Utilizing a precision supplement delivery system to provide protein and energy supplementation to beef heifers grazing fall native range pasture during midgestation

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The objectives of this study were to evaluate the effects of providing a protein and energy supplement using precision feeding technology to beef heifers during midgestation grazing fall native range pasture on body weight, supplement intake, metabolic status and diet digestibility. We observed that heifers assigned to receive supplementation on fall pasture tended to be heavier than nonsupplemented controls and had altered blood concentrations of blood urea nitrogen (BUN) and nonesterified fatty acids (NEFA), suggesting an influence of supplementation on energy balance and nitrogen metabolism in supplemented heifers. However, impacts on body weights of the calves exposed to different maternal nutritional environments during the second trimester of gestation were limited.

Summary

Our objectives were to utilize precision feed delivery systems to deliver a protein and energy supplement to beef heifers grazing fall native range pastures and to evaluate the effects of supplementation during midgestation on body weight, supplement intake and metabolic status. The potential impacts on birth and pasture turnout weights of the calves born to females exposed to protein and energy supplementation or the control diet (pasture grazing only) were also evaluated. We observed that heifers receiving supplementation tended to be heavier than nonsupplemented heifers, but we did not observe an impact on calf birth or pasture turnout body weights. Metabolic status appeared to be improved in supplemented heifers, as circulating concentrations of blood urea nitrogen and nonesterified fatty acids reflected a more positive energy balance and nitrogen recycling state compared with control-fed heifers. Measures of digestibility also improved with supplement delivery as forage nutritive value fell in the late fall.

Introduction

Nearly one-third of the heifer calves in North Dakota are retained each year as replacement females, making their development critical to the future productivity and genetic progress of the state's beef industry. Because first-calf heifers must simultaneously support fetal growth, lactation and their own continued growth, their nutrient requirements exceed those of mature cows. In North Dakota spring-calving herds, however, midgestation coincides with the fall grazing season, when native range forage quality declines substantially, creating nutritional challenges for both the pregnant heifers and their developing calves (Schauer et al., 2005; Llewellyn et al., 2006). Therefore, the objectives of this project were to determine whether strategic corn-based protein and energy supplementation via a precision delivery system during midgestation could improve nutrient digestibility, maternal metabolic status and subsequent performance of the dam and her offspring. We hypothesized that beef heifers receiving supplemental protein/energy while grazing low-quality fall pasture during midgestation would have differing hormone/metabolite profiles and have enhanced measures of digestibility on pasture compared with nonsupplemented cohorts. We further hypothesized that calves born to protein/energy-supplemented dams would exhibit altered postnatal growth compared with calves born to nonsupplemented dams.

Procedures

To accomplish these objectives, Angus-based heifers (n = 30; initial body weight [BW] = 960 ± 79.3 lb) were bred by live cover bulls, then stratified by BW and randomly assigned to one of two treatments at approximately day 90 of pregnancy

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(start of second trimester). Heifers were assigned to either graze native range pasture (**CON**; n = 15) or the same native range pasture plus have access to a protein and energy supplement (**SUPP**; n = 15) delivered at a rate of 0.6% of BW on a dry-matter basis using SmartFeed Pro units from C-Lock, Inc. in two enclosed trailers on the pasture (Figure 1). The protein and energy supplement was a corn and dried distillers grains-based supplement with 18% crude protein. Treatments were applied for 59 days beginning in late September and concluding in late November. Following the end point collection at the end of the 59-day period, heifers were managed on a common diet in a single pen until pasture turnout in the spring.

Supplement intake was controlled for all animals in the pasture with the use of a radio frequency identification (RFID) tag. The RFID tag associated with each animal either allowed access to the supplement via a gate that opened at a maximum intake level assigned daily (SUPP) or did not allow access to the feeders (CON). This system allowed individualized management and feed intake records of each animal on a daily basis.

