PROTEIN SUPPLEMENTATION:
DAILY, ONCE EVERY 5 DAYS, OR ONCE EVERY 10 DAYS

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Impact Statement

Ruminants consuming low-quality forage can be supplemented with protein as infrequently as once every 10 days while maintaining adequate intake and not negatively affecting nutrient digestibility or livestock performance when compared with daily supplementation. For livestock producers providing protein supplements to grazing livestock in extensive management scenarios, this management technique may save considerable time, fuel, and money when compared with providing supplemental protein on a daily basis.

Introduction

In the northern Great Plains, calculated winter feed costs often total $100 to 200 per animal unit per year. Management and nutritional practices that decrease winter feed costs, while maintaining rangeland health, may increase profitability for livestock producers in southwest North Dakota. One management alternative that may decrease winter feed costs is to extend the grazing season through the winter months of December, January, and February. Protein supplementation may be necessary during this time period, and the costs associated with providing supplemental protein can be substantial (labor, fuel, hours). Current research suggests that the frequency of protein supplementation may be able to be decreased to once every 6 days while maintaining livestock performance (Houston et al., 1999; Bohnert et al., 2000). If the frequency of protein supplementation can be decreased from daily to once every 10 days, labor and fuel costs can be significantly decreased.

Table 1. Affect of supplementation interval on labor and fuel costs for a northern Great Plains cow/calf or sheep operation[a]

	Supplementation Interval			
	Daily	Once every 3 days	Once every 6 days	Once every 10 days[b]
Labor (hr)[c]	75	25	12.5	7.5
Fuel ($)[d]	$225.00	$75.00	$37.50	$22.50
Labor ($)[c]	$750.00	$250.00	$125.00	$75.00
Total ($)	$975.00	$325.00	$162.50	$97.50
Benefit (hr)	0	50	62.5	67.5
Benefit ($)	0	$650.00	$812.50	$877.50

[a]Calculated based on a 250 head cow/calf herd (1250 head ewe flock) for a 30 day supplementation period.
[b]Costs projected assuming similar performance across supplementation strategies.
[c]Labor calculated as 2.5 hours/supplementation event and $10.00/hour.
[d]Fuel costs calculated as 3 gallons/supplementation event at $2.50/gallon.

Materials and Methods

Digestion Study:

Animals and Diets. Sixteen wethers (69 ± 2 lbs.) were used in a completely randomized design (Cochran and Cox, 1957) to evaluate the efficacy of N use in lambs fed low quality forage (5% CP barley straw) and supplemented with soybean meal (**SBM**) daily or infrequently. Treatments included daily (**D**), once every 5 d (**5D**), or once every 10 d (**10D**) supplementation, as well as a negative control (ad-libitum barley straw; **CON**). Wethers were randomly allotted to treatments (n=4) and housed in individual metabolism crates within an enclosed barn with continuous lighting. All supplemented wethers received the same amount of supplement over a 10-d period; therefore, the 5D and 10D treatments received fivefold and tenfold the amount of supplement (N basis) on their respective supplementation d compared with D treatments. The amount of CP supplied by each supplement was 0.15% of BW/day (averaged over a 10-d period) based on intake and protein requirements (NRC, 1985). Quantities of supplement were based on initial BW. Wethers had continuous access to fresh water and chopped barley straw (4 – 8 cm length). Barley straw was provided (in two equal portions; 0700 and 1700) daily at 120% of the average intake for the previous 5 d, with feed refusals from the previous day determined before feeding. A trace mineral salt mix was available free choice and an intramuscular injection of vitamins A, D, and E was administered to each wether at the onset of the trial to safeguard against deficiency. Ingredient and nutrient content of the barley straw and supplement are described in Table 1.

