REPORT NO. 47

WESTERN DAKOTA SHEEP & BEEF DAY

February 8, 2006

HETTINGER ARMORY

Hettinger Research Extension Center
and
Department of Animal and Range Sciences
North Dakota State University

February 8, 2006

Dear Producer:

On behalf of the Hettinger Research Extension Center and the Department of Animal and Range Sciences, let us welcome you to "Sheep& Beef Day". This report collectively represents North Dakota State University's efforts at both locations to provide information for the support of the livestock industry. We welcome your comments as grassroots users of the efforts of both Extension and Experiment Station resources. Your constructive comments assist us to participate meaningfully in the future of your industry. We hope that the expansion of the former "Sheep Day" to include beef cattle accurately represents the livestock industry that we are supporting in western North Dakota.

A collective, positive, and participatory attitude by producers and caretakers of their land grant resources will go far to solve problems confronting the livestock industry.

Best wishes for a day of sharing and learning.

Timothy C. Faller
Director
Hettinger Research Extension Center
NDSU, Hettinger, ND
(701) 567-4323

Donald Kirby
Chair
Dept. of Animal & Range Sciences
NDSU, Fargo, ND
(701) 231-8386

Four hundred copies of this publication were printed at a cost of approximately $2.75 each.

47TH ANNUAL SHEEP AND BEEF DAY PROGRAM
HETTINGER RESEARCH EXTENSION CENTER
NORTH DAK0TA STATE UNIVERSITY
FEBRUARY 8, 2006

8:30 AM	**TOUR TIME -** HREC will be open for tours of facilities.	
9:30 AM	**DOORS OPEN** - coffee at Hettinger Armory sponsored by Farm Bureau	
10:00 AM	**EARLY BIRD DOOR PRIZE DRAWING**	
10:05 AM	**HETTINGER and NDSU RESEARCH REPORTS**	
10:05	Ms. Jessica Evoniuk	Valine-association Scrapie
10:20	Ms. Kristy-Layne Nelson	Dormant Season Grazing
10:35	Dr. Christopher Schauer	Crude Protein Supplementation Frequency
10:50	Ms. Michele Stamm	Southwest Feeders Report-Cattle and Lamb
11:05	Dr. Christopher Schauer	Lamb finishing research at HREC
11:20	Ms. Nancy Hodur	Production and Marketing Practices of Northern Great Plains Livestock Producers
11:35	Mr. Dan Nudell	Update on Sheep Electronic Identification
11:50 AM	**UPDATE FROM ND LAMB AND WOOL PRODUCERS ASSOCIATION** Brent Stroh, President – North Dakota Lamb and Wool Producers Association	
12:00 NOON	**LUNCH: AMERICAN LAMB AND BEEF DINNER**	
1:00 PM	**WELCOME**	
1:10 PM	**ESTROUS SYNCHRONIZATION TECHNIQUES FOR BEEF AND SHEEP** Dr. Kim Vonnahme, NDSU Assistant Professor-Reproductive Physiology	
2:10 PM	**UPDATE OF THE NATIONAL ANIMAL IDENTIFICATION SYSTEM FOR SHEEP AND BEEF** Dr. Jim Clement, North Dakota Department of Agriculture	
2:40 PM	**INTRODUCTION OF NEW NDSU SHEEP EXTENSION SPECIALIST** Dr. Justin Luther	
3:15 PM	**CLOSING COMMENTS AND FUTURE DIRECTIONS AT HREC** Tim Faller, Director, Hettinger Research Extension Center	

TABLE OF CONTENTS

Section I: Research Reports

Section II: Sheep Management

SECTION I

REPORTS OF RESEARCH IN PROGRESS

HETTINGER RESEARCH EXTENSION CENTER
AND
MAIN STATION AT FARGO

NORTH DAKOTA STATE UNIVERSITY

47TH ANNUAL SHEEP & BEEF DAY

HETTINGER RESEARCH EXTENSION CENTER
HETTINGER, NORTH DAKOTA

FEBRUARY 8, 2006

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

C.S. Schauer[1], J. Caton[2], D. Drolc[1], D. Pearson[1], D. Stecher[1], and M. Stamm[1]

[1]Hettinger Research Extension Center, NDSU, Hettinger, ND
[2]North Dakota State University, Fargo, ND

Acknowledgements: We would like to thank the ND SBARE for funding this project.

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.

Literature Cited

AOAC. 1990. Official Methods of Analysis (15th Ed.). Association of Official AnalyticalChemists, Arlington, VA.

Bohnert, D.W., C.S. Schauer, and T.C. DelCurto. 2002. Influence of rumen protein degradability and supplementation frequency on performance and nitrogen use in ruminants consuming low-quality forage: Cow performance and efficiency of nitrogen use in wethers. J. Anim. Sci. 80:1629-1637.

Cochran, W.G., and G.M. Cox. 1957. Experimental Designs (2nd Ed.). John Wiley & Sons, New York.

Houston, J.E., B.S. Engdahl, and K.W. Bales. 1999. Supplemental feeding interval for adult ewes. Sheep & Goat Res. Journ. 15:87-93.

NRC. 1985. Nutrient Requirements of Sheep (6th Ed.). National Academy Press, Washington, D.C.

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

	Treatment[a]					*P*-value[c]			
Item	CON	D	5D	10D	SEM[b]	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.

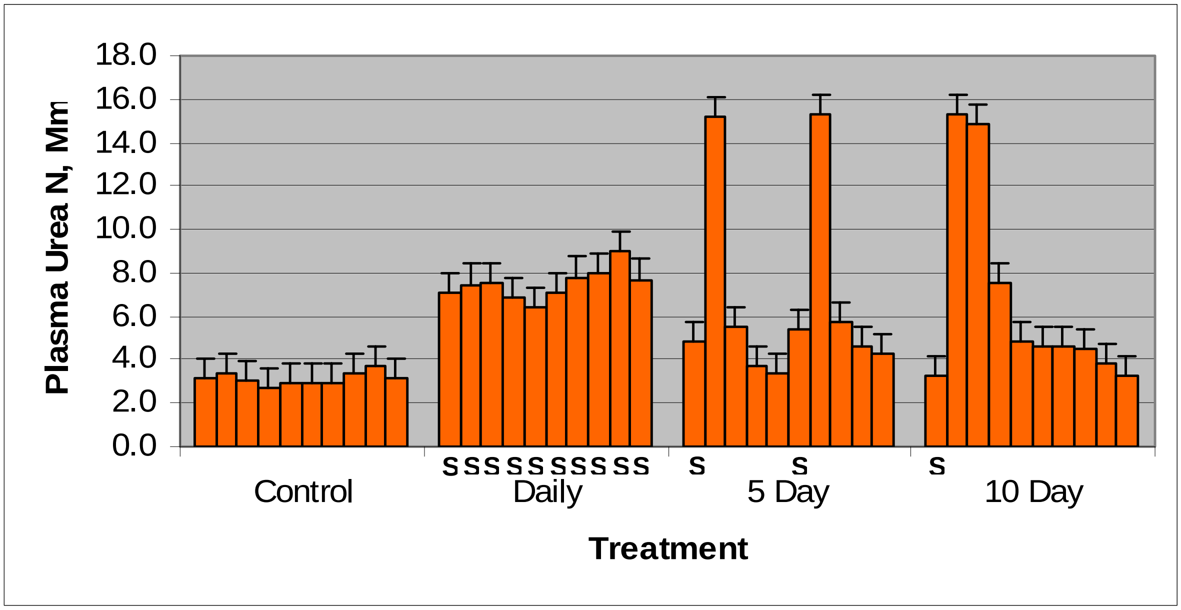


Figure 1. Effect of crude protein supplementation frequency on plasma urea N (m*M*) of lambs. Columns from left to right for each treatment represent d 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 of a 10-d supplementation period, respectively. Treatment were as follows: Control; Daily = crude protein supplementation 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.

EFFECTS OF DORMANT SEASON GRAZING ON HERBAGE PRODUCTION AND PLANT GROWTH

Kristy-Layne Nelson[1], Kevin Sedivec[1], Jackie Olson[2], Mitch Faulkner[3], Tim Faller[4], Christopher Schauer[4].

[1]Graduate Student, Extension State Rangeland Specialist, Animal and Range Sciences Department, NDSU, Fargo
[2]Assistant Professor of Agriculture, Dickinson State University, Dickinson, ND
[3]Range Specialist, Bureau of Land Management, Lander WY
[4]Director, and Post-Doc Research Associate, Hettinger Research Extension Center, NDSU, Hettinger, ND

Impact Statement

Preliminary data indicated that brief early summer use of dormant-season pastures and winter stocking rates intended to achieve 50% utilization of standing aboveground biomass is the preferred management grazing option, relative to grazing treatments of 30 or 50% winter utilization with no summer use.

Introduction

Winter, or dormant-season grazing, is practiced by many North and South Dakota livestock producers in an effort to lower winter feed costs. Dormant-season grazing, while not an exclusive winter-grazing period, is defined as grazing during that time period between plant quiescence in late fall and green up in early spring. Although adequate information exists regarding nutritional management of winter grazing cattle, little is known about the ecological effects of these practices on range or pasture land in the upper Midwest and northern Great Plains. Furthermore, research emphasizing inferences for specific winter-grazing management is lacking. Various aspects of dormant-season grazing have been examined in a variety of ecosystem types, and conventional wisdom dictates that defoliation during winter months while plants are dormant has little to no effect on plant vigor (Riesterer et al. 2000).

Vallentine (2001) stated that determining when to harvest standing forage is dependent on plant factors, physical site factors, animal factors, and economic and management factors. Determining the effectiveness and practicality of dormant-season grazing requires assessing management practices to address these four points. Research is abundant regarding the effects of grazing and clipping on rangeland condition and productivity, animal production, and economics during the growing season, yet insufficient information exists regarding the effects of such practices during the dormant season. Furthermore, with the implementation of new grazing management techniques that include season-of-use changes, differences in economic return, plant growth and vigor, and subsequent plant-species composition can be expected.

Winter grazing is an appealing management option to many ranchers. Producing hay or purchasing winter feeds is labor and capital intensive, while winter grazing offers the potential for flexibility in making management decisions. Furthermore, this practice allows for a more efficient utilization of range resources. The objectives of this study were to determine the impacts of winter grazing on herbage production, growth rate of dominant grass species (short-term), and changes in plant species composition using various levels and combinations of winter and summer use (long-term subsequent research).

Study Area

This study was located in Adams County, North Dakota and Perkins County, South Dakota. The Adams County study site was approximately 62 ha and located 8 km southwest of Hettinger, North Dakota (El. 817m) on sections 16, T129N, R96W and 25, R97W, T129N. The Perkins County study site was approximately 58 ha and located 25 km south of Lodgepole, South Dakota (El. 803m) on sections 13, T19N, R12E, and 18, T19N, R13E.

Climate

Western North and South Dakota are characterized by a continental, cool temperate, semi-arid climate with warm summers and cold winters. Average annual precipitation is about 41 cm/yr near Hettinger, North Dakota and Lodgepole, South Dakota (Owenby and Enzell 1992). Approximately 70% of the precipitation at both locations occurs during the growing season occurring from April through early October. The study locations receive 120-130 frost-free d/yr (Omodt et al. 1968) with the warmest month, July, averaging 22º Celsius. January is the coldest month with an average temperature of –8º Celsius (Owensby and Ezell 1992).

Growing-season precipitation was 28.6 cm in 2000, which was 7.6 cm below the annual average, with all months except May and July below average during the growing season. The 2001 growing season was characterized as a dry spring and wet July, with average precipitation 4.0 cm below the 30-year average. The fall and winter of 2000-01 received above average precipitation; however the fall and winter of 2001-02 received considerably less precipitation, particularly in November and December. In 2002, growing-season precipitation was 13.74 cm, which was 20.42 cm below the annual average. All growing season months were below average. Less-than-average precipitation was received in November and December of 2002. Growing-season precipitation received in 2003 was 6.68 cm below the 30-year average, with only the months of May and September receiving above average precipitation during the growing season. During the 2004 growing season, precipitation was 11.6 cm below the 30-year average. Only the months of July amd October were above average precipitation.

Monthly average temperatures were generally above the 30-year average in 2000, with the exception of June, November, and December. Warmer-than-average temperatures characterized the winter of 2001-2002, as November and December 2001 and January and February 2002 were substantially warmer than the 30-year average. The winter of 2002-2003 also had warmer-than-average temperatures compared to the 30-year average. Spring and summer temperatures were near average for 2000-2003. The winter of 2003-2004 was characterized by warmer than average temperatures. The year 2004 fell below the 30-year average in nearly every month except March, September and November. Temperatures in 2005 were similar with numbers either near or below the 30-year average. The only months above average were April and September.

Vegetation

The study areas were found in the northern mixed-grass prairie and described as the Missouri Slope Vegetation Zone (SCS 1984). The plant communities are described as a wheatgrass-needlegrass vegetation type (Barker and Whitman 1994). Dominant midgrass species were western wheatgrass and needle-and-thread (*Stipa comata* Trin. & Rupr.), and dominant short graminoid species were thread-leaf sedge (*Carex filafolia* Nutt.) and blue grama (Bouteloua gracilis; Barker and Whitman 1994; Shiflet 1994). Plant names were referenced from McGregor et al. (1986) and USDA-USFS (2002).

Uplands of the study areas were represented by shallow ecological sites. The soils were moderately coarse to moderately fine textured with restricting layers of shales and sandstone occurring at depths of 25 to 50 cm below the soil surface. This site is comprised of upland sedges (*Carex spp*.), little bluestem, blue grama, prairie sandreed (*Calamovilfa longifolia* (*Hook.*) Scribn.), western wheatgrass, prairie junegrass, fringed sagewort, and numerous upland forb species. Average total primary production on shallow ecological sites in the Dakotas varies from 1,350 to 2,000 kg/ha (Sedivec et al. 1991).

Midland sites on the North and South Dakota study areas were comprised of a loamy ecological site with well-drained, moderately deep and medium to fine textured soils. Plant communites were comprised of western wheatgrass, needle-and-thread, blue grama, Kentucky bluegrass (*Poa pratensis* L.), prairie junegrass, cheatgrass (*Bromus tectorum* L.), upland sedges (*Carex* spp.), green needlegrass (*Stipa viridula* Trin.) and numerous forb species. Average total primary production on these sites range from 1,700 to 3,150 kg/ha (Sedivec et al. 1991).

Materials and Methods

Treatments: Two study areas (blocks) were selected in North and South Dakota based on similar range condition and native plant species composition. Each study area was blocked and divided into four paddocks with one of four treatments 1) 50% summer-utilization (season-long control; **SL**), 2) 25% summer use for 2 weeks in early and mid June and 50% dormant-season utilization [flash grazing (Hart 2001); **FL**], 3) 30% dormant-season utilization (**DS 30**), and 4) 50% dormant-season utilization (**DS 50**) assigned randomly to a paddock within block. The SL treatment was a 32 ha paddock and the dormant-season-use treatments were each 9 ha paddocks in North Dakota. The South Dakota DS 30 and SL treatment paddocks each 12 ha; the FL treatment was 15 ha; and the DS 50 treatment was 19 ha.

Stocking Rates: Stocking rates for the summer-use treatments were determined using the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Technical Guide (2001) for the Missouri Slope Vegetation Zone. Summer use paddocks were surveyed for ecological site composition using the USDA SCS soil surveys for Adams County, North Dakota (Ulmer 1987) and Perkins County, South Dakota. (Wiesner 1980). The stocking rate for the season-long grazing treatment was calculated for a 4-month grazing period beginning June 1 and ending October 1. The North Dakota site was stocked at 0.76 ha/AUM with ten 544 kg cows and their calves. The South Dakota site was stocked at 0.63 ha/AUM with seven 280 kg spayed heifers (Table 3). Summer use of the flash grazing paddocks was targeted for 25% utilization.

The summer-use FL treatment grazing carrying capacities were calculated by stocking for 50% use of the total available AUMs in June while considering that 50% of the total annual production occurred by mid June, thus achieving a 25% utilization of total annual biomass. The

North and South Dakota sites were stocked with ten and sixteen 1200 lb. cows and calves or 1.78 ha/AUM and 1.69 ha/AUM, respectively, for two weeks.

Stocking rates for the winter grazing treatments were calculated after determining dry-standing plant biomass on 15 Nov. 2000. Ten randomly placed $0.25m^2$ frames were clipped for each ecological site (n=2) existing within a given replicate (n=20). The USDA SCS (Wiesner 1980, Ulmer 1987) soil survey maps and technical guides were used to estimate ecological site composition within each paddock to calculate total standing biomass. Final stocking rates for each treatment were computed by calculating 25% grazing-use efficiency with 50% disappearance (Laycock et al. 1972, Pearson 1975) and a dry matter intake for an 1150 lb non-lactating cow (NRC 1996).

The North Dakota DS 50 and FL grazing treatments were each stocked with four 1200 lb. cows, or 1.23 and 1.22 ha/AUM, respectively, and the DS 30 treatment was stocked with three 1200 lb. cows, or 1.64 ha/AUM. The DS 50 treatment was stocked with 11 cows or 1.02 ha/AUM, the FL treatment stocked with 8 cows or 0.95 ha/AUM, and the DS 30 treatment stocked with 6 cows or 1.02 ha/AUM at the South Dakota site. All South Dakota treatments were stocked with cows weighing an average of 1150 lb.

Winter grazing cattle were allowed ad libitum access to white salt and trace minerals and were supplemented with 3 lb/day on an as-fed basis of 30% crude protein all-natural cake. During the winter grazing period of 2000-2001, cattle grazed as snow cover allowed for 53 days beginning November 15 on both the North and South Dakota study sites. During the dormant-season grazing period of 2001-2002, cattle grazed on the North Dakota site for 53 days beginning November 15. The cattle on the South Dakota site grazed for 35 days and animal numbers were increased to meet set stocking rate guidelines, as turn out was delayed until January 12 due to mechanical failures affecting the watering system. Cattle were allowed to graze at both the North Dakota and South Dakota sites for 53 days beginning on November 15 during the 2002-2003 and 2003-2004 winter grazing period. During the 2004-2005 winter grazing period, cattle grazed on the North Dakota sites for 50 days beginning November 22, while the cattle on the South Dakota site grazed for 56 days beginning November 15. Cattle grazed the North Dakota site for 51 days during the 2005-2006 winter grazing season beginning November 15. Cattle grazed for 36 days on the South Dakota site beginning November 29 and were pulled off early due to crusted snow.

Table 1 reports ha/AUM comparisons of treatments and percent reduction in carrying capacities compared to the SL treatment (control). From a perspective of utilized AUMs, the dormant season only grazing treatments had reduced carrying capacities relative to season-long use, however, the FL treatment numerically increased carrying capacities slightly relative to season-long use (3.2 to 5.3%).

Table 1. Stocking rate comparisons among grazing treatments in North and South Dakota.

	SL	FL	DS 30	DS 50
N.D.				
Ha/AUM	0.8	0.7	1.6	1.2
% Difference from SL	0.0	+5.3	-115.8	-61.8
S.D.				
Ha/AUM	0.6	0.6	1.0	0.9
% Difference from SL	0.0	+3.2	-61.9	-38.1

SL = season-long summer grazing, FL = 25% summer use for 2 weeks in early and mid June and 50% dormant season utilization, DS30 = 30% dormant season utilization, DS50 = 50% dormant season utilization

Herbage Disappearance: The degree of disappearance of graminoids and forbs for each treatment was determined using a paired-plot clipping technique (Milner and Hughs 1968). Twenty cages were distributed in each pasture during the treatment period. One plot within and outside each cage was clipped using a 0.25m^2 quadrat. Clipped herbage was separated into grasses and forbs, dry matter weights recorded, and kg/ha plant biomass and standard error of the mean calculated for each ecological site. Percent utilization and standard errors of the mean were calculated for graminoids and forbs combined and graminoids alone.

In the summer through winter periods of 2000-2001, 5 cages were systematically placed on each of the 2 shallow ecological sites and 2 loamy ecological sites before grazing began on each treatment (n=20), with the exception of the South Dakota 30% treatment where only 5 cages were placed on a shallow ecological site since this site made up only 10% of the study area on the treatment. During the winter of 2001 on the North Dakota sites, 5 plots were clipped for both the loamy and shallow ecological sites on the 30% treatment, 5 shallow plots were clipped on the 50% treatment, and no plots were clipped on the FL treatment due to ice and snow cover. On the summer treatments of 2001, the 20 sites within each pasture selected for the tiller study were used to determine utilization. In 2001-2002, 2002-2003, 2003-2004 and 2004-2005 all plots from the winter grazing treatments were clipped since ice and snow cover did not prevent clipping as it had in 2000-2001.

In May 2004, 30 cages were distributed evenly across the entire pasture, regardless of ecological differences. This created a more representative sampling of the pastures.

Leaf Heights: A study examining leaf heights throughout the growing season was initiated in May of 2001 to determine the growth patterns of western wheatgrass, needle-and-thread, thread-leaf sedge, and blue grama within each treatment. The species were selected as they were described as the predominant forage base of the study region (Barker and Whitman 1994, Shiflet 1994). Furthermore, these species are described as commonly existing together in various successional stages of rangeland in western North Dakota (Hansen and Hoffman 1988). Goetz (1963) monitored the growth and development of native range plants in western North Dakota and used leaf height as a main indicator of plant growth. Furthermore, researchers have correlated leaf and plant height with plant vigor, forage yield, competition, range condition and trend, and defoliation levels (Short and Woolfolk 1956, Buwai and Trlica 1977).

Twenty locations indicative of the dominant forage base were selected randomly within each treatment in May 2001. On each location, a 0.25 m^2 quadrat was selected containing at least 10 western wheatgrass tillers, 5 needle-and-thread tillers, 10 thread-leaf sedge tillers, and10 blue grama tillers. Cool-season tillers were marked with uniquely-colored rings upon the selection of each site in mid May and each tiller measured monthly until senescence was observed for each species. Western wheatgrass and needle-and-thread tillers were measured mid monthly for leaf height (height of tallest leaf) from May to August. Thread-leaf sedge was measured mid monthly for leaf height from May to July. Blue grama was the only warm-season grass investigated for growth, thus leaf heights were measured mid monthly during its growth period as described by Goetz (1964), from June to September. Needle-and-thread and thread-leaf sedge were not measured in 2002 and 2003 to improve random distribution of the plots throughout the four treatments.

Thirty locations were selected in May 2004 within each treatment. On each location, a 0.25 m^2 quadrat was selected containing 10 western wheatgrass tillers (cool season) and 10 blue grama tillers (warm season). Tillers were marked with uniquely colored rings and measured monthly until senescence. Western wheatgrass was measured from May until August and blue grama was measured from June until September.

Herbage production was analyzed as a randomized complete design with the GLM procedure of SAS (SAS Inst., Inc., Cary, NY) using frame as the experimental unit. The model included treatment, year, and treatment X year using the residual error term. When differences were found ($P < 0.05$), a mean separation was conducted using a Tukey's Honesty Significant Difference Test (Steel and Torrie, 1980).

Results and Discussion

Herbage Production: No differences in herbage production were found between locations (P=0.30). Following one year of treatment, peak primary production on the winter-only and flash treatments were not different (P>0.05) than the SL control treatment (Figure 1). In 2002, peak primary production on the SL control treatment was lower (P<0.05) than FL and DS 50. No differences (P>0.05) in peak primary production were found on SL, FL, and DS 30 following the third year (2003) of treatment; however peak herbage production was lower (P<0.05) on DS 50 compared to the other three treatments (Figure 1). In 2004 as well as in 2005, the SL treatment had lower (P<0.05) peak herbage production than the DS 50 and 30 treatments. The FL treatment had lower production (P<0.05) than the DS 30% in 2004, and lower production (P<0.05) than the DS 50% in 2005.

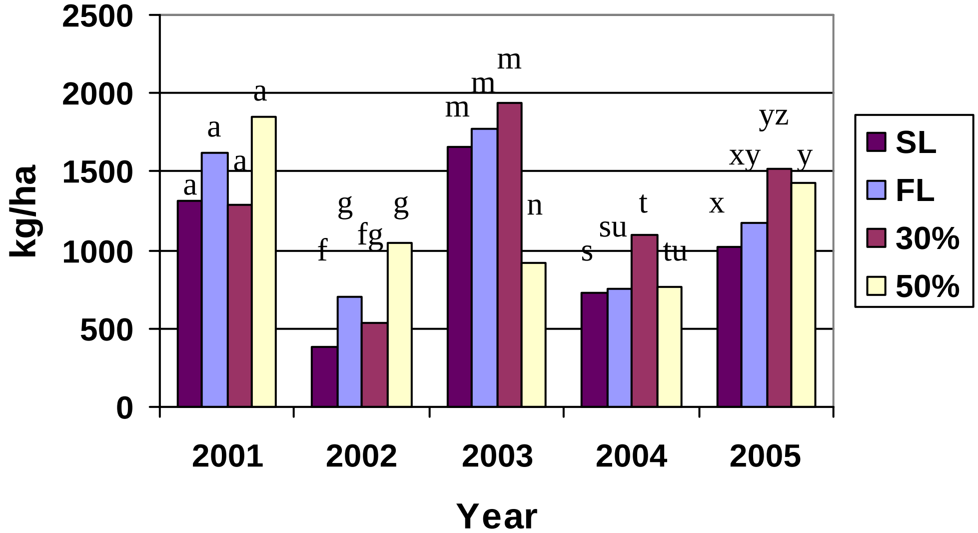


Figure 1. Peak grass production (mean ±S.E.) on the season-long (SL), June flash and 50% dormant-season use (FL), 30% dormant-season use (DS 30), and 50% dormant-season use (DS 50) for 2001-2005.
[ab]Treatments with the same letter are not significantly different (P>0.05).
[fg]Treatments with the same letter are not significantly different (P>0.05).
[mn]Treatments with the same letter are not significantly different (P>0.05).
[stu]Treatments with the same letter are not significantly different (P>0.05).
[xyz]Treatments with the same letter are not significantly different (P>0.05).

On average, moderate dormant-season grazing treatments did not effect herbage production, which corresponds with data reported by Coughenour (1991) who found increased nitrogen in live and dead grasses and fringed sagebrush on winter grazed areas. Increases in various aspects of rangeland productivity under moderate growing-season grazing use versus light or no grazing use were reported by Manley et al. (1995). Comparisons of grazed and ungrazed range in Wyoming revealed elevated levels of C and N in subsurface soil on grazed areas. This phenomenon is attributed to the reduction of litter and standing plant biomass as these sources immobilize a significant amount of N and C. Furthermore, increased animal traffic may enhance physical breakdown of residual plant material and soil incorporation. Likewise, Schacht et al. (1998) observed that mowing dormant range of switchgrass, little bluestem, and big bluestem resulted in a higher yield of annual growth than a non-mowed control. Engle et al. (1998) also reported which grazing strategies emphasizing defoliation during the dormant season that decreased probability of multiple defoliations during the growing season were less detrimental than those that increased the probability of multiple defoliations, such as the FL treatment in this study. Relevant research by Auen and Owensby (1988), Coughenour (1991); Engle et al. (1998), Schacht et al. (1998) and Reisterer et al. (2000) indicate dormant-season harvesting of grasses had little or no negative effect on subsequent herbage production.

Leaf Heights: No significant interaction was found for treatment by month, which means that all months react in the same way to the treatments. In 2001, the SL treatment leaf heights were higher than the FL treatment (Figure 2). The FL treatment leaf heights were lower (P<0.05) than the DS 50 treatment. Negative effects of grazing treatment on late growing season plant production were also observed by Trent et al. (1988). Fall grazed winter wheat plants relied on photosynthesis later in the growing season than non-grazed wheat plants, as they were unable to draw from carbohydrate reserves during grain filling. Similarly, Buwai and Trlica (1977) found heavy quiescent defoliation of western wheatgrass reduced TNC relative to a non-defoliated control. Furthermore, moderate and heavy dormant defoliation of western wheatgrass reduced both herbage yield and plant height when compared to the control.