Consecutive-day body weights, blood serum and pasture clippings were collected at the beginning (September), midpoint (October) and end (December) of the 59-day supplementation period. Consecutive-day body weights were used to assign the heifers to their individual supplement allotments (SUPP heifers only) at 0.6% of body weight on a dry-matter basis. Weights were also collected from the dam prior to calving (late January) and at pasture turnout (May) and from the calves born in the spring at birth (April) and again at pasture turnout to evaluate the potential long-term outcomes on maternal supplementation during the second trimester of gestation.

Blood samples were analyzed for concentrations of glucose, nonesterified fatty acids (NEFA) and blood urea nitrogen (BUN) to assess metabolic status of the dams throughout the supplementation period. A chemical analysis was performed on pasture clippings collected throughout the supplementation period to assess the expected decline in forage quality as the grazing season advanced.

Digestibility trials were conducted immediately before supplementation in the fall (period 1) and again near the end of the 59-day grazing period (period 2) via oral administration of chromium oxide boluses for 10 consecutive days at the start and end of the feeding trial, with five consecutive days (day 5 through 10 of bolus administration) of spot-collected fecal samples. The concentration of chromium in the fecal samples was utilized to predict daily fecal output, and subsequent calculations of nutritive composition of the feed available (supplement and forage) and in the feces were used to estimate digestibility.

Statistical Methods

Individual animal was considered the experimental unit as intake of the supplement was monitored on an individual basis. All variables were analyzed using the MIXED

Figure 1. Images show one of the SmartFeed Pro units (C-Lock, Inc.) in use on a single native range pasture. Both SUPP and CON heifers were placed together in a single pasture, and RFID tags fitted to each animal either allowed or denied access to the feeding units (Right). Supplement allowances were programmed on the C-Lock online interface and were reset automatically on a daily basis. Once a heifer reached her daily feed allowance, she was no longer able to access the supplement for the remainder of the day.

procedure of SAS with repeated measures applied where appropriate. Results are presented as LSMEANS with the standard error of the mean. Variables were analyzed for the effect of F0 treatment, day of gestation/age and the respective interaction. Significance was considered at $P \leq 0.05$, and tendencies considered at $0.05 < P \leq 0.10$.

Results and Discussion

As expected, crude protein levels in the native range pasture decreased from 8.6% in September to 5.8% in November. Neutral detergent (NDF) and acid detergent fiber (ADF) increased, however, from mid-September to late November, with NDF increasing from 61.1% to 67.6% and ADF increasing from 34.1% to 38.1% from September to November. Supplement intake recorded from the SmartFeed Pro system (Figure 2) indicated that, despite average daily feed allowances set for SUPP heifers across the 59-day supplement access period at 6.05 lb dry-matter per day (0.6% of BW), the actual dry-matter consumption of supplement was only 4.90 lb per day (0.47% of BW).

Digestibility trials were conducted at the beginning (day -13 to day -4 prior to supplement access (period 1)) and near the end of the supplementation period (day 50 to day 59 (period 2)). During period 1, CON and SUPP heifers had similar forage intake, fecal output and apparent diet digestibility ($P \geq 0.10$; Table 1), suggesting that the groups entered the study with comparable intake and nutrient utilization. Consistent with the decline in forage nutritive value described above, fecal output increased (DM, OM, NDF, ADF) in both treatments ($P \leq 0.01$) and apparent dry matter (DM) and crude protein (CP) digestibility decreased in CON heifers ($P \leq 0.03$) throughout the grazing season. During period 2, CON heifers consumed more forage than SUPP heifers (26.94 vs. 22.55 lb DM/d), whereas SUPP heifers consumed 5.84 lb supplement DM/d during period 2 (10 d average), resulting in only a modest increase in total DMI (28.37 vs. 26.94 lb/d). This represented a substitution rate of approximately 0.75 lb forage DM per kilogram of supplement DM consumed. Despite lower forage intake, SUPP heifers had greater ($P = 0.01$) DM digestibility than CON heifers during trial 2 (46.5 vs. 41.5%) and markedly greater ($P < 0.01$) CP digestibility (41.2 vs. 11.9%). This particularly large improvement in CP digestibility suggests that, at least in part, the greater CP supply provided by the supplement and the replacement of low-quality mature forage with a feed ingredietn containing more readily digestible protein.

