Winter protein management during late gestation alters range cow and steer progeny performance[1]

J. T. Mulliniks,* J. E. Sawyer,† C. P. Mathis,‡[2] S. H. Cox,* and M. K. Petersen§[3]

*Department of Animal and Range Sciences, New Mexico State University, Las Cruces 88003; †Department of Animal Science, Texas A&M University, College Station 77843; ‡Extension Animal Sciences and Natural Resources Department, New Mexico State University, Las Cruces 88003; and §USDA-ARS Fort Keogh Livestock and Range Research Laboratory, Miles, City, MT 59301

ABSTRACT: A 4-yr study was conducted at Corona Range and Livestock Research Center, Corona, NM, to establish if a protein-dense self-fed supplement could substitute for a traditional hand-fed (range cube) supplement that is less protein dense and minimize or maintain cow BW and BCS during late gestation and the subsequent steer progeny feedlot performance, health, and economic viability. Late gestation cows received one of 3 supplementation strategies: 1) 36% CP cottonseed meal base supplement (CSM; positive control) fed 3 times per week, 2) self-fed supplement (SMP) comprising 50% animal protein sources (blood meal and feather meal) and 50% trace mineral package, or 3) brief and intermittent supplementation of CSM based on periods of acute environmental stress (VAR; negative control) by ranch management. Initiation of supplementation varied across years due to changing forage conditions and climatically imposed grazing constraints but always ended approximately 2 wks before calving each year. Across all 4 yr, supplement consumption averaged 0.65, 0.21, and 0.04 kg·head^{-1}·d^{-1} for CSM, SMP, and VAR, respectively. After weaning, steers were preconditioned for 45 d and were received and treated as custom fed commercial cattle at a feedlot in mid November each year. Cow BW and BCS were not influenced ($P \geq 0.13$) by prepartum supplementation; however, the strategy did have an effect on BW and BCS change with cows managed in the VAR group. Cows managed in the VAR group lost the greatest ($P < 0.05$) amount of BW and BCS whereas no differences were measured between CSM and SMP groups. Prepartum supplementation strategies did not influence ($P = 0.98$) pregnancy rates. Calf weaning, initial feedlot and final BW, and HCW were unaffected ($P \geq 0.80$) by prepartum supplementation of the dam. Steers from dams fed CSM and VAR had a greater percentage treated for sickness than SMP steers ($P = 0.03$), which resulted in a tendency ($P = 0.07$) for medicine costs to be greater in steers from CSM and VAR cows. The use of a self-fed package supplement was equally effective as use of a traditional hand-fed, oilseed-based supplement in maintaining BW and BCS during late gestation. In addition, these results imply that although nutrition treatment of cows during the prenatal period had no effect on calf growth performance, calves from cows fed SMP had improved feedlot health.

Key words: beef cattle, fetal programming, protein supplementation, reproduction

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INTRODUCTION

Cows have the ability to modify energy metabolism during periods of moderate feed restriction and realimentation, which allows for development of management and supplemental strategies in pregnant beef cows (Freetly et al., 2008). In addition, efficiency of N use is increased during these times of nutrient restriction in beef cows (Freetly and Nienaber, 1998). Previous studies have demonstrated that low amounts of supplemental protein, particularly sources high in RUP, may be used efficiently (Coomer et al., 1993;

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[2]Present address: King Ranch Institute for Ranch Management, Kingsville, TX 78363.

[3]Corresponding author: mark.petersen@ars.usda.gov
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Sawyer et al., 2012). The use of small quantities of high supplemental RUP ingredients combined with salt and minerals sustained ruminal function with low quality warm season forage diets (Sawyer et al., 2012). Consistent with nutrient dose–response relationships, it was hypothesized that low quantities of a high RUP supplement can minimize BW and BCS loss in mature cows grazing dormant winter range.