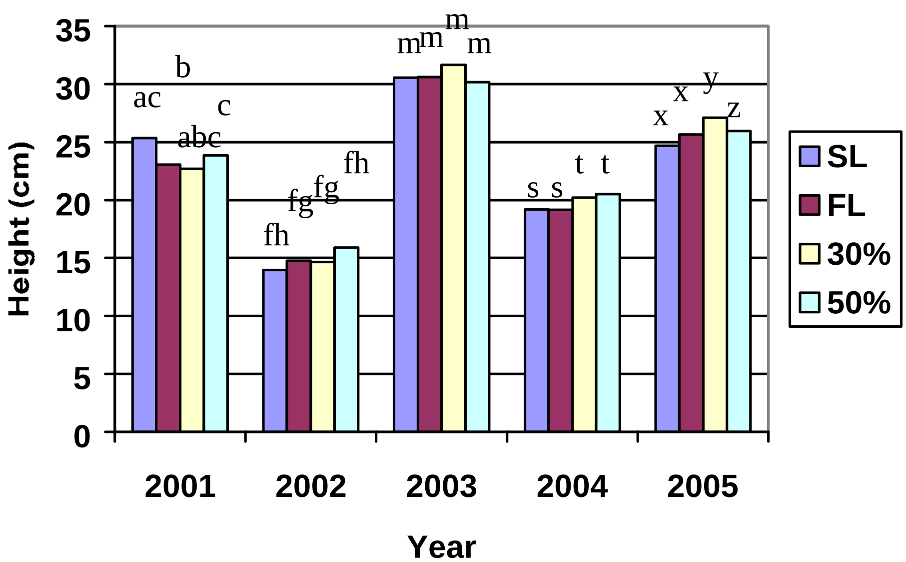


Figure 2. Western wheatgrass leaf heights in July (Peak) (mean ±S.E.) on the season-long (SL), June flash and 50% dormant-season use (FL), 30% dormant-season use (DS 30), and 50% dormant-season use (DS 50) for 2001-2005.
[abc]Treatments with the same letter are not significantly different (P>0.05).
[fgh]Treatments with the same letter are not significantly different (P>0.05).
[mn]Treatments with the same letter are not significantly different (P>0.05).
[st]Treatments with the same letter are not significantly different (P>0.05).
[xyz]Treatments with the same letter are not significantly different (P>0.05).

In 2002, the FL and DS 30 treatments had lower western wheatgrass heights (P<0.05) than the DS 50 treatments. In 2003, no differences (P<0.05) in western wheatgrass leaf heights were detected among any treatments (Figure 2).

In 2004, the leaf heights in the FL and SL treatments were shorter (P<0.05) than the DS 30 and DS treatment leaf heights (Figure 2). Western wheatgrass leaf heights on the FL and SL treatments were also lower (P<0.05) than the DS 30 and DS 50 treatments in 2005. The DS 30 treatment also had lower leaf heights (P<0.05) than the DS 50 treatment.

Light winter use (DS 30) resulted in shorter leaf heights than heavy winter use for needle-and-thread, thread-leaf sedge, and blue grama in 2001. Light winter use also resulted in lower needle-and-thread and blue grama leaf heights than SL. These data suggest increased utilization during the dormant period result in increased herbage yield the following year. Treatment by date interactions were not detected (P<0.05) for blue grama in 2001, thus monthly leaf height data were combined. However, in 2002 there was treatment by date interactions (P<0.05) in July. No treatment by date interaction was detected (P<0.05) in 2003.

As with the western wheatgrass leaf heights, no month by treatment interaction was detected. In 2001, the SL and FL treatments were lower (P<0.05) than DS 30 treatment The DS 30 treatment leaf heights were lower (P<0.05) than the DS 50 treatment (Figure 3). In 2002, the SL treatment leaf heights were lower (P<0.05) than the FL and DS 50 treatments. There were no differences found (P<0.05) in blue grama leaf heights in 2003 (Figure 3). In 2004, the SL treatment blue grama leaf heights were shorter (P<0.05) than the FL, DS 30, and DS 50 treatments. The leaf heights for the FL and DS 30 treatments were lower (P<0.05) than the DS 50 treatment. Blue grama leaf heights for the SL treatment were lower (P<0.05) than the FL and DS 30 treatments in 2005. The FL and DS 30 treatments had lower (P<0.05) leaf heights than the DS 50.

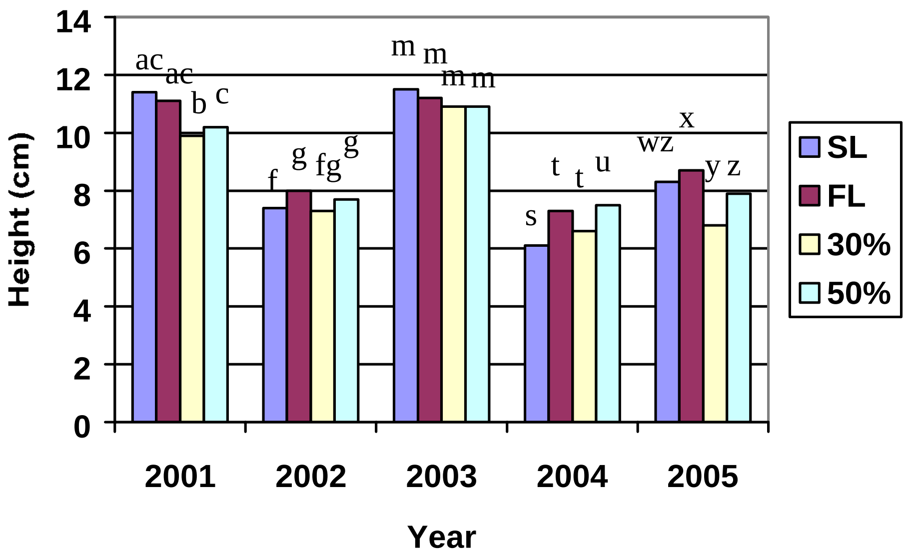


Figure 3. Blue grama leaf heights (mean ±S.E.) in August (Peak) on the season-long (SL), June flash and 50% dormant-season use (FL), 30% dormant-season use (DS 30), and 50% dormant-season use (DS 50) for 2001-2005.
[abc]Treatments with the same letter are not significantly different (P>0.05).
[fg]Treatments with the same letter are not significantly different (P>0.05).
[mn]Treatments with the same letter are not significantly different (P>0.05).
[st]Treatments with the same letter are not significantly different (P>0.05).
[wxyz]Treatments with the same letter are not significantly different (P>0.05).

These findings are consistent with the peak herbage production observations and studies by Coughenour (1991) and Manley et al. (1995) who reported positive effects on herbage production with increased levels of herbage removal during the dormant season. If dormant-season defoliation is not detrimental to needle-and-thread, blue grama, and thread-leaf sedge, removal of standing-dead plant material and the corresponding reduction in litter on the soil surface may be important to subsequent herbage production and plant growth. Removal of standing dead plant material has been reported to elevate soil temperatures, thus accelerating decomposition and mineralization in the spring. Furthermore, nutrient turnover rates are accelerated under grazed systems by returning mineral nitrogen to the soil in a readily decomposable form, thereby bypassing slower plant litter decomposition pathways (Coughenour 1991).

Summary

During the months of May through November in 2000, seasonal forage availability declined considerably between the time of peak production and the beginning of the winter grazing season. Considering these losses, stockpiling of forage throughout the growing season for use in late fall or winter results in lost herbage production potential. Furthermore, AUMs/ha for winter-only grazing areas were severely reduced relative to season-long grazing use. Incorporating a brief early-summer grazing period on winter pastures can increase land use and reduce economic loses by increasing stocking rates.

From an ecological and land-use efficiency perspective, a dormant-season grazing system that incorporates moderate early summer use combined with winter stocking rates utilizing 50% of the standing plant biomass is a preferable, and moreover, a beneficial management alternative. This method yielded greater herbage production than other treatments and resulted in greater needle-and thread and thread-leaf sedge leaf heights than the season-long or DS 30 grazing treatments. This method reduced western wheatgrass leaf heights late in the growing season in 2001, however, western wheatgrass and blue grama leaf heights were not affected in 2002 and 2003 compared to summer grazing alone. If the conclusion is made that dormant-season defoliation has little effect on these grasses, limiting litter accumulation on stockpiled pastures by ensuring at least moderate utilization (50%) of standing plant biomass may positively affect subsequent herbage production. Furthermore, SL grazing may have a more negative affect on needle-and-thread and thread-leaf sedge growth than winter use at higher (50%) utilization levels. The direct effects of dormant-season grazing on individual plant species versus conventional SL use, at present, is undistinguished in relevant literature. This research indicates western wheatgrass and blue grama were generally unaffected by dormant-season grazing.

Conclusion

Preliminary data regarding dormant-season grazing of native rangeland in the western Dakotas indicated that brief early summer use of dormant-season pastures and winter stocking rates intended to achieve 50% utilization of standing aboveground biomass is the preferred management option, relative to grazing treatments of 30 or 50% winter utilization with no summer use. This method was beneficial from both a land-use and ecological standpoint. Subsequent data are necessary; however, to evaluate the long-term ecological and economic sustainability of this management.

Literature Cited

Auen, L.M. and C.E. Owensby. 1988. Effects of dormant-season herbage removal on Flint hills rangeland. J. Range Manage. 41:481-482.

Barker, W.T. and W.C. Whitman. 1994. Rangeland cover types of the northern Great Plains. *In:* Shiflets, T.N., Rangeland cover types of the United States. Soc. for Range Manage., Denver, CO. 154pp.

Buwai, M. and M.J. Trlica. 1977. Multiple defoliation effects on herbage yield, vigor, and total nonstructural carbohydrates of five range species. J. Range Manage. 30:164-171.

Coughenour, M.B. 1991. Biomass and nitrogen response to grazing of upland steppe on Yellowstone's northern winter range. J. Appl. Ecol. 28:71-82.

Engel, R.K., J.T. Nichols, J.L. Dodd, and J.E. Brummer. 1998. Root and shoot responses of sand bluestem to defoliation. J. Range Manage. 51:42-46.

Goetz, H. 1963. Growth and development of native range plants in the mixed grass prairie of western north Dakota. M.S. Thesis. North Dakota State Univ., Fargo. 165pp.

Hansen, P.L. and G.R. Hoffman. 1988. The vegetation of the Grand River/Cedar River, Sioux, and Ashland Districts of the Custer National Forest: a habitat type classification. Gen. Tech. Rep. RM-157. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 68p.

Hart, R.H. 2001. Where the buffalo roamed-or did they? Great Plains Res. 11:83-102.

Laycock, W.A., H. Buchanan, and W.C. Krueger. 1972. Three methods for determining diet, utilization, and trampling damage on sheep ranges. J. Range Manage. 25:352-356.

Manley, J.T., G.E. Schuman, J.D. Reeder, and R.H. Hart. 1995. Rangeland soil carbon and nitrogen responses to grazing. J. Soil and Water Cons. 50:294-298.

McGregor, R.L., T.M. Barkley, R.E. Brooks, and E.K. Schofield 1986. Flora of the Great Plains. University Press of Kansas. Lawrence, K.S..

Milner, C. and R.E. Hughes. 1968. Methods of the measurement of primary production of grassland. Blackwell Sci. Pub. Oxford, England.

National Research Council. 1996. Nutrient requirements for beef cattle (7th ed.) Nat. Acad. of Sciences-NRC, Washington, D.C.

Omodt, H.W., G.A. Johnsgard, D.D. Patterson, and O.P. Olson. 1968. The major soils of North Dakota. Dept. of Soils, Ag. Exp. Sta. North Dakota State Univ., Fargo. Bull. No. 472. 60 pp.

Owenby, J.R. and D.S. Ezell. 1992. Monthly station normals of temperature, precipitation, and heating and cooling degree days 1961-1990, North Dakota. Climatography of the United States No. 81. NOAA, National Climatic Data Center. Asheville, NC. 60pp.

Pearson, H.A. 1975. Herbage disappearance and grazing capacity determinations of southern pine bluestem ranges. J. Range Manage. 28:71-73.

Riesterer, J.L. M.D. Casler, D.J. Undersander, and D.K. Combs. 2000. Seasonal yield distribution of cool-season grasses following winter defoliation. Agron. J. 92:974-980.

Schacht, W.H., A.J. Smart, B.E. Anderson, L.E. Moser, and R. Rasby. 1998. Growth responses of warm-season tallgrasses to dormant-season management. J. Range Manage. 51:442-446.

Sedivec, K.K., D.L. Dodds, and D. Gault. 1991. Range Site Identification. N.D. State Univ. Ext. Serv. Bull. R-580 (Revised). N.D. Univ. Fargo. 7 pp.

Shiflet, T.N. 1994. Rangeland cover types of the United States. Soc. Range Manage. Denver, CO. 152 pp.

Short, L.R. and E.J. Woolfolk. 1956. Plant vigor as a criterion for range condition. J. Range Manage. 9:66-69.

SPSS. 2000. Statistical procedures for social science. Marketing Dept. SPSS. Inc. Chicago, Ill.

Steel, R.G.D and J.H. Torrie. 1980. Principles and Procedures of Statistics. (2nd Edition), McGraw-Hill, New York Company. New York, NY.

Trent, J.D., L.L. Wallace, T.J. Svejcar, and S. Christiansen. 1988. Effects of grazing on growth, carbohydrate pools, and mycorrhizae in winter wheat. Can. J. Plant Sci. 68:115-120.

Ulmer, M.G. 1987. Soil survey of Adams County, North Dakota. U.S. Gov. Print Off. Washington, D.C. 174p.

United States Department of Agriculture Natural Resource Conservation Service. 2001. Range Technical Guidelines. Bismarck, ND.

United States Department of Agriculture Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory 2002. Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/ [2002, February].

Vallentine, J.F. 2001. Grazing Management. Academic Press. San Diego, CA..

Whitman, W.C., D.W. Bolin, E.W. Klosterman, K.D. Ford, L. Moomaw, D.G. Hoag, and M.L. Buchanan. 1951. Carotene, protein, and phosphorus in grasses of western North Dakota. N.D. Agr. Exp. Sta. Bull. No. 370. Fargo. 55p.

Wiesner, H.C. 1980. Soil survey, Perkins County, South Dakota. U.S. Gov. Print Off. Washington, D.C. 195p.

LAMB MUSCLE SELENIUM CONCENTRATION PLATEAUS FOLLOWING 56 DAYS OF SELENIUM SUPPLEMENTATION

C.S. Schauer[1], J. Held[2], J. Daniel[2], J. Caton[3], P. Hatfield[4], R. Stobart[5], J.O. Hall[6], D.M. Stecher[1], D. Pearson[1], and D. Drolc[1]

[1]Hettinger Research Extension Center, NDSU, Hettinger, ND
[2]South Dakota State University, Brookings, SD
[3]North Dakota State University, Fargo, ND
[4]Montana State University, Bozeman, MT
[5]University of Wyoming, Laramie, WY
[6]Veterinary Diagnostic Laboratory, Utah State University, Logan, UT

Acknowledgements: We would like to thank the South Dakota Agricultural Experiment Station and the Four-State Ruminant Consortium for funding this project.

Impact Statement

Lambs supra-supplemented with selenium have skeletal muscle selenium concentrations at levels that may prevent lung, colorectal, and prostate cancer in humans. Providing supranutritional levels of selenium for up to 56 days enhances muscle selenium concentration, however, muscle selenium concentration appears to plateau following 56 days of supplementation. These results indicate that future research is necessary to determine the lamb-to-lamb variability in muscle selenium concentration associated with supra-selenium supplementation protocols. Additionally, efforts are needed to ascertain the likely level of demand for a high-selenium lamb product, and the marketing techniques required to deliver that product to the consumer.

Introduction

Selenium (Se) deficiency in humans is not considered to be an issue in the United States, however, recent research suggests that humans who consume in excess (2 to 4 fold) of the recommended dietary allowance (RDA = 55 μg Se/d) of Se may reduce their chance for developing lung, colorectal, and prostate cancer by 30, 50, and 70%, respectively (Clark et al., 1996). Although tablets of Se as selenite or high Se yeast are available, the American Dietetic Association encourages people to consume nutrients through food whenever possible, including meats and grains.

Taylor et al. (2002) documented that circulating plasma Se concentration of finishing beef steers was elevated by feeding high Se (60 to 70 $\mu g \cdot kg^{-1}$ BW $\cdot$ d^{-1}) wheat, hay, or sodium selenate supplement by d 21 of feeding. Additionally, Lawler et al. (2004) reported that beef steers fed feedstuffs naturally high in Se (65 $\mu g \cdot kg^{-1}$ BW $\cdot$ d^{-1}) had Se concentration in semitendinosus muscle greater than those fed control or selenate supplemented animals. The inability of the sodium selenate supplement to increase muscle Se concentration is likely linked to the organic sources of Se containing primarily selenomethionine, which accumulates in tissue to a greater extent than other forms of Se. Results by Lawler et al. (2004) were similar to those of Hintze et al. (2001), reporting that a moderate sized portion of high Se beef would supply the Se necessary to achieve the cancer protection benefits described by Clark et al. (1996). Research by Schauer et al. (2005) indicates that feeding supranutritional levels of selenoyeast for 56 days to lambs prior to harvest can increase lamb muscle Se levels to concentrations required to prevent cancer in humans. However, a plateau in muscle Se concentration has not been reached by feeding supranutritional levels of Se for up to 56 d. Research by Schauer et al. (2005) and Taylor (2005) reported a linear increase in muscle Se concentration for 56 d of supranutritional Se supplementation, indicating that muscle Se concentration may continue to increase as length of supra-supplementation of Se continues beyond 56 d. Although the four state region has soils high in Se, the variability of Se concentration in forages (and subsequently grazing livestock) indicate that a feeding program for finishing livestock is necessary to ensure animals of both low and high Se status can achieve the desired Se concentration in skeletal muscle (Lawler et al., 2002).

Research by Lawler et al (2004) indicates that hot carcass weight, longissimus muscle area, backfat thickness, marbling score, quality grade, and yield grade of beef steers was not affected by supra-Se supplementation during the finishing time period. However, kidney, pelvic, and heart fat tended to be higher for animals supplemented with high Se wheat compared to animals supplemented with high Se hay or sodium selenate. Similarly, Schauer et al (2005) reported no differences in carcass quality of finished lambs fed supranutritional levels of Se for up to 56 d.

Our four state team's goal is to develop feeding strategies for finishing lambs that increase the Se content of lamb skeletal muscle to levels that will provide for cancer protection in humans while utilizing locally grown forages and grains. The marketing of these lamb meats as high Se organic supplements will provide marketing cooperatives an opportunity to develop a niche market for high Se lamb meat, and provide the beef industry with a model of feeding Se to finishing beef steers for the development of additional niche marketing.

Materials and Methods

In year 2 of a two year study, a randomized complete design was used to evaluate the influence of duration of supra-Se supplementation in finishing rations on a) lamb skeletal muscle Se concentration; b) finishing period body weight gain and feed efficiency; and c) carcass characteristics. The North Dakota State University Institutional Animal Care and Use Committee reviewed and approved animal care and use protocols used during this study. One-hundred sixty wethers (78 ± 0.7 lbs initial BW) were stratified by weight and assigned randomly to one of 20 pens (8 lamb/pen) for an eight-four day finishing phase. Pens were then assigned to one of 5 treatments (4 replications/treatment); supra-selenium supplementation for the final 84, 56, 28, 14, or 0 days of feeding prior to harvest. Wethers were wormed on day 0. Diets were approximately 73% corn and 25% alfalfa provided daily at 8:00 am to ensure ad libitum intake (NRC, 1985; Table 1). Diets were isonitrogenous and isocaloric (Table 1). Feed offered was recorded daily and feed refusals collected and recorded when significant amounts of refused feed accumulated in the feeders. Selenium for supra-selenium supplementation treatments (14, 28, 56, and 84 days) was provided as selenoyeast to provide approximately 50 μg • kg^{-1} BW • d^{-1} Se (2.6 ppm ration concentration; Table 1). Initial and final weights were two-day weights, and single day interim weights were taken once every 28 days to aid in monitoring health and potential Se toxicity.

Blood (jugular venipuncture into EDTA) was collected on day 0 and 84 to determine the change in circulating Se status. Blood samples were centrifuged and plasma collected. Plasma samples were frozen at -30°C until analysis for Se. Wethers were harvested at Iowa Lamb Corp. in Hawarden, IA. Skeletal muscle samples (approximately 5 g of foreshank) were removed for the determination of Se concentration. Skeletal muscle samples were frozen at -30°C until analysis for Se. Skeletal muscle samples (0.3 - 0.5 g) and plasma samples were analyzed for Se by a commercial laboratory (Utah Veterinary Diagnostic Laboratory). Additionally, carcass characteristics were evaluated following harvest. Hot carcass weight (**HCW**), backfat, bodywall thickness, and ribeye area (**REA**) were measured. Yield and quality grade were determined subjectively by a USDA grader. Feed to gain ratios, ADG, and % boneless closely trimmed retial cuts (**%BCTRC**) were calculated. Dry matter intake (**DMI**), body weight (**BW**), feed:gain (**F:G**), ADG, blood and skeletal muscle Se concentration, and carcass characteristic data were analyzed as a randomized complete design with the GLM procedure of SAS (SAS Inst. Inc., Cary, NY) using pen as the experimental unit. The model included treatment. Orthagonal contrast statements included 1) Control vs supra-Se supplementation; 2) linear effect of supra-Se supplementation; and 3) quadratic effect of supra-Se supplementation.

Results

Length of supra-selenium supplementation did not affect performance measures of DMI, final weight, gain, F:G, and ADG ($P \geq 0.28$; Table 2), carcass characteristics (fat depth, body wall thickness, REA, and HCW; $P \geq 0.29$; Table 2) or carcass quality ($P \geq 0.31$; Table 2).

Initial and final plasma Se concentrations were similar for all lambs ($P \geq 0.06$; Table 3). Muscle Se (wet and dry) concentration increased quadratically ($P = 0.05$) as length of supra-Se supplementation increased (Table 3).

Discussion

Lamb performance, carcass characteristics, and carcass quality of lambs in this study were not affected by the length of supra-selenium supplementation. These results are similar to results in steers (Hintze et al., 2002; Lawler et al., 2004) and lambs (Schauer et al., 2005). Unlike the results reported by Schauer et al. (2005), we did not observe a decrease in DMI and HCW as length of supra-Se supplementation increased, suggesting the previous results for DMI and HWC may be misleading.

Muscle Se concentration in our trial quadratically increased ($P = 0.05$) as length of supra-selenium supplementation increased. These results are similar to results of other researchers for beef (Lawler et al., 2004) and sheep (Van Ryssen et al., 1989; Ehlig et al., 1967; Taylor, 2005). However, our trial indicates a plateau in muscle Se concentration may be reached, which has not been previously reported. Taylor (2005) reported that although gut tissue (kidney, lever, spleen, and duodenum) selenium concentration appeared to plateau after 56 d of supra-Se supplementation (2.9 ppm), he did not observe a similar plateau in muscle Se concentration. Similarly, Schauer et al. (2005) observed a linear increase in muscle Se concentration following 56 d of supra-Se supplementation (1.89 ppm), but did not observe a plateau in muscle Se concentration. These results suggest that supra-selenium supplementation for the purpose of enhancing muscle selenium concentration should be withheld for the final 56 days of lamb finishing.

North Americans acquire their daily Se requirement primarily from wheat grain and beef (Schubert et al., 1987; Holden et al., 1991; Hintze et al., 2001). A ¼ lb portion of lamb from lambs fed a supra-selenium supplemented diet would provide approximately 147, 146, 95, 64, and 42 µg Se/day (wet basis; 84, 56, 28, 14, and 0 day supra-selenium supplementation, respectively). While the 28 d supplemented treatment in this trial provided adequate selenium to meet the recommended dietary allowance for selenium in humans (RDA = 55 µg Se/day for females and 70 µg Se/day for males), the selenium concentration in lamb skeletal muscle tissue for the 84 and 56 day selenium supplemented treatment would provide approximately 200% of the RDA for selenium. This level falls within the range indicated by Clark et al. (1996; 2 to 4 fold the RDA) for humans to reduce their chance of developing lung, colorectal, and prostate cancer. Our results suggest that animals may prove to be an excellent "filter" for preventing Se toxicity in humans who are consuming high Se diets for the prevention of cancer. Because of the plateau in muscle Se concentration, humans may be prevented from consuming toxic levels of Se if red meat is the source of supra-Se in their diet.

Implications

Development of feeding protocols for achieving high selenium lamb will aid producers in developing a niche market for the sale of lamb as an organic selenium supplement, as well as adding value to locally grown forages through the finishing of lambs. Additionally, the beef industry may derive benefit from this research as a model of feeding beef cattle to achieve high selenium status for the purpose of niche marketing. Our results indicate the supplementing selenium during the finishing phase can result in a lamb product that is naturally high in selenium. Muscle selenium concentrations may plateau following 84 days of supra-selenium supplementation, indicating a need to concentrate the supra-supplementation of selenium into the final 84 days of finishing.

Literature Cited

Clark, L.C., G.F. Combs Jr., B.W. Turnbull, E.H. Slate, D.K. Chalker, J. Chow, L.S. Davis, R.A. Glover, G.F. Graham, E.G. Gross, A. Krongrad, J.L. Lesher Jr., H.K. Park, B.B Sanders Jr., C.L. Smith, and J.R. Taylor. 1996. Effects of selenium supplementation for cancer prevention in patients with carcinoma of the skin. A randomized controlled trial. Nutritional Prevention of Cancer Study Group. J. Am. Med. Assoc. 276:1957-1963

Ehlig, C.F., D.E. Hogue, W.H. Allaway, and D.J. Hamm. 1967. Fate of selenium from selenite or selenomethionine with or without vitamin E in lambs. J. Nutr. 92:121-126.

Hintze, K.J., G.P. Lardy, M.J. Marchello, and J.W. Finley. 2001. Areas with high concentrations of selenium in the soil and forage produce beef with enhanced concentrations of selenium. J. Agric. Food Chem. 49:1062-1067.

Hintze, K.J., G.P. Lardy, M.J. Marchello, and J.W. Finley. 2002. Selenium accumulation in beef: Effect of dietary selenium and geographical area of animal origin. J. Agric. Food Chem. 50:3938-3942.

Holden, J.M., S. Gebhardt, C.S. Davis, and D.G. Lurie. 1991. A nationwide study of the selenium contents and variability of white bread. J. Food Compos. Anal. 4:183-195

Lawler, T.L., J.B. Taylor, E.E. Grings, J.W. Finley, and J.S. Caton. 2002. Selenium concentration and distribution in range forages from four locations in the northern great plains. Proc. West. Sect. Amer. Soc. of Anim. Sci. 53:7-9.

Lawler, T.L., J.B. Taylor, J.W. Finley, and J.S. Caton. 2004. Effect of supranutritional and organically bond selenium on performance, carcass characteristics, and selenium distribution in finishing beef steers. J. Anim. Sci. 82:1488-1493.

NRC. 1985. Nutrient Requirements of Sheep (6th Rev. Ed.). National Academy Press, Washington, DC.

Schauer, C.S. J. Held, J. Daniel, J. Caton, P. Hatfield, R. Stobart, L.P. Anderson, J.O. Hall, D.M. Stecher, D. Pearson, and D. Drolc. 2005. Development of high selenium lamb as a human health food. Western Dakota Sheep & Beef Day. 46:6-10

Schubert, A., J.M. Holden, and W.R. Wolf. 1987. Selenium content of a core group of foods based on a critical evaluation of published analytical data. J. Am. Diet. Assoc. 87:285-299.

Taylor, J.B. 2005. Time-dependent influence of supranutritional organically bound selenium on selenium accumulation in growing wether lambs. J. Anim. Sci. 83:1186-1193.

Taylor, J.B., T.L. Lawler, J.W. Finley, and J.S. Caton. 2002. Effect of high selenium feeds on selenium status in finishing beef steers. Proc. West. Sect. Am. Soc. Anim. Sci. 53:534-536.

Van Ryssen, J.B.J., J.T. Deagen, M.A. Beilstein, and P.D. Whanger. 1989. Comparative metabolism of organic and inorganic selenium by sheep. J. Agric. Food Chem. 37:1358-1363.