Circulating blood metabolites for heifers during the fall grazing period also indicated differences in nitrogen and energy metabolism between treatments as the supplementation period progressed. Concentrations of BUN were greater in SUPP heifers compared with CON at the midpoint and end of the fall feeding period but similar at the start of the trial, as identified with an interaction of treatment and day ($P = 0.02$; Table 2). Similarly, concentrations of NEFA were also greater in SUPP heifers compared with CON at the end-point blood collection but were similar at the beginning and midpoint of the feeding trial, as observed as an interaction between treatment and day ($P = 0.01$). No differences were observed between SUPP and CON for concentrations of blood glucose throughout the feeding period ($P \geq 0.11$); however, a day effect was observed ($P = 0.03$) in which glucose concentrations increased throughout the feeding period for both CON and SUPP heifers.

The blood metabolite responses support the differences in nutrient

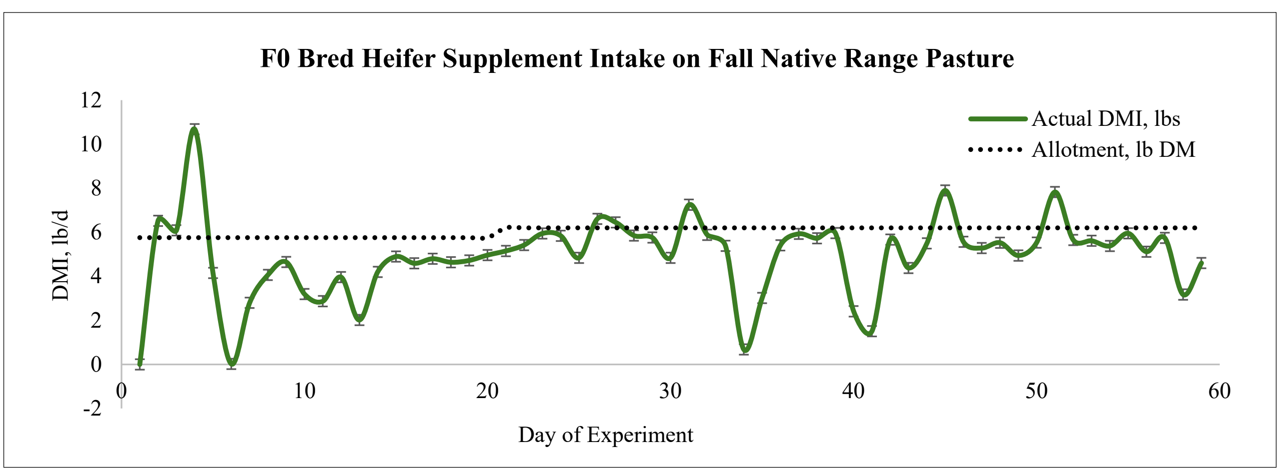

Figure 2. Daily average supplement intakes (solid line; lb DMI) throughout the 59-day feeding period during midgestation. The average daily allotment for all heifers assigned to receive the SUPP diet is represented by the dotted line. Error bars on the solid line represent the standard error of the mean.

utilization observed during period 2. As forage CP declined through the grazing season, greater apparent CP digestibility in SUPP heifers was accompanied by greater circulating BUN, supporting increased nitrogen availability and metabolism in response to protein and energy supplementation. Conversely, lower BUN concentrations in CON heifers were consistent with reduced dietary nitrogen availability as forage quality declined. Greater NEFA concentrations in CON heifers at the end of supplementation further suggest increased mobilization of body fat reserves as nutrient availability from pasture became increasingly limited. Collectively, the digestibility and circulating metabolite responses indicate that

Table 1. Diet digestibility in bred heifers during the second trimester of pregnancy while grazing native range pastures with (n = 15) or without (n = 15) protein and energy supplementation delivered at a rate of 0.6% of BW on a DMB.

