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Supplementation strategy during late gestation alters steer progeny health in the feedlot without affecting cow performance☆

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ABSTRACT

Implementation of minimal supplemental strategies during late gestation has been reported to potentially increase post-weaning progeny health in the feedlot. Therefore, to investigate the effects of nutritional management strategies during late gestation on cow and subsequent steer progeny performance, 103 gestating cows grazing dormant winter range were utilized at Corona Range and Livestock Research Center, Corona, NM. Cows were supplemented with (1) a 36% crude protein (CP) supplement (CSM) fed 3×/wk at a rate of 454 g cow^{-1} d^{-1}, (2) self-fed supplement comprised of 50% corn gluten meal and 50% mineral (SMP; 28% CP), or (3) cows fed no protein supplement during late gestation (NS). Cows were supplemented for 60 d from December until 2 wk prior to calving. Supplement consumption was 0.45, 0.17, and 0.00 kg/d for CSM, SMP, and NS. After weaning, steers were preconditioned for 45 d and were received and treated as custom-fed commercial cattle at a feedlot in mid-November. Cow BW and BCS were not influenced ($P \geq 0.55$) by late gestation management strategy throughout the study. Prepartum supplementation strategies did not influence ($P = 0.75$) subsequent pregnancy rates. Calf BW at weaning, during the feedlot phase, and HCW were not different ($P \geq 0.52$) among dam prepartum treatments. A greater percentage of steers from dams fed CSM and NS were treated for sickness than SMP steers ($P = 0.05$). Death loss in the feedlot was greater ($P = 0.02$) for steers from CSM dams. Steer carcass traits and quality were not different ($P \geq 0.17$) among prepartum management strategies. Net profit in the feedlot was decreased ($P = 0.05$) in steers from CSM dams compared to steers from SMP and NS dams. In this study, the non-supplement treatment was as effective as SMP treatment for cow performance and profitability in the feedlot. This study indicates that feeding a high ruminally undegradable protein self-fed supplement during late gestation increases calf feedlot health in the feedlot compared to a traditional hand-fed, oilseed-based supplement.

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1. Introduction

Profitability of beef cattle production is highly correlated to management of production costs. Feed is the primary cost in beef production, accounting for up to 70% of total costs (Herd et al., 1998). Consequently, supplementation costs can be minimized by reducing the amount of supplement required per animal and frequency of pasture delivery. This can be accomplished by utilizing concentrated protein sources that are used efficiently in potent formulas at smaller amounts. Sawyer et al. (2012) reported that the use of small quantities of high supplemental ruminally undegradable protein (RUP) ingredients combined with salt and minerals sustained ruminal function with low quality warm season forage diets. Mulliniks et al. (2012) reported that feeding a self-fed high RUP supplement lowered feed costs by 44% compared to hand feeding a 36% CP range cube 3 times per week, while maintaining cow performance. In addition, Mulliniks et al. (2012) reported lower calf morbidity in the feedlot by feeding dams small quantities of a high RUP supplement during late gestation. Thus, protein supplementation in a small quantity of high RUP may have the potential to decrease production costs while optimizing cow and calf performance.

We hypothesized that low quantities of a high RUP supplement can minimize BW and BCS loss in mature cows grazing dormant winter range and positively influence calf health in the feedlot. Therefore, the objective of this study was to evaluate effects of a late gestation supplementation strategy for reducing BW and BCS loss of gestating cows grazing dormant forage on subsequent steer progeny feedlot performance, health, and economic viability.

2. Materials and methods

2.1. Study area

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 at New Mexico State University's Corona Range and Livestock Research Center (CRLRC), Corona, NM, USA. The CRLRC is located in central NM with an average elevation of 1900 m and average rainfall of 401 mm, most of which occurs in July and August (Torell et al., 2008). Forages at this study site were primarily blue grama (*Bouteloua gracilis*), threeawns (*Aristida* spp.), and common wolftail (*Lycurus phleoides*) (Knox, 1998; Forbes and Allred, 2001).

2.2. Prepartum supplementation

Gestating Angus and Angus-cross cows ($n = 103$) ranging from 3 to 9 year of age were stratified by BW at weaning and randomly assigned to 1 of 6 replications. Each group was randomly assigned to 1 of 6 pastures ranging from 260 to 2023 ha. Treatments were randomly assigned to each pasture, resulting in 2 replicates/treatment. Pastures contained 355–674 kg/ha of standing forage and were stocked 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.