Table 1. Dietary ingredient and nutrient composition of lamb finishing diets

Ingredient	Feedstuff Se concentration, ppm	Diets[a] Control	Selenium Diet
		%, DM basis	
Corn	0.12	73.09	72.85
Alfalfa	0.21	24.65	24.64
Trace Mineral[b]	---	0.44	0.44
Selenoyeast	614	---	0.24
CTC[c]	---	0.52	0.52
Limestone	---	0.87	0.87
Ammonium Chloride	---	0.44	0.44
Nutrient Composition of Diet			
CP, %		13	13
TDN, %		83	83
ADF, %		9.59	10.05
Ca:P		3.32	3.01
Selenium, ppm		0.57	2.60
Selenium intake, $\mu g \bullet kg^{-1}$ $BW \bullet d^{-1}$		4.34	50.17

[a]Control = no supra-selenium supplementation with selenoyeast; Selenium Diet = supplementation with selenoyeast for the final 14, 28, 56, or 84 days of finishing.
[b]Trace mineral: 95.5% NaCl, 3,500 ppm Zn, 2,000 ppm Fe, 1,800 ppm Mn, 350 ppm Cu, 100 ppm I, and 60 ppm Co.
[c]CTC (4G) was formulated to provide 48 g/ton chlortetracycline.

Table 2. The influence of supra-selenium supplementation on feedlot lamb performance and carcass characteristics

	Treatment[a]						*P*-value[c]		
Item	Control	14 day	28 day	56 day	84 day	SEM[b]	Control vs Supp.	Linear	Quadratic
Dry Matter Intake, lbs/hd/day	3.10	3.07	3.10	3.19	3.02	0.06	0.91	0.83	0.36
Final Weight, lbs	121	122	121	125	121	1.2	0.39	0.52	0.29
Gain, lbs	43	44	44	47	43	1.3	0.49	0.69	0.29
Average Daily Gain, lbs/day	0.52	0.53	0.52	0.56	0.52	0.02	0.41	0.59	0.31
F:G	6.04	5.80	6.00	5.72	5.89	0.15	0.28	0.43	0.57
Hot Carcass Weight, lbs	59	59	59	61	58	0.9	0.76	0.86	0.28
Fat Depth, in	0.18	0.21	0.18	0.19	0.18	0.02	0.82	0.74	0.78
Ribeye Area, in^2	2.6	2.5	2.5	2.6	2.7	0.1	0.58	0.25	0.09
Quality Grade[d]	3.0	3.0	3.0	3.0	3.0	0.03	0.62	0.49	0.56
Yield Grade	2.4	2.3	2.2	2.4	2.4	0.11	0.53	0.76	0.31
% BCTRC[e]	45.8	45.6	45.7	45.8	45.8	0.18	0.65	0.82	0.56

[a]Control = no supra-selenium supplementation with selenoyeast; 14 days = supplementation with selenoyeast for the final 14 days of finishing; 28 days = supplementation with selenoyeast for the final 28 days of finishing; 56 days = supplementation with selenoyeast for the final 56 days of finishing; 84 days = supplementation with selenoyeast for the final 84 days of finishing.
[b]Standard Error of Mean; n = 4 .
[c]*P*-value for Control vs supra-selenium supplemented treatments and linear and quadratic affect of supra-selenium supplementation.
[d]1 = utility; 2 = good; 3 = choice; 4 = prime.
[e]% boneless closely trimmed retail cuts (49.936-(0.0848*D5)-(4.376*E5)-(3.53*F5)+(2.456*G5)).

Table 3. The influence of supra-selenium supplementation on feedlot lamb muscle and plasma selenium concentration

	Treatment[a]						*P*-value[c]		
Item	Control	14 day	28 day	56 day	84 day	SEM[b]	Control vs Supp.	Linear	Quadratic
Initial plasma Se concentration, ppm	0.17	0.15	0.16	0.17	0.16	0.005	0.06	0.54	0.23
Final plasma Se concentration, ppm	0.26	0.28	0.26	0.25	0.26	0.025	0.92	0.53	0.89
Muscle Se concentration, ppm; DM	1.41	2.12	3.25	4.73	4.80	0.09	< 0.001	< 0.001	0.01
Muscle Se concentration, ppm; wet	0.37	0.56	0.84	1.29	1.30	0.03	< 0.001	< 0.001	0.05

[a]Control = no supra-selenium supplementation with selenoyeast; 14 days = supplementation with selenoyeast for the final 14 days of finishing; 28 days = supplementation with selenoyeast for the final 28 days of finishing; 56 days = supplementation with selenoyeast for the final 56 days of finishing; 84 days = supplementation for the final 84 days of finishing.
[b]Standard Error of Mean; n = 4 .
[c]*P*-value for Control vs supra-selenium supplemented treatments and linear and quadratic affect of supra-selenium supplementation.

INFLUENCE OF DRIED DISTILLERS GRAINS ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING LAMBS

C.S. Schauer, P.B. Berg, M. Stamm, D.M. Stecher, D. Pearson, and D. Drolc

Hettinger Research Extension Center, NDSU, Hettinger, ND

Acknowledgements: We would like to thank the North Dakota Corn Utilization Council for donating the dried distillers grains for this project.

Impact Statement
Dried distillers grains replacing up to 30% of the corn portion of a corn and alfalfa based finishing ration increased lamb performance and had no negative effect on lamb carcass traits.

Introduction
Coproducts from the ethanol industry are increasingly available in the northern Great Plains as the ethanol industry continues to expand. Dried distillers grain (**DDG**), one such coproduct, is an excellent source of energy and protein for beef cattle and sheep (Lardy, 2003). North Dakota, Minnesota, and South Dakota annually produced about 900,000 tons of DDG, approximately 80% of which are fed to ruminants. Research in beef cattle backgrounding and finishing diets report that DDG can be fed as a source of supplemental protein and/or energy at levels up to 20% of the diet dry matter (Lardy, 2003). However, DDG are high in potassium, phosphorus, and sulfur, and care must be used when feeding DDG at the upper limits of the recommendation. Little research has evaluated the inclusion of dried distillers grains as a replacement for concentrate in lamb finishing rations. Schauer et al. (2005) reported that DDG can be included at levels up to 15% of a finishing ration with no negative affect on lamb performance or carcass traits. While it is widely accepted that DDG are an excellent source of protein and energy, the unique problems of feeding feedstuffs high in phosphorus and sulfur to sheep warrant additional research. Maintaining a calcium to phosphorus ratio of 2:1 or greater for the prevention of urinary calculi may become difficult as the level of DDG included in lamb finishing rations increases. This study was designed to evaluate how lambs respond to increasing levels of DDG in a finishing ration.

Materials and Methods
A randomized complete design was used to evaluate the influence of DDG in lamb finishing diets. One-hundred forty four wethers (54 ± 0.3 lbs initial BW) were stratified by weight and breed (western white-faced Rambouillet and western white-faced Rambouillet X Katahdin) and assigned randomly to 9 pens (16 wethers/pen). Pens were then assigned to one of three diets; 0% replacement of corn with DDG (**Control**), 15 % replacement of corn with DDG (**15%**), or 30% replacement of corn with DDG (3**0%**; Table 1). Wethers were fed a finishing diet for 119 days. The control diet consisted of 73% corn and 25% alfalfa hay. Rations were formulated as to maintain a Ca:P ratio of 2:1 or greater and sulfur was monitored (0.40% of diet; Table 1). Rations were mixed and ground through a grinder-mixer and provided ad-libitum via bulk feeders. Wethers were weighed on day 0, 28, 56, 84, and 119. Initial and final weights were an average of two-day weights. Following the 119 day finishing period, wethers were harvested and carcass data collected at Iowa Lamb Corp, Hawarden, IA. Feedlot performance and carcass

trait data were analyzed as a randomized complete design using the GLM procedure of SAS (SAS Inst. Inc., Cary, NY). The model included treatment. Contrast statements included 1) Control vs DDG inclusion; and 2) linear effect of DDG inclusion.

Results

The effects of treatments on feedlot performance and carcass traits are shown in Table 2. Final weight, gain, ADG, mortality, and ribeye area were affected by treatment ($P \leq 0.05$). Final weight and total gain increased linearly ($P = 0.04$ and $P = 0.02$, respectively) as level of DDG inclusion increased. Subsequently, ADG increased linearly ($P = 0.02$). However, intake was not affected ($P = 0.67$), resulting in a Feed:Gain ratio that was not different ($P = 0.20$) than Control. While the majority of carcass traits were not affected by treatment ($P \geq 0.42$), ribeye area increased ($P = 0.01$) in a similar trend to total gain and ADG. Hot carcass weight averaged 69 lbs, resulting in carcasses averaging choice with a yield grade of 3.8 and 45% boneless closely trimmed retail cuts.

Discussion

Dried distillers grains replacing up to 30% of the corn portion of a corn and alfalfa based finishing ration improved lamb weight gain, resulting in an increased ribeye area. Other researchers suggest that DDG can be an effective replacement of concentrate with no affect of livestock performance compared to control rations. Erickson et al. (1989) provided up to 28% of a finishing ration as DDG and observed no negative affects on performance. Similarly, Schauer et al. (2005) replaced up to 15% of the total ration with DDG and found no difference in lamb performance or carcass traits. However, our data suggests an increase in performance from increasing levels of DDG. In our trial, the crude protein levels of the DDG rations are in excess of the requirements for lambs during this stage of production (NRC, 1985). In the CON ration, CP may be limiting as corn CP concentrations are substantially lower than DDG CP concentrations. Future research is needed to determine if adequate performance can be maintained while utilizing lower quality forages than alfalfa with DDG replacing a portion of the concentrate in the diet. Additionally, future research should evaluate increased inclusion of DDG, beyond 30% of the concentrate portion of the diet. While Ca:P ratios may be able to be maintained, diet palatability may begin to decrease as additional limestone is added, resulting in decreased performance. Additionally, inclusion above 30% of the concentrate portion may result in sulfur concentrations greater than toxicity values reported by the NRC (1985). Sulfur toxicity may result in decreased intake, performance, and potentially polio as well as health problems associated with sulfur binding to copper, resulting in copper deficiencies.

Implications

The expansion of the ethanol industry in the region may result in an increase in the availability of dried distillers grains. When appropriately priced relative to corn and/or barley, dried distillers grains can effectively replace up to 30% of the concentrate portion of a corn-based lamb finishing ration with no negative effects on feedlot performance or carcass traits.

Literature Cited

Erickson, D.O., B.L. Moore, P.T. Berg, and M. Swantek. 1989. Distillers dried grains compared to soybean meal in barley or milo diets for finishing lambs. Western Dakota Sheep Day. 30:6-11.

Lardy, G.P. 2003. Feeding coproducts of the ethanol industry to beef cattle. NDSU Ext. Serv. Bull. AS-1242.

NRC. 1985. Nutrient Requirements of Sheep (6th Rev. Ed.). National Academy Press, Washington, DC.

Schauer, C.S., L.P. Anderson, D.M. Stecher, D. Pearson, and D. Drolc. 2005. Influence of dried distillers grains on feedlot performance and carcass characteristics of finishing lambs. Western Dakota Sheep & Beef Day. 46:31-33.

Table 1. Dietary ingredient and nutrient composition of control and dried distillers grain diets

	Diets[a]		
Ingredient	Control	15%	30%
		%, DM basis	
Corn	73.0	61.5	50.1
Dried distillers grain	---	11.25	22.5
Alfalfa	25.0	25.0	25.0
Ammonium Chloride	0.49	0.49	0.49
Trace mineral[b]	0.49	0.49	0.49
CTC[c]	0.60	0.60	0.60
Limestone[d]	0.50	0.70	0.90
Nutrient Concentration			
CP, %	11.7	14.6	18.4
TDN, %	82.2	82.8	84.6
ADF, %	9.5	10.6	11.8
Sulfur, %[e]	0.14	0.21	0.30
Ca, %	0.65	0.77	1.19
P, %	0.27	0.36	0.43

[a]Control = 0% replacement of corn with dried distillers grains; 15 = replacement of 15% of corn with dried distillers grains; 30 = replacement of 30% of corn with dried distillers grains.
[b]Trace mineral: 95.5% NaCl, 3,500 ppm Zn, 2,000 ppm Fe, 1,800 ppm Mn, 350 ppm Cu, 100 ppm I, and 60 ppm Co.
[c]CTC (4G) was formulated to provide 48 g/ton chlortetracycline.
[d]Limestone addition was formulated to maintain a Ca:P of 2.0 or greater.
[e]Sulfur may be toxic at 0.40% of diet.

Table 2. The influence of dried distillers grains on feedlot lamb performance and carcass characteristics

	Treatment[a]				*P*-value[c]	
Item	Control	15%	30%	SEM[b]	Control vs DDG	Linear
Initial Wt, lbs	54	54	55	0.27	0.13	0.42
Final Wt, lbs	124	124	129	1.48	0.04	0.04
Gain, lbs	66	68	74	1.86	0.06	0.02
Average Daily Gain, lbs/day	0.45	0.52	0.60	0.03	0.13	0.02
Dry Matter Intake, lbs/hd/d	4.13	4.23	4.23	0.09	1.0	0.45
F:G	9.33	8.2	7.1	0.76	0.34	0.08
Mortality	2	1	0.3	0.4	0.27	0.02
Hot Carcass Weight, lbs	69	70	70	1.5	1.0	0.65
Leg score	12	12	12	0.3	1.0	1.0
Conformation score	11	12	12	0.3	1.0	0.50
Fat Depth, in	0.35	0.34	0.32	0.02	0.65	0.47
Body Wall Thickness, in	0.99	1.00	1.02	0.04	0.77	0.60
Ribeye Area, in^2	2.5	2.5	2.6	0.02	0.05	0.01
Quality Grade[d]	Choice	Choice	Choice	0.2	0.27	1.0
Yield Grade	3.9	3.8	3.6	0.2	0.65	0.47
%BCTRC[e]	44.7	44.4	44.6	0.3	0.59	0.93

[a]Control = 0% replacement of barley with dried distillers grains; 15 = replacement of 15% of barley with dried distillers grains; 30 = replacement of 30% of barley with dried distillers grains.
[b]Standard Error of Mean; n = 3 .
[c]*P*-value for Control vs DDG treatments and linear affect of dried distillers grains inclusion.
[d]Utility, Good, Choice, or Prime.
[e]% boneless closely trimmed retail cuts (49.936-(0.0848*D5)-(4.376*E5)-(3.53*F5)+(2.456*G5)).

INFLUENCE OF KATAHDIN BREEDING ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING LAMBS

C.S. Schauer[1], P.B. Berg[2], D. Nudell[1], T.C. Faller[1], D.M. Stecher[1], D. Pearson[1], and D. Drolc[1]

[1]Hettinger Research Extension Center, NDSU, Hettinger, ND
[2]North Dakota State University, Fargo, ND

Acknowledgements: We would like to thank the North Dakota Corn Utilization Council for donating the dried distillers grains for this project.

Impact Statement
Our results indicate the ½ blood and ¾ blood Katahdin lambs performed adequately in the feedlot compared to Rambouillet bred lambs. We observed no decrease in average daily gain or yield and quality grades for Katahdin lambs compared to conventionally bred lambs.

Introduction
In spite of the demonstrated improvement of range and profit potential, few cattle ranchers have chosen bio-control of leafy spurge with sheep over chemical control. Sell et al. (1998) reported the reasons for this reluctance: 72% of the ranchers cited lack of proper equipment; 44% thought sheep/goats competed for the same forage as cattle; 41% felt they lacked the expertise to work with sheep/goats; and 40% thought adding sheep/goats would be too time consuming. Sell et al. (1998) also point out that no local decision makers (county or township commissioners, county agents, weed board members, and state legislators) from North or South Dakota felt that sheep or goats were very effective in controlling leafy spurge.

One alternative that may convince beef producers to include sheep in their grazing plan for the control of noxious weeds is to use a breed of sheep that does not require shearing; hence, the management of the sheep enterprise would be similar to that of managing beef. Preliminary data from the Animal and Range Science Department at NDSU indicates that the Katahdin breed is hardy, shows indications of parasite resistance, and will produce offspring which shed their fleece growth annually (data supports the need for a 75% Katahdin breed influence for shedding to be consistent; Moore et al., 2001). Additionally, the breed shows indications of potential for accelerated lambing with acceptable fertility (Wildeus, 1997). As a breed, they are smaller framed and slower growing when compared to Columbia and Hampshire sired lambs, but may have improved feed conversion (Moore et al., 2004). Carcass characteristics do not appear different from conventional breeds commonly used in commercial production in the US (Moore et al., 2004). However, one concern for lamb feeders is the possibility of a pelt discount at slaughter time due to the presence of hair instead of wool. Little published research has evaluated the influence of Katahdin breeding on lamb feedlot performance and carcass characteristics compared to contemporaries.

The study hypothesis is: 1) Katahdin influenced lambs will have lower average daily gain, feed intake, and feed:gain, and require more days on feed to achieve a similar carcass weight compared to Rambouillet influenced lambs. This study will contribute data toward the objectives of NCR-190: Increased Efficiency of Sheep Production.

Materials and Methods

This study was conducted in conjunction with the dried distillers grain trial described in this publication. A randomized complete design was used to evaluate the influence of Katahdin breeding on lamb feedlot performance and carcass characteristics. One-hundred forty four wethers (54 ± 0.3 lbs initial BW) were stratified by weight and breed (western white-faced Rambouillet and western white-faced Rambouillet X Katahdin) and assigned randomly to 9 pens (16 wethers/pen; approximately 48 Rambouillet, 48 Rambouillet X Katahdin **[1/2 Katahdin]** and 48 Rambouillet x Katahdin X Rambouillet **[3/4 Katahdin]**). Pens were then assigned to one of three diets; Control, 15 % replacement of corn with DDG (15%), or 30% replacement of corn with DDG (30%; Table 1). Wethers were fed a finishing diet for 119 days. The control diet consisted of 73% barley and 25% alfalfa hay. Rations were formulated as to maintain a Ca:P ratio of 2:1 or greater and sulfur below the toxicity range (0.40% of diet; Table 1). Rations were mixed and ground through a grinder-mixer and provided ad-libitum via bulk feeders. Wethers were weighed on day 0, 28, 56, 84, and 119. Initial and final weights were an average of two-day weights. Following the 119 day finishing period, wethers were harvested at Iowa Lamb Corp., Hawarden, IA and carcass data collected. Feedlot performance and carcass trait data were analyzed as a randomized complete design using the GLM procedure of SAS (SAS Inst. Inc., Cary, NY). There was no interaction ($P \geq 0.32$) between breed and dried distillers grains inclusion on lamb performance, therefore, the affects of breed were analyzed without ration type included in the model. The model included breed and the experimental unit was animal. Planned pairwise comparisons (least significant difference) were used to separate breed least square means when the F-test was significant ($P < 0.10$).

Results and Discussion

Gain, average daily gain (ADG), and ribeye area were not affected ($P \geq 0.20$) by breed type (Table 2). Final weight, hot carcass weight, fat depth, body wall thickness, and quality and yield grade were affected ($P \leq 0.04$) by breed type (Table 2). Final weights and hot carcass weights were higher for ½ Katahdin than ¾ Katahdin lambs, with Rambouillet lambs intermediate. This response is largely because initial weights were highest for ½ Katahdin lambs, followed by Rambouillet and ¾ Katahdin lambs. Because of the higher final and carcass weights, carcass data followed a similar trend. Fat depth, body wall thickness, yield grade, and quality grade were highest for ½ Katahdin lambs, with Rambouillet and ¾ Katahdin lambs being similar, expect for quality grade, for which Rambouillet lambs were higher than ¾ blood lambs. The percentage of boneless closely trimmed retail cuts (**% BCTRC**) reflected the amount of fat cover for the ½ Katahdin lambs, resulting in a slight reduction in the % of BCTRC compared to Rambouillet and ¾ Katahdin lambs.

Our responses for performance are not similar to those observed by other researchers. Moore et al. (2004) reported a decrease in ADG for Katahdin influenced lambs compared to lambs sired by Columbia and Hampshire rams. Direct comparisons of Katahdin feedlot performance between trials are difficult because of breed differences between Columbia and Hampshire sired lambs and Montadale/Rambouillet sire lambs. However, the differences observed between trials clearly indicate a need for additional research to determine the interactions between other breed types and Katahdin on feedlot performance. Additionally, future research is needed to determine what affect Katahdin breeding has on carcass characteristics and percent retail product. Our results for carcass characteristics are not consistent with results reported by Moore et al. (2004).

Implications

As beef producers and land managers continue the struggle for the control of noxious weeds, the need for a low-input sheep breed becomes of increased importance. Additionally, because of the lack of shearers, especially for small "farm flocks", a need for an alternative to wool breeds is needed. The Katahdin breed of hair sheep, possibly bred to a traditional wool ewe, may become an alternative that is appealing to beef producers as they require little to no shearing. This breed alternative may make a sheep enterprise more appealing to beef producers by decreasing the input and labor costs that have traditionally been the limiting factor for including sheep in a beef operation. Currently, our results indicate the ½ and ¾ blood Katahdin lambs performed adequately in the feedlot compared to Rambouillet bred lambs.

Literature Cited

Moore, B.L., P.T. Berg, R.G. Haugen, W. Limesand, D.A. Redmer, and A. Grazul-Bilska. 2001. Evaluation of Katahdin and Wiltshire Horn (hair sheep breeds): Their effectiveness in low input management schemes. Western Dakota Sheep Day. 42:72-76.

Moore, B.L., P.T. Berg, W. Limesand, and D. Tufte. 2004. Evaluation of Katahdin hair sheep: Their use in North Dakota Management Schemes. Western Dakota Sheep and Beef Day. 45:44-49.

NRC. 1985. Nutrient Requirements of Sheep (6th Rev. Ed.). National Academy Press, Washington, DC.

Sell, R.S., D.A. Bangsrud, F.L. Leistritz, and D.J. Nudell. 1998. Ranch operators' perception of leafy spurge. Ag. Econ. Report 400-S. In: Western Dakota Sheep Day Report. 39:83-90.

Wildeus, S. 1997. Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. J. Anim. Sci. 75:630-640.

Table 1. Dietary ingredient and nutrient composition of diets fed to Katahdin x Rambouillet and Rambouillet lambs

	Diets[a]		
Ingredient	Control	15%	30%
	%, DM basis		
Corn	73.0	61.5	50.1
Dried distillers grain	---	11.25	22.5
Alfalfa	25.0	25.0	25.0
Ammonium Chloride	0.49	0.49	0.49
Trace mineral[b]	0.49	0.49	0.49
CTC[c]	0.60	0.60	0.60
Limestone[d]	0.50	0.70	0.90
Nutrient Concentration			
CP, %	11.7	14.6	18.4
TDN, %	82.2	82.8	84.6
ADF, %	9.5	10.6	11.8
Sulfur, %[e]	0.14	0.21	0.30
Ca, %	0.65	0.77	1.19
P, %	0.27	0.36	0.43

[a]Control = 0% replacement of corn with dried distillers grains; 15 = replacement of 15% of corn with dried distillers grains; 30 = replacement of 30% of corn with dried distillers grains.
[b]Trace mineral: 95.5% NaCl, 3,500 ppm Zn, 2,000 ppm Fe, 1,800 ppm Mn, 350 ppm Cu, 100 ppm I, and 60 ppm Co.
[c]CTC (4G) was formulated to provide 48 g/ton chlortetracycline.
[d]Limestone addition was formulated to maintain a Ca:P of 2.0 or greater.
[e]Sulfur may be toxic at 0.40% of diet.

Table 2. The influence of Katahdin breeding on feedlot lamb performance and carcass characteristics

	Breed[a]				
Item	Rambouillet	½ Katahdin	¾ Katahdin	SEM[b]	*P* value[c]
Gain, lbs	70	72	66	3	0.21
Final Wt, lbs	127[y]	139[z]	104[x]	3	< 0.001
Average Daily Gain, lbs/day	0.58	0.61	0.55	0.02	0.20
Hot Carcass Weight, lbs	68[y]	76[z]	59[x]	1	< 0.001
Fat Depth, in	0.29[x]	0.38[y]	0.28[x]	0.02	< 0.002
Body Wall Thickness, in	0.95[x]	1.10[y]	0.91[x]	0.03	< 0.001
Ribeye Area, in^2	2.5	2.6	2.4	0.1	0.20
Quality Grade[d]	11.6[y]	12.0[z]	11.2[x]	0.1	0.002
Yield Grade	3.3[x]	4.2[y]	3.2[x]	0.2	0.002
% BCTRC[e]	45[y]	44[x]	45[y]	0.4	0.03
Mortality	0.3[xy]	0.1[x]	0.7[y]	0.2	0.04

[a]1/2 Katahdin = Katahdin x Rambouillet; ¾ Katahdin = ½ Katahdin x Rambouillet; Rambouillet = Rambouillet.

[b]Standard Error of Mean; n = 9 .

[c]*P*-value for Katahdin vs Rambouillet.

[d]1 = utility; 2 = good; 3 = choice; 4 = prime.

[e]% boneless closely trimmed retail cuts (49.936-(0.0848*D5)-(4.376*E5)-(3.53*F5)+(2.456*G5)).

[xyz]Within a row, means without a common superscript differ ($P < 0.10$).

MULTI-SPECIES GRAZING AND SINGLE SPECIES GRAZING ON LEAFY SPURGE INFESTED RANGELAND (Ten-Year Summary)

C.S. Schauer[1], K.K. Sedivec[2],
T.C. Faller[1], S. Kronberg[3], D.M. Stecher[1]

[1]NDSU Hettinger Research Extension Center, Hettinger
[2]Animal and Range Sciences Department, North Dakota State University, Fargo
[3]Northern Great Plains Agricultural Research Center, USDA-ARS, Mandan

Acknowledgments: We would like to give special and well-deserved thanks to the Hettinger Research Extension Center staff. Also we would like to thank Dennis Whitted for his help in collecting vegetative data.

Impact Statement
Sheep or cattle/sheep grazing reduced leafy spurge stem density by 99% after ten years of grazing. However, sheep grazing alone achieved this reduction within 4 years, while cattle/sheep grazing required five years to achieve a similar reduction.

Introduction

Leafy spurge (*Euphorbia esula* L.) is North Dakota's most destructive noxious weed, invading over 1,200,000 acres of North Dakota land, primarily rangeland (North Dakota Dept. of Agriculture 2002). Leafy spurge has been reported in at least 35 states and six Canadian provinces (USDA, NRSCS 1999). This weed, which is extremely persistent and competitive, has contributed significantly to economic losses in the livestock industry. Thompson et al. (1990) estimated that land depreciation losses were over $137 million in North Dakota due to leafy spurge infestations. Leitch et al. (1994) reported that total direct and secondary annual impacts were over $86 million in North Dakota and over $129.5 million in the upper Midwest.

The use of sheep as a biocontrol agent in the control of leafy spurge is not a new concept. In the late 30's and early 40's Christensen et al. (1938), Helgeson and Thompson (1939) and Helgeson and Longwell (1942) indicated that sheep consumed leafy spurge and should be integrated into management strategies in controlling leafy spurge, however, there was limited promotion. Herbicides continue to be the primary method for control of leafy spurge (Lym et al. 1995). Many areas infested with leafy spurge, however, are in environmentally sensitive areas and most herbicides for controlling leafy spurge are not labeled for application in these sensitive areas. Therefore, many land managers have chosen alternative control agents, such as Angora goats or sheep. Research conducted in the 1980's and 1990's has shown that sheep or goats will reduce leafy spurge stem densities and increase grass and grass-like disappearance, and reported significant benefits in using multi-species grazing to manage leafy spurge infested rangelands (Prosser 1995).

Multi-species grazing allows rangeland managers to utilize a wider diversity of vegetation than single-species grazing (Merrill et al. 1966). The utilization of more than one livestock species on a rangeland containing various vegetative communities provides the potential of increasing species diversity, vegetative production, and ultimately red meat production. The economic losses associated with leafy spurge invasion require that the spread of leafy spurge is controlled and ultimately reversed. While it is known that sheep may help control the spread and actually reduce leafy spurge infestation, research is need that describes the long term trends in forb and shrub species density and richness, herbage production, and livestock gains resulting from multi- and single-species grazing of leafy spurge infested rangelands. No long term published research is available describing the ecological impact of multi- and single-species grazing with sheep and/or cattle, as well as the ideal rate at which to replace cattle with sheep to achieve leafy spurge reduction.