	Period 1[1] Treatment		*Period 2* Treatment			*P*-values[4]		
Item[2]	CON	SUPP	CON	SUPP	SEM[3]	TRT	Day	TRT×Day
DM								
Forage intake, kg/d	9.49^{a}	9.98^{a}	12.22^{b}	10.22^{a}	0.428	0.13	<0.01	0.01
Supplement intake, kg/d	0 a	0^{a}	0^{a}	2.65^{b}	0.065	<0.01	<0.01	<0.01
Total intake, kg/d	9.49	9.98	12.22	12.87	0.449	0.24	<0.01	0.82
Fecal output, kg/d	5.15	5.22	7.15	6.87	0.221	0.71	0.01	0.17
Digestibility, %	46.51^{a}	47.34^{a}	41.51^{b}	46.52^{a}	1.000	0.01	0.01	0.03
OM								
Forage intake, kg/d	8.41^{a}	8.85^{a}	10.76^{b}	9.00^{a}	0.378	0.13	<0.01	0.01
Supplement intake, kg/d	0^{a}	0^{a}	0^{a}	2.54^{b}	0.063	<0.01	<0.01	<0.01
Total intake, kg/d	8.41	8.85	10.76	11.55	0.399	0.16	<0.01	0.56
Fecal output, kg/d	4.02	4.07	5.62	5.49	0.181	0.85	<0.01	0.39
Digestibility, %	52.69	53.56	47.83	52.35	1.054	0.01	0.01	0.07
NDF								
Forage intake, kg/d	5.83^{a}	6.11^{a}	8.26^{b}	6.91^{c}	0.280	0.10	<0.01	0.01
Supplement intake, kg/d	0^{a}	0^{a}	0^{a}	0.74^{b}	0.018	<0.01	<0.01	<0.01
Total intake, kg/d	5.83^{a}	6.11^{a}	8.26^{b}	7.65^{c}	0.286	0.61	<0.01	0.03
Fecal output, kg/d	2.75	2.78	4.08	3.96	0.148	0.80	<0.01	0.41
Digestibility, %	53.27	54.32	50.65	48.18	1.110	0.51	0.01	0.06
ADF								
Forage intake, kg/d	3.26^{a}	3.41^{a}	4.66^{b}	3.90^{c}	0.158	0.09	<0.01	0.01
Supplement intake, kg/d	0^{a}	0^{a}	0^{a}	0.22^{b}	0.005	<0.01	<0.01	<0.01
Total intake, kg/d	3.26^{a}	3.41^{a}	4.66^{b}	4.12^{c}	0.159	0.28	<0.01	0.01
Fecal output, kg/d	1.67	1.66	2.39	2.21	0.088	0.40	<0.01	0.12
Digestibility, %	49.05^{ab}	51.01^{a}	48.81^{ab}	46.27^{b}	1.241	0.80	0.02	0.03
CP								
Forage intake, kg/d	0.80^{a}	0.85^{a}	0.71^{b}	0.59^{b}	0.030	0.35	<0.01	0.01
Supplement intake, kg/d	0^{a}	0^{a}	0	0.48^{b}	0.012	<0.01	<0.01	<0.01
Total intake, kg/d	0.80^{a}	0.85^{a}	0.71^{a}	1.07^{b}	0.034	<0.01	0.01	<0.01
Fecal output, kg/d	0.61	0.62	0.62	0.63	0.026	0.74	0.64	0.74
Digestibility, %	24.36^{a}	24.53^{a}	11.94^{b}	41.21^{c}	2.638	<0.01	0.36	<0.01

[1]Trial 1 was conducted for 10 d from 09/11/2024 to 9/20/2024 prior to the initiation of treatments (CON, n = 15; SUPP, n = 15). Trial 2 was conducted for 10 d from 11/12/2024 to 11/21/2024 while treatments were applied. Both trials took place on a single, native range pasture and supplement delivery was controlled and limited to SUPP heifers via an electronic feeder.