A positive control supplementation strategy was developed based on a hand-fed, 36% CP cottonseed meal protein based supplement (CSM; Table 1) fed 3×/week at a rate of 454 g cow^{-1} d^{-1}. A negative control strategy was also developed, where cows received no supplementation during late gestation (NS). A strategy utilizing a small package size, self-fed supplement (SMP) was developed from previous findings (Sawyer et al., 2012; Mulliniks et al., 2012). This supplement was formulated to evaluate corn gluten meal as a substitute for animal proteins used in Sawyer et al. (2012) and Mulliniks et al. (2012). The supplement was 28% CP and was composed of 50% corn gluten meal and 50% mineral supplement. Ingredients for the SMP supplement were mechanically mixed and hand bagged at the CRLRC. The mineral portion of this supplement was designed to provide the same level of mineral intake as the *ad libitum* mineral supplement provided to the CSM and NS treatments. The target individual cow intake of this supplement was 200 g/d. Feed tubs that contained up to 45.5 kg of SMP were placed within 30 m of the pasture water source. Throughout the study tubs always contained a minimal quantity SMP and were refilled as needed. Feed deliveries and feed remaining (SMP) was recorded for each treatment to validate consumption rates. Supplementation was initiated in December and ended the first week in February. The feeding rate, duration of supplement feeding periods, and total consumption are shown for each treatment in Table 2.

The rationale for the design of the supplements was taken from the results of Sawyer et al. (2012) and Mulliniks et al. (2012). The three supplementation strategies were aimed at establishing if a protein dense self-fed supplement targeted for 200 g consumption per day could substitute for a traditional, less protein dense range cube supplement hand-fed at 454–953 g/d for cows grazing protein deficient low-quality dormant native range forage. The three strategies differ 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 change response to the respective strategy.

Cows were weighed at initiation of the supplementation period (December 15th), and termination of the supplementation period (February 3rd). Supplementation period was terminated approximately 2 weeks prior to the start of calving. Body condition scores (1 = emaciated, 9 = obese; Wagner et al., 1988) were assigned at these periods to each cow by visual observation and palpation by 2 trained technicians.

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

	Prepartum supplement[a]	
Item	CSM (%)	SMP (%)
Ingredients		
Cottonseed meal	56.94	–
Urea	1.20	–
Wheat middlings	21.45	–
Corn gluten meal	–	50.00
Soybean meal	10.00	–
Dried distillers grain	–	1.00
Molasses	9.00	–
Salt	–	19.40
Potassium chloride	0.95	2.00
Monocalcium phosphate	0.30	22.55
Manganese sulfate	0.06	0.15
Magnesium oxide	–	3.35
Trace mineral premix	0.02	1.30
Copper sulfate	0.01	0.25
	Prepartum supplement[a]	
Item	CSM (g/d)	SMP (g/d)
CP	163	48
RDP	105	19
RUP	58	29

[a] CSM: 36% CP cottonseed meal base supplement fed 3×/week; SMP: small self-fed supplement comprised of 50% corn gluten meal and 50% mineral package.

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

	Prepartum supplementation[a]		
Item	CON	SSP	NS
Rate, g/d	454	170	0
Duration, d	39	39	0
Total fed, kg	17.7	6.6	0

[a] CSM: 36% CP cottonseed meal base supplement fed 3×/week; SMP: small self-fed supplement comprised of 50% corn gluten meal and 50% mineral package; NS: nonsupplemented cows.

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

2.3. Calf performance

After weaning, all calves were preconditioned, conforming to Value Added Calf-45 (VAC-45) management guidelines (Anon., 2005). Steers (n = 62) were fed at a commercial feedlot (Celebrity Feeders, Felt, OK, USA). Initial BW for the finishing phase was calculated from the final BW of the backgrounding phase. 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 of weaning.