The objectives of this study were to test the effects of multi-species and single species grazing treatments using cattle and sheep on: 1) differences in leafy spurge control, plant species richness and density, plant species diversity, 2) evaluate differences in utilization levels by plant type and herbage production, and 3) evaluate differences in livestock weight gain.

Study Area

This study was conducted on Section 32, T139N, R81W of Morton County owned by the North Dakota State Correction Center in south central North Dakota, approximately two miles southwest of Mandan, and on the north half of Section 9 T138N, R81W of Morton county on native rangeland operated by the USDA-ARS Northern Great Plains Research Laboratory, approximately three miles south of Mandan. The study area was located in the Missouri Slope Prairie region. Vegetation in this region is typical of northern mixed grass prairie (Barker and Whitman 1989) and classified as a wheatgrass-grama-needlegrass (*Agropyron*, *Bouteloua*, *Stipa*) plant community (Shiflet 1994).

Grazing treatments were multi-species and single-species grazing on three replicated 20 acre blocks. Replicates one and two were within the North Dakota State Correction Center land and replicate three was on the USDA-ARS Northern Great Plains Research Laboratory. Each of the replicates were subdivided into 5 acre plots and the plots were treated with cattle only (**CO**), sheep only (**SO**), cattle and sheep (**CS**), or a non-use control (**NU**). Treatments were randomly allocated within each block in 1996, and treatments were applied through 2005. The experimental design was a randomized complete block design (**RCBD**).

Sheep were placed on treatments approximately 15 May and cattle 1 June when native cool season grass species reach grazing readiness (3-4 leaf stage). Livestock species were removed from treatments when 50 to 60 percent degree of grass and grass-like species use was achieved, or before 15 September.

Stocking rates include two yearling steers for CO from 1996 to 2005; twelve mature ewes in 1996, ten-mature ewes 1997 and 1998, and seven mature ewes from 1999 to 2005 for SO; one yearling steer and six mature ewes in 1996 and one yearling steer and five mature ewes from 1997 to 2005 for CS. Stocking rates were approximately 1.5 AUM/acre for CO, SO, and CS. Stocking rates for this trial were designed for 3.5 months of grazing for the steers and 4 months of grazing for the ewes. The adjusted sheep stocking rates for SO and CS were due to a decrease in leafy spurge production following treatment application.

Materials and Methods

Leafy spurge stem density counts were obtained using a permanent 109.4 yard line transect and counts collected approximately every 5 ½ yards using a 1.08 ft^2 quadrat. One transect was systematically placed in each of the four treatments (CO, SO, CS, and NU) for each replicate. Transects were selected based on leafy spurge location within the treatments to assure full length of transect comprised leafy spurge. Leafy spurge densities were monitored over eight years to evaluate the effectiveness of sheep grazing with single or multi-species management in the control of leafy spurge. Leafy spurge stem densities were evaluated at the end of May.

Forb and shrub species diversity and density was determined using a 2.7 ft^2 quadrat. Nested within the 2.7 ft^2 quadrat was a 1.08 ft^2 quadrat used to determine grass and grass-like species diversity. Data was collected from 109.4 yard transects with readings conducted approximately every 5 ½ yards. Data was collected on all treatments and replicate from the leafy spurge transect developed to monitor leafy spurge stem density counts. One native (non-infested) 109.4 yard transect was located within each replicated treatment to monitor species diversity and density changes that may naturally occur due to treatment. Readings were collected from the native transects annually, except in 1997 and 2003. The leafy spurge transects were monitored annually.

Leafy spurge, grass and grass-like, shrub, and forb herbage production were determined by clipping in late July in all treatments when vegetative species reached peak production (Whitman et al. 1952). Each plot was stratified into 7.67 x 7.67 yard grid. A 7.67 yard buffer strip was implemented to prevent an edge effect. Twenty-five plots were clipped on the grid within each plot using a 2.7 ft^2 quadrat.

Degree of disappearance of leafy spurge, grass and grass-likes, forbs, and shrubs were determined for each treatment at the end of the grazing season by stratifying each treatment into 7.67 by 7.67 yard quadrats in 1996, 1997, 1998, and 1999. Twenty-five quadrats were clipped within the grid using a 2.7 ft^2 quadrat for each grazed and non-use treatment to determine the degree of disappearance. The method of determining degree of disappearance was changed in 2000 due to the change in herbage production on the grazing treatments. Degree of disappearance was monitored using the pair-plot technique in 2000. Five cages were systematically placed within each grazing treatment (CO, SO, and CS) in leafy spurge infested sites. Two frames within each cage and two out of each cage were clipped after the removal of livestock species.

Livestock performance and production were collected for both cattle and sheep by determining average daily gain (**ADG**) and gain per acre, respectively. Both classes of livestock were weighed prior to pasture turn out and at the end of grazing season.

Treatment and year effects for leafy spurge stem density, forb and shrub density, herbage production, degree of disappearance, and livestock performances were analyzed using a GLM procedure of SAS (SAS Inst. Inc., Cary, NY). Mean separation was performed using Tukey's Honesty Significant Difference when significant ($P \leq 0.05$) differences were found. Shannon Wiener Index was used to calculate species diversity indices for both leafy spurge infested and non-infested range sites. Treatment and year effects of species diversity were analyzed using a non-parametric test.

Results and Discussion

A significant ($P < 0.05$) reduction in leafy spurge stem density occurred after one grazing season for SO and again after two grazing seasons (Table 1). Leafy spurge stem density was decreased ($P < 0.05$) after three years of grazing for CS. Leafy spurge was reduced from 10.4 stems/1.08 ft^2 in 1996 to 0.8/1.08 ft^2 stems in 1999 for SO; a reduction of 92% after four grazing seasons and 99% after ten grazing seasons. Leafy spurge stem densities were reduced ($P < 0.05$) by 99% after ten grazing seasons for CS, and were similar ($P < 0.05$) to SO by year 5. Leafy spurge stem density for CO and NU were reduced ($P < 0.05$) by 91 and 89%, respectively, after ten grazing seasons; however, reductions in years 6 through 10 were probably the result of bio-control insects invading the research plots in 2001. Leafy spurge stem densities were reduced ($P < 0.05$) from 9.8 stems/1.08 ft^2 in 1996 to 0.9 stems/1.08 ft^2 in 2005 for CO, and from 9.8 stems/1.08 ft^2 in 1996 to 1.1 stems/1.08 ft^2 in 2005 for NU (Table 1).

Leafy spurge and non-infested range sites were significantly different ($P < 0.05$) in forb and shrub density at the beginning of the study in 1996 (Table 2). A treatment x site (leafy spurge or native) interaction was observed after ten grazing seasons for forb and shrub density ($P = 0.002$) as well as graminoid density ($P = 0.01$). However, when analyzing the data within treatment, it appears little change has occurred in the native and leafy spurge infested sites as leafy spurge stem density decreased over time (Tables 2 and 3).

Peak herbage production is listed in Table 4. Changes in production are the result of variation in annual precipitation and temperature. Steer ADG did not exhibit a treatment by year interaction ($P = 0.91$) or a treatment effect ($P = 0.18$). However, a year effect ($P = 0.05$) was observed. While extreme variation in performance exists, it appears the majority of the variation is related to precipitation events (Tables 4 and 5). However, ewe ADG exhibited a treatment by year interaction ($P < 0.001$). But once again, much of the variation appears to be linked to precipitation events (Table 5). These results would suggest multi-species grazing had no significant negative or positive impact on sheep or cattle performance compared with single species grazing.

Conclusion

Sheep grazing, either as a sole enterprise or mixed with cattle is an effective tool in controlling leafy spurge. When replacing cattle AUM's with sheep AUM's, leafy spurge stem density was reduced by 99% after ten years of grazing. Similarly, when grazing sheep and cattle together, leafy spurge stem density was reduced by 99% after ten years of grazing. However, the reduction took five years to achieve for cattle and sheep grazing, while grazing with sheep alone took only four years to achieve a similar reduction. Large differences in forb, shrub, and grass species diversity do not appear to be present after ten grazing seasons. While subtle differences exist for livestock performance on a treatment basis, it appears that the majority of variation for livestock performance is precipitation related, not related to multi-species grazing.

Literature Cited

Barker, W.T. and W.C. Whitman. 1989. Vegetation of the northern Great Plains. Rangelands. 10:266-272.

Leitch, J.A., F.L. Leistritz, and D.A. Bangsund. 1994. Economic effect of leafy spurge in the upper Great Plains: methods, models, and results. Agri. Econ. Rep. No. 316. North Dakota State Univ. Agri. Econ. Dept., Fargo.

Merrill, L.B., P.O. Reardon, and C.L. Leinweber. **1966.** Cattle, sheep, goats...mix'em up for higher gains. Texas Agr. Prog. 12:13-14.

North Dakota Department of Agriculture. **2002.** North Dakotas Noxious Weeds and New Invasive Weeds: 2001 Survey Results. North Dakota Dept. of Agric., State Capitol, Bismarck.

Prosser, C.W. 1995. Multi-species grazing of leafy spurge infested rangeland in North Dakota. M.S. Thesis. N.D. State Univ., Fargo. 80 pp.

Shiflets, T.N. 1994. Rangeland cover types of the United States. Soc. for Range Manage. Denver, CO. 152 pp.

Thompson, F., F.L. Leistritz, and J.A. Leitch. 1990. Economic impact of leafy spurge in North Dakota. NDSU Agric. Exp. Sta. Econ. Rep. No. 257.

USDA, NRSCS 1999. The PLANTS database (http://plants.usda.gov/index.html). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Accessed October 14, 2003.

Whitman, Warren, C., D.W. Bolin, E.W. Klostermann, K.D. Ford, L. Moomaw, D.G. Hoag, and M.L.Buchanan. 1951. Caroten, protein, phosphorus in grasses of western North Dakota. Agr. Exp. Sta., N.D. Agr. College. N. D. Agr. Exp. Sta. Bull. No. 370.

Table 1. Effect of multi- and single-species grazing on leafy spurge stem density/ 1.08 ft^2

	Treatment[a]				
Year	**CO**	**SO**	**CS**	**NU**	**SEM[b]**
1996	9.8	10.4	11.6	9.8	1.9
1997	12.0	6.8	12.3	11.4	1.9
1998	10.8	2.5	11.8	11.1	1.9
1999	11.1	0.8	6.5	10.5	1.9
2000	6.2	0.6	2.1	8.1	1.9
% Change	**37%[x]**	**94%[y]**	**82%[y]**	**17%[x]**	**---**
2001[c]	5.0	0.3	0.8	5.4	1.9
2002[c]	2.5	0.3	0.2	2.3	1.9
2003[c]	3.4	0.3	0.4	3.7	1.9
2004[c]	2.0	0.3	0.3	1.2	1.9
2005[c]	0.9	0.1	0.1	1.1	1.9
% Change	**91%[x]**	**99%[x]**	**99%[x]**	**89%[x]**	**---**

[a] CO = cattle only; SO = sheep only; CS = cattle and sheep; NU = control.
[b]Standard Error of Mean; n = 3.
[c]Bio-control insects present in all treatments and replications.
[xy]Within a row, means without a common superscript differ ($P < 0.05$).

Table 2. Effect of multi- and single-species grazing on forb and shrub species density/2.7 ft^2

	Treatment[a]									
Year	CON	COS	SON	SOS	CSN	CSS	NUN	NUS	SEM[b]	*P*[c]
1996	6.7[d]	1.8[e]	5.8[d]	1.1[e]	4.5[d]	0.9[e]	7.8[d]	1.1[e]	1.10	< 0.002
2005	5.0[d]	10.9[e]	1.8[d]	1.2[d]	1.9[d]	1.7[d]	8.0[d]	13.0[d]	1.96	< 0.002

[a] CON = cattle only non-infested; COS = cattle only leafy spurge infested; SON = sheep only non-infested; SOS = sheep only leafy spurge infested; CSN = cattle and sheep non-infested; CSS = cattle and sheep leafy spurge infested; NUN = control non-infested; NUS = control leafy spurge infested.
[b]Standard Error of Mean; n = 3.
[c]*P*-value for F-test of treatment
[d,e] Within a row and treatment, means without a common superscript differ ($P < 0.05$).

Table 3. Effect of multi- and single-species grazing on graminoid species density/1.08 ft^2

	Treatment[a]									
Year	CON	COS	SON	SOS	CSN	CSS	NUN	NUS	SEM[b]	*P*[c]
1996										
2005	3.2[d]	2.5[d]	3.7[d]	3.8[d]	2.6[d]	3.6[d]	1.5[d]	2.1[d]	0.43	0.01

[a] CON = cattle only non-infested; COS = cattle only leafy spurge infested; SON = sheep only non-infested; SOS = sheep only leafy spurge infested; CSN = cattle and sheep non-infested; CSS = cattle and sheep leafy spurge infested; NUN = control non-infested; NUS = control leafy spurge infested.
[b]Standard Error of Mean; n = 3.
[c]*P*-value for F-test of treatment
[d] Within a row and treatment, means without a common superscript differ ($P < 0.05$).

Table 4. Peak herbage production (lb/acre) for graminoids, forbs, shrubs, and leafy spurge for 1996 through 2005

	Treatment			
Year	Graminoid	Forb	Shrub	Leafy Spurge
1996	1529	117	83	405
1997	1317	84	15	445
1998	1058	46	15	350
1999	1608	170	14	409
2000	1651	95	9	625
2001*	2244	91	29	287
2002*	1791	48	7	251
2003*	1419	90	82	275
2004*	1591	84	18	147
2005*	1499	250	107	285

*Bio-control insects present (2001, bio-control insects were found in all treatments and reps).

Table 5. Effect of multi- and single-species grazing on livestock average daily gains (lb/d; SE in parentheses)

	Treatment[a]				
Year	Steer	SEM[b]	SO Ewe	CS Ewe	SEM
1996	1.65[wxy]	0.18	0.16[uvw]	0.16[wxyz]	0.04
1997	1.36[xyz]	0.18	0.08[wxy]	0.09[xyz]	0.05
1998	1.09[z]	0.20	0.03[y]	0.06[z]	0.05
1999	1.66[wxy]	0.18	0.11[vwxy]	0.18[wxyz]	0.05
2000	1.93[w]	0.18	0.20[uv]	0.22[w]	0.05
2001	1.79[wx]	0.18	0.23[u]	0.20[wxy]	0.05
2002	1.44[wxyz]	0.18	0.13[uvwx]	0.21[wx]	0.05
2003	1.28[yz]	0.18	-0.31[cz]	0.06[dz]	0.05
2004	1.24[yz]	0.18	0.11[vwxy]	0.11[wxyz]	0.05
2005	1.31[xyz]	0.18	0.04[xy]	0.08[yz]	0.05

[a]Steer = average daily gain for steers for both treatments; SO Ewe = ewe average daily gain for the sheep only treatment; CS Ewe = ewe average daily gain for the cattle and sheep treatment.
[b]SEM = Standard Error of Mean; n = 3.
[cd]Within a row and species, means without a common superscript differ ($P < 0.05$).
[wx,yz]Within a column and livestock species, means without a common superscript differ ($P < 0.05$).

EFFECTS OF MULTI-SPECIES GRAZING ON LEAFY SPURGE INFESTED RANGELAND USING TWICE-OVER ROTATION AND SEASON-LONG GRAZING TREATMENTS (Ten-Year Summary)

C.S. Schauer[1], K.K. Sedivec[2],
T.C. Faller[1], D.M. Stecher[1], S. Kronberg[3]

[1]NDSU Hettinger Research Extension Center, Hettinger
[2]Animal and Range Sciences Department, North Dakota State University, Fargo
[3]Northern Great Plains Agricultural Research Center, USDA-ARS, Mandan

Acknowledgments: We would like to give special and well-deserved thanks to the Hettinger Research Extension Center staff. Also we would like to thank Dennis Whitted for their help in collecting vegetative data.

Impact Statement

Season-long grazing of cattle and sheep will reduce leafy spurge in fewer grazing seasons than twice-over rotation grazing of cattle and sheep; however, trends indicate that in time twice-over rotation grazing will provide similar control to season-long grazing.

Introduction

Herbicides continue to be the primary method to control and eradicate leafy spurge (*Euphorbia esula* L.; Lym et al. 1995). However, it is not economically feasible to control large infestations (Bangsund et al. 1996). Most herbicides which provide effective control of leafy spurge are not labeled for use in environmentally sensitive areas. This noxious weed, which is extremely persistent and competitive, has contributed significantly to economic losses to the livestock industry (Leitch et al. 1994). The economic losses associated with leafy spurge invasion require that the spread of leafy spurge is controlled and ultimately reversed.

Use of grazing as a biological control for leafy spurge has become more acceptable in recent years. Goats have been reported to be an excellent tool to control and reduce leafy spurge infestations (Sedivec and Maine 1993; Hanson 1994; Prosser 1995; Sedivec et al. 1995). The use of sheep as a control method was proven successful as early as the late 1930s and early 1940s by Helgeson and Thompson (1939) and Helgeson and Longwell (1942). However, there have been many disagreements in the literature concerning utilization of leafy spurge by sheep (Landgraf et al. 1984) due to the aversive chemicals found in the latex of leafy spurge. Research by Lym and Kirby (1987) reported that cattle totally or partially avoid leafy spurge infested sites and intensify use on non-infested sites.

Multi-species grazing, the concurrent use of rangeland by more than one kind of animal, has been advocated to maximize animal production/acre (Merrill and Miller 1961). The utilization of more than one livestock species on a rangeland which contains various vegetative communities provides the potential of increasing species diversity, vegetative production, and ultimately red meat production/acre. However, no published reports have documented the potential use of sheep and cattle in a multi-species grazing approach to improve graminoid species use, increase plant richness, and to control leafy spurge on leafy spurge infested rangeland.

The objectives of this study were to:

1) Determine effects of multi-species grazing using twice-over rotation grazing system (**TOR**), season-long grazing treatments (**SL**), and non-use treatment (**NU**) on leafy spurge control.

2) Evaluate species diversity, herbage production, degree of disappearance of herbage, and livestock performance on TOR and SL using a multi-species grazing program.

Study Area

The research was conducted on two separate tracts of land in Morton County. The first tract was Sections 31 and 32, T139N, R81W, in south central North Dakota, approximately two miles southwest of Mandan. This tract consisted of 603 acres of native rangeland owned by the North Dakota State Correctional Center. The second tract was on the north half of Section 9, T138N, R81W on 237 acres of native rangeland operated by the Northern Great Plains Research Laboratory, approximately three miles south of Mandan. Both tracts are found in the Missouri Slope Prairie Region and associated with the Heart River Watershed. Vegetation in this region is typical of northern mixed grass prairie (Barker and Whitman 1988) and classified as a wheatgrass-grama-needle grass (*Agropyron*, *Bouteloua*, *Stipa*) plant community (Shiflet 1994). Leafy spurge infestations were mapped before the study and estimated to cover 30 percent of each tract of rangeland.

The TOR consists of four pastures grazed by one herd of cow/calf pairs and mature dry ewes. A total of 96 animal units (AU) of cattle (eight five 1200 lb. cows with calves) and 33 AU of sheep (two hundred 135 lb. mature white-face ewes without lambs), or a total 532 animal unit months (AUM), grazed the TOR treatment in 1996 and 1997. Cattle AU were reduced to 85 AU of cattle (seventy six 1200 lb. cows with calves) in 1998; however, sheep AU remained the same and a total 491 AUM grazed the TOR in 1998. In 1999 - 2005, stocking rates were increased to 120 AU of cattle (85 – 1420 lb cows with calves) and 42 AU of sheep (250 – mature white-face ewes without lambs), or 810 AUM of grazing. The overall stocking rate was 0.88 AUM/acre in 1996 and 1997, 0.82 AUM/acre in 1998, and 1.3 AUM/acre in 1999 - 2005. Cattle and sheep are rotated through the four pastures twice each year.

The SL treatment was grazed moderately light in 1996 due to lack of range evaluation data and unknown carrying capacities. Twenty-seven AU of cattle (thirty five 700 lb. yearling steers) and 8 AU of sheep (forty eight 135 lb. mature white-face ewes without lambs), or a total 144 AUM, grazed the SL treatment in 1996. Stocking densities were increased in 1997 - 2005 to include 37 AU of cattle (forty nine 705 lb. yearling steers) and 13 AU of sheep (seventy eight 135 lb. mature white-face ewes without lambs), or a total 250 AUM. The overall stocking rate was 0.61 AUM/acre in 1996 and 1.05 AUM/acre in 1997 - 2005. Cattle and sheep graze one pasture the entire grazing season each year.

Sheep were placed on pasture approximately 15 May each year when leafy spurge was ready for grazing and cattle on 1 June when native cool season grass species reach grazing readiness (3-4 leaf stage). Livestock species were removed from the treatments when 50 to 60 percent degree of graminoid disappearance was reached, or by 1 October.

Materials and Methods

Objective 1

Leafy spurge stem density was determined in three 32 ft by 16 ft exclosures/treatment. Each exclosure was subdivided in two 16 ft by 16 ft plots with one plot randomly assigned a grazed treatment (TOR or SL) and the second plot an ungrazed treatment (NU). A 2.5 ft buffer was placed along the inside border of each grazed and ungrazed plot to prevent an edge effect. Each plot was further stratified into 1.08 ft^2 (0.1 m^2) quadrats and each quadrat assigned a number. Ten 1.08 ft^2 quadrats were randomly selected in each treatment for leafy spurge stem density counts. Leafy spurge stem densities were collected in the first week of June throughout the duration of the study.

Objective 2

Forage production and degree of disappearance for leafy spurge, grass and grass-like, shrubs, and other forbs were determined using a pair-plot clipping technique (Milner and Hughes 1968). Eight cages were dispersed in each of the four pastures of the TOR; four cages in leafy spurge infested sites and four in non-infested sites. Twelve cages were systematically placed in the SL pastures; six cages in leafy spurge infested sites and six cages on non-infested sites. Two plots were clipped from each cage using a 2.7 ft^2 (0.25 m^2) frame.

Livestock performance and production were determined for both cattle and sheep and expressed as average daily gain (**ADG**). Weights were taken when animals were allocated to and removed from pastures each year.

Treatment and year effects for leafy spurge stem density, species richness, forb and shrub density, herbage production, degree of use, and livestock performance were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NY). Mean separation was performed using Tukey's Honesty Significant Difference when significant ($P < 0.05$) differences were found. Shannon Wiener Index was used to calculate species diversity indices for both leafy spurge infested and non leafy spurge infested range sites. Treatment and year effect's of species diversity was analyzed using a non-parametric test.

Results and Discussion

Leafy spurge stem density decreased ($P \leq 0.05$) on the SL after four grazing seasons while taking seven grazing seasons to achieve a similar decrease ($P \leq 0.05$) on TOR (Table 1). Following ten grazing seasons, leafy spurge stem density was reduced 100% for SL, and 94% for TOR. These results support trends observed by Lym et al. (1997), who evaluated multi-species grazing with cattle and angora goats. They reported season-long grazing reduced leafy spurge stem density faster than rotational grazing. Results of both studies suggest that season-long grazing using a multi-species approach will reduce leafy spurge stem density faster than rotational grazing.

Plant species diversity on non-infested and leafy spurge infested range sites was different ($P \geq 0.05$) in 1996 because of experimental design (Table 2). A year by site (grazed or ungrazed) by treatment interaction was observed after ten years of grazing ($P < 0.001$). Forb and shrub species density increased ($P < 0.05$) for leafy spurge infested sites in the TOR treatment, with no affect ($P > 0.05$) for the TOR native and the SL leafy spurge infested sites. However, forb and shrub species density decreased ($P < 0.05$) for the SL native site. One possible explanation for the decrease in forb and shrub species density for SL grazing could be the preference of sheep for leafy spurge. It appears that the sheep consumed the leafy spurge in the SL treatment to a greater extent that for TOR (supported by a quicker decrease in stem density for SL). This increased grazing pressure on these sites may have resulted in forb and shrub species being stressed by the increased in grazing pressure. While TOR did not decrease in stem density as quickly as SL, this slightly lower grazing pressure may have enhanced forb and shrub population, by decreasing leafy spurge stem density without the extra grazing pressure harming the forb and shrub species.

Cow and calf ADG for TOR and steer ADG for SL exhibited a year affect ($P < 0.001$). Cow ADG was highest ($P < 0.05$) in 2000, and lowest ($P < 0.05$) in 1998 (Table 3). However, calf ADG was highest ($P < 0.05$) in 2004, and lowest ($P < 0.05$) in 1997 (Table 3). Steer ADG was highest ($P < 0.05$) in 1999 and lowest ($P < 0.05$) in 2005 (Table 3). Ewe ADG for TOR was highest ($P < 0.05$) in 1996, and lowest ($P < 0.05$) in 2005. Season-long ewe ADG was highest ($P < 0.05$) in 2001, and lowest ($P < 0.05$) in 1999 and 2003. Results for ewe ADG are not readily explainable, as performance did not follow available standing forage. However, it appears that performance declined as leafy spurge stem density decreased, resulting in a decreased availability of nutrients from the leafy spurge for the sheep.

Conclusion

Season-long grazing of cattle and sheep will reduce leafy spurge in fewer grazing seasons than twice-over rotation grazing. However, it appears that with additional time twice-over rotation grazing will provide similar control to season-long grazing. Results for plant species diversity are inconclusive at this time. Additional years of treatment application should begin to yield significant results. Livestock performance results indicate that yearly variation exists, regardless of grazing management.

Literature Cited

Bangsund, D.A., D.J. Nudell, R.S. Sell, and F.L. Leistritz. 2000. Economic analysis of Controlling leafy spurge with sheep. N.D. Agr. Exp. Stat. N.D. Univ. Agr. Econ. Rep. No. 431-S. Fargo.

Bangsund, D.A., J.A. Leitch, and F.L. Leistritz. 1996. Economic analysis of herbicide control of leafy spurge in rangeland. N.D. State Univ. Agr. Exp. Sta., Agr. Econ. Rep. No. 342-S. Fargo. 11 p.

Barker, W.T. and W.C. Whitman. 1988. Vegetation of the northern Great Plains. Rangelands. 10:266-272.

Hanson, T.P. 1994. Leafy spurge control using Angora goats. M.S. Thesis. N.D. State Univ. Fargo. 111 p.

Helgeson, E.A. and E.J. Thompson. 1939. Control of leafy spurge by sheep. N.D. Agr. Exp. Sta. Bimonthly Bull. 2(1):5-9.

Helgeson, E.A. and E.J. Longwell. 1942. Control of leafy spurge by sheep. N.D. Agr. Exp. Sta. Bimonthly Bull. 4(5):10-12.

Landgraf, B., P.K. Fay, and K.M. Havstad. 1984. Utilization of leafy spurge by sheep. Weed Sci. 32(3):348-352.

Leitch, J.A., F.L. Leistritz, and D.A. Bangsund. 1994. Economic effect of leafy spurge in the upper Great Plains: methods, models, and results. Agr. Econ. Rep. No. 316. N.D. State Univ. Agr. Econ. Dept. Fargo.

Lym, R.G. and C.G. Messersmith. 1987. Carbohydrates in leafy spurge roots as influenced by environment. J. Range Manage. 40:139-144.

Lym, R.G., C.G. Messersmith, and R. Zollinger. 1995. Leafy spurge identification and control. N.D. State Univ. Ext. Serv. Circ. W-765 (revised). Fargo. 4 p.

Lym, R.G., K.K. Sedivec, and D.R. Kirby. 1997. Leafy spurge control with angora goats and herbicides. J. Range Manage. 50:123-128.

Merrill, L.B. and Miller. 1961. Economic analysis of year long grazing rate studies on substation No.14 near Sonora. Texas Agr. Prog. 12:13-14.

Merrill, L.B., P.O. Reardon, and C.L. Leinweber. 1966. Cattle, sheep, goats... mix'em up for higher gains. Texas Agr. Prog. 12:13-14.

Milner, C. and R.E. Hughes. 1968. Methods of the measurement of primary production of grassland. Blackwell Sci. Publ., Oxford, England.