Implementation of minimal supplemental protein strategies during late gestation may have the potential to affect postweaning progeny performance. However, the effect of reduced input prepartum range cow nutritional strategies on calf well-being from weaning through the feedlot is not well known. Previous research (Stalker et al., 2006; Larson et al., 2009) has suggested evidence for prenatal influences on steer progeny from cows grazing dormant winter range with and without protein supplementation. However, the extent of management or undernutrition during pregnancy on subsequent calf performance in the feedlot has not been well defined. Therefore, the objective of this study was to establish if a protein-dense self-fed supplement could substitute for a traditional hand-fed (range cube) supplement that is less protein dense and minimize or maintain cow BW and BCS during late gestation and subsequent steer progeny feedlot performance, health, and economic viability.

MATERIALS AND METHODS

All animal handling and experimental procedures were in accordance with guidelines set by the New Mexico State University Institutional Animal Care and Use Committee.

This study was conducted over 4 consecutive yr at New Mexico State University Corona Range and Livestock Research Center (**CRLRC**), Corona, NM. The CRLRC is located in central New Mexico with an average elevation of 1,900 m. Annual precipitation averages 401 mm, with approximately 70% of annual precipitation occurring from May to October. Forages at this study site were primarily blue grama (*Bouteloua gracilis*), threeawns (*Aristida* spp.), and common wolftail (*Lycurus phleoides*).

Prepartum Supplementation

During the 4 yr study, 333 gestating Angus and Angus-cross cows from 3 to 9 yr of age were used. Each year, cows were stratified by breed and BW at weaning and randomly assigned to 1 of 6 replications or subherds such that subherds contained the same proportion of Angus and crossbred cows. Cows in the study the previous year were reassigned randomly to a treatment regardless of their treatment in the previous year. Each subherd was randomly assigned to 1 of 6 pastures containing 260 to 2,023 ha. Treatments were randomly assigned to each pasture, resulting in 2 subherd replications per treatment within each of the 4 yr. Pastures contained approximately 355 to 674 kg/ha of standing forage and were stocked at a rate that was 50% less than the Natural Resources Conservation Service recommended rate so that forage availability was assumed not to limit cow productivity (USDA-NRCS, 2002). Therefore, harvested forages were not fed during the study.

Due to variation in annual forage conditions and climatically imposed grazing constraints, the duration of the supplementation period strategically varied by year. Supplements were fed for 27, 62, 93, and 51 d, respectively, for yr 1 to 4. In all years, supplementation strategies were initiated when a combination of low temperatures, snow cover, wind duration, decreased cow condition, and trimester of pregnancy contributed to increasing energy requirements. A positive control strategy was developed based on a hand-fed, 36% CP cottonseed meal protein based cubed supplement (**CSM**; Table 1) fed 3 times per week at a rate of 953 (yr 1), 757 (yr 2), or 454 $g \cdot cow^{-1} \cdot d^{-1}$ (yr 3 and 4). Consistent with the annual variation in cow and forage conditions, the feeding rate for CSM varied by year. A negative control strategy was also developed, which allowed for brief and intermittent supplementation based on periods of acute environmental stress, such as snow cover, and is best described as variable supplementation (**VAR**). The VAR strategy, as a negative control, better reflects minimal practices that could be implemented by commercial operations in comparison with a no supplementation strategy that would rarely be found in extensive production settings. This VAR strategy relied on managerial discretion (based on experience) to supply supplement when conditions were determined to be critical for cattle well-being, but the directive was to minimize usage. The VAR strategy used the same batch of supplement formulation as CSM supplement and, when supplied, was always fed twice weekly, at the rate of 454 $g \cdot cow^{-1} \cdot d^{-1}$. Cows receiving VAR were fed for the equivalent of 10 d in yr 1, 8 d in yr 2, and 0 d in yr 3 and 4. Cows receiving CSM and VAR had ad libitum access to a salt–mineral supplement.

