2005

2005 South Dakota Beef Report

Department of Animal and Range Sciences, South Dakota State University

Agricultural Experiment Station, South Dakota State University

Cooperative Extension Service, South Dakota State University

2005 South Dakota

BEEF REPORT

South Dakota State University
College of Agriculture and Biological Sciences
Cooperative Extension Service

The faculty members of the Animal and Range Sciences Department are always ready to answer your questions. Our Brookings phone number is (605) 688-5165. Staff members in Rapid City (RC) may be reached at 605-394-2236. Our staff member at Ft. Pierre may be reached at 605-223-7731. Please feel free to give any one of us a call or check out our departmental website: http://ars.sdstate.edu. You can find this report and other information at http://ars.sdstate.edu/extbeef/Publications.htm

FACULTY

	SPECIALTY	RESPONSIBILITY
BRUNS, Kelly W.	Live Animal/Carcass Evaluation	Teaching, Research
CLAPPER, Jeffrey A.	Swine Reproductive Physiology	Research, Teaching
DANIEL, Jay	Sheep Reproductive Physiology	Research, Teaching
EIDE, Jennifer	Equine Management	Teaching
GATES, Roger (RC)	Range Management	Extension, Research
HELD, Jeffrey E.	Sheep Nutrition, Production and Management	Extension
HOLT, Simone	Ruminant Nutrition	Extension, Research, Teaching
JOHNSON, Patricia S. (RC)	Range Science	Research, Teaching
MADDOCK, Robert	Meat Science	Teaching, Research
MCFARLAND, Douglas C.	Muscle Biology	Research, Teaching
MELROE, Tyler	Livestock Judging Team Coach	Teaching
MOUSEL, Eric	Range Livestock Management	Extension, Teaching
PEDERSEN, Carsten	Swine Nutrition	Research
PERRY, George	Beef Reproductive Management	Research, Extension
PRITCHARD, Robbi H.	Ruminant Nutrition	Research, Teaching
PRUITT, Richard	Cow-Calf Management	Teaching, Research
ROSA, Artur	Molecular Genetics	Research, Teaching
SMART, Alexander	Range Management	Teaching, Research
STEIN, Hans	Swine Nutrition	Teaching, Research
THALER, Robert	Swine Nutrition	Extension, Teaching
ULLERICH, Mark	Rangeland Outreach	Extension, Research
WALKER, Julie (Ft. Pierre)	Ruminant Nutrition	Extension
WERTZ, Aimee	Ruminant Nutrition	Teaching, Research
WRIGHT, Cody L.	Cow-Calf Management	Extension, Research
WULF, Duane	Meat Science	Research, Teaching

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Mission

The overall mission of the Department of Animal and Range Sciences parallels South Dakota State University's Land Grant Mission of providing education, research and professional outreach through the Cooperative Extension Service to the Citizens of South Dakota. Two of the specific missions of the Department of Animal and Range Sciences are 1) to conduct research related to the animal and range sciences that will enhance the understanding and development of livestock and related industries, and 2) to transfer to the citizens of South Dakota research technology and information on livestock production, range management and related livestock industries, which will enhance the quality of life of all persons. The goal of this Annual Beef Report is to disseminate new knowledge that is discovered at South Dakota State University to the producers and livestock industries of South Dakota.

Biological Variation and Treatment Differences

Variability naturally exists among individual animals and plants. This variation can create problems when interpreting results from experiments. For example: when cattle in one treatment (X) have a numerically higher average daily gain compared to cattle in another treatment (Y), this difference in weight might be due to animal variation and not due to the treatments. Statistical analysis attempts to remove or reduce the natural variation that