Prosser, C.W. 1995. Multi-species grazing of leafy spurge infested rangeland in North Dakota. M.S. Thesis. N.D. State Univ. Fargo. 80 p.

Sedivec, K.K. and R.T. Maine. 1993. Angora goat grazing as a biological control for leafy spurge infested rangeland. In: Proc. 1993 Leafy Spurge Symp. Cranby, Colo.

Sedivec, K.K., W.T. Barker, and C.W. Prosser. 1995. Intensive grazing of Angora goats on leafy spurge infested rangeland. p. 34-36. In: Proc. Leafy Spurge Symp. Fargo, N.D.

Shiflets, T.N. 1994. Rangeland cover types of the United States. Soc. for Range Manage., Denver, CO. 154 pp.

Table 1. Effect of season-long and twice-over ration grazing on leafy spurge stem density/ 1.08 ft^2

	Treatment[a]		
Year	SL	TOR	SEM[b]
1996	14.37[x]	13.20[x]	2.28
1997	12.33[x]	15.90[x]	2.28
1998	11.57[x]	12.77[x]	2.28
1999	5.70[x]	13.43[y]	2.28
2000	1.15[x]	9.00[y]	2.28
% Reduction	**92%**	**32%**	---
2001	0.07[x]	9.53[y]	2.28
2002	0.00[x]	3.37[x]	2.28
2003	0.13[x]	3.53[x]	2.28
2004	0.03[x]	0.53[x]	2.28
2005	0.00[x]	0.80[x]	2.28
% Reduction	**100%**	**94%**	---

[a] SL = seaon-long; TOR = twice-over ration.
[b]Standard Error of Mean.
[xy]Within a row, means without a common superscript differ ($P < 0.05$).

Table 2. Effect of season-long and twice-over ration grazing on forb and shrub species density/2.7 ft^2

	Treatment[a]					
Year	SLN	SLS	TORN	TORS	SEM	P[c]
1996	14.79[dy]	0.06[cy]	8.46[dy]	0.94[cy]	2.88	< 0.001
2005	4.8[cz]	2.08[cy]	6.98[dy]	15.39[cz]	2.88	< 0.001

[a] SLN = season-long non-infested; SLS = season-long leafy spurge infested; TORN = twice-over ration non-infested; TORS = twice-over ration leafy spurge infested.
[b]Standard Error of Mean.
[c]P-value for F-test of treatment
[d,e] Within a row and treatment, means without a common superscript differ ($P < 0.05$).
[yz]Within a column, means without a common superscript differ ($P < 0.05$).

Table 3. Effect of multi- and single-species grazing on livestock average daily gains (lb/d; SE in parentheses)

	Treatment[a]				
Year	TOR Cow	TOR Calf	SL Steer	TOR Ewe	SL Ewe
1996	0.79[uvw]	2.34[st]	1.99[x]	0.32[z]	0.26[w]
1997	1.00[wx]	2.32[s]	1.84[vw]	0.25[wx]	0.28[w]
1998	0.00[t]	2.42[t]	1.54[t]	0.26[x]	0.23[v]
1999	0.67[uv]	2.64[v]	2.09[y]	0.24[vw]	0.17[st]
2000	1.39[y]	2.86[w]	1.91[wx]	0.30[y]	0.19[tu]
2001	0.85[vw]	2.55[u]	1.79[v]	0.20[u]	0.32[x]
2002	0.82[vw]	2.60[uv]	1.60[tu]	0.22[v]	0.21[uv]
2003	1.18[xy]	2.64[v]	1.66[u]	0.24[vw]	0.15[s]
2004	0.81[uvw]	3.00[x]	1.58[tu]	0.17[t]	0.23[v]
2005	0.59[u]	2.58[uv]	1.16[s]	0.15[s]	0.21[uv]
SEM	0.09	0.03	0.05	0.01	0.01

[a]TOR Cow = cow average daily gain for twice-over ration; TOR Calf = calf average daily gain for twice-over rotation; SL Steer = steer average daily gain for season-long; TOR Ewe = ewe average daily gain for twice-over ration; SL Ewe = ewe average daily gain for season-long.
[stuvwxyz]Within a column and livestock species, means without a common superscript differ ($P < 0.05$).

Effects of overnutrition and undernutrition on in vitro fertilization (IVF) and early embryonic development in sheep

A.T. Grazul-Bilska, E. Borowczyk, W. Arndt, J. Evoniuk, M. O'Neil, J.J. Bilski, R.M. Weigl, James D. Kirsch, Kim C. Kraft, K.A. Vonnahme, D.A. Redmer, L.P. Reynolds and J.S. Caton.

Department of Animal and Range Sciences, North Dakota State University, Fargo, ND, USA

ABSTRACT

Nutrition has been shown to influence several reproductive functions including hormone production, oocyte competence and fertilization, and early embryonic development. To determine effects of maternal diet on in vitro fertilization (IVF) and early embryonic development, ewes (n = 48; 58.4 ± 1.7 kg initial body weight [BW]; 2.3 ± 0.1 initial body condition score [BCS]) were divided into control, overfed (ad libitum feeding) and underfed (60% of control) nutritional planes for 8 weeks before oocyte collection. Ewes were individually fed once daily with pelleted diets containing 2.4 Mcal of ME/kg and 13% CP (DM basis). Control ewes were fed to maintain BW and offered 760 g/day/50 kg. Synchronization of estrus was performed using progestagen sponges for 14 days. Follicular development was induced by twice daily injections of follicle stimulating hormone (FSH) on days 13 and 14 of the estrous cycle. During the 8 week experiment, control ewes lost 1.0 ± 0.9 kg, overfed ewes gained 11.8 ± 1.1 but underfed ewes lost 14.2 ± 0.9 kg, and BCS increased by 0.7 ± 0.2 and by 2.0 ± 0.1for control and overfed ewes, respectively, but decreased by 0.7 ± 0.1 for underfed ewes to compare with initial BCS. Oocytes were collected from all visible follicles on day 15 of the estrous cycle. After IVF, the proportion of developing embryos was evaluated throughout the 8 day culture period. Overnutrition and undernutrition decreased ($P < 0.0001$) rates of cleavage, and morula and blastocyst formation (from 85% to 51% and 48%; from 63% to 18 and 28% and from 40% to 5% and 6% for control, overfed and underfed ewes, respectively). However, number of visible follicles (large and small), total number of oocytes, number of healthy oocytes and percentage of healthy oocytes were similar for control and underfed ewes. These data indicate that overnutrition and undernutrition of donor ewes resulting in lower BW and BCS, has a negative effect on oocyte quality which results in lower rates of cleavage, and morula and blastocyst formation. These data demonstrate that nutrition level substantially affect IVF and early embryonic development.

Key words: *overnutrition, undernutrition, assisted reproduction, IVF, embryo, sheep*

INTRODUCTION

Assisted reproductive technologies (ART) have many applications in agriculture. Research directed toward improved quality of oocytes and in vitro embryo production has predominantly focused on optimization of culture conditions (Thompson, 1997; Guler et al., 2000; Rizos et al., 2002) and/or diet manipulation of donor ewes (O'Callaghan et al., 2000; Lozano et al., 2003; Peura et al., 2003) and cows (Yaakub et al., 1999; Sinclair et al., 2000; Armstrong et al., 2001).

Nutritional status is a major factor influencing an animal's ability to reproduce (Robinson, 1990; Webb et al., 1999; O'Callaghan et al., 2000). Nutrition has a significant impact on numerous reproductive functions including hormone production, fertilization and early embryonic development (Boland et al., 2001; Armstrong et al., 2003; Boland and Lonergan, 2005). Nutritional status has been correlated with embryo survival and is a key factor influencing efficiency in ART (Armstrong et al., 2003; Webb et al., 2004). Conflicting results have been reported for the effects of low or high energy diets on oocyte quality and early embryonic development in ruminants (Kendrick et al., 1999; Boland et al., 2001; Papadopoulos et al., 2001). For example in sheep, low energy diets decreased cleavage rates compared with high energy diets (Papadopoulos et al., 2001). In contrast, a higher proportion of ova from ewes on low calorie diets were considered viable compared with those from ewes on high calorie diets (McEvoy et al., 1995). For cows, positive (Nolan et al., 1998; Kendrick et al., 1999; Boland et al., 2001), negative (Yaakub et al., 1999; Armstrong et al., 2001) or no effects (Tripp et al., 2000) of plane of nutrition (high or low energy diets) on oocyte quality, fertilization rate and early embryonic development have been reported. Therefore, additional study should clarify the effects of nutritional plane on oocyte quality and early embryonic development.

We hypothesized that overfeeding or underfeeding of donor ewes would alter oocyte quality as measured by the rates of fertilization and early embryonic development in vitro. Therefore, the aim of the present study was to evaluate the effects of nutritional plane (control vs. overfed or underfed) on follicular development, in vitro fertilization (IVF), and early embryonic development in FSH-treated ewes.

MATERIALS AND METHODS

Treatment of animals

Western range (predominantly Targhee and Rambouillet) 2-3 years old ewes were standardized for live weight and body condition score (BCS). Ewes were housed and fed in individual pens (0.86 x 1.47 m) at the Animal Nutrition and Physiology Center under 14 h of darkness and 10 h of light at 12°C with free access to water and mineral supplements. Ewes were divided into three groups: control (n = 13 ewes) received a maintenance diet (see below), overfed (n = 18 ewes) fed ad libitum, and underfed (n = 17 ewes) received 60% of the maintenance diet for two months before oocyte collection. Once a week, during the duration of the experiment ewes were weighed and BCS was evaluated. Estrus was synchronized by insertion of chrono-gest sponges (Intervet, UK) to the uterus for 14 days. By using vasectomized rams, estrus was detected 40-48 hours after sponge withdrawal. Ewes received twice daily (morning and evening) injections with FSH-P (Sioux Biochemical, Sioux Center, IA, USA) on days 13 (5 mg/injection) and 14 (4 mg/injection) following estrus (day 0) as described before (Stenbak et al., 2001). On day 15 of the estrus cycle ewes were ovariectomized (Luther et al. 2005). The study was initiated during the normal breeding season in August and finished in November. All procedures were performed at the animal experimental facilities of North Dakota State University (NDSU) located in Fargo, ND, USA (approximately 46.9° latitude and -96.8° longitude) and were approved by the Institutional Animal Care and Use Committee of NDSU.

Nutritional management

After arrival and a 3 day adaptation to individual pens and pelleted diets, ewes were allocated randomly to three nutritional groups as described above. The diet contained:

dehydrated beet pulp, 36.5%; dehydrated alfalfa, 20.3%; corn, 24.2%; soy hulls, 16%; soybean meal, 3.0% (% of dietary DM). The pelleted (0.48 cm diameter) diet, which was prepared and analyzed on site, supplied 2.4 Mcal/ME and 130 g crude protein (13%) per kg of diet DM basis and was offered in one portion daily. Dietary management procedures for both groups were similar to those described by Scheaffer et al., 2004a,b. The maintenance diet, which was prepared and analyzed on site on a weekly basis, supplies 2.4 Mcal/kg of metabolizable energy and 130 g crude protein (13%) per kilogram diet and was offered in one equal ration daily. The control group received 760 g/day/50 kg (100%), overfed group was fed ad libitum (200% or more of control) and the underfed group received 456 g/day/50 kg (60%) of the maintenance diet (dry matter basis).

Oocyte collection

Following ovariectomy, ovaries were immersed in PBS and transported to the laboratory in an incubator at 39°C. The number of visible small ($\leq$ 3mm) and large (> 3mm) follicles on each ovary was determined, and cumulus oocyte complexes (COC) were isolated by opening each visible follicle with a scalpel blade and flushing it two to three times with oocyte collection medium (Grazul-Bilska et al., 2003, 2005; Luther et al., 2005). Under a stereomicroscope, COC were recovered from each dish and transferred to a petri dish containing fresh collection medium without heparin. Cumulus oocyte complexes were then evaluated and categorized as healthy or atretic based on their morphology (Thompson et al., 1995). All COC were then washed three times in maturation medium (TCM-199 containing 10% fetal bovine serum, ovine FSH [5 μg/mL; oFSH-RP-1; NIAMDD-NIH, Bethesda, MD, USA], ovine LH [5 μg/mL; oLH-26; NIADDK-NIH], estradiol -17β [1 μg/mL; Sigma St. Louis, MO, USA], glutamine [2 mM; Sigma], sodium pyruvate [0.25 mM; Sigma], epidermal growth factor [10 ng/mL; Sigma,] and penicillin/streptomycin [100 units/mL penicillin and 100 μg/mL streptomycin; Gibco, Grand Island, NY, USA]; Grazul-Bilska et al. 2003, 2005; Luther et al. 2005). Total number of oocytes used for IVF was 162 for control, 264 for overfed and 232 for underfed ewes.

In vitro maturation

Oocytes were matured in vitro in maturation medium for 24 h at 39°C in 5% CO_2 and 95% air followed by cumulus cell removal using 1% (wt/vol) hyaluronidase (Type I; Sigma) in PBS. The oocytes were again evaluated for health based on morphology. Oocytes classified as healthy were used for IVF and were transferred to equilibrated fertilization medium consisting of synthetic oviductal fluid (SOF) prepared in our laboratory (Stenbak et al., 2001) and 2% heat-inactivated sheep serum collected from sheep on day 0-1 of the estrous cycle (Grazul-Bilska et al., 2003, 2005; Luther et al., 2005).

In vitro fertilization and embryo culture

Frozen capacitated semen pooled from 4 Hampshire rams was thawed and viable sperm were separated using the swim up technique (Grazul-Bilska et al., 2005). The sperm (0.5 to 1.0 x 10^6 sperm/mL) were added to the IVF medium containing oocytes and incubated for 18 h at 39ºC, 5% O_2, 5% CO_2 and 90% N_2. The presumptive zygotes were then washed three times with culture medium without glucose (SOF supplemented with BSA, glutamine, MEM non-essential amino acids, BME amino acids [Sigma] and penicillin/streptomycin) and cultured in the same medium for 24 h at 39ºC, 5% O_2, 5% CO_2 and 90% N_2 (Grazul-Bilska et al., 2003, 2005). The dishes were then evaluated to determine the number of cleaved oocytes. The embryos were transferred to culture medium containing glucose (1.5 mM). After 48 h, the developmental stage was evaluated and embryos were transferred to fresh culture medium with glucose. The rate of cleavage (number of cleaved vs. non-cleaved oocytes), and the rate of early embryonic development (time and percentage reaching stage of morula or blastocyst) were evaluated every second day during 8 day culture.

Statistical analysis

To compare changes in BW, average daily gain (ADG) and BCS during the experiment, number of follicles and oocytes, and oocyte quality variables (e.g., the rates of cleavage, and morula and blastocyst formation) for control and underfed ewes, data were analyzed statistically by using the GLM program of SAS (SAS Inst., Inc., Cary, NC). Means were separated using the method of least significant difference. In addition, data for the proportion of overfed and underfed ewes providing oocytes which developed to blastocyst stage were analyzed by Chi-square.

RESULTS

At the time treatment was initiated, BW was similar for control, overfed and underfed groups (56.7± 2.1, 60.7± 1.2 and 57.8 ± 1.8 kg respectively; Figure 1A). At the end of 8 week the experiment, BW of overfed ewes was greater ($P<0.01$) than control or underfed ewes, and BW of underfed ewes was lower ($P < 0.05$) than control ewes (Figure 1A). Changes in BW were significantly different ($P < 0.001$) for nutrition groups at week 8 (Table 1). Average daily gains were greater or lower ($P < 0.001$) for overfed or underfed compared with control ewes during the during 8 week of experiment, respectively (Table 1). When compared to initial BW, control ewes lost 1.0 ± 0.9 kg, overfed ewes gained 11.8 ± 1.1 but underfed ewes lost 14.2 ± 0.9 kg over the 8 week experiment.

At the beginning of treatment, BCS was similar for control, overfed and underfed ewes (2.3 ± 0.1, 2.3 ± 0.1 and 2.4 ± 0.1 respectively; Figure 1B). Body condition score of overfed ewes was greater ($P < 0.001$) than control or underfed ewes at week 8 of the experiment (Figure 2B). Changes in BCS were significantly different ($P < 0.001$) for nutrition groups at week 8 (Table 1). During 8 week experiment, BCS increased by 0.7 ± 0.2 and by 2.0 ± 0.1 for control and overfed ewes, respectively, but decreased by 0.7 ± 0.1 for underfed ewes to compare with initial BCS.

Mean number of visible follicles, number of large and small follicles, total number of oocytes, number of healthy oocytes, percentage of healthy oocytes, and the number of oocytes used for IVF per ewe were similar for control, overfed and underfed groups (Table 1). The number of oocytes cleaved, cleavage rates, number of morula and blastocysts and the rates of morula and blastocyst formation were greater ($P < 0.0001$ to 0.057) for control compared with overfed or underfed ewes (Table 1). Proportion of ewes providing oocytes which developed to blastocyst stage tended ($P<0.1$) to be greater in underfed than overfed ewes.

Table 1. Effects of nutrition on the follicular development, the number collected oocytes, the number of healthy oocytes, the rates of cleavage and morula and blastocyst formation, and BW, ADG and BCS

Parameter	Control	Overfed	Underfed	*P* value
Number of ewes	13	18	17	
Total follicles (n)	27.5 ± 2.7	26.7 ± 2.2	25.8 ± 2.2	0.885
Large follicles (n)	12.9 ± 1.1	14.8 ± 1.5	14.5 ± 1.4	0.638
Small follicles (n)	14.5 ±2.3	11.9 ± 1.3	11.3 ± 1.6	0.402
Total Oocytes (n)	26.1 ± 2.8	25.9 ± 2.2	23.3 ± 2.4	0.651
Healthy oocytes (n)	22.5 ± 2.7	24.3 ± 2.0	21.5 ± 2.2	0.641
Healthy oocytes (%)	86.1 ± 4.5	94.7± 1.4	92.5 ± 1.6	0.063
Oocytes used for IVF	12.5 ± 0.9	14.7 ± 1.2	13.6 ± 1.4	0.490
Cleaved oocytes (n)	10.5 ± 0.9	7.5 ± 1.2	6.6 ± 1.1	0.057
Cleavage rate (%)	84.8 ± 2.5	51.1 ± 7.0	48.0 ± 5.1	0.0001
Morula (n)	6.5 ± 0.5	1.7 ± 0.5	1.7 ± 0.4	0.0001
Morula (%)	63.2 ± 4.8	17.6 ± 4.8	27.6 ± 6.5	0.0001
Blastocyst (n)	4.2 ± 0.4	0.4 ± 0.2	0.4 ± 0.1	0.0001
Blastocyst (%)	40.1 ± 3.6	5.0 ± 3.4	6.4 ± 3.2	0.0001
Initial BW (kg)	56.7 ± 2.1	60.7 ± 1.2	57.8 ± 1.8	0.232
Final BW (kg)	55.7 ± 1.6	72.5 ± 1.1	43.7 ± 1.2	0.0001
Difference in BW (kg)	-1.0 ± 0.9	11.8 ± 1.1	-14.2 ± 0.9	0.0001
ADG (kg)	-0.02 ± 0.01	0.20 ± 0.02	-0.24 ± 0.01	0.0001
Initial BCS	2.3 ±0.1	2.3 ± 0.1	2.4 ± 0.1	0.299
Final BCS	3.0 ±0.2	4.2 ± 0.1	1.8 ± 0.1	0.0001
Difference in BCS	0.7 ± 0.2	2.0 ± 0.1	-0.7 ± 0.1	0.0001

*All values (mean ± SEM) are expressed per ewe.

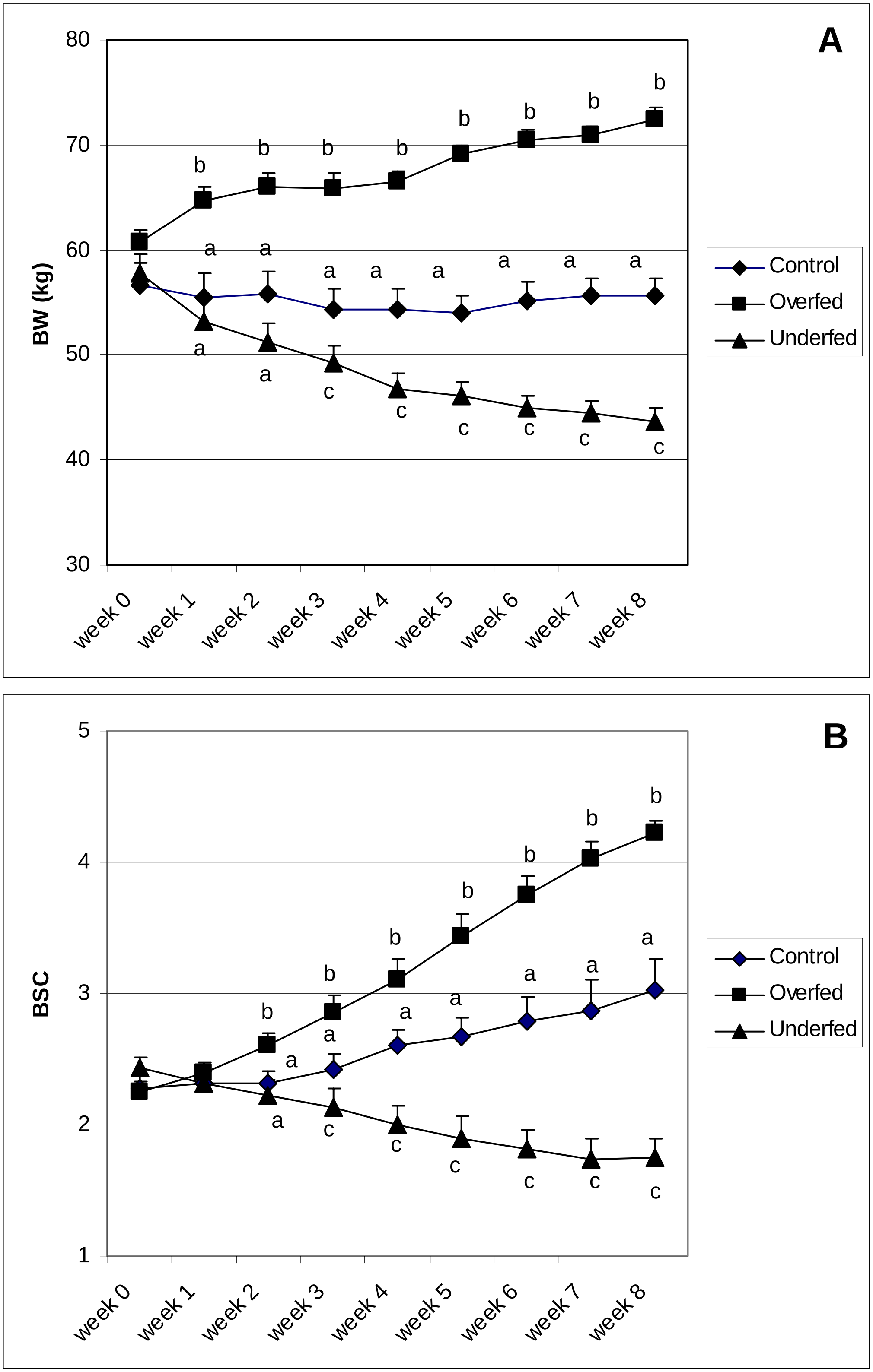


Figure 1. Body weight (A) and BCS (B) in control (black bars), overfed (grey bars) and underfed (open bars). $^{a,b,c}P < 0.0001$; Means ± SEM with different superscripts differ within a specific week.

DISCUSSION

The present study demonstrated that overfeeding and underfeeding of ewes resulted in lower BW and BCS when compared to control ewes. Furthermore, oocytes derived from overfed and underfed ewes yielded fewer zygotes, morulas and blastocysts and had lower rates of cleavage, and morula and blastocyst formation compared with oocytes derived from control ewes.

In previous studies, for mature ewes fed a low energy diet (approximately 0.5 - 0.6 times maintenance energy requirement) for 3 to 4 week, decreased BCS (from 2.61 to 2.1 and from 2.5 to 2.33; Abecia et al., 1999 and Lozano et al., 2003, respectively) was observed along with decreased cleavage rates, number of good quality embryos and the rates of pregnancy. On the other hand, ewes ad libitum feeding for approximately 3 week resulted in enhanced BCS (from 2.58 to 2.7), but lower superovulation responses, lower number of good quality oocytes and embryos, and a greater percentage of poorly developed embryos in mature ewes (Lozano et al., 2003). In addition, Snijders et al. (2000) demonstrated that rates of cleavage and blastocyst formation from oocytes derived from cows with BCS 1.5-2.5 were lower (70.4 vs. 77.4%, and 6.8% vs. 11.4%, respectively) compared with those from cows with BCS 3.3-4.0 during the first or third lactation. These data and also our data indicate that decreased or increased BCS may be associated with decreased oocyte quality measured by the rates of in vitro fertilization and early embryonic development in sheep. This suggests that BCS can be used to predict successful embryonic development in sheep. However, determination of BCS is relatively subjective and may vary from study to study.

In the present experiment, nutritional plane had no effect on the number of ovarian follicles. Peura et al. (2003) reported for adult ewes that low (0.7 x) or high (1.3 x) maintenance diets for 3 to 5 months before FSH-induced superovulation did not affect ovulation rates. Moreover, superovulatory responses after FSH-treatment were not affected by 0.5 x, 1.0 x or 1.5 x maintenance diet fed during peri-conception period in adult ewes (Kakar et al., 2005). These data indicates that these specific nutritional treatments did not affect follicular development measured by the number of follicles or ovulations in sheep. The number of follicles was similar in lactating dairy cows (not treated with FSH) receiving low (1.52 Mcal NE_l /kg DM) or high (1.78 Mcal NE_l /kg DM) energy diet for approximately 25 week postpartum (Kendrick et al., 1999) and in yearling beef heifers (not treated with FSH) fed ad libitum or 0.75 x ad libitum for 100 d (Tripp et al., 2000). On the other hand, FSH-treated beef heifers fed a low energy (9.6 Mcal/kg ME/d) diet for 17 to19 days had more follicles than cows fed a high energy (28.6 Mcal/kg ME/d) diet (Nolan et al., 1998). Thus, these results show that nutritional treatments had no effect on the number of visible follicles in sheep but not in cows. Moreover, number of follicles in the present study was similar to that previously reported for FSH-treated mature ewes fed a maintenance diet during the normal breeding season and seasonal anestrus (Stenbak et al., 2001; Grazul-Bilska et al., 2003; Luther et al., 2005).

The cleavage rates were lower for overfed (51%) or underfed (48%) compared with control (85%) ewes in our study. Papadopoulos et al. (2001) have also shown that cleavage rates were decreased (from 88% to 66%) in ewes fed a low energy (0.5 x maintenance energy requirements) diet in comparison with a high energy (2 x maintenance energy requirements) diet for 28 days. Similar to our results for overfed or underfed ewes, low cleavage rates, 51% and 35%, were observed for ewes underfed (0.5 x maintenance energy requirements) and overfed (ad libitum intake) for approximately 24 days, respectively (Lozano et al., 2003). This indicates that inadequate diet (e.g., underfeeding or feeding ad libitum) affects oocyte quality measured by IVF rates in sheep. In addition, rates of cleavage similar to cleavage rates in our control group were reported for mature sheep fed a maintenance diet (Watson et al., 1994; Ledda et al., 1997; O'Brien et al., 1997). Thus, the rates of fertilization may be influenced by different nutritional regimens under which oocytes were developed in the maternal environment.