The last strategy used a self-fed supplement (**SMP**) formulated to contain 50% protein-dense high-RUP source and 50% mineral supplement according to the results found by Sawyer et al. (2012). The mineral portion of the SMP supplement was designed to provide the same level of mineral intake as the ad libitum supplement supplied to cows receiving CSM and VAR treatments. Ingredients for the SMP supplement were mechanically mixed and hand bagged at the CRLRC. Target intake rate of this supplement was 200 $g \cdot cow^{-1} \cdot d^{-1}$. Feed tubs that contained up to 45.5 kg of SMP were placed within

Table 1. Composition (as-fed basis) of protein supplements consumed by cow grazing dormant native range during the last trimester

Item	Supplement[1]	
	CSM and VAR	SMP
Ingredients, %		
Cottonseed meal	56.94	–
Urea	1.20	–
Wheat middlings	21.45	–
Corn gluten meal	–	–
Porcine blood meal	–	25.00
Hydrolyzed feather meal	–	25.00
Soybean meal	10.00	–
Dried distillers grain	–	1.00
Molasses	9.00	–
Salt	–	19.35
Potassium chloride	0.95	2.00
Monocalcium phosphate	0.30	22.50
Manganese sulfate	0.06	0.15
Magnesium oxide	–	3.30
Trace mineral premix	0.02	1.25
Copper sulfate	0.01	0.20
g/d		
CP	221	89
RDP	163	25
RUP	58	65

[1]CSM = CSM = 36% CP cottonseed meal base supplement fed 3 times per week. SMP = self-fed supplement comprising 50% animal protein sources (blood meal and feather meal) and 50% trace mineral package. VAR = brief and intermittent supplementation of CSM based on periods of acute environmental stress.

30 m of the pasture water source. Throughout the study tubs always contained a minimal quantity SMP and were refilled as needed. The mean intake across years for SMP (weighted by duration of supplementation period) was 202 g·cow^{-1}·d^{-1}.

The rationale for the design of the supplements was taken from the results of Sawyer et al. (2012), a precedent to the current study. The 3 supplementation strategies were aimed at establishing if a protein-dense self-fed supplement targeted for 200 g of consumption per day could substitute for a traditional hand-fed (range cube) supplement that is less protein dense and fed at 454 to 953 g/d. This study was designed to test the findings from Sawyer et al. (2012) on a large scale production setting across the variability of years. Sawyer et al. (2012) reported that 40 g/d of CP from a high RUP supplement could replace 160 g/d of CP of a RDP supplement as measured by N retention and total tract NDF digestibility in cows consuming low-quality forages. This lack of differential responses may have been influenced by the slow ruminal fermentability of the basal diet (4.1% CP; 75% NDF; OM basis), low ruminal N concentration creating a negative N concentration gradient to encourage N recycling, and enhanced efficiency of N use due to suspected low ruminal N losses when feeding low levels of supplemental N (i.e., 40 g/d). In addition, Mathis et al. (2000) observed no effect of increased RDP supplementation on intake or digestibility when warm season hay was fed, suggesting that ruminal N supply considered necessary for digestion of slowly fermentable low-quality forages maybe less than generally practiced. If this is true, protein sources greater in RUP used as supplement sources may improve CP use efficiency when fed at low amounts by maintaining a consistent and minimal ruminal N supply and by reducing ruminal and metabolic N losses (Coomer et al., 1993). Because minimal amounts of CP (~40 g/d) were needed to maintain total tract NDF digestion of a low-quality hay (Sawyer et al. 2012), it is likely that protein-dense sources greater in RUP could be added to a self-fed mineral program for ease of delivery and provide an amount of CP for high use efficiency intended for maintenance of beef cows grazing dormant rangeland in extensive environments.

The 3 strategies can be characterized by differences in feed amount consumed, protein concentration, protein degradability, frequency, and delivery method. However, the objective of the supplementation strategies was to optimize late gestation BW and BCS response to the respective strategy. The supplementation component of the 3 strategies by design were confounded; however, Sawyer et al. (2012) had previously demonstrated that fiber digestion could be similar if a smaller amount of supplement that was more protein dense and less ruminally degradable replaced a greater amount of supplement and protein if fed to cows consuming slowly degradable low quality hay. This study took the next step to test if the findings of Sawyer et al. (2012) would recur in an applied-field scale range setting where frequency and delivery method varied.