Experimental Periods and Sampling Procedures. The experimental period was 30 d. Forage intake was determined on d 19 to 28. In addition, samples of barley straw, SBM, and orts were collected on d 19 to 28 and dried at 55°C for 48 h. On d 21 to 30, total fecal and urine output were collected. Urine was composited daily by wether (25% of total; weight basis) and stored at 4°C. Sufficient 6 *N* HCl (150 mL) was added to urinals daily to maintain urine pH < 3. A sub-sample of each daily fecal sample (7.5%; weight basis) was dried at 55°C for 96 h to calculate fecal DM. On d 21 to 30, 12 mL of blood was collected from the jugular vein at 4 h after feeding using a heparinized syringe. The blood samples were immediately transferred to vacutainers and placed on ice for transport to the lab. Blood samples were centrifuged (5000 × *g*, 15 min) and plasma harvested and stored (-20°C). Dried samples were ground through a Wiley mill (1-mm screen). Daily samples of barley straw and SBM were composited and daily ort samples composited by lamb on an equal weight basis (20% as-fed). Feed, orts, and fecal samples were analyzed for DM and OM (AOAC, 1990) and NDF and ADF (Ankom 200 Fiber Analyzer, Ankom Co., Fairport, NY). Feed, orts, fecal, and urine samples were analyzed for N using a Kjeltec Auto 1030 Analyzer (Tecator AB, Höganäs, Sweden). Plasma samples were assayed for urea N using the Sigma Diagnostics Procedure 535 (Sigma Chemical Co., St. Louis, MO) and a UV/VIS spectrophotometer (Spectronic 710 Spectrophotometer, Bausch & Lomb, Inc., Rochester, NY).

Statistical Analysis. Data were analyzed as a completely randomized design using the GLM procedure of SAS (SAS Inst. Inc., Cary, NY) with animal serving as experimental unit. Plasma urea N was analyzed using the REPEATED statement with the MIXED procedure of SAS. The model included wether and treatment. Contrast statements included: 1) CON vs protein supplementation; 2) D vs infrequent supplementation; 3) 5D vs 10D; and 4)linear effect of supplementation frequency. Response variables included: 1) DM, OM, NDF, and N intake; 2) total tract digestibility of DM, OM, NDF, and N; 3) N balance; 4) digested N retained; and 4) plasma concentration of urea N.

Ewe Performance Study:

Animals and Diets. Sixty pregnant (approximately 90 d) ewes were stratified by age and body condition score (**BCS**) and assigned randomly within stratification to one of three treatments (as described in the lamb N balance study above, but not including the unsupplemented negative control) in a completely randomized design (Cochran and Cox, 1957) to evaluate ewe performance and lamb birth weight when consuming low quality forage (5% CP barley straw) and supplemented with SBM daily or infrequently. They were sorted by treatment and allotted randomly to 1 of 12 reps (five ewes/rep; four reps/treatment). Protein supplements were offered as D, 5D, or 10D at 0800 to provide approximately 0.11% of BW/day of CP (averaged over a 10-d period) until lambing based on intake and protein requirements (NRC, 1985). Ewes had continuous access to fresh water and chopped barley straw (4 – 8 cm length). A trace mineralized salt mix was available free choice. Ingredient and nutrient content of the barley straw and supplement are described in Table 1.

Experimental Periods and Sampling Procedures. Ewe body weight (**BW**) and BCS were measured every 14 until lambing and within 14 d following lambing for a total of approximately 57 d. All weights were two-day unshrunk weights. Ewe BCS was judged independently by two observers. The same technicians measured BCS throughout the experiment. Forage and supplement samples (approximately 200 g) were collected weekly, dried at 55°C for 48 h, ground through a Wiley mill (1-mm screen), and composited by month for analysis of ADF and NDF, N, and OM as described in the N balance study.

Statistical Analysis. Ewe and lamb performance data were analyzed as a completely randomized design using the GLM procedure of SAS with replication serving as experimental unit. The model included treatment. Orthogonal contrast statements included: 1) D vs infrequent supplementation; 2) 5D vs 10D; and 3) linear effect of supplementation frequency. Response variables included: 1) ewe weight change; 2) ewe BCS change; and 3) lambing birth rate and average lamb weight.