[2]Variables evaluated included: DM, dry matter; OM, organic matter; NDF, neutral detergent fiber; ADF, acid detergent fiber; CP, crude protein; EE, ether extract.

[3]Standard error of the mean.

[4]Means within a row lacking a common superscript differ ($P \leq 0.05$).

supplementation helped mitigate the nutritional challenges associated with declining fall forage quality.

These physiological responses were accompanied by differences in subsequent maternal performance. Although a treatment by day interaction was not detected (P = 0.44), SUPP heifers tended (P = 0.08) to be heavier than CON from the end of the feeding period through pasture turn out (Figure 3). At the end of the feeding period (day ~150 of gestation), SUPP heifers were approximately 19.5 lb heavier than CON and 71.2 lb heavier than CON prior to calving. During the grazing period in midgestation, SUPP heifers tended (P = 0.07) to have a greater average daily gain (2.4 lb/d) compared with CON heifers (2.1 lb/d). Interestingly, despite body weight differences in the SUPP and CON heifers at precalving and pasture turnout, we did not observe body weight differences at birth and at pasture turnout in calves born to these dams ($P \geq 0.69$). Average birth weights for calves were 72.7 and 79.1 lb for CON and SUPP, respectively, and average pasture turnout weights for calves were 154.8 and 155.2 lb, respectively.

The tendency for SUPP heifers to remain heavier after supplementation concluded suggests that the benefits associated with improved nutrient utilization and metabolic status during the fall grazing period may have persisted into late gestation and early lactation. Although subsequent

Table 2. Blood metabolites in F0 pregnant beef heifers on fall pasture with grazing access (CON) or grazing access plus a protein and energy supplement (SUPP).

	Treatment[1]			*P*-Values[4]		
Item[3]	CON	SUPP	SEM[2]	TRT	Day	TRT×Day
Glucose, mg/dL				0.15	0.03	0.11
Start	48.9	47.6	2.26			
Mid-Point	47.8	49.3	2.26			
End	49.4	55.0	2.30			
NEFA, μmol/L				<0.01	<0.01	<0.01
Start	215.6^{b}	198.8^{bc}	19.81			
Mid-Point	129.0^{d}	143.4^{cd}	19.46			
End	292.6^{a}	196.9^{bc}	22.07			
BUN, mg/dL				<0.01	<0.01	0.02
Start	15.5^{a}	16.4^{a}	0.84			
Mid-Point	6.8^{d}	10.8^{c}	0.84			
End	10.2^{c}	13.7^{b}	0.84			

[1]F0 bred heifers were assigned to graze native range pasture (**CON**; n = 15) or graze the same native range pasture plus have access to a protein and energy supplement (**SUPP**; n = 15) delivered at a rate of 0.6% of BW on a dry-matter basis. Treatments were applied to the F0 dams in late September (start) through late November (end).
[2]Standard error of the mean.
[3]Metabolites evaluated included glucose, nonesterified fatty acids (NEFA) and blood urea nitrogen (BUN).
[4]Means lacking a common superscript differ ($P \leq 0.05$).