Steers were received and treated as one cohort of custom-fed commercial cattle at the feedlot in mid-November, and were managed according to existing standard operating procedures in place at the feedlot. At receiving, steers were given an identification tag, growth hormone implant (Component ES, VetLife Inc., Overland Park, KS), vitamin injection (Durvet Inc., Blue Springs MO), insecticide (Ivomec, Merial, Duluth, GA), vaccination against Gram (−) bacteria (Endovac-Bovi, IMMVAC Inc., Columbia, MO), vaccination against Chlostrium (Essential 4, Colorado Serum Co., Denver, CO) and vaccination against bovine respiratory disease (Titanium 5, AgriLabs, St. Joseph, MO). Steers were fed a step up diet for approximately 21 d before receiving a high concentrate finishing diet. Experienced feedlot staff diagnosed morbidity by subjective visual appraisal in compliance with current feedlot policy. Steers were processed for a secondary application of growth implant (Component TE-S, VetLife Inc., Overland Park, KS, USA) at 80 d. Steers were visually appraised by experienced feedlot management for a single marketing date to achieve optimum performance. Steers were harvested in a commercial facility (National Packing Co., Liberal, KS, USA). Hot carcass weight was recorded at slaughter and carcass traits were evaluated by an independent data collection service (Cattle Trail LLC, Johnson, KS, USA) following chilling. Steers were sold through the National Beef Grid and premiums and discounts were applied using HCW and USDA yield and quality grade. Net profit was calculated from the finishing net income.

2.4. 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 using the MIXED procedure (SAS Inst. Inc., Cary, NC, USA) to test all main effects and all possible interactions with pasture as the experimental unit. Tukey–Kramer adjusted least squares means were computed and a significance level was set at $P \leq 0.05$. Differences in pregnancy rates were analyzed using logistic regression (PROC GLIMMIX of SAS; SAS Inst. Inc., Cary, NC, USA) utilizing a model that included the fixed effects of prepartum supplementation strategy. Calf performance data was analyzed as a completely randomized design using the MIXED procedure (SAS Inst. Inc., Cary, NC, USA) with pasture from cow prepartum supplementation as the experimental unit. Categorical (carcass quality grade and yield grade and calf feedlot morbidity) data were analyzed using the PROC GLIMMIX 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.

3. Results

3.1. Prepartum supplementation

Cow BW was not different (P=0.81; Table 3) at the initiation of the supplementation period among treatments. In addition, final BW prior to calving was not different (P=0.78) among late gestation management strategies. In this study, all treatment groups lost similar (P=0.54) BW over the 60 d supplementation period during late gestation. Body condition score at the initiation of the study was not different (P=0.91; Table 3) among late gestation treatments. Pre-caving BCS were similar (P=0.55) among supplementation strategies, resulting in no differences (P=0.36) in BCS change during late gestation. In the current study, pregnancy rates were unaffected (P=0.98) by prepartum supplementation strategy.

3.2. Calf performance

Steer BW at weaning was not influenced (P=0.52; Table 4) by dam's gestation supplementation strategy. After a 45-d post weaning preconditioning period, steer initial BW in the feedlot was not different (P=0.52) among dam's gestation treatment. Correspondingly, steer final feedlot BW was not different (P=0.91) among cow prepartum treatments, which resulted from no differences in ADG throughout the finishing phase (P=0.87). Calves from SMP supplemented dams were treated less for respiratory disease during the finishing phase than calves from CSM and NS dams (P=0.05; Table 4). Death loss was also lower (P=0.02) for calves from SMP and NS supplemented dams relative to calves from CSM supplemented dams. Steer HCW were not influenced (P=0.91; Table 5) by dam's gestation treatment. Similarly, marbling score, 12th-rib fat thickness, LM area, and yield grades were unaffected ($P \geq 0.17$) by dam's late gestation treatment. Percentage of steers grading Choice or greater was not different (P=0.60) between dam's late gestation treatment.

3.3. Economic analysis

Calf value at weaning was not influenced (P=0.49; Table 6) by late gestation supplementation strategy. Deducting late gestation feed and mineral cost, net return for calves if sold at weaning were similar (P=0.45) by dam treatments. Due to

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

Item	Prepartum supplementation[a]				
	CSM	SMP	NS	SEM[b]	*P*-value
n	34	34	35	–	–
Cow BW, kg					
Initial	574	573	576	9	0.81
Final	572	564	563	9	0.78
BW change	−2	−9	−13	7	0.54
Body condition score					
Initial	5.0	5.0	5.0	0.1	0.99
Final	5.3	5.1	5.1	0.2	0.55
BCS change	0.3	0.1	0.1	0.1	0.36
Pregnancy rate, %	94	94	97	3	0.75

[a] CSM: 36% CP cottonseed meal base supplement fed 3×/week; SMP: small self-fed supplement comprised of 50% corn gluten meal and 50% mineral package; NS: nonsupplemented cows.
[b] SE of treatment means; *n* = 2 pastures/treatment.