Composition of each supplementation was the same over the 4 yr of this study. Supplementation for all strategies ended approximately 2 wk before the expected initiation of parturition based on breeding season dates. Under management conditions in this study, the prepartum supplementation period ended the first week in February each year. Delivery amounts were recorded each week so that total inputs could be determined and consumption per cow on a weekly basis could be calculated for each supplementation strategy. Feed remaining in the open tub feeder for SMP was weighed once a week and subtracted from the amount of feed delivered the previous week to calculate intake. Supplementation rate, duration of supplemental feeding periods, total consumption, and supplemental costs are shown for each supplementation strategy by year for each prepartum treatment in Table 2. Efficiency of supplement use was expressed by the differences in BW change between supplemented

(CSM and SMP cows) and unsupplemented strategies (i.e., relative to VAR). The efficiency of supplement use was calculated as follows: [BW change between supplemented cows (CSM or SMP) – BW change of VAR cows]/kg of supplement fed.

Cows were weighed at weaning (October), initiation of the supplementation period, and termination of the supplementation period (February). Body condition scores (1 = emaciated and 9 = obese; Wagner et al., 1988) were assigned at these periods to each cow by visual observation and palpation by 2 trained technicians.

After the termination of the prepartum treatments, all cows were managed together in the same pasture. A 60-d breeding season was used in all years and was initiated in early or mid May with all cows managed as a single herd. Cows were exposed to fertile bulls at a ratio of approximately 1:25. Initiation of breeding occurred on average 65 ± 2 d postpartum across all years. Cows were fed CSM for 55 ± 2 d after calving at a rate of 908 g/d 3 times per week. At weaning, cows were diagnosed pregnant by rectal palpation.

Table 2. Feeding rate, duration of supplemental period, and total amount of supplement fed to cows receiving different supplements

	Prepartum supplementation[1]		
Item	CSM	SMP	VAR
Yr 1			
Cows, n	28	27	27
Rate, g/d	953	281	454
Duration, d	27	27	9.5
Total fed, kg	25.7	7.6	4.3
Supplementation cost[2], $/cow	11.54	5.75	2.86
Yr 2			
Cows, n	26	26	25
Rate, g/d	757	172	454
Duration, d	62	62	8
Total fed, kg	46.9	10.7	3.6
Supplementation cost, $/cow	21.57	8.08	4.03
Yr 3			
Cows, n	36	36	35
Rate, g/d	454	249	454
Duration, d	93	93	0
Total fed, kg	42.2	23.2	0
Supplementation cost, $/cow	20.94	17.54	3.84
Yr 4			
Cows, n	22	23	22
Rate, g/d	454	139	454
Duration, d	51	51	0
Total fed, kg	23.2	7.1	0
Supplementation cost, $/cow	11.48	5.37	2.10

[1]CSM = CSM = 36% CP cottonseed meal base supplement fed 3 times per week. SMP = self-fed supplement comprising 50% animal protein sources (blood meal and feather meal) and 50% trace mineral package. VAR = brief and intermittent supplementation of CSM based on periods of acute environmental stress.

[2]Winter supplementation cost = cost of protein supplementation + cost of mineral supplementation.

Calf Performance

After weaning, all calves were preconditioned, conforming to Value Added Calf-45 management guidelines (Anonymous, 2005). Steers (n = 103) were entered into the New Mexico Ranch to Rail Program. Steers were fed at a commercial feedlot (Double A Feeders, Clayton, NM). Initial BW for the finishing phase was calculated from the final BW from the backgrounding phase. Each year, weaning prices were individually applied to each calf based on prices in the New Mexico Weekly Weighted Average Feeder Cattle Report (USDA CB LS 795) for the week steers were weaned.