In the present study, the number of morulas and blastocysts and the rate of morula and blastocyst formation were lower for overfed and underfed ewes compared with control ewes. In contrast, Lozano et al. (2003) demonstrated that restricted diets (0.5 x of maintenance diet for about 24 days) did not affect the rates of blastocyst formation in mature sheep. Moreover, supplementation with urea to the diet with low energy (0.5 x of maintenance) did not affect the blastocyst cell number and blastocyst hatching rate in sheep (Papadopoulos et al., 2001). Studies of McEvoy (1995) demonstrated that embryos in the early stage of development, produced in vivo and then cultured in vitro collected from mature ewes fed a low calories (0.6 x maintenance) diet for about 2 week, were considered more viable, had a greater protein synthesis index and number of nuclei in the blastocyst compared with those produced in ewes fed a high calorie diet. In addition, the greater number of cells in blastocysts produced in vivo was observed for ewes fed low calories diet (0.5 x maintenance diet) to compare with ewes fed 1 x or 1.5 x maintenance diet during peri-conception period (Kakar et al., 2005). Data from these two studies indicate that ewe is able to respond to acute changes in nutrition during peri-conception period, resulting in changes of embryonic development. For yearling beef heifers, restriction of dietary energy (75% of ad libitum fed) did not affect the rate of blastocyst formation (Tripp et al., 2000). Therefore, it seems that the level of overfeeding or feed restriction and/or length of specific feeding reported in some studies were not severe enough to induce a negative impact on the rate of blastocyst formation, which was observed in the current study. Moreover, the effects of nutritional treatment on blastocyst formation may also depend on specific diet composition and breed.

Numerous experiments indicate that nutrition has direct effects on some reproductive function by affecting hormonal production (O'Callaghan and Boland, 1999; Lucy, 2003; Hunter et al., 2004). For example, for underfed or overfed mature ewes with enhanced or decreased blood progesterone concentrations, respectively, altered oocyte and embryo quality was observed (Lozano et al., 2003). This indicates that effects of nutrition on oocyte and embryonic development may be indirectly linked through regulation of hormone secretion. In the present study, we have not evaluated the level of hormones in peripheral blood. Therefore, future studies should be undertaken to further define association between hormone levels and oocyte quality.

The effects of nutrition on oocyte and embryonic development may reflect the general energy balance (e.g., maintenance diet vs. low or high energy diets) but also can be attributed to the specific nutrients in diets, such as vitamins, minerals and other supplements (Wrenzycki et al., 2000). For example, Tarin et al. (1998) observed that supplementation with a mixture of vitamins C and E to the maternal diet enhanced the number of ovulations but did not affect the rates of cleavage or blastocyst formation in mice. Moreover, McEvoy et al. (1997) demonstrated that high concentration of urea in diet fed for 12 week increased embryo mortality and decreased pregnancy rates after embryo transfer in mature sheep. Additional studies should be undertaken to determine which nutritional factors affect oocyte quality.

In conclusion, our results demonstrate that overnutrition and undernutrition did not affect number of developing follicles, number of recovered oocytes, number and percentage of healthy oocytes per ewe, but decreased number of cleaved oocytes, and the rates of fertilization and morula and blastocyst formation. These data indicate that donor animals likely require specific nutritional management procedures to provide the highest quality oocytes for ART. Nutrition of donor animals seems to be a key component affecting development of oocytes and the preimplantation embryo. We manipulated total dietary intake in the present study, but future investigations that address specific dietary nutrient composition should provide insight into the underlying mechanisms associated with changes in efficiency of in vitro embryo production.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Tim Johnson, Mr. Wes Limesand and Mr. Terry Skunberg, and other members of our laboratory for their technical assistance.

LITERATURE CITED

Abecia, J. A., F. Forcada, and J. M. Lozano. 1999. A preliminary report on the effect of dietary energy on prostaglandin F2alpha production in vitro, interferon-tau synthesis by the conceptus, endometrial progesterone concentration on days 9 and 15 of pregnancy and associated rates of embryo wastage in ewes. Theriogenology 52:1203-1213.

Armstrong, D. G., J. G. Gong, and R. Webb. 2003. Interactions between nutrition and ovarian activity in cattle: physiological, cellular and molecular mechanisms. Reproduction Suppl. 61:403-414.

Armstrong, D. G., T. G. McEvoy, G. Baxter, J. J. Robinson, C. O. Hogg, K. J. Woad, R. Webb, and K. D. Sinclair. 2001. Effect of dietary energy and protein on bovine follicular dynamics and embryo production in vitro: associations with the ovarian insulin-like growth factor system. Biol. Reprod. 64:1624-1632.

Boland, M. P., P. Lonergan, and D. O'Callaghan. 2001. Effect of nutrition on endocrine parameters, ovarian physiology, and oocyte and embryo development. Theriogenology 55:1323-40.

Boland, M. P. and P. Lonergan. 2005. Effects of nutrition on fertility in dairy cows. Adv. Dairy Techn. 15:19-33.

Grazul-Bilska, A. T., J. T. Choi, J. J. Bilski, R. M. Weigl, J. D. Kirsch, K. C. Kraft, L. P. Reynolds, and D. A. Redmer. 2003. Effects of epidermal growth factor on early embryonic development after in vitro fertilization of oocytes collected from ewes treated with follicle stimulating hormone. Theriogenology 59:1453-1461.

Grazul-Bilska, A. T., D. Pant, J. S. Luther, P. P. Borowicz, C. Navanukraw, J. S. Caton, M. A. Ward, D. A. Redmer and L. P. Reynolds. 2005. Pregnancy rates and gravid uterine parameters in naturally bred ewes and ewes after transfer of in vitro produced embryos, and in single, twin and triplet pregnancies. Anim. Reprod. Sci. (in press).

Guler, A., N. Poulin, P. Mermillod, M. Terqui, and Y. Cognie. 2000. Effects of growth factors, EGF and IGF-1, and estradiol on in vitro maturation of sheep oocytes. Theriogenology 54:209-218.

Hunter, M.G., R.S. Robinson, G.E. Mann, and R. Webb. 2004. Endocrine and paracrine control of follicular development and ovulation rate in farm species. Anim. Reprod. Sci. 82-93:461-477.

Kakar, M.A., S. Maddocks, M.F. Lorimer, D.O. Kleemann, S.R. Rudiger, K.M.Hartwich, and S.K. Walker. 2005. The effect of peri-conception nutrition on embryo quality in the superovulated ewe. Theriogenology 64:1090-1103.

Kendrick, K. W., T. L. Bailey, A. S. Garst, A. W. Pryor, A. Ahmadzadeh, R. M. Akers, W. E. Eyestone, R. E. Pearson, and F. C. Gwazdauskas. 1999. Effects of energy balance of hormones, ovarian activity, and recovered oocytes in lactating Holstein cows using transvaginal follicular aspiration. J. Dairy Sci. 82:1731-1741.

Ledda, S., L. Boglio, P. Calvia, G. Leoni, and S. Naitana. 1997. Meiotic progression and developmental competence of oocytes collected from juvenile and adult ewes. J. Reprod. Fertil. 109:73-78.

Lozano, J. M., P. Lonergan, M. P. Boland, and D. O'Callaghan. 2003. Influence of nutrition on the effectiveness of superovulation programs in ewes: effect on oocyte quality and post-fertilization development. Reproduction 125:543-553.

Lucy, M. C. 2003. Mechanisms linking nutrition and reproduction in postpartum cows. Reproduction Suppl. 61:415-427.

Luther, J. S., D. A. Redmer, L. P. Reynolds, J. T. Choi, D. Pant, C. Navanukraw, D. R. Arnold, A. N. Scheaffer, P. Borowicz, J. D. Kirsch, R. M. Weigl, K. C. Kraft, and A. T. Grazul-Bilska. 2005. Ovarian follicular development and oocyte quality in anestrous ewes treated with melatonin, and controlled internal drug release (CIDR) device and follicle stimulating hormone. Theriogenology 63:2136-2146.

McEvoy, T. G., J. J. Robinson, R. P. Aitken, P. A. Findlay, R. M. Palmer, and I. S. Robertson. 1995. Dietary-induced suppression of pre-ovulatory progesterone concentrations in superovulated ewes impairs the subsequent in vivo and in vitro development of their ova. Anim. Reprod. Sci. 39:89-107.

McEvoy, T. G., J. J. Robinson, R. P. Aitken, P. A. Findlay, and I. S. Robertson. 1997. Dietary excesses of urea influence the viability and metabolism of preimplantation sheep embryos and may affect fetal growth among survivors. Anim. Reprod. Sci. 47:71-90.

Nolan, R., D. O'Callaghan, R. T. Duby, P. Lonergan, and M. P. Boland. 1998. The influence of short-term nutrient changes on follicle growth and embryo production following superovulation in beef heifers. Theriogenology 50:1263-1274.

O'Brien, J. K., S. L. Catt, K. A. Ireland, W. M. C. Maxwell, and G. Evans. 1997. In vitro and in vivo developmental capacity of oocytes from prepubertal and adult sheep. Theriogenology 47:1433-1443.

O'Callaghan, D., and M. P. Boland. 1999. Nutritional effects on ovulation, embryo development and the establishment of pregnancy in ruminants. Anim. Sci. 68:299-314.

O'Callaghan, D., H. Yaakub, P. Hyttel, L. J. Spicer, and M. P. Boland. 2000. Effect of nutrition and superovulation on oocyte morphology, follicular fluid composition and systemic hormone concentrations in ewes. J. Reprod. Fertil. 18:303-313.

Pant, D., L. P. Reynolds, J. S. Luther, P. P. Borowicz, T. Stenbak, J. J. Bilski, R. M. Weigl, F. Lopes, M. L. Johnson, D. A. Redmer, and A. T. Grazul-Bilska. 2005. Expression of connexin 43 and gap junctional intercellular communication in cumulus oocyte complex in sheep. Reproduction 19:191-200.

Papadopoulos, S., P. Lonergan, V. Gath, K. M. Quinn, A. C. Evans, D. O'Callaghan, and M. P. Boland. 2001. Effect of diet quantity and urea supplementation on oocyte and embryo quality in sheep. Theriogenology 55:1059-1069.

Peura, T. T., D. O. Kleemann, S. R. Rudiger, G. S. Nattrass, C. J. McLaughlan, and S. K. Walker. 2003. Effect of nutrition of oocyte donor on the outcomes of somatic cell nuclear transfer in the sheep. Biol. Reprod. 68:45-50.

Rizos, D., F. Ward, P. Duffy, M. P. Boland, and P. Lonergan. 2002. Consequences of bovine oocyte maturation, fertilization or early embryo development in vitro versus in vivo: implications for blastocyst yield and blastocyst quality. Mol. Reprod. Dev. 61:234-248.
Robinson, J. J. 1990. Nutrition in the reproduction of farm animals. Nutr. Res. Rev. 3:961-966.
Sinclair, K. D., M. Kuran, F. E. Gebbie, R. Webb, and T. G. McEvoy. 2000. Nitrogen metabolism and fertility in cattle: II. Development of oocytes recovered from heifers offered diets differing in their rate of nitrogen release in the rumen. J. Anim. Sci. 78:2670-2680.
Snijders, S. E. M., P. Dillon, D. O. Callaghan, and M. P. Boland. 2000. Effect of genetic merit, milk yield, body condition and lactation number on in vitro oocyte development in dairy cows. Theriogenology 53:981-989.
Stenbak, T. K., D. A. Redmer, H. R. Berginski, A. S. Erickson, C. Navanukraw, M. J. Toutges, J. J. Bilski, J. D. Kirsch, K. C. Kraft, L. P. Reynolds, and A. T. Grazul-Bilska. 2001. Effects of follicle stimulating hormone (FSH) on follicular development, oocyte retrieval, and in vitro fertilization (IVF) in ewes during breeding season and seasonal anestrous. Theriogenology 56:51-64.
Tarin, J., J. Ten, F. J. Vendrell, M. N. M. De Oliveira, and A. Cano. 1998. Effects of maternal ageing and dietary antioxidant supplementation on ovulation, fertilization and embryo development in vitro in the mouse. Reprod. Nutr. Dev. 38:499-508.
Thompson, J. G. 1997. Comparison between in vitro-derived and in vitro-produced pre-elongation embryos from domestic ruminants. Reprod. Fertil. Dev. 9:341-354.
Thompson, J. G., D. K. Gardner, P. A. Pugh, W. H. McMillan, and H. R. Tervit. 1995. Lamb birth weight is affected by culture system utilized during in vitro pre-elongation development of ovine embryos. Biol. Reprod. 53:1385-1391.
Tripp, M. W., J. C. Ju, T. A. Hoagland, J. W. Riesen, X. Yang, and S. A. Zinn. 2000. Influence of somatotropin and nutrition on bovine oocyte retrieval and in vitro development. Theriogenology 53:1581-1590.
Watson, A. J., P. H. Watson, D. Warnes, S. K. Walker, D. T. Armstrong, and R. F. Seamark. 1994. Preimplantation development of in vitro-matured and in vivo-fertilized ovine zygotes: comparison between coculture on oviduct epithelial cell monolayers and culture under low oxygen atmosphere. Biol. Reprod. 50:715-724.
Webb, R., R. G. Gosden, E. E. Telfer, and R.M. Moor. 1999. Factors affecting folliculogenesis in ruminants. Anim. Sci. 68:257-284.
Webb, R., P.C. Garnsworthy, J.-G. Gong, D.G. Armstrong. 2004. Control of follicular growth: local interactions and nutritional influences. J. Anim. Sci. 82(E-Suppl.):E63-E74.
Wrenzycki, C., P. De Sousa, E. W. Overstrom, R. T. Duby, D. Herrmann, A. J. Watson, H. Niemann, D. O'Callaghan, and M. P. Boland. 2000. Effects of superovulated heifer diet type and quantity on relative mRNA abundances and pyruvate metabolism in recovered embryos. J. Reprod. Fertil. 118:69-78.
Yaakub, H., D. O'Callaghan, and M. P. Boland. 1999. Effect of type and quantity of concentrates on superovulation and embryo yield in beef heifers. Theriogenology 51:1259-1266.

PRODUCTION AND MARKETING PRACTICES OF NORTHERN GREAT PLAINS LIVESTOCK PRODUCERS

Nancy M. Hodur[1], F. Larry Leistritz[1], and Dan Nudell[2*]

[1] Department of Agribusiness and Applied Economics, North Dakota State University
[2]Hettinger Research Extension Center, North Dakota State University

Ruminant livestock production in North Dakota, South Dakota, Montana, and Wyoming is critical to the region's economy. Producers in the four-state area are continually looking for opportunities to increase income and improve the viability of their farm and ranch operation. This study identified factors that influence and perhaps constrain producers' ability or willingness to background feeder cattle. Study objectives were to identify and document producers' current production and marketing practices as well as identify stock growers' perceptions of opportunities for and impediments to expansion of the ruminant livestock industry in the study area. The potential for growth in the livestock sector through expanded backgrounding and retained ownership appears to be substantial.

Introduction

Ruminant livestock production in North Dakota, South Dakota, Montana, and Wyoming is critical to the region's economy. For example in 2002, 59 percent of farms and ranches in the four-state study area raised beef cattle, while more than 8 percent raised sheep and lambs (USDA 2004). Producers in the four-state area are continually looking for opportunities to increase income and improve the viability of their farm and ranch operation. Accordingly, the Four-state Ruminant Consortium, an integrated research and extension program, was created to do just that. Specifically, the purpose of the four-state ruminant consortium is to enhance economic development in the target study area of southwestern North Dakota, northwestern South Dakota, southeastern Montana, and northeastern Wyoming by strengthening and capturing value from the ruminant livestock industry.

One of the more widely applicable possibilities for adding value through the regions's ruminant livestock sector appears to be backgrounding feeder calves. However, while economic analysis has indicated that stockgrowers in the study area could typically increase their net returns by backgrounding feeder calves, relatively few producers are presently backgrounding feeder calves. A more thorough understanding of current livestock production, management, and marketing practices would facilitate research and extension programs as well as serve as a baseline for future evaluation of the impact of the four-state ruminant consortium program.

* Special acknowledgment to Clint Clark, South Dakota State University Extension Service, Tayna Daniels, University of Wyoming Extension Service, Duane Griffith, Montana State University Extension Service, and Dean Bangsund, Department of Agribusiness and Applied Economics, North Dakota State University for guidance and assistance in the development of the survey instrument.

To identify the socioeconomic impediments inhibiting producers from backgrounding feeder cattle, this study sought to identify managerial, social, and institutional factors that influence and perhaps constrain producers' ability or willingness to background feeder cattle. Study objectives were to identify and document producers' current production and marketing practices as well as identify stock growers' perception of opportunities for and impediment to expansion of the ruminant livestock industry in the study area.

Methods

A mail questionnaire was delivered to 5,971 livestock producers in 37 counties in the four-state study area (Figure1). The questionnaire was designed to solicit a wide variety of information about operators' current production practices, including marketing, backgrounding, retained ownership, herd management, and feed and forage practices. The questionnaire also solicited operators' attitudes on a wide variety of issues related to opportunities for and impediments to the expansion of the ruminant livestock industry in the study area as well as asking respondents to identify what types of information would be of most interest to them and in what form they would prefer that information be delivered. Overall response rate was just below 20 percent with by-state response rates of 17 percent in North Dakota, 20 percent in Montana, 21 percent in South Dakota, and 22 percent in Wyoming. This report summarizes selected findings from the survey of livestock operators in the four-state area. Complete survey results pending publication early in 2006.

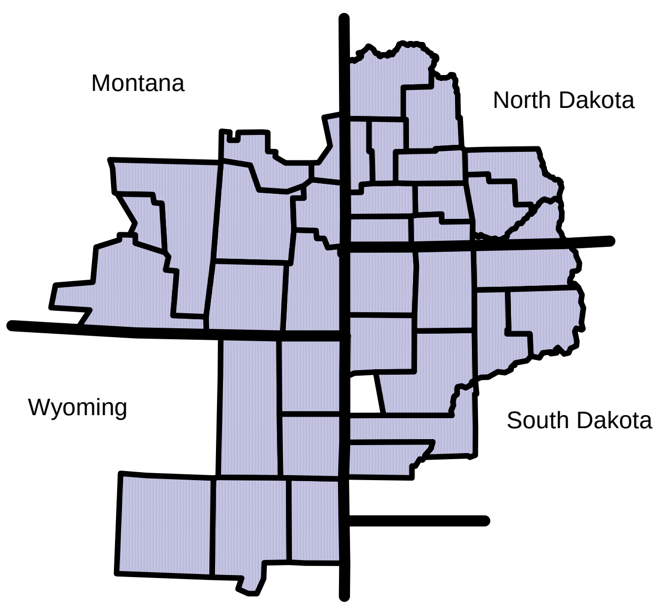


Figure 1. Study Area

Results

Current Production Practices

Producers in the four-state study area had on average 215 commercial beef cows, 36 commercial beef replacement heifers, and 61 feeder calves (Table 1) on their ranch as of January 1, 2005. Respondents most frequently (34 percent) reported 1 to 100 head of cows, while a large majority of producers, 80 percent, reported from 1 to 300 head of cows, ranging from 75 percent in Wyoming to 87 percent in North Dakota. Twelve percent of respondents in North Dakota reported more than 300 head of cows compared to 21 percent in South Dakota, 22 percent in Wyoming and 25 percent in Wyoming.

The average number of feeder calves on the ranch as of January 1, 2005 was reported to be 61 head, ranging from 46 head in South Dakota to 74 head in Montana. Because many producers sell part or all of their calves before January 1, respondents were also asked how many calves they typically raise annually from their own cows. Overall, respondents reported an average of 204 feeder calves raised, ranging from 163 in North Dakota to 245 in Wyoming (Table 1). Respondents most frequently reported raising from 1 to 100 head of calves (35 percent) with about three-fourths reporting 1 to 300 head of calves from their own cows.

Roughly two thirds (65 percent) of feeder calves in the study area were weaned in October with most of the remaining feeder calves weaned in November (data not shown). Only 8 percent of feeder calves were weaned in months other than October and November. Per state results were consistent with overall results. Weaning weights were most frequently in the 500 to 600 pound range (64 percent) with an average weaning weight of 562 pounds (Table 2). There was very little variation in average weaning weights by state. Weaning weights for the remaining calves were fairly evenly divided. Seventeen percent were weaned between 400 and 500 pounds, and 16 percent were weaned between 600 and 700 pounds with very few weaned at over 700 pounds or under 400 pounds (less than 3 percent). Results in North Dakota, South Dakota, and Montana were consistent with overall results; however, Wyoming ranchers reported weaning slightly more feeder calves in the 400 to 500 pound range (26 percent) and slightly fewer feeder calves in the 600 to 700 pound range (9 percent) (Table 2).

Marketing of Weaned Calves

About three-fourths of respondents reported marketing at least some of their calves at weaning, right off the cow (Table 3). Statewide averages ranged from 63 percent of respondents in North Dakota to 81 percent of respondents in Montana that marketed at least some of their calves at weaning. Across the four states, few respondents (6 percent) indicated marketing at least some of their calves 15 to 45 days after weaning while a third indicated marketing at least some of their calves 46 to 120 days after weaning. North Dakota producers more frequently (49 percent) marketed at least some of their calves 46 to 120 days after weaning, and Wyoming producers less frequently (15 percent) marketed at least some of their calves 46 to 120 days after weaning.

Table 1. Number of Commercial Beef Cows, Commercial Beef Replacement Heifers, and Feeder Calves on Ranch as of January 1, 2005, Rancher Survey, 2005

Item	Total	North Dakota	South Dakota	Montana	Wyoming
	---percent---				
Commercial Beef Cows					
None	1.6	1.9	.6	2.1	2.4
1 to 100	34.4	37.6	31.1	33.5	37.4
101 to 200	27.7	33.7	27.7	26.1	21.1
201 to 300	16.5	14.0	19.5	16.6	14.5
301 to 400	8.4	6.6	9.1	9.9	7.2
401 to 500	3.5	3.1	3.1	3.9	4.2
more than 500	7.9	3.1	8.8	8.1	13.2
(n)	(1036)	(258)	(328)	(284)	(166)
Average	215	173	228	218	249
(n)	(1038)	(258)	(328)	(284)	(166)
Commercial Beef Replacement Heifers					
None	30.7	36.8	26.5	31.7	27.7
1 to 100	62.3	60.5	66.2	58.8	63.2
101 to 200	5.1	1.9	5.5	6.3	7.2
201 to 300	1.1	0.8	1.2	1.1	1.2
301 to 400	0.3	0.0	0.0	1.1	0.0
401 to 500	0.3	0.0	0.0	1.1	0.0
more than 500	0.6	0.0	0.6	0.0	0.6
(n)	(1036)	(258)	(328)	(284)	(166)
Average	36	22	38	43	40
(n)	(1038)	(258)	(328)	(284)	(166)
Feeder Calves					
None	58.7	46.9	60.4	66.9	59.6
1 to 100	27.5	37.2	27.1	21.5	23.5
101 to 200	5.6	7.7	4.6	4.9	5.4
201 to 300	3.4	4.7	3.7	1.4	4.2
301 to 400	1.2	0.8	2.1	0.3	1.2
401 to 500	1.2	0.8	0.6	1.1	3.0
more than 500	2.5	1.9	1.5	3.9	3.1
(n)	(1036)	(258)	(328)	(284)	(166)
Average	61	64	46	74	64
(n)	(1038)	(258)	(328)	(284)	(166)
Calves Raised from Own Cows					
none	4.5	3.8	2.1	8.0	4.2
1 to 100	35.8	38.6	32.3	35.7	38.0
101 to 200	25.6	32.6	25.8	22.1	19.7
201 to 300	14.7	12.3	18.9	12.1	14.8
301 to 400	7.6	7.2	8.6	8.4	4.9
401 to 500	4.4	2.5	4.8	4.8	5.6
501 to 1000	6.4	2.5	6.9	7.2	10.6
more than 1000	1.0	0.4	0.3	1.6	2.1
(n)	(918)	(236)	(291)	(249)	(142)
Average	204	163	215	207	245
(n)	(920)	(236)	(291)	(249)	(142)

Table 2. Weaning Weights, Rancher Survey, 2005

	Total	North Dakota	South Dakota	Montana	Wyoming
	-----------	-----------	percent	-----------	-----------
Weaning Weights					
300 to 400 pounds	1.6	2.1	1.6	0.0	3.9
401 to 500 pounds	17.3	16.5	14.0	16.7	26.0
501 to 600 pounds	64.3	63.2	64.3	67.3	61.0
601 to 700 pounds	16.1	16.9	19.4	15.6	9.1
701 to 800 pounds	0.6	1.2	0.6	0.4	0.0
(n)	(979)	(242)	(314)	(269)	(154)
	-----------	-----------	pounds	-----------	-----------
Average	562	567	568	563	539
Median	560	570	575	560	550

Respondents also indicated they market a majority of their calves at weaning. Overall, respondents indicated they market 61 percent of their calves at weaning, 17 percent of their calves at 46 to 120 days after weaning, 5 percent retain ownership or partial ownership through backgrounding, 4 percent retain ownership or partial ownership through finishing and slaughter, and only 3 percent are marketed 15 to 45 days after weaning. A slightly smaller percentage of calves in North Dakota are marketed at weaning (51 percent) compared to the other states (63 to 67 percent) and a slightly larger percentage (29 percent) of North Dakota calves are marketed at 46 to 120 days compared to 9 percent in Wyoming, 13 percent in Montana and 15 percent in South Dakota. Average weight of steer calves marketed at weaning was 587 pounds with little variation between the state averages. Average weight of heifer calves marketed at weaning was 548 pounds.

Changes in Cow/Calf Pairs and Changes in Calves Backgrounded, Fed, or Finished

Across the four state area, nearly 50 percent of respondents indicated the number of cow/calf pairs in their herd had declined, on average by one-third (Table 4). There was some variability between states as 64 percent of respondents in Wyoming indicated the number of cow/calf pairs in their herd had declined in the last five years, while only 35 percent of respondents in North Dakota indicated the number of cow/calf pairs in their herd had declined in the last five years. The average percentage decline was smallest in Montana with an average reduction of 28 percent and largest in Wyoming with an average reduction of 38 percent.

Alternately, on average 24 percent of respondents indicated the number of cow/calf pairs in their herd had increased by an average of 39 percent (Table 4). Thirty-two percent of respondents in North Dakota reported an increase in cow/calf pairs in the past five years of on average 31 percent, compared to only 15 percent of Wyoming respondents that indicated an increase of on average 35 percent. Respondents in Montana that indicated an increase in the number of cow/calf pairs reported an average increase of 50 percent.

Roughly half of all respondents indicated the number of calves backgrounded, fed, or finished either partially or totally on their own ranch or elsewhere had not changed in the last five years (Table 4). Thirty percent indicated the number of calves backgrounded, fed or finished has decreased in the last five years by on average 45 percent. Variability between states ranged from 53 percent of respondents in Wyoming that indicated an average decline of 48 percent to 30 percent of respondents in North Dakota that indicated an average decline of 51 percent.