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

Item	Prepartum supplementation[a]			SEM[b]	*P*-value
	CSM	SMP	NS		
n	19	22	21	–	–
Weaning BW, kg	251	236	254	11	0.52
Feedlot Performance					
Initial BW, kg	277	267	284	10	0.52
Final BW, kg	573	563	572	18	0.91
ADG, kg	1.43	1.46	1.42	0.05	0.87
DOF[c]	204	204	204	–	–
% Treated for sickness	37	0	25	10	0.05
% Death loss	16	0	0	2	0.02

[a] CSM: 36% CP cottonseed meal base supplement fed 3×/week; SMP: small self-fed supplement comprised of 50% corn gluten meal and 50% mineral package; NS: nonsupplemented cows.
[b] SE of treatment means; *n* = 2 pastures/treatment.
[c] DOF = total number of days cattle were on feed.

Table 5
Effects of dam supplementation strategy during late gestation on carcass traits in steer progeny.

Item	Prepartum supplementation[a]			SEM[b]	*P*-value
	CSM	SMP	NS		
n	19	22	21	–	–
HCW, kg	364	358	364	12	0.91
Marbling score[c]	538	526	518	10	0.43
12th-rib fat, cm	1.70	1.56	1.76	0.08	0.34
LM area, cm^2	79.59	78.56	74.01	1.64	0.17
Yield grade	3.3	2.9	3.0	0.2	0.49
Choice or greater, %	68	88	81	13	0.60
Select, %	32	12	19	12	0.61

[a] CSM: 36% CP cottonseed meal base supplement fed 3×/week; SMP: small self-fed supplement comprised of 50% corn gluten meal and 50% mineral package; NS: nonsupplemented cows.
[b] SE of treatment means; *n* = 2 pastures/treatment.
[c] Marbling score: 500 = small^0.

differences in percent treated for sickness, there was a tendency for medicine costs to be lower in calves from SMP dams (P=0.06; Table 6) relative to steers from dams fed NS and CSM during late gestation. In addition, feedlot total costs were lower (P=0.05) for steers from SMP cows than CSM or NS cows. Gross income also tended (P=0.09) to be decreased for steers from CSM with no difference between SMP and NS steers. Thus, net profit was greater (P=0.05) for steers from SMP and NS dams relative to steers from CSM dams.

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

Item	Prepartum supplementation[a]			SEM[b]	*P*-value
	CSM	SMP	NS		
n	19	22	21	–	–
Pre-weaning phase					
Supplementation cost[c], $US/cow	13.51	7.24	2.48	–	–
Returns, $US/steer					
Calf value	653.66	632.05	654.61	13.36	0.49
Minus supplement cost	640.15	624.81	652.13	13.35	0.45
Post-weaning phase, $US/steer					
Feed cost	445.98	452.54	452.54	–	–
Medicine cost	19.85	0.00	20.44	8.89	0.06
Feedlot total cost	1119.14	1084.59	1127.59	10.48	0.05
Gross income	977.48	1170.05	1181.86	48.11	0.09
Net profit	−141.66	85.47	54.27	39.42	0.05

[a] CSM: 36% CP cottonseed meal base supplement fed 3×/week; SMP: small self-fed supplement comprised of 50% corn gluten meal and 50% mineral package; NS: nonsupplemented cows.
[b] SE of treatment means; *n* = 2 pastures/treatment.
[c] Supplmentation costs = late gestation protein supplementation costs plus mineral supplementation cost.

4. Discussion

4.1. Prepartum supplementation

This study found that cow BW during late gestation was not influenced by type or amount of supplementation. In a similarly designed study, Mulliniks et al. (2012) reported that feeding either a 36% CP cottonseed meal supplement or a self-fed supplement similar to SMP maintained BW during late gestation when cows were grazing dormant range. In this study, all treatment groups lost similar BW during a 60 d supplementation period, which indicates that nutrient limitations existed during this period, and that these restrictions were not corrected by supplementation strategy. One difference between these and previous results are that SMP supplement fed in Mulliniks et al. (2012) was formulated to be 40% CP and contained blood meal and feather meal, whereas SMP in this study was 28% CP and contained corn gluten meal as the sole protein source. The concentration of CP in the SMP supplement in the current study might have been too low to be as effective in small amounts as observed for cows in Mulliniks et al. (2012). Crude protein intake for Mulliniks et al. (2012) was twice the amount delivered in this study (93.6 g/d vs. 46.9 g/d, respectively).