Steers were received and processed as custom fed commercial cattle at the feedlot in mid November each year and were managed according to the procedures in place at the feedlot. Due to limited number of steers each year and treatment application occurring in utero, from birth on, steers across all prepartum treatments were commingled and managed together (during preconditioning and feedlot phases). Because only the steers in the current study were commingled across treatments in 1 feedlot pen each year, every steer had equal opportunity to be exposed to and challenged to the same factors that could initiate morbidity, thus eliminating any confounding environmental factors that are intimately associated with pen effects. Therefore, any differences in feedlot performance were due to an in utero treatment effect and truly reflected the ability of the steer to cope with the stress of the commercial feedlot environment. Steers were fed a step up diet for approximately 21 d before receiving a high concentrate finishing diet formulated by the commercial feedyard. Each year, experienced feedlot staff (individuals varied) diagnosed morbidity by subjective visual appraisal in compliance with the current feedlot policy. At receiving, all steers were administered a growth-promoting implant (Component ES, VetLife Inc., Overland Park, KS) and preventive pharmaceuticals based on feedlot management procedures. Steers were processed for a secondary application of growth implant at d 74 to 94 of the feedlot phase. At this time, an interim BW was recorded and steers were individually assigned to a marketing group using ultrasound technology and computer software from the Cattle Performance Enhancement Co. (Oakley, KS). Steers were harvested in a commercial facility (National Packing Co., Liberal, KS). Hot carcass weight was recorded at slaughter and carcass traits were evaluated by an independent data collection service (Cattle Trail LLC, Johnson, KS) after chilling. Steers were sold through the National Beef Grid and premiums and discounts were applied using HCW, USDA yield, and quality grade. Net profit was calculated from the finishing net income.

Statistical Analysis

Normality of data distribution and equality of variances of measurements were evaluated using PROC UNIVARIATE, the Levene test, and PROC GPLOT, respectively. Prepartum supplementation cow performance data (cow BW, BW gain, BCS, and BCS change) were analyzed as a completely randomized design with a 3 × 4 arrangement of supplement and year (main effects) using the MIXED procedure (SAS Inst. Inc., Cary, NC) to test all main effects and all possible interactions with pasture within year as the experimental unit. The model included fixed effects of supplement, year, and their interaction using the Kenward-Roger degrees of freedom method. Differences in pregnancy rates were analyzed using logistic regression (PROC GLIMMIX of SAS) using a model that included the fixed effects of prepartum supplementation strategy, year, and their interactions. Calf performance data was analyzed as a completely randomized design with a 3 × 4 arrangement of cow prepartum supplementation strategy and year (main effects) using the MIXED procedure of SAS with pasture within year from cow prepartum supplementation as the experimental unit. Categorical [carcass quality grade and yield grade, and calf feedlot morbidity] data were analyzed using the PROCGLIMMIX procedure of SAS using the same model as described previously. A binomial distribution was assumed for categorical data, with the ILINK option of the LSMEANS statement used to calculate least square means for the proportions.

RESULTS AND DISCUSSION

Prepartum Supplementation

No significant year × supplementation strategy interactions were observed ($P > 0.10$). The lack of year × supplementation strategy interactions indicates that a strategic method to supplementation each year did not add variation due to differences in duration or rate of supplement consumption and that cows responded to these strategies consistently across years. Additionally, the lack of interaction indicates that any differential responses due to annual variation in feeding rate or supplementation duration would be entirely explained by main effect terms.

Cows assigned to different strategies had similar BW before the study at weaning ($P = 0.54$; Table 3) and gained BW from weaning until the beginning of supplementation; therefore, BW at the initiation of supplementation was similar among treatments ($P = 0.38$). Supplementation strategy influenced BW change during the winter supplementation period ($P = 0.01$). Cows receiving CSM or SMP exhibited similar BW changes, essentially reflecting BW maintenance. However, cows receiving VAR supplement strategy lost BW during the supplementation period. These results indicate that nutrient limitations existed during this period and that these deficiencies were corrected by provision of either CSM or SMP. Body condition score was similar at the initiation and termination of supplementation ($P \geq 0.13$); however, BCS change was affected ($P = 0.05$) by treatments. Cows receiving CSM or SMP maintained BCS during the supplementation period whereas cows receiving VAR lost condition. Pregnancy rates were unaffected ($P = 0.98$) by prepartum supplementation strategy. Stalker et al. (2006) and Larson et al. (2009) also found no difference in pregnancy rates in protein supplemented and unsupplemented strategies during late gestation.