Table 3. Marketing Feeder Calves, Time of Marketing, Rancher Survey, 2005

Activity	Total	North Dakota	South Dakota	Montana	Wyoming
	percent				
Respondents that:					
Market at least some calves at weaning, right off the cow	73.8	63.3	76.9	80.7	71.9
Market at least some calves 46 to 120 days after weaning	33.1	48.8	31.3	31.5	15.1
Other[1]	31.1	24.6	35.1	31.7	32.1
Retain ownership or percentage ownership through backgrounding	10.5	10.1	12.7	7.4	12.0
Retain ownership or percentage ownership through finishing and slaughter	9.3	9.7	9.5	8.5	9.4
Market at least some calves 15 to 45 days after weaning	6.2	6.9	2.8	8.2	8.8
(n)	(993)	(248)	(316)	(270)	(159)
Average percent of calves marketed at each of the following:	percent				
At weaning, right off the cow	61.2	51.3	63.3	67.0	62.6
46 to 120 days after weaning	17.2	29.2	15.1	13.4	9.4
Other[1]	8.7	5.8	10.3	9.0	9.6
Retain ownership or percentage ownership through backgrounding	5.2	5.3	6.1	3.6	5.9
Retain ownership or percentage ownership through finishing and slaughter	4.2	4.6	3.8	3.5	5.7
15 to 45 days after weaning	3.4	3.8	1.4	3.5	6.4
(n)	(730)	(248)	(316)	(270)	(159)
	pounds				
Weight of steer calves marketed at weaning	587	598	596	580	560
(n)	(742)	(164)	(238)	(224)	(114)
Weight of heifer calves marketed at weaning	548	557	552	550	530
(n)	(730)	(149)	(224)	(207)	(106)

[1]Other: replacement heifers, sold for breeding stock, production sales, market grass fed stock wholesale, sell as yearlings, culled summer heifers, bull sales, 120 days after weaning

Table 4. Percentage Change in the Number of Cow/Calf Pairs and the Number of Calves Backgrounded, Fed, or Finished Either Partially or Totally on Own Ranch or Elsewhere in the Last Five Years, Rancher Survey, 2005

Change	Total	North Dakota	South Dakota	Montana	Wyoming
	-----------	-----------	percent	-----------	-----------
Cow Calf Pairs					
Decreased	47.7	35.5	48.9	47.3	64.1
Stayed the Same	28.1	32.3	28.8	28.0	20.4
Increased	23.8	31.8	21.6	24.7	15.0
(n)	(1011)	(248)	(319)	(275)	(167)
Average Decrease	33.0	30.6	35.1	28.3	38.0
(n)	(468)	(87)	(151)	(129)	(101)
Average Increase	39.2	30.8	40.1	50.0	35.2
(n)	(228)	(77)	(65)	(62)	(24)
Calves Backgrounded, Fed, or Finished					
Stayed the Same	46.1	47.3	42.0	55.3	36.4
Decreased	30.5	30.5	44.1	29.9	52.7
Increased	15.7	22.3	13.9	14.7	10.9
(n)	(796)	(203)	(245)	(217)	(129)
Average Decrease	45.5	50.6	43.9	40.6	48.5
(n)	(247)	(51)	(88)	(55)	(53)
Average Increase	58.9	61.4	53.5	68.5	40.4
(n)	(108)	(41)	(27)	(28)	(12)

Alternately, 16 percent of respondents indicated the number of calves backgrounded, fed, or finished had increased on average 59 percent in the last five years. While the percentages of respondents reporting increases were moderate, average increases were quite substantial. Eleven percent of respondents in Wyoming reported an average increase of 40 percent, 14 percent of respondents in South Dakota reported a 68 percent increase, 15 percent of respondents in Montana reported a 68 percent increase, and 22 percent of respondents in North Dakota reported an increase of 61 percent.

Respondents most frequently indicated drought conditions and inadequate feed supply as the reason why the number of calves they backgrounded, fed, or finished had declined in the past five years (Table 5). Ninety-one percent of respondents indicated drought conditions forced herd reductions while 54 percent indicated an inadequate feed supply contributed to the decline. Other factors that influenced a decline were cited by respondents far less frequently.

Increased cattle prices and increased access to pasture land were cited by one-third of respondents as issues that influenced their decision to increase the number of calves backgrounded, fed, or finished either totally or partially in the last five years (Table 5). Roughly 25 percent indicated better marketing and risk management skills influenced their decision, while 23 percent indicated expanded feedlot capacity and adequate winter feed were issues that influenced their decision to increase the number of backgrounded, fed, or finished feeder calves.

Table 5. Reasons that Influenced Decision to Increase or Decrease the Number of Calves Backgrounded, Fed, or Finished Either Partially or Totally on Own Ranch or Elsewhere in the Last Five Years, Rancher Survey, 2005

Item	Total
	---percent---
Influences to Decrease	
Drought conditions forced herd reduction	91.5
Inadequate feed supply	53.7
Cash flow restrictions	11.9
Loss of leased or rented land	10.5
Retired, retiring, or semi-retired	5.8
Inadequate labor/labor restrictions	5.8
Sold ranch and/or liquidated stock	2.7
Inadequate or loss of local markets	0.7
Transferring the operation to a family member or relative	1.0
(n)	(294)
Influences to Increase	
Increase in cattle price	33.9
Increased access to pasture land	33.9
Developed better marketing and risk management skills	25.6
Expanded feedlot capacity	23.1
Now have adequate winter feed	23.1
Family member or other relative(s) joined farm/ranch operation	16.5
(n)	(121)

Changes Under Consideration in the Next Five Years

Respondents most frequently indicated that increasing their cow/calf herd was under consideration in the next five years (Table 6). Overall, 57 percent of respondents indicated they were considering increasing their cow/calf herd. Statewide averages ranged from a low of 51 percent of respondents in Wyoming considering expanding their cow/calf herd in the next five years to a high of 59 percent in both South Dakota and Montana. Few respondents (16 percent) indicated decreasing their cow/calf herd was under consideration. Nineteen percent of all respondents indicated they were considering increasing the number of feeder calves backgrounded while 14 percent indicated they were considering increasing the number of feeder calves retained through backgrounding and /or finishing. Respondents in North Dakota and South Dakota more frequently were considering increasing the number of feeder calves backgrounded, 27 and 22 percent respectively, compared to 14 percent in Montana and 13 percent in Wyoming. Respondents next most frequently indicated they were considering liquidating their herd. Overall 12 percent of respondents indicated they were considering liquidating their herd in the next 5 years. Statewide responses ranged from a low of 9 percent in South Dakota to17 percent in North Dakota.

Table 6. Types of Changes Under Consideration in the Next 5 Years, Rancher Survey 2005

Change	Total	North Dakota	South Dakota	Montana	Wyoming
	--------------------	percent	--------------------		
Increasing my cow/calf herd	57.3	54.5	59.5	59.5	51.3
Increasing the number of feeder calves that I background	19.5	27.3	22.4	13.8	13.2
Decreasing my cow/calf herd	16.4	16.7	13.4	16.6	21.0
Increasing the number of feeder calves that I retain ownership in through backgrounding and /or finishing	14.5	15.8	14.1	15.4	11.8
Liquidating my herd	12.4	16.7	9.4	11.0	14.6
Expanding my feedlot capacity	7.3	15.3	6.1	5.7	1.3
Decreasing the number of feeder calves that I background	3.6	4.8	2.2	2.4	6.6
Switching to or adding other ruminant livestock production	1.9	1.9	1.8	0.8	4.0
Decreasing the number of feeder calves that I retain ownership in through backgrounding and /or finishing	1.8	2.9	1.8	1.2	1.3
(n)	(885)	(209)	(277)	(247)	(152)

Demographics

Most respondents' operations were focused on livestock sales. Overall, 82 percent of respondents' gross farm income was from livestock sales (Table 7). Averages were slightly lower in North Dakota with 72 percent of gross farm income from livestock sales and slightly higher in Wyoming with 92 percent of gross farm income from livestock sales. Net farm/ranch income was very important to household income. On average, two-thirds of household income was from net farm and ranch income with state averages ranging from 59 percent of household income from farm and ranch income in Wyoming to 72 percent of household income from farm/ranch income in South Dakota. Sole proprietorships were the most frequently reported type of farm/ranch business structure (71 percent) with more sole proprietorships in North Dakota (83 percent) and fewer in Wyoming (56 percent). Alternately, there were more corporations in Montana and Wyoming, 21 percent and 15 percent respectively, than in South or North Dakota, 8 percent and 1 percent, respectively. Variations in state laws likely explain the difference. Respondents' average age was 54 with an average of 28 years in operation with little variation between states (data not shown).

Table 7. Respondent Demographics, by State, Rancher Survey, 2005

Change	Total	North Dakota	South Dakota	Montana	Wyoming
	--------------------------percent-------------------------------				
Percentage gross farm income from each of the following:					
Livestock sales	82.1	71.8	85.3	81.8	91.7
Crop sales	11.9	20.4	9.7	11.9	3.2
Custom hire	2.0	2.5	2.1	2.0	1.3
Other[1]	2.6	3.6	2.0	1.9	3.2
(n)	(996)	(244)	(313)	(275)	(164)
Percentage of Household Income from each of the following:					
Net farm/ranch income	66.1	61.4	72.3	67.5	58.7
Off-farm employment income (spouse's off-farm job, non-farm business)	25.5	30.4	21.4	24.2	28.1
Other farm/ranch related business (leased hunting rights, guided hunting, agri-tourism, bed and breakfast, etc.)	2.3	1.7	1.6	2.5	4.3
Other[2]	2.3	1.1	2.6	3.0	2.9
Energy leases, mineral rights	1.6	2.4	0.1	0.6	4.8
(n)	(969)	(242)	(300)	(269)	(157)
Farm/Ranch Business Structure					
Sole proprietor	71.0	82.9	76.8	62.7	56.4
Partnership	13.8	14.2	12.9	12.3	17.8
Corporation	11.0	1.2	8.1	20.6	15.3
LLC	2.7	0.8	1.6	2.2	8.0
Other[3]	1.4	0.8	0.6	2.2	2.4
(n)	(997)	(246)	(310)	(276)	(163)

[1]Other: off-farm rent, tourism, government payments, CRP, spouse off-farm income, rodeo, commercial hunting, USDA/crop insurance, outfitting, pasturing cattle, labor, milk, investments, hay sales
[2]Other: Social Security/retirement, investments, rent, hire out, dirt moving, CRP, estate settlement, trucking, timber, spouse off-farm income, interest income, stocks
[3]Other: living trust, joint venture, family agreement, sub S corporation, limited partnership, lease, owned by boss

Key Finding, Implications, and Conclusions

Herd sizes for a large majority of ranch operations in the four state study area fall into the 100 to 300 head range. Respondents reported on average 36 replacement heifers, about a 15 percent replacement rate and reported raising about 200 calves from their own cows annually. Calves are weaned throughout the study area in October and November with weaning weights in the 500 to 600 pound range. While weaning weights are fairly consistent throughout the study area, Wyoming producers reported weaning slightly more calves in the 400 to 500 pound range and slightly fewer in the 600 to 700 pound range. Most respondents market a majority of their calves at weaning at an average weight of 587 pounds. Roughly half of respondents indicated a reduction in the number of cow/calf pairs in the last five years, citing drought and an inadequate feed supply as reasons. More operators in Wyoming reported reductions in cow/calf pairs than the overall average and fewer operators in North Dakota reported reductions in cow/calf pairs in the last five years. While only roughly 20 percent of respondents reported an increase in their cow/calf herd, increases were substantial, ranging from 31 percent in North Dakota to 50 percent in Montana.

While respondents most frequently reported a decline in the number of cow/calf pairs, respondents most frequently reported 'no change' in the number of calves backgrounded, fed, or finished in the last five years, and roughly a third reported a decline in the number of calves backgrounded, fed, or finished in the last five years. While only 16 percent reported an increase in the number of calves backgrounded, fed, or finished in the last five years, the increases, like the increases in respondents' cow/calf herds, were fairly substantial. Increases in the number of calves backgrounded, fed, or finished ranged from an average increase of 41 percent in Montana to 51 percent in North Dakota. Increased cattle prices and increased access to pasture land were cited as reasons that influenced the decision to increase the number of calves backgrounded, fed or finished in the last five years.

Half of the respondents in the study area reported they were considering increasing their cow/calf herd in the next five years. About 20 percent indicated they were considering increasing the number of feeder calves backgrounded, and 14 percent indicated they were considering increasing the number of calves retained through backgrounding and/or finishing. Far fewer respondents (16 percent) were considering decreasing their cow calf herd. A very small number of respondents were considering reducing the number of feeder calves backgrounded (4 percent) and fewer yet reported considering decreasing the number of feeder calves retained through backgrounding and/or finishing (2 percent). Finally, livestock sales are the largest component of respondent gross farm income, and net farm/ranch income is the largest component of household income.

Currently most ranchers in the study area market a majority of their calves at weaning. Considering that a minority of ranchers in the study area currently background or retain ownership or a percentage ownership, the potential for growth in the livestock sector through expanded backgrounding and retained ownership appears to be substantial. Because the questionnaire effectively targeted those operations in the four state area that are primarily livestock production operations, additional findings from this survey of ranchers in the four-state area should provide valuable insight to research and extension personnel as they look to find ways to expand the livestock sector and improve the profitability and viability of livestock operations in the region.

References

U.S. Department of Agriculture. 2004. *2002 Census of Agriculture, Vol. 1, Ch.2, County Level Data*. Website- http://www.nass.usda.gov/census/census02/volume1.

SOUTHWEST FEEDERS PROJECT: BACKGROUNDING NORTH DAKOTA ANGUS ASSOCIATION'S STEER CALVES FOR THE 2006 NATIONAL ANGUS CARCASS CHALLENGE

M. M. Stamm, C.S. Schauer, D.M. Stecher, D. Pearson and D. Drolc

NDSU-Hettinger Research Extension Center, Hettinger, ND

INTRODUCTION

Since 1991, Certified Angus Beef LLC has sponsored a feedlot gain and carcass contest for cattle producers in which calves were fed out to gain valuable finishing performance and carcass information. Since that time, the feedlot gain and carcass contest has evolved into the National Angus Carcass Challenge (NACC) feeding competition. According to Mark McCully, supply development director for CAB, the competition is "designed to find the highest value group of Angus-sired cattle and provide an opportunity for discovery and recognition in a competitive format". The NACC ranks carcass values on enrolled pens of finished calves and winners are determined by placing harvest data on a fixed value contest grid. Individual carcass data (hot carcass weight, USDA quality and yield grade and CAB® certification status) is provided to each participant to discover the true economic value of each animal fed out in the competition. This information gives valuable insights regarding the genetics within the participating producer's beef herds, enabling them to improve culling and selection focuses and to improve or maximize the genetic potentials of their animals. To be a Challenge participant, an individual or group of individuals must enroll a minimum 40 calves that are sired by a registered Angus bull; however, cow herd genetics can vary. The calves must be 51% black hided and can be either steers or heifers; calves are fed out as single sex groups at CAB approved feedlots. The enrolled calves must be slaughtered between January 1 and December 15, 2006 at a CAB licensed packing plant in a maximum of two slaughter dates in order to qualify for the 2006 contest. Producers earn premiums and/or are assessed discounts (specific dollar amounts) for quality grade, yield grade and carcass weight specifications that are within and out of specification for the Certified Angus Beef Brand (Table 1).

Table 1. Specifications to qualify for the CAB Brand

► 51% black hide
► Neck hump of less than 2 inches
► "A" maturity (9-30 months)
► Modest or higher degree of marbling
► Medium or better marbling texture
► USDA Yield Grade (YG) 3.9 or leaner
► Moderately thick or thicker muscling
► No internal hemorrhages (capillary ruptures)
► No dark-cutting characteristics

The average carcass premium/cwt is calculated by processing the actual "pay" data (hot carcass weight, USDA quality and yield grade, CAB® certification status) for each animal's carcass through the contest grid (Table 2). The contest grid is used as a means of ranking entered lots and is not offered by licensed packers as a marketing option. Contest winners are announced the following January at the National Western Stock Show in Denver, Colorado. More than $25, 000 in cash and other prize packages are annually awarded to winning lots of Angus calves.

Table 2. NACC 2006 Contest Grid

Quality Grade Premiums/ Discounts	
Prime	+ $12.00
Certified Angus Beef®	+ $5.00
Choice	PAR
Select	- 8.00
Standard/Ungraded/No Roll	- $20.00
Hardbones	- $20.00
Dark Cutters	- $20.00
Yield Grade Premiums/Discounts	
YG 1 & 2 Choice or Better	+ $4.00
YG 1 & 2 Select	+ $1.00
YG 3	PAR
YG 4	- $20.00
YG 5	- $25.00
Carcass Weight Premiums/Discounts	
549 lbs./down	- $20.00
550-599 lbs.	- $5.00
600-649 lbs.	PAR
650-749 lbs.	+ $1.50
750-849 lbs.	+ $3.00
850-949 lbs.	PAR
950-1,000 lbs.	- $10.00
1,001 lbs./up	- $30.00

2006 North Dakota Angus Association Carcass Challenge

This fall, the North Dakota Angus Association (NDAA) had twelve producers chose to participate for the first time in the 2006 NACC. Southwest Feeders was chosen as the backgrounding feedlot for the NDAA calves. Seventy spring born (February through May) Black Angus sired calves were brought to Hettinger, ND from October 24, 2005 through November 1, 2005 and assigned to ten head pens based on arrival dates at Southwest Feeders. Two Angus producers each submitted ten claves for this year's Challenge which filled one pen respectively by themselves. As a result, these two producers' calves did not share pen space with any other participating producer's steers. The other ten participating producers submitted five steer calves and shared pen space with one other participating Angus producer. The Angus producers involved in the carcass challenge were located throughout the entire state of North Dakota.

MATERIALS AND METHODS

Calves were weighed and rectal body temperatures taken after a rest period to determine initial arrival weight at Southwest Feeders and the incidence of respiratory illness (BRD complex). This weight was used as the baseline for all performance and economic analysis for the entire backgrounding period. Steers having a rectal body temperature of 105 degrees F or greater were given a subcutaneous injection of Excede (Ceftiofur Crystalline Free Acid, Pfizer Animal Health) antibiotic in the middle one-third of the posterior aspect of the ear. Cattle were provided a fifteen day feed acclimation period before starting the backgrounding test.

Calves were weighed in two day intervals at the start (mid November), middle (day 28, mid December) and end (day 54, early January) of the backgrounding feed test following completion of the acclimation period. The middle weigh period was used to aid in tracking animal health and performance while providing report information back to participating Angus producers. The backgrounding test period ended January 9, 2006 and calves were shipped the morning of January 10, 2006 to Decatur County Feed Yard LLC in Oberlin, KS for the final finish feeding phase.

The backgrounding ration consisted of a barley haylage, 8 lbs rolled barley grain with a one pound inclusion of a locally produced protein/mineral supplement containing Rumensin at 450 grams/ton (Table 3). Target average daily gain (ADG) for the feeding ration was 2.60 lbs. Daily pen feed adjustments were made based on individual bunk calls made prior to cattle being fed once daily (9:00 AM). Custom feeding fees were charged back to the participating producers according to a signed custom feeding agreement. Deccox crumbles were fed throughout the entire feeding period for coccidiosis prevention.

Calves were implanted with a Ralgro implant on November 10, 2005 during the acclimation period. Animals were individually weighed prior to the morning feeding for on-test and off-test weights. Vaccines for the North Dakota Angus Association cattle were donated by Merial Animal Health and Boehringer Animal Health companies. A health protocol was established through a local veterinary clinic and included a monthly pen walk through by the attending veterinarian. Data collected and reported back to participating Angus producers included: individual starting weights, 28 day interim weight and end weights, ADG, dry matter intake, feed conversion, total cost of gain, and health status and illness treatments.

Table 3. North Dakota Angus Association Backgrounding Diet (% DM basis)

	Total Diet	Barley Silage	Barley Grain	Supplement
% of diet, As Fed	100	80.93	16.95	2.12
% DM	48.5	38.2	90.7	92.8
Crude Protein, %	14.8	13.1	15.8	34.8
Ne_m , Mcal/lb	0.8	0.61	0.93	0.74
Ne_g , Mcal/lb	0.44	0.35	0.63	0.46
Ca, %	0.85	0.53	0.08	10.77
P, %	0.36	0.31	0.45	0.54
Cu, ppm	19	4	15	279
Zn, ppm	74	24	56	984
Mn, ppm	69	28	28	1025
Deccox, mg	170			170
Rumensin, mg	213			213

RESULTS AND DISCUSSION

Calves enrolled in the Challenge came from various production management and feeding regimes prior to their arrival at Southwest Feeders. Initially, the calves ranged in weight from 468 lbs to 724 lbs, with an average body weight of 607 lbs. Four steers had to be treated with Excede antibiotic at the initial weighing due to having rectal body temperatures 105^{o} or greater. Steers were fed 10 gram chlortetracycline crumbles at the 10 mg/lb bodyweight treatment level for treatment of bacterial pneumonia (shipping fever) for a period of six days after their arrival. The next two weeks post arrival, the weather was still erratic with extremes in daytime and nighttime temperatures. During this time, steers were kept on a lower level of chlortetracycline due to the presence of snotty noses.

Final weights on the Angus steers ranged from 608 lbs to 872 lbs with an overall group average of 768 lbs at the end of the backgrounding period. One steer was pulled from the carcass challenge and returned to the home ranch due to poor growth performance and health issues during the last period. Total weight gains on the steers ranged from 48 lbs (for the steer that was removed from the competition) to 225 lbs with an overall group average of 161 lbs. Average daily gain ranged from 0.76 to 3.62 lbs (Figure 1) with an overall group average of 2.52 lbs (Table 4). The 2.52 lb ADG is a bit lower than the target gain of 2.60 lbs; however, during the last three weeks of the feeding period, pen conditions deteriorated becoming extremely muddy due to thawing from warm environmental temperatures.

Total dry matter intake ranged from 17.31 lbs to 20.10 lbs with an overall group average of 19.16 lbs (approximately 2.49 % body weight; Table 4.). Dry matter feed conversion (feed:gain) ranged from 5.24 lbs to 11.46 lbs (Figure 2) with an overall group average of 8.67 lbs for the entire feeding period (Table 4). Dry matter feed conversions also increased due to pen conditions late in the feeding period and overall slower weight gains by the calves in the final feeding period.

Table 4. Feeding performance of all pens combined.

	Trial
DMI, lbs	19.16
DMI, % BW	2.49%
F:G (feed:gain)	8.67
ADG, lb/d	2.52

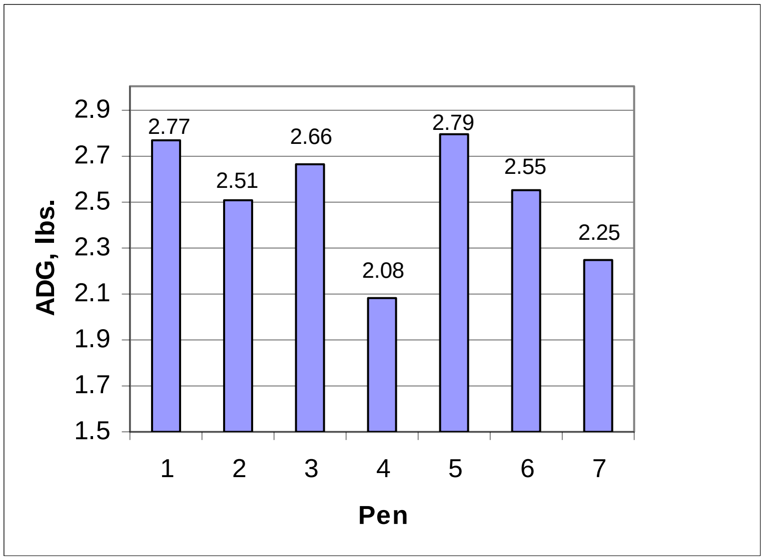
Total feed costs ranged from $ 71.02 to $ 82.61, with a group average of $ 76.82. Total yardage costs ranged from $ 17.50 to $ 19.00 with a group average of $18.15. Total costs of gain ranged from $0.48/lb gained to $1.48/lb gained with an overall group average of $0.66/lb.

Calves that had to be treated for respiratory disease or high fevers using Excede or A180 (Danofloxacin mesylate, Pfizer Animal Health) antibiotics incurred treatment costs of $18.52 to $21.61 and $9.725 per antibiotic shot (for Excede or A180 antibiotics respectively) which contributed to higher total costs of gain for the first 28 days of the feeding period as compared to their respective ranch mates or pen mates.

We were aggressive in our drug treatment of the carcass challenge steers. Death loss for the Angus steers was zero percent. A zero percent death loss tends to result in higher drug and treatment costs. If one steer had died, the expired steer costs would need to be absorbed by the other four or nine remaining steers owned by an individual producer. We feel the slightly higher total costs of gain during the backgrounding period, resulting from slightly higher drug costs, are worth the expense so as to maintain health of all the calves in the carcass challenge.

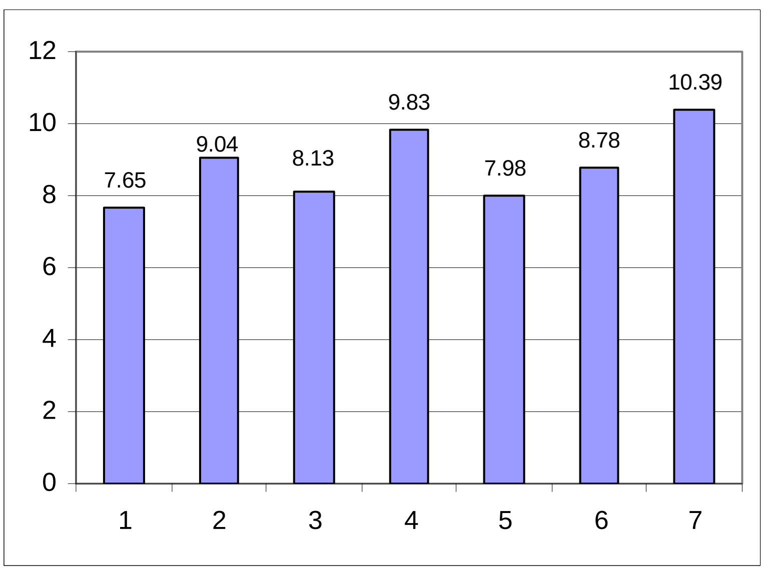
CONCLUSIONS

Results of the 2006 NDAA Calf Backgrounding Test for the 2006 NACC provided valuable information to the cooperating Angus producers involved in the Challenge. The weather throughout the entire backgrounding period provided above normal temperatures, causing deteriorating pen conditions late in the feeding period which impacted final weight gains and feed efficiencies of the Angus steers. Despite commingling animals and varying production management regimes, calf health was adequately maintained during the backgrounding period resulting in zero percent death loss.



Max Pen ADG = 2.79 lb/d, Min Pen ADG = 2.08 lb/d, Avg Pen ADG = 2.52 lb/d

Figure 1. Average Daily Gain by pen



Highest Pen F:G = 10.39, Lowest Pen F:G = 7.65, Avg Pen F:G = 8.67

Figure 2. Dry Matter feed required per pound of gain by pen

PRELIMINARY REPORT FOR SOUTHWEST FEEDERS PROJECT: PROFITABLE CALF BACKGROUNDING INTEGRATING ANNUAL FORAGE CROPS

M.M. Stamm[1], C.S. Schauer[1], L.M.M.Surber[2], S. D. Cash[2], A. Todd[2], D.M. Stecher[1], D. Pearson[1], and D. Drolc[1]

[1] Hettinger Research Extension Center, NDSU, Hettinger, ND
[2] Montana State University, Bozeman, MT

Acknowledgements: We would like to thank the South Dakota Agricultural Experiment Station and the Four-State Ruminant Consortium for funding this project.

IMPACT STATEMENT

Barley harvested as hay and silage had greater potential as a backgrounding forage for steer calves as compared to oat and winter wheat harvested as hay.

INTRODUCTION

In the four-state region of Montana, North Dakota, South Dakota and Wyoming, cereal forages have become an increasingly important crop. Few statistics are available, but cereal hay is harvested on over 500,000 acres in the region. One explanation for the popularity of cereal forages may be the current drought conditions and their use as an emergency hay crop. Additionally, small grains are used in crop rotations to renovate alfalfa stands. This methodology is an effective way to reduce costs associated with weed and disease control. Small grains harvested as hay are a significant source of winter forage for livestock producers in the four-state region. These forages are widely adapted, and they can be an inexpensive and readily available feed source. Cereal forages are easier to grow when compared to alfalfa in terms of seed drills, herbicides, and risk and require similar harvesting techniques as legumes (S.D. Cash, personal communication; Helsel and Thomas, 1987). Proper harvesting can maximize feed value.

Research has shown striking differences in feeding value among cereal forage species and across stages of maturity at harvest. Khorasani et al. (1997) determined that barley had the highest forage quality followed by triticale and then oat. Barley has often been determined to have higher forage quality when compared to oat, wheat, or triticale (Cherney and Martin, 1982; Cherney et al., 1983, McCartney and Vaage, 1994). In addition, Khorasani et al. (1997) found that the nitrate concentration in barley and triticale declined rapidly with advancing maturity while the nitrate concentration of oat remained elevated. Research centers in the four-state region have been evaluating several annual crops for forage production. A summary of research at Central Agricultural Research Center, Moccasin, Montana and Sheridan Research and Extension Center, Sheridan, Wyoming is presented in Table 1. Some small grains that are cut for hay have rough awns. Rough or barbed awns of cereal grains can affect palatability and can cause mouth irritation. Bolsen and Berger (1976) found lambs consuming awned wheat silage had decreased dry matter intake (DMI) compared to those consuming awnless wheat silage. Many new annual forage crops are being developed as hooded, awnless, or awnletted (very short awns). The experimental winter wheat line set for release from Montana State University (MSU) in 2005 is awnless. In addition, the most recent release of forage barley 'Hays' from MSU is hooded.