Body condition scores at all time periods during this study were not different among late gestation treatments. Body condition score were increased or maintained with all 3 supplemental strategies from the initiation of the study until the termination; however, the amount of BW loss in the treatments was not enough to alter BCS. Body condition score at parturition has been shown to affect the duration of the postpartum interval and conception rate in beef cows (Houghton et al., 1990). In the current study, pregnancy rates were unaffected by prepartum supplementation strategy. In agreement, Mulliniks et al. (2012) reported no differences in pregnancy rates with similar late gestation supplementation strategies.

4.2. Calf performance

Steer BW at weaning and initial feedlot BW were not influenced by dam's gestation supplementation strategy. Correspondingly, steer final feedlot BW was not different among cow prepartum treatments, which resulted from no differences in ADG throughout the finishing phase. This result is supported by Mulliniks et al. (2012), which reports similar results in the feedlot with similar late gestation supplementation strategies.

Morbidity associated with bovine respiratory disease in fed cattle is near 20% of the total cattle on feed (Faber et al., 1999). However, protein type, such as high RUP supplements, during the last trimester of pregnancy have been previously reported to decrease percentage of calves treated for respiratory disease (Mulliniks et al., 2012). In this study, calves from SMP dams were not treated for respiratory disease during the feedlot phase, while the percent of steers from CSM and NS dams treated was 37 and 25%, respectively. This decreased percentage of steers treated in the feedlot in SMP calves can have a substantial effect on feedlot net income. Fulton et al. (2002) reported calves that were not treated to return $US40.64, $US58.35, and $US291.93 more when compared to calves treated 1, 2, and 3+ times, respectively. Death loss was also lower for calves from SMP and NS supplemented dams relative to calves from CSM supplemented dams. Although cows in the NS treatment group did not receive any protein supplement during late gestation, calves from these cows did not have an increase in morbidity or mortality compared to calves from CSM supplemented cows. Morbidity and mortality associated with respiratory disease in newly weaned or received cattle are problematic for the feeding industry and result in major economic losses (Galyean et al., 1999). Protein supplementation during late gestation has been implicated in reducing proportions of steers treated for bovine respiratory disease in the feedlot compared with calves from nonsupplemented dams (Larson et al., 2009). However, in the current study and in Mulliniks et al. (2012), there were differences in percent steers treated in the feedlot between types of protein supplemented during late gestation. The decreased sickness and death loss in the feedlot for steers from dams that consumed SMP may be due to the metabolizable amino acid profile (both composition and quantity) of the protein source. Furthermore, Carter et al. (2011) suggested that supplemental branched-chain amino acid improves the adaptive immune response in feedlot steers.

Maternal nutrition during gestation has been previously shown to affect fetal skeletal muscle and adipose tissue growth and development (Du et al., 2010). However, in this study, steer hot carcass weight, marbling score, 12th-rib fat thickness, LM area, and yield grades were unaffected by dam's late gestation treatment. In a similar study, Mulliniks et al. (2012) reported no differences in steer carcass quality or carcass traits from their dam's late gestation nutritional treatment. 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.

4.3. Economic analysis

After deducting feed costs, net profit at weaning was not influenced by late gestation supplementation strategy. In contrast, protein supplementation during late gestation has been reported to increase calf weaning value compared to cows without protein supplementation while grazing dormant winter range (Larson et al., 2009). However, this study did find difference in costs and income in the feedlot phase. Feedlot total costs were lower for steers from SMP cows than CSM or NS cows, resulting in greater net profit for steers from SMP and NS dams relative to steers from CSM dams. Larson et al. (2009) reported an increase in net feedlot profit when cows received a protein supplement during late gestation compared to no protein supplement, which does not agree with the increased net income from calves born from NS dams in the current study. Since steers were finished in the feedlot at the same point; net profit in this study was directly influenced by morbidity and mortality differences among the late gestation supplementation treatments.

5. Conclusion

Late gestation nutritional strategy had no effect on cow performance (BW, BCS, or pregnancy rate) or calf growth through the finishing phrase. However, our findings indicate a relationship between protein type during late gestation and calf health and profitability in the feedlot. This study indicated that calves born from dams receiving a self-fed high RUP supplement, consumed at relatively low quantities, were treated less for sickness, had decreased death loss, and had increased feedlot net profit. Thus, these results indicate that high RUP supplements during late gestation may have positive effects on calf health. In conclusion, considering the late gestation supplementation costs and profitability in the feedlot, feeding SMP during late gestation appears to be advantageous for producers while lowering winter feed costs, decreasing calf feedlot morbidity, and increasing feedlot profitability.

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