In this study, both CSM and SMP were effective at maintaining cow BW and condition during late gestation in an extensive, large pasture environment. This study supports the finding of Sawyer et al. (2012) that concluded 40 g/d of CP had similar N retention and total tract digestibility (NDF and DM) as 160 g/d of CP.

Table 3. Effects of supplementation type on reproduction, BW, and BCS in gestating cows grazing native dormant range

	Prepartum supplementation[1]				
Item	CSM	SMP	VAR	SEM[2]	P-value
Cow BW, kg					
Weaning[3]	468	472	481	9	0.54
Initiation of supplementation	509	516	531	9	0.38
End of supplementation	515	518	517	11	0.98
BW change, kg					
Initial BW to final BW	6[a]	2[a]	–14[b]	3	0.01
Cow BCS					
Weaning[3]	4.4	4.9	4.9	0.2	0.13
Initiation of supplementation	5.0	5.0	5.0	0.1	0.41
End of supplementation	5.1	5.0	4.5	0.2	0.13
BCS change					
Initial BCS to final BCS	0.1[a]	0.0[a]	–0.5[b]	0.1	0.05
Pregnancy rate, %	95	94	94	0.7	0.98

[a,b]Means with different superscripts differ ($P \leq 0.05$).

[1]CSM = 36% CP cottonseed meal base supplement fed 3 times per week. SMP = self-fed supplement comprising 50% animal protein sources (blood meal and feather meal) and 50% trace mineral package. VAR = brief and intermittent supplementation of CSM based on periods of acute environmental stress.

[2]SE of treatment means; n = 2 pastures per treatment.

[3]Before supplementation.

However, the supplements were used with different efficiencies. Efficiency of supplement use can be expressed as the difference in BW change between supplemented and unsupplemented strategies (i.e., relative to VAR) per unit of supplement fed. Using this calculation, CSM was used with an efficiency of 0.57 kg BW spared/kg supplement fed. The SMP supplement was used with an efficiency of 1.32 kg BW spared/kg supplement consumed, a 132% increase in apparent use efficiency. Increased use efficiency resulted in decreased feed costs for cows fed SMP relative to CSM despite greater per unit feed costs for SMP. Applying the unit feed costs for CSM, SMP, and VAR to the total consumption pooled across years results in per cow costs of US$16.39, $9.19, or $3.31/cow, respectively. Because cows receiving VAR failed to maintain BW, SMP was the most economical strategy for BW maintenance in this study. However, cows receiving VAR lost only 14 kg during the study with no difference in pregnancy rates; therefore, protein supplementation during late gestation in environmental conditions similar to conditions in this study may not be warranted to alter pregnancy rates.

Calf Performance

Calf weaning BW was not influenced ($P = 0.99$; Table 4) by the gestation supplementation strategy of the dam. Larson et al. (2009) reported that protein supplementation during late gestation increased calf weaning BW. After a 45-d postweaning precondition period, steer entry feedlot BW was not different ($P = 0.80$) among the gestation treatment of the dam. Similarly, steer final BW was unaffected ($P = 0.81$) among cow prepartum treatments, resulting in no difference in ADG throughout the finishing phase ($P = 0.46$). Stalker et al. (2006) found similar results when beef cows were either supplemented or not supplemented during gestation. However, Larson et al. (2009) reported a tendency for steers from protein supplemented cows to have heavier final feedlot BW and HCW than calves from cows receiving no protein supplementation.

Calves from SMP supplemented dams were treated for respiratory disease less during the finishing phase than calves from CSM and VAR dams ($P = 0.03$; Table 4). However, death loss was unaffected ($P = 0.89$) by the gestation treatment of the dam. Economic losses resulting from morbidity and mortality associated with respiratory disease in newly weaned or received cattle are problematic for the feeding industry (Galyean et al., 1999). Medicinal costs and percentage of steers treated in the feedlot can have a substantial effect on feedlot net income. Therefore, reduced medicine costs and fewer calves treated will impact profitability. Feedlot morbidity may cost more than mortality when expenses associated with medical treatments are com-

Table 4. Effects of dam supplementation strategy during the last trimester on calf performance from weaning through the finishing phase

	Prepartum supplementation[1]				
Item	CSM	SMP	VAR	SEM[2]	P-value
Weaning BW, kg	252	253	253	5	0.99
Feedlot performance					
Initial BW, kg	274	276	278	4	0.80
Final BW, kg	505	512	511	8	0.81
ADG, kg	1.42	1.46	1.38	0.04	0.46
DOF[3]	166	164	173	5	0.41
% treated for sickness	48[a]	16[b]	37[a]	8	0.03
% death loss	4.1	4.6	3.3	4.6	0.89

[a,b]Means with different superscripts differ ($P \leq 0.05$).

[1]CSM = 36% CP cottonseed meal base supplement fed 3 times per week. SMP = self-fed supplement comprising 50% animal protein sources (blood meal and feather meal) and 50% trace mineral package. VAR = brief and intermittent supplementation of CSM based on periods of acute environmental stress.

[2]SE of treatment means; n = 2 pastures per treatment.

[3]DOF = total number of days cattle were on feed.

bined with reduced income of chronic cattle due to premature sale and reduced performance during and after illness (Smith, 1998). McNeill et al. (1996) reported that "healthy" calves had greater daily BW gains and 12% more grade USDA Choice than cattle classified as "sick" at some point in the finishing phase. One reason for the decreased sickness in the feedlot for steers from mothers that consumed SMP may be due to the metabolizable AA profile (both composition and quantity) of the high RUP supplement. Essential AA flow, originating from feed consumed, to the duodenum is increased with RUP supplementation (Merchen and Titgemeyer, 1992), which may have a positive impact on fetal development. Supplementing with high RUP may also increase nutrient use efficiency for gestating cows similar to that reported by Waterman et al. (2006) in lactating cows, resulting in improved calf health from birth through weaning. Furthermore, supplementation of high RUP to gestating ewes has been shown to improve postnatal lamb health and increase colostral IgG concentrations. Redden et al. (2008) also found an increase in antibodies specific to the antigen in lamb serum for parainfluenza type 3 immune transfer when 3-yr-old ewes were fed a high RUP supplement, resulting in an increase of 6% more kilograms of lamb weaned per ewe. Larson et al. (2009) reported more calves from non-protein-supplemented cows received treatment for bovine respiratory disease between weaning and slaughter.

Steer HCW and dressing percentage were not influenced ($P \geq 0.78$; Table 5) by the gestation treatment of the dam. Similarly, marbling score, 12th-rib fat thickness, LM area, and yield grades were unaffected ($P \geq 0.23$) by the late gestation treatment of the dam. Percentage of

Table 5. Effects of dam supplementation strategy during the last trimester on carcass traits in steer progeny

	Prepartum supplementation[1]				
Item	CSM	SMP	VAR	SEM[2]	*P*-value
HCW, kg	318	323	322	6	0.80
Dressing percentage[3]	62.89	62.89	63.06	0.19	0.78
Marbling score[4]	458	487	487	13	0.23
12th-rib fat, cm	1.38	1.42	1.36	0.07	0.81
LM area, cm^2	80.86	82.29	80.54	1.16	0.54
Yield grade	2.7	2.6	2.5	0.1	0.58
Choice or greater, %	33	44	56	7	0.11
Select, %	67	56	44	6	0.12

[1]CSM = 36% CP cottonseed meal base supplement fed 3 times per week. SMP = self-fed supplement comprising 50% animal protein sources (blood meal and feather meal) and 50% trace mineral package. VAR = brief and intermittent supplementation of CSM based on periods of acute environmental stress.

[2]SE of treatment means; n = 2 pastures per treatment.

[3]Dressing percentage = HCW/final unshrunk BW.

[4]Marbling score: 500 = small^0.

Table 6. Economic returns of winter supplementation in cows grazing dormant winter range and progeny of the dam in the feedlot

	Prepartum supplementation[1]				
Item	CSM	SMP	VAR	SEM[2]	*P*-value
Preweaning phase					
Winter supplementation cost, $/cow	16.39	9.19	3.31	–	–
Returns, $/steer					
Calf value	628.24	627.14	626.78	4.59	0.97
Minus supplement cost	611.85	617.95	623.57	4.59	0.19
Postweaning phase, $/steer					
Feed cost	249.60	243.19	263.53	–	–
Medicine cost	23.25	9.58	29.59	6.00	0.07
Feedlot total cost	936.90^{ab}	921.66^{b}	963.16^{a}	11.00	0.05
Gross income	927.77	914.20	944.19	58.95	0.94
Net profit	–9.13	–7.46	–18.97	55.97	0.98

[a,b]Means with different superscripts differ ($P \leq 0.05$).

[1]CSM = 36% CP cottonseed meal base supplement fed 3 times per week. SMP = self-fed supplement comprising 50% animal protein sources (blood meal and feather meal) and 50% trace mineral package. VAR = brief and intermittent supplementation of CSM based on periods of acute environmental stress.

[2]SE of treatment means; n = 2 pastures per treatment.

steers to grade Choice or greater was not different (*P* = 0.11) between the late gestation treatment of the dam. In contrast, Larson et al. (2009) reported that more steers from protein-supplemented dams graded USDA modest marbling score or greater than steers from non-protein-supplemented dams. Underwood et al. (2010) concluded that cows grazing on improved pasture (with greater nutrient intake) during late gestation had similar marbling score in subsequent steer progeny relative to cows grazing dormant native range.

Economic Analysis

Calf value at weaning was not influenced (*P* = 0.97; Table 6) by prepartum supplementation strategy. Deducting winter feed and mineral cost, net return for calves if sold at weaning were similar (*P* = 0.19) by dam treatments. In contrast, Larson et al. (2009) reported that protein supplementation during late gestation had a $16 decrease in income at weaning compared with cows without protein supplementation grazing dormant winter range.

Due to differences in percentage treated for sickness, there was a tendency for medicine costs to be less in calves from SMP dams (*P* = 0.07; Table 6) in comparison with steers whose dams were fed VAR and CSM. In addition, total feedlot costs were reduced (*P* = 0.05) for steers from SMP cows than CSM or VAR cows. However, this decrease in total feedlot costs did not equate to differences in either gross income (*P* = 0.94) or net profit (*P* = 0.98). Larson et al. (2009) reported an increase in net feedlot profit when cows received a protein supplement during late gestation compared with no protein supplement.

Protein supplementation was effective for maintenance of BW and BCS in prepartum gestating cows. The use of a self-fed package supplement (i.e., SMP) was equally effective to a traditional hand-fed, oilseed-based supplement. The small package supplement was used with greater use efficiency with less winter supplementation cost. Although either supplement (CSM or SMP) might serve to mitigate production risk through reduced BW and condition losses, SMP supplement was more efficacious at optimizing the supplementation cost. However, late gestation supplementation strategy had no effect on pregnancy rates or pre- and postnatal calf growth and lifetime BW gain. It is likely that severe environmental stresses during gestation might play a bigger role in calf performance than the range of nutritional regimes reported here. However, this study does reveal that calves born from dams provided a high RUP supplement, consumed at relatively low quantities, were treated less for sickness and had decreased feedlot costs. This implies that there may be nutrient or ingredient formulations for range prepartum supplements that have positive effects on calf health and performance. In conclusion, considering the cost for prepartum supplementation and potentially reduce calf costs in the feedlot, feeding SMP during gestation appears to be a viable alternative to more conventional methods and reduces winter feed costs and decreases calf feedlot morbidity.

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