Table 1. Yield and Quality Data from the Central Montana Agriculture Research Center, Moccasin, MT and Sheridan Research and Extension Center, Sheridan, WY Trials in 2003

	DM Yield, t/a	NDF, %	ADF, %	CP, %	NO_3-N, ppm
Moccasin, MT					
Triticale	4.0	60.3	34.5	13.0	905
Winter Wheat	3.5	59.1	32.5	13.9	544
Forage Barley	2.0	48.9	25.5	10.0	350
Forage Oat	1.3	50.7	25.3	11.0	1500
Sheridan, WY					
Triticale	3.2	65.1	36.9	7.8	319
Winter Wheat	3.5	67.3	36.6	8.4	173

Most hay crops (including cereal hay) are fed on-site for livestock winter rations, and they also may be included as the major component in a backgrounding ration. Backgrounding is a means of economically adding value to calves and increasing profit by using an inexpensive feed such as barley to increase weight gain prior to entering a feedlot. Backgrounding allows retained ownership of calves past weaning when prices may be higher and allows lightweight or later born calves to add weight before marketing. A backgrounding program allows for skeletal and muscle development and adds a higher potential for compensatory gain (Rasby et al. 1994). In previous 60-day backgrounding studies at MSU, steers fed a diet comprised of approximately 17.6 lb of chopped barley hay, 5.7 lb cracked barley and 1 lb of a commercial 32% crude protein (CP) supplement had average daily gains (ADG) of about 2.64 lb/day (Surber et al., in progress). The four-state region has a unique mixture of crop and livestock production. Cereal forages provide an excellent option to capitalize on developing alternative copping systems that will provide added value through backgrounding cattle.

Scientists in the four-state region are working on solutions to address some of the questions and concerns associated with growing and feeding cereal forages. In some areas of the four-state region, winter cereals have distinct advantages over spring cereals in terms of production, water use efficiency and their seasonal distribution of workload. Montana State University is developing new cultivars of awnletted winter wheat and triticale and new lines of barley forage that show promise to improve forage quality and feeding value. Awnletted winter wheat cultivars have the potential to be dual purpose crops for producers, while there are limited markets for triticale feed or grain. Cereal forages appear to be very promising; however, cultivar development has only focused on the absence of awns or biomass production. Further, direct comparisons of these experimental crops with more traditional cereal forage crops in terms of feeding performance have yet to be made. Backgrounding feeding trials were designed and conducted in the late fall 2005 to assess the following objectives: 1) obtain animal performance comparisons of experimental and traditionally grown cereal forages, 2) demonstrate animal performance for an experimental awnless winter wheat cultivar and 3) evaluate steer cost of gain for the experimental and traditionally grown cereal forages. Our intent is to provide crop and livestock producers with more options to add value to commodities such as hay and calves.

MATERIALS AND METHODS

A performance study was conducted using eighty crossbred steer calves purchased from a local sale barn in late fall, 2005. Steer calves initial body weight averaged 678 lbs (± 109 lb). Calves were stratified by weight and randomly allotted to one of 16 pens (5 steers/pen) with pen serving as experimental unit. Pens were then assigned to one of four cereal forage dietary treatments (4 replications/treatment): 1) barley (variety 'Robust') harvested as hay (**BH**); 2) barley (variety 'Robust') harvested as silage (**BS**); 3) oat (variety 'Loyal') harvested as hay (**OH**) and 4) a new awnless winter wheat cultivar (variety 'Willow Creek') developed by MSU harvested as hay (**WH**). Cereal forages utilized in the feeding trial were seeded at the recommended rates for the soil types and environment for southwest North Dakota and Miles City, MT. Barley hay and silage and oat hay harvest were conducted at the same stage of maturity (soft dough stage) during the months of June and July 2005 at the HREC. The winter wheat hay cultivar was grown and harvested near Miles City, MT by a commercial farmer and was delivered to HREC.

Backgrounding diets consisted of a roughage source (BH, BS, OH or WH); 8 lb of rolled barley and 1 lb of a locally produced 32% CP supplement containing Rumensin at 450 gram/ton. Diets were isocaloric (Table 2). Target ADG for the feeding ration was 2.60 lbs. Deccox crumbles were fed throughout the entire feeding period for coccidiosis prevention. Steers were given ad libitum access to their diets and fresh water throughout the feeding trial. All hay sources were chopped to a 2.5 inch chop length by a custom hay processor.

When calves were initially weighed upon arrival at Southwest Feeders, rectal body temperatures were taken to determine the incidence of respiratory illness (BRD complex) on the calves. Steers having a rectal body temperature of 105 degrees F or greater were given a subcutaneous injection of Excede (Ceftiofur Crystalline Free Acid, Pfizer Animal Health, Exton, PA) antibiotic in the middle one-third of the posterior aspect of the ear. When calves were processed, steers were vaccinated twice with Pyramid 5 vaccine (Bovine Rhinotracheitis-Virus Diarrhea-Parainfluenza-3-Respiratory Syncytial Virus; modified live virus; Fort Dodge Animal Health, Overland, KS) and Ultrabac® 7 Clostridial vaccine (Pfizer Animal Health, Exton, PA); vaccinated once with One Shot® bacterin-toxid for *Mannheimia haemolytica* (Pfizer Animal Health, Exton, PA), and poured with Dectomax® Pour-On dewormer (doramectin; Pfizer Animal Health, Exton, PA) for internal and external parasites. Calves were implanted with a Ralgro® implant (Schering-Plough Animal Health Corporation, Kenilworth, NJ) at the beginning of the backgrounding study.

Steers were fed backgrounding diets for a period of 57 days following an 8 day diet adaptation period. Pen feed adjustments were based on individual bunk calls made prior to the cattle being fed once daily (9:00 am). Animals were individually weighed prior to the morning feeding for 2 day on-test, 28 day interim and 2 day off-test weights. A health protocol was established through a local veterinary clinic including a monthly pen walk-through by the attending veterinarian. Diet and feed refusals (orts) were taken once every 14 d and fecal samples were collected midway (d 28) and upon completion (d 57) of the trial. Diet and fecal samples were composited by pen and analyzed for dry matter (**DM**), organic matter (**OM**), nitrogen (**N**; AOAC, 2000), NDF, ADF (Van Soest et al, 1991) and indigestible acid detergent fiber (**IADF**; Bohnert et al., 2002). Indigestible ADF will be used as an internal marker to estimate fecal output and to calculate apparent nutrient digestion. Individual diet ingredient samples were analyzed by Midwest Laboratories (Omaha, NE), a commercial laboratory using wet chemistry and ICAP methods for mineral analysis; Midwest Laboratories is a certified by the National Forage Testing Association.

Backgrounding performance, feed intake and nutritional data was analyzed as a randomized complete block design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC) to test the main effects of dietary forage source. Pen was used as the experimental unit. Planned pairwise comparisons (least significant difference) were used to separate forage least square means when the protected *F*-test was significant ($P < 0.10$).

Table 2. Dietary ingredient and nutrient compositions of diets fed to crossbred steer calves

	Diets, % DM Basis			
Ingredient	Barley Silage	Barley Hay	Oat Hay	Wheat Hay
Barley Silage	63.30	---	---	---
Barley Hay	---	56.08	---	---
Oat Hay	---	---	54.28	---
Wheat Hay	---	---	---	58.76
Barley grain	31.48	37.67	39.22	35.38
32% CP supplement[a]	4.02	4.82	5.01	4.52
Deccox crumbles	1.2	1.43	1.49	1.35
Nutrient Concentration				
DM, %	48.5	85.4	82.0	91
CP, %	14.8	14.4	13.5	14.2
NE_m , Mcal/lb	0.80	0.81	0.83	0.81
$NE_{g,}$, Mcal/lb	0.44	0.45	0.46	0.45
Ca, %	0.85	0.81	0.83	0.72
P, %	0.36	0.39	0.36	0.33
K, %	1.80	1.54	1.98	1.55
Cu, ppm	19	22	22	22
Zn, ppm	74	90	82	75
Mn, ppm	69	98	112	111
Deccox, mg	170	170	170	170
Rumensin, mg	213	213	213	213

[a] 32% Commercial supplement (as fed): 32% CP, min Ca 10%, min P 0.50%, min K 1.4%, min Mg 0.5%,Vit A min 50,000 IU/lb, Vit D_3 min 5,000 IU/lb, Vit E min 150 IU/lb, min Cu 260 ppm, min Zn 915 ppm, min Mn 945 ppm.

RESULTS AND DISCUSSION

Initial weights were not affected by dietary treatment ($P = 0.87$; Table 3). Steers consuming barley hay and barley silage did not have differing final weights; however, steers consuming oat hay had lower final weights compared to the barley hay and barley silage steers, but higher final weights as compared to the steers consuming winter wheat hay (*P* = 0.09; Table 3). Both total weight gain and total ADG was influenced by treatments (*P* < 0.001; Table 3). Calves on the barley silage diet had the highest total weight gain and ADG of all four treatments (*P* < 0.05); however, the steers consuming the barley hay diet had higher total weight gains and ADG than both the steers consuming the oat and winter wheat hay diets(*P* < 0.05). At press time, feed intake data and total mixed rations, orts, and fecal samples had had not been analyzed. It is quite possible that physical and/or nutritional characteristics of the oat and winter wheat hays negatively influenced feed intake for these treatments, leading to lower ending weights and ADG. Since the steers consuming the oat hay diet had a higher body weight at the end of the feeding trial as compared to the winter wheat hay steers, it appears that steers consuming the oat hay diet may have had higher dietary feed intakes as compared to the steers consuming winter wheat hay.

Table 3. The influence of diet on backgrounding steer performance

	Treatments[a]					
Item	BH	BS	OH	WH	SEM[b]	*P* value[c]
Initial Wt, lbs	686	674	674	677	11.1	0.87
Final Wt, lbs	844^z	857^z	824^y	819^x	11.7	0.09
Total gain, lbs	159^y	183^z	150^x	143^x	4.9	< 0.001
ADG, lbs/day	2.78^y	3.21^z	2.63^x	2.50^x	0.09	< 0.001

[a]BH = Barley Hay; BS = Barley Silage; OH = Oat Hay; WH = Winter Wheat Hay.
[b]Standard Error of Mean; n = 4.
[c]*P* value for *F* test of treatment.
[xyz]Within a row, means without a common superscript differ (*P*<0.10).

IMPLICATIONS

In this backgrounding study, barley hay and barley silage illustrated greater potential for use as a feedstuff in backgrounding cattle rations as compared to oat and winter wheat harvested as hay. More research is needed to further define if the variety of grains used for the forages had negative influences on feed intake by backgrounding steers. Utilizing cereal grains as forage crops in post-weaning cattle rations offers unique business opportunities to producers in the region, especially in times of drought.

LITERATURE CITED

AOAC. 2000. Official Methods of Analysis (17th Ed.). Association of Official Analytical Chemists, Gaithersburg, MD.

Bolsen, K. K. and L. L. Berger. 1976. Effects of type and variety and stage of maturity on feeding values of cereal silages for lambs. J. Anim. Sci. 42: 168-174.

Bohnert, D. W., C. S. Schauer, S. J. Falck, and T. DelCurto. 2002. Influence of rumen protein degradability and supplementation frequency on steers consuming low-quality forage: II Ruminal fermentation characteristics. J. Anim. Sci. 80: 2978-2988.

Cherney, J. H., and G. C. Marten. 1982. Small grain crop forage potential: I. Biological and chemical determinants of quality and yield. Crop Sci. 22: 227-231.

Cherney, J. H., G. C. Marten, and R. D. Goodrich. 1983. Rate and extent of cell wall digestion of total forage and morphological components of oats and barley. Crop Sci. 23: 213-216.

Helsel, Z. R., and J. W. Thomas. 1987. Small grains for forage. J. Dairy Sci. 70: 2330-2338.

Khorasani, G. R., P. E. Jedel, J. H.Helm, and J. J. Kennelly. 1977. Influence of stage of maturity on yield components and chemical composition of cereal grain silages. Can. J. Anim. Sci. 77: 259-267.

McCartney, D. H., and A. S. Vaage. 1994. Comparative yield and feeding value of barley, oat and triticale silages. Can. J. Anim. Sci. 74: 91-96.

Rasby, R., I. Rush and R. Stock. 1994. Wintering and backgrounding beef calves. Cooperative Extension, Institute of Ag. And Natural Resources, Univ. of NE, Lincoln, NE. Nebguide G94-1228-A.

Surber, L. M. M., J. G. P. Bowman, P. F. Hensleigh, A. L. Todd, J. J. Kincheloe, S. D. Cash and M. A. Thompson. 2004. Backgrounding beef steer performance and diet digestibility of barley varieties harvested for forage. J. Anim. Sci. (in prep.).

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74: 3583-3597.

INITIAL OBSERVATIONS ON ELECTRONIC IDENTIFICATION OF SHEEP AT HETTINGER RESEARCH AND EXTENSION CENTER

D. Nudell, C.S. Schauer, D. Pearson, D. Drolc, and D. Stecher

Hettinger Research Extension Center, NDSU, Hettinger, ND

Impact Statement

Electronic identification of livestock is a hot-button issue for livestock producers across the United States. Hettinger Research and Extension Center (HREC) has tagged approximately 400 hundred head of adult ewes with electronic tags and plans to have the entire inventory tagged by the end of 2006. This paper describes some of our preliminary observations on the use of electronic identification at HREC.

Materials Used

The equipment we use is simple, rugged and fairly inexpensive. This is not to say that the equipment is affordable for small operations; it is not, but it is affordable for medium to large sized sheep flocks or for an entrepreneur who wishes to purchase equipment to do custom work.

We are currently using an Allflex full-duplex button tag, a wireless RFID Tag Reader (model BT3, purchased from Ag Info Link) a Hewlett Packard iPAQ hx2000 pocket PC, and an electronic scale head to record weight information. The pocket pc, associated software, and tag reader cost about $2000. The initial tags were priced at about two dollars each. We plan to switch to an electronic tag this year that includes a dangle that will carry our flock number and provide a visual tag number.

Results and Discussion

We tagged three bands of ewes at the research center in 2005. On the 4th of May 2005 we tagged 152 head of mature ewes in the upper right ear. Total time for tagging was 90 minutes or about 35 seconds each. On May 5 an additional group of 142 head was tagged. Again, this took approximately 90 minutes or 38 seconds per animal. Finally, on the 6th of May we tagged an additional 119 head of half blood Katahdin yearlings in approximately 90 minutes or about 45 seconds per head. In total, 413 head were tagged at an average rate of one animal every 40 seconds. Two people completed the tagging for all three bands that were tagged. The facility consisted of a pen large enough to hold the entire band and a smaller pen that was used to crowd the animals while they were tagged. The ewes were crowded tight and one person climbed in the pen among the sheep to tag them. The other person filled the tagger and recorded information with the palm pilot.

Time spent working animals as they are sent to various research locations has been dramatically reduced with this new technology. For example: on May 12, 2005, two-hundred ninety six animals needed to be weighed and recorded before being shipped to a research pasture in Morton County. Weight and animal identification were obtained in 1 hour and 50 minutes using the wand and the electronic scale head. Labor for this operation consisted of 2 people. This new technology allowed us to process animals at a rate of one every 22 seconds.

On the 15th of May a second band on animals was shipped to Camp Grafton, ND. This band did not need to be weighed. They were scanned for identification only. In 1 hour and 10 minutes we were able to identify and record 161 animals. Time per animal was 26 seconds to record animal identification and location being shipped to.

On September 1, 2005 we scanned 296 fall lambing ewes in 3.5 hours. Time per animal was approximately 43 seconds per head.

Implications

Our initial conclusions are that the technology works and it is not difficult to use. The cost per animal for the tags is not prohibitive, but the cost for equipment to read the tags is not viable for small flocks at this time. We can envision veterinarians or some other custom operation offering the equipment for rent or offering tag reading as a service. It appears that tag retention is adequate, and we will monitor this response and will report on tag retention next year.

SECTION II

SHEEP MANAGEMENT

TIMOTHY C. FALLER
DIRECTOR
HETTINGER RESEARCH EXTENSION CENTER

JUSTIN LUTHER
EXTENSION SHEEP SPECIALIST
NORTH DAKOTA STATE UNIVERSITY

47TH ANNUAL SHEEP & BEEF DAY

HETTINGER RESEARCH EXTENSION CENTER
HETTINGER, NORTH DAKOTA

FEBRUARY 8, 2006

Shearing Feeder Lambs

by
Roger G. Haugen,
NDSU Extension Sheep Specialist

History on Shearing Lambs

* Shearing feeder lambs 6 to 8 weeks prior to marketing has been promoted by buyers, feedlots and extension people
* Traditional $3.00 to $5.00 unshorn lamb discounts

Processor's Perspective

* Cleaner
* Easier to process
* Contain less low valued by-products (wool, manure and burrs)
* Prime pelts are valuable

Producer Perception

* Distorted definition of "value-added marketing" – selling 5 lbs of thirty cent wool at a $90.00/cwt live lamb price
* Sell a few pounds of manure and mud
* Shearing costs and labor

WHY SHEAR?

Budget – compares marketing two 130 lb lambs (one shorn & one unshorn) at a $90.00/cwt market with a $4.00/cwt unshorn discount.

Revenue	Lamb	+$5.20	($117.00 - $111.80) Shorn vs unshorn difference
	Wool	+$1.50	Wool value @ $0.30/lb x 5 lbs
Expenses	Shearing	-$1.75	Shearing cost
	Feed	-$1.80	Feed for extra 5 lbs of gain to replace the removed wool (6:1 conversion w/feed @ $0.06/lb)
Total		**+$3.15**	Return to producer for shearing

Equation to "plug in" Own Figures

* (diff. in lamb value + shorn wool value) - (shearing cost + extra feed cost) = net change

* 130 lb lambs@ $90/cwt w/ $4/cwt wool disc: ($5.20 + $1.50) - ($1.75 + $1.80) = +$3.15

Pelt Influences

* Pelt value variations of $2.00 to $18.00/pelt create similar lamb dollar value fluctuations
* Especially true when there is an abundant supply of lambs

Grades and Classifications of Pelts - Wool Length

Unshorn	Shorn	
Spring: $1^{1/4}$ to 3"	Fall Clip	1 to 2"
Wool: 3" and over	No. 1	5/8 to 1"
	No. 2	3/8 to 5/8"
	No. 3	1/8 to 3/8"
	No. 4	0 to 1/8"

Wool Marketing Loan Program Unshorn Pelts

* LDP rate for the day you lose beneficial interest in Unshorn Slaughter Lamb @ 6.865 lbs wool/lamb
* Example: 6.865 lbs x LDP rate (24 cents 11/03/03) = $1.65 per head eligible
* If repayment rate on the upgraded wool is above loan rate, there will NOT be an unshorn lamb pelt LDP

Additional Factors to Consider

* Health and Feed Efficiency -"shearing lambs is like cultivating corn - they just seem to grow better".
* Shearing is important when temperatures are above 40F.
* Shearing is important when heavy fleeced, white-faced lambs are being fed.
* Shearing reduces barn moisture, improves ventilation and bedding conditions and contributes to a cleaner product.
* Food safety for the consumers.
* *The single most common food safety issue confronting the lamb industry is dirty pelts and related processing contamination.*
* Unshorn lambs increase the likelihood of wool and manure contamination of the carcass during pelt removal.
* Manure contamination contributes to food safety concerns while wool contamination can alter flavor.

Shearing as a Management and Marketing Tool

* If feedlots are muddy and sloppy, shearing shortly after arrival can prevent manure build-up on the fleece.
* Early shearing avoids excessive dirty pelt discounts and keeps the shearers happier.
* Shearing provides producers and buyers with a ready look at their end product.
* Producer are more likely to visualize and market lambs at the appropriate time and finish.

Exceptions to Consider

* Winter feedlots with minimal to non-existent protective housing, shearing would be ill advised.
* Summer time when flies are out, shearing would be ill advised.

FLOCK CALENDAR OUTLINE

The following guidelines are neither inclusive nor intended to fit every sheep operation. Each operation is different, therefore, each "calendar of events" should be tailored to each flock's needs.

PRIOR TO BREEDING

1. Bag and mouth ewes and cull those that are not sound.

2. Replace culled ewes with top-end yearlings or ewe lambs.

3. Keep replacement ewe lambs on growing ration.

4. Evaluate sires:

   a. Be sure they are vigorous, healthy and in good breeding condition.

   b. Rams should be conditioned at least a month before the breeding season. Flush rams in poor condition.

   c. Allow at least two mature rams (preferably three) or four buck lambs per 100 ewes.

   d. Utilize production records to evaluate anticipated breeding ability.

5. Flush ewes:

   a. One pound grain/day two to five weeks before breeding (usually 17 days).

   b. If ewes are over-conditioned, the effect of flushing will be lessened.

6. Vaccinate ewes for vibriosis and enzootic abortion (EAE).

7. Identify all ewes and rams with ear tags, paint brands or tattoos.

BREEDING

1. The ovulation rate of a ewe tends to be lowered at the first part of the breeding season. Vasectomized or teaser rams run with the ewes through the first heat period tend to stimulate them and increase the ovulation rate at the second heat period.

2. Use a ram marking harness or painted brisket to monitor breeding. Soft gun grease with paint pigment mixed in works well for painting the brisket. A color sequence of orange, red and black is recommended with colors being changed every 17 days.

3. Leave rams in NO LONGER than 51 days (35 days is more desirable).
   a. An exception may be with ewe lambs. Allowing them four heat cycles or 68 days may be beneficial.

4. Remove rams from ewes after the season (don't winter rams with ewes).

PRIOR TO LAMBING — EARLY PREGNANCY (First 15 Weeks)

1. Watch general health of ewes. If possible sort off thin ewes and give them extra feed so they can catch up.

2. Feed the poor quality roughage you have on hand during this period, saving the better for lambing.

3. An exception to the above is feeding pregnant ewe lambs. They should receive good quality roughage and grain (about 20 percent of the ration) during this period.

LAST SIX WEEKS BEFORE LAMBING

1. Trim hooves and treat for internal parasites.

2. Six to four weeks before lambing feed 1/4 to 1/3 pound grain/ewe/day.

3. Shear ewes before lambing (with highly prolific ewes at least a month before is preferred). Keep feeding schedule regular and watch weather conditions immediately after shearing (cold).

4. Vaccinate ewes for enterotoxemia.

5. Control ticks and lice immediately after shearing.

6. Four weeks before lambing increase grain to ½ to 3/4 pound/ewe/day (usually done immediately after shearing).

7. Give A-D-E preparations to ewes if pastures and/or roughage are or have been poor quality.

8. Feed selenium-vitamin E or use an injectable product if white muscle is a problem. **Caution —** Don't do both.

9. Check facilities and equipment to be sure everything is ready for lambing.

10. Two weeks before lambing increase grain to 1 pound per ewe per day.

LAMBING

1. Be prepared for the first lambs 142 days after turning the rams in with the ewes, even though the average pregnancy period is 148 days.

2. Watch ewes closely. Extra effort will be repaid with more lambs at weaning time. Saving lambs involves a 24-hour surveillance. Additional help at this time is money well spent.

3. Put ewe and lambs in lambing pen (jug) after lambing (not before).

4. Grain feeding the ewes during the first three days after lambing is **not** necessary.

5. Be available to provide assistance if ewe has troubles.

6. Disinfect lamb's navel with iodine as soon after birth as possible.

7. Be sure both teats are functioning and lambs nurse as soon as possible.

8. Use additional heat sources (heat lamps, etc.) in cold weather.

9. Brand ewe and lambs with identical number on same sides. Identify lambs with ear tags, tattoos or both.

10. Turn ewe and lambs out of jug as soon as all are doing well (one to three days).

11. Bunch up ewes and lambs in small groups of four to eight ewes and then combine groups until they are a workable size unit.

12. Castrate and dock lambs as soon as they are strong and have a good start (two days to two weeks of age). Use a tetanus toxoid if tetanus has been a problem on the farm (toxoids are not immediate protection. It takes at least ten days for immunity to build).

13. Vaccinate lambs for soremouth at one to two weeks of age if it has been a problem in the flock.

14. Provide a place for orphaned lambs. Make decision on what lambs to orphan as soon after birth as possible for the best success. Few ewes can successfully nurse more than two lambs.

END OF LAMBING TO WEANING

1. Feed ewes according to number of lambs suckling. Ewes with twins and triplets should receive a higher plane of nutrition.

2. Provide creep feed for lambs (especially those born during the winter and early spring).

3. Vaccinate lambs for overeating at five weeks and seven weeks of age.

WEANING

1. Wean ewes from lambs, not lambs from the ewes. If possible, remove ewes from pen out of sight and sound of lambs. If lambs have to be moved to new quarters, leave a couple of ewes with them for a few days to lead the lambs to feed and water locations.

2. Lambs should be weaned between 50 and 60 days of age or when they weigh at least 40 pounds and are eating creep and drinking water. The advantage of early weaning is that the ewe's milk production drops off to almost nothing after eight weeks of lactation.

3. Grain should be removed from the ewe's diet at least one week prior to weaning and low quality roughage should be fed. Restriction of hay and water to the ewe following weaning lessens the chance of mastitis to occur. Poorer quality roughage should be fed to the ewes for at least 10 to 14 days following weaning.

4. Handle the ewes as little as possible for about 10 days following weaning. Tight udders bruise easily. If possible, bed the area where the ewes will rest heavily with straw to form a soft bed for the ewes to lay on.

WEANING TO PRE-BREEDING

1. If ewes go to pasture, treat for internal parasites.

2. Feed a maintenance ration to the ewes. Put ewe lambs that lambed back on a growing ration once they have quit milking.

3. Adjust ewe's conditions so they can be effectively flushed for next breeding season. Don't get ewes too fat prior to breeding.

REARING LAMBS ARTIFICIALLY (ORPHANS) — MANAGEMENT TIPS

Within 2 to 4 hours after birth, decide which lambs among those from multiple births you should remove. Look for the weaker, or smaller ones to choose for artificial rearing. It is important to make this decision early. Relatively weak lambs remaining with the ewes can experience more stress than those reared artificially. Consider the following tips:

- It is essential that newborn lambs receive colostrum milk. Cow's colostrum will work if ewe's milk is not available. Do not dilute with water or warm too quickly if colostrum is frozen.

- Lambs should be removed from sight and hearing distance of ewe.

- Provide a warm, dry, draft-free area to start lambs.

- Use a good milk replacer that is 30% fat and at least 24% protein. Each lamb will require from 15 to 20 pounds of replacer to weaning.

- Use good equipment. Self priming nipple and tube assemblies have been found to be excellent for starting lambs.

- Lambs may require some assistance the first day or two to teach them to nurse on whatever feeding device is used.

- Start on nurser quickly. Young lambs start easier.

- Self feed cold milk replacer after lambs are started. Milk replacers should be mixed with warm water for best results and then cooled down. Lambs fed cold milk grow well with less problems from scours and other digestive disturbance. Cold milk keeps better too.

- There is a Formaldehyde solution commercially available that retards bacterial growth in milk (1 cc/gallon milk).

- Hang a light over the milk replacer feeding device and dry ration feeder.

- Avoid placing young lambs with older lambs, as they may be pushed aside and not be able to obtain milk replacer. Remember that lambs nursing ewes drink 25 to 40 times per 24 hours. Best results have been obtained when lambs are fed in groups of 3 to 4 initially. After lambs are successfully trained, they can be handled in groups of 25.

- Inject lambs in the first few days with Iron Dextran, Vitamin A-D-E, and Selenium-Vitamin E. At 15 days of age, vaccinate for overeating (Colostridum perfringen type C & D).

- Provide lambs a high-quality creep feed as soon as possible. Provide ample fresh water in front of lambs at all times. Do not feed hay or oats the first three weeks of age as it encourages bloat. Caution! Do not feed leafy alfalfa until two weeks after weaning, as it may encourage bloat.
- Wean lambs abruptly at 21-30 days of age. When to wean depends upon whether lambs are eating creep feed and drinking water. Newly weaned lambs will go backwards for several days. Don't be alarmed, they will make compensating gains later on.