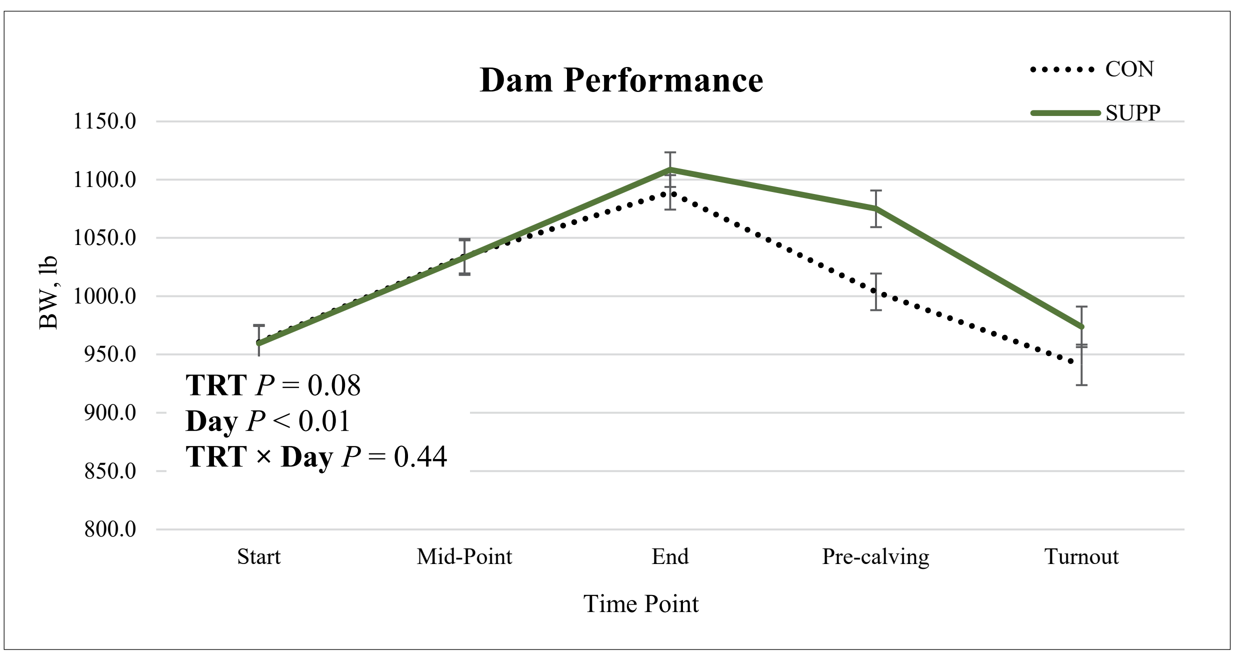

Figure 3. Body weights of F0 pregnant heifers during the 59-day feeding trial (start to end) followed by precalving and pasture turnout time points.

reproductive performance of the dams in this study was not evaluated, entering the second breeding season at a greater BW and potentially improved nutritional status may better position young females to support the concurrent demands of lactation, continued maternal growth, and reproduction. Whether this carryover advantage ultimately translates into improved pregnancy success and long-term productivity in the herd warrants further investigation.

Conclusions

From a production standpoint, strategic protein and energy supplementation during midgestation buffered the nutritional challenges associated with declining fall forage quality and resulted in performance advantages that persisted beyond the supplementation period. Improved nutritional status and dam performance observed here may better position females for the demands of late gestation, lactation and the subsequent breeding season. Although reproductive performance was not evaluated, it is unclear whether these carryover benefits translate into improved breed-back success; however, we suspect that an improved nutritional state and body condition after calving may be associated with reproductive advantages in the next breeding season.

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Literature Cited

Llewellyn, D. A., R. C. Cochran, T. T. Marston, D. M. Grieger, C. G. Farmer, and T. A. Wickersham. 2006. Influence of limited fall protein supplementation on performance and forage utilization by beef cattle grazing low-quality native grass pastures. *Anim. Feed Sci. Tech.* 127:234-250.

NASEM, 2016. Nutrient requirements of beef cattle. 8th revised ed. Washington, DC: National Academics Press.

Schauer, C., D. W. Bohnert, D. C. Ganskopp, C. J. Richards, and S. J. Falck. 2005. Influence of protein supplementation frequency on cows consuming low-quality forage: Performance, grazing behavior, and variation in supplement intake. *J. Anim. Sci.* 83:1715-1725.