Results and Discussion

Digestion Study:

Intake of hay DM and OM was affected by CP supplementation frequency ($P \leq 0.05$) with 5D and 10D supplementation frequency linearly decreasing ($P \leq 0.06$) hay DM and OM intake (Table 2). Total DM and OM intake responded similarly, with total DM and OM intake exhibiting a linear decrease ($P = 0.06$) as supplementation frequency decreased. Also, daily NDF and N intake decreased linearly ($P = 0.06$) as supplementation frequency decreased; but all supplemented treatments had higher N intake than CON ($P < 0.001$; Table 2). Apparent total tract digestibility of N for supplemented lambs was approximately 300% greater ($P < 0.001$) than the CON, with no difference ($P \geq 0.40$) because of supplementation frequency (Table 2). Daily fecal excretion of N was decreased ($P < 0.001$) and urinary excretion of N was increased ($P < 0.001$; Table 2). As supplementation frequency decreased, fecal N excretion exhibited a linear decrease ($P < 0.001$); however, no difference was noted due to crude protein supplementation frequency for urinary N excretion ($P \geq 0.70$). Daily N balance and digested N retained were greater ($P \leq 0.01$) with CP supplementation, with no difference observed for supplementation frequency ($P \geq 0.27$). Treatment x time interactions ($P < 0.001$) were observed for plasma urea N. However, after considering the nature of the interactions, we concluded that discussing treatment means while providing the treatment x time figure would aid in interpretation and discussion of the data (Figure 1). Lamb plasma urea N was greater ($P < 0.001$) in CP-supplemented lambs than in CON (Table 2). No difference was observed due to crude protein supplementation frequency ($P \geq 0.28$) for lamb plasma urea N concentrations.

Results for the digestion study are similar to results for similar studies evaluating once every 6 d crude protein supplementation (Bohnert et al., 2002). Bohnert el al. (2002) reported that lambs supplemented crude protein as infrequently as once every 6 d had similar digested N retained to daily supplementation, even though in their trial N balance was decreasing as supplementation frequency decreased. In our trial, the negative values for N balance and daily digested N retained indicate that the lambs were loosing weight, however, the values for 5D and 10D supplemented treatments were similar in magnitude to D, and in all cases were less negative than CON. These results suggest that ruminants consuming low-quality forage are capable of efficiently conserving N when supplemented with crude protein as infrequently as once every 10 d. Daily plasma urea N concentrations reported in Figure 1 support this conclusion. For the 10D supplemented treatment, plasma urea N appeared to maintain a peak concentration for 2 d, whereas the peak for 5D was restrained to one d. A maintenance of the plasma urea N peak for an additional day indicates that N may have been recycled for 10D longer than for 5D, resulting in similar N balance for the two treatments.

Performance Study:
Pre-lambing (within 14 d of lambing) and post-lambing (within 14 d of lambing) weight and BCS change were not negatively affected by crude protein supplementation frequency (Table 3). In fact, as supplementation frequency decreased, pre-lambing weight change trended towards increasing linearly ($P = 0.06$). However, the rest of the weight and BCS change data indicate that supplementation frequency had no affect on weight and BCS change ($P \geq 0.26$). Crude protein supplementation frequency had no affect ($P \geq 0.21$) on lambing date or average lamb birth weight (Table 3).

Results for the performance study support results derived from the digestion study, indicating that crude protein supplementation frequency can be decreased to once every 10 d for ruminants consuming low-quality performance. Our performance results are similar to results for once every 6 or 7 d crude protein supplementation observed by Bohnert et al. (2000) and Houston et al. (1999). These are the first data, that we are aware of, suggesting that crude protein supplementation frequency can be decreased to once every 10 d for ruminant consuming low-quality forage.

Implications
No negative affects on N balance, body weight and body condition score, and lambing date and birth weight were observed for once every 10 supplementation of crude protein when compared to daily and once every 5 day supplementation. Livestock producers in the northern Great Plains

may consider crude protein supplementation with soybean meal once every 10 d as a management alternative for reducing dormant season supplementation costs.

