 120 days of age (Lake et al., unpublished data). Thus, improving linoleic acid status of the neonatal calf appears to bolster immune status/function under certain situations but not others. Additional research is needed to identify how provision of supplemental fat to the cow influences immune status and (or) function of the neonate.

## CONCLUSIONS

Nutritional programs are one of the most important factors influencing biological efficiency of beef cattle production systems. Beef cattle researchers have directed modest attention on high-fat supplements for the reproducing beef cow. From the information presented herein it is not possible to suggest that fat supplements will always improve production efficiency of cow-calf units. There are instances, however, where provision of supplemental fat may afford beef cattle producers the opportunity to increase efficiency of beef cattle production. Anticipated responses of beef cattle to dietary fat, in addition to recommendations for including fat in the beef herd's diet are outlined on following pages.

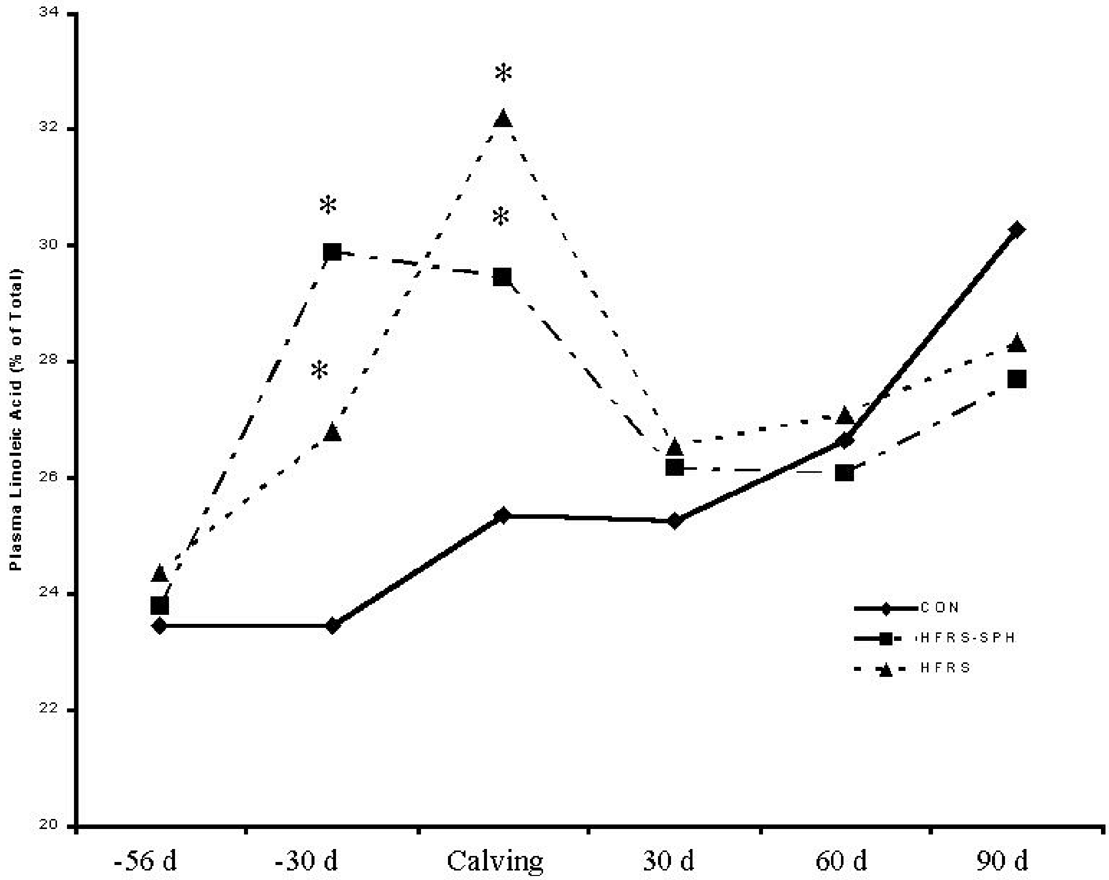


Figure 1. Weight percentage of plasma linoleic acid in corn-soybean meal control (CON), High-Fat Range Supplement (HFRS, Consolidated Nutrition, Omaha, NE), and High-Fat Range Supplement with lipid from soybean soapstock (HFRS-SPH, Consolidated Nutrition, Omaha, NE) fed 56 d prepartum to primiparous cows. A treatment by time affect was noted ($P$=0.0001), points with asterisks (*) differ from CON ($P$<0.02). Source: Alexander et al. (2002).

## EXPECTED RESPONSES AND RECOMMENDATIONS

1. Beef cows fed fat postpartum will exhibit increased ovarian follicular growth and development. Although this nutritional strategy enhances luteal activity, cows fed supplemental fat during this period did not exhibit increased reproductive performance. It is possible to impair the cow's ability to conceive at first service by feeding fat high in linoleic acid. Therefore, caution must be exercised when feeding fat to postpartum beef cows. Fat supplementation for postpartum cows cannot be recommended as a method to improve reproduction, but in the same vain, overall reproductive performance was not affected by supplementing fat to postpartum cows. The decision to include fat in the diet of postpartum beef cows should be based on

whether or not this nutritional regimen is compatible with the operation's production goals and if it is economically feasible.

2. Supplementing the beef cow's diet with fat for approximately 60 days before parturition resulted in a 6.4% improvement in pregnancy rates during the subsequent breeding season. Therefore, feeding fat to cows for the last 60 days of gestation can be recommended as a method to improve overall reproductive efficiency.
3. Calf birth weight was not affected by feeding fat to beef cows during late gestation. Calves born to cows fed fat prepartum had greater plasma linoleic acid and greater tolerance to the cold when born in and exposed to colder environments. Furthermore, the possibility exists to bolster immune status and function of neonatal calves by supplementing their dams with fat prepartum. Thus, feeding fat to beef cows for approximately 60 days before calving may be recommended as a method to assist neonatal calves combat adverse environmental conditions.

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