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Table 1. Ingredient and nutrient content of barley straw and supplement

Item	Barley Straw	Supplement
Supplement composition		
Soybean meal, % DM	---	100
Nutrient composition		
CP, % DM	4.99	52.6
OM, % DM	90.9	92.7
NDF, % DM	71.8	18.2
ADF, % DM	43.7	4.9

Table 2. Effect of supplementation frequency on lamb intake, diet digestibility, and nitrogen balance

Item	Treatment[a]				SEM[b]	*P*-value[c]			
	CON	D	5D	10D		CON vs supp.	D vs 5D and 10D	5D vs 10D	Linear SF
Daily DM Intake, g/kg BW									
Hay	18.3	17.7	15.0	14.4	1.1	0.06	0.05	0.68	0.06
Supplement[d]	0.0	2.8	2.8	2.8					
Total	18.3	20.4	17.8	17.1	1.07	0.94	0.05	0.68	0.06
Daily OM Intake, g/kg BW									
Hay	16.7	16.1	13.7	13.1	1.0	0.06	0.05	0.68	0.05
Supplement[e]	0.0	2.5	2.5	2.5					
Total	16.7	18.7	16.2	15.6	1.0	0.93	0.05	0.68	0.06
Daily NDF Intake, g/kg BW	13.1	13.1	11.3	10.8	0.7	0.14	0.05	0.69	0.06
Daily N Intake, g/kg BW	0.147	0.373	0.344	0.335	0.012	<0.001	0.05	0.63	0.06
Total Tract Digestibility, %									
DM	43.8	50.7	51.6	52.1	0.01	0.001	0.46	0.75	0.43
OM	45.0	52.3	53.0	54.1	0.01	0.001	0.44	0.56	0.34
NDF	43.9	46.0	46.2	47.9	0.02	0.18	0.63	0.48	0.45
N	16.1	64.1	66.6	65.7	0.02	<0.001	0.40	0.74	0.57
Daily N Excretion, g/kg BW									
Fecal	0.123	0.134	0.115	0.116	0.009	<0.001	< 0.001	< 0.001	< 0.001
Urinary	0.096	0.247	0.256	0.248	0.014	<0.001	0.77	0.70	0.95
Daily N balance, g/kg BW	-0.072	-0.008	-0.027	-0.029	0.014	0.01	0.27	0.93	0.31
Daily Digested N retained, %[f]	-308.7	-3.4	-11.7	-13.8	9.0	<0.001	0.42	0.88	0.43
Plasam Urea N, m*M*	3.12	7.49	6.80	6.69	0.55	<0.001	0.28	0.88	0.32

[a]CON = control; D = soybean meal every day; 5D = soybean meal every 5th day; 10D = soybean meal every 10th day.

[b]n = 4.

[c]CON vs supp. = control vs supplemented treatments; D vs 5D and 10D = daily vs. once every 5 and 10 day treatments; 5D vs 10D = 5 day vs 10 day treatments; Linear SF = linear effect of supplementation frequency.

[d]D received 2.8 g/kg BW daily; 5D received 14 g/kg BW once every 5 days; 10D received 28 g/kg BW once every 10 days.

[e]D received 2.5 g/kg BW daily; 5D received 12.5 g/kg BW every 5th d; 10D received 25 g/kg BW every 10th d.

[f]Calculated as (Daily N retention, g/kg BW/Daily N digested, g/kg BW) x 100.

Table 3. Effect of supplementation frequency on ewe performance and lamb birth weight

	Treatment[a]				*P*-value[c]		
Item	D	5D	10D	SEM[b]	D vs 5D and 10D	5D vs 10D	Linear SF
Supplement DMI, g/d[d]	145	145	145				
Initial weight, lbs.	164	164	165	0.9	0.90	0.47	0.64
Initial body condition score	3.0	3.25	3.0	0.1	0.50	0.25	1.00
Weight change, lbs.							
Prelambing[e]	3.8	3.4	12.4	2.8	0.26	0.05	0.06
Postlambing[f]	-7.1	-3.7	-7.3	3.1	0.68	0.43	0.96
Body condition score change							
Prelambing[e]	-0.1	-0.1	-0.1	0.1	0.80	0.75	0.95
Postlambing[f]	-0.2	-0.3	-0.2	0.2	0.94	0.70	0.90
Lamb birth date, Gregorian d	265	267	264	2	0.75	0.36	0.85
Lambing rate	1.6	1.2	1.6	0.2	0.30	0.09	1.00
Average lamb birth weight, lbs.	11.3	11.2	10.4	0.4	0.42	0.25	0.21

[a]D = soybean meal every day; 5D = soybean meal every 5th day; 10D = soybean meal every 10th day.

[b]n = 4.

[c]D vs 5D and 10D = daily vs. once every 5 and 10 day treatments; 5D vs 10D = 5 day vs 10 day treatments; Linear SF = linear effect of supplementation frequency.

[d]D received 1.95 g/kg BW daily; 5D received 9.75 g/kg BW once every 5 days; 10D received 19.5 g/kg BW once every 10 days.

[e]Within 14 d of lambing.

[f]Within 14 d after lambing.

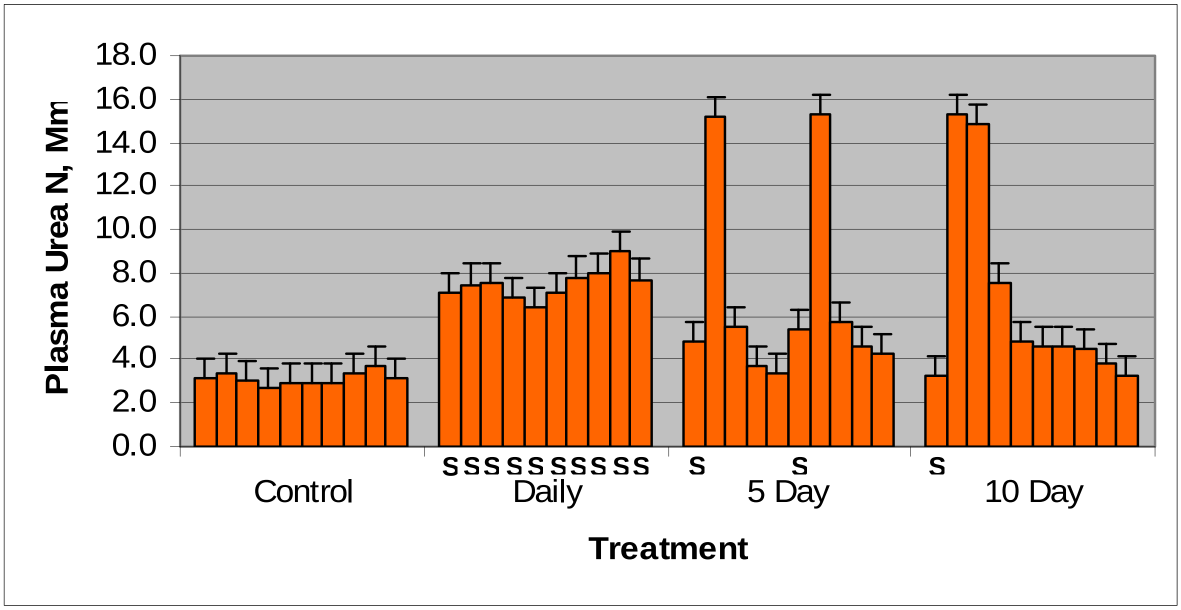

Figure 1. Effect of crude protein supplementation frequency on plasma urea N (m*M*) of lambs. Columns from left to right for each treatment represent d 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 of a 10-d supplementation period, respectively. Treatment were as follows: Control; Daily = crude protein supplementation daily; 5 Day = crude protein supplementation every 5th d; 10 Day = crude protein supplementation every 10th d. Each column with an S below represents a supplementation day. Treatment x time interaction ($P < 0.01$). SEM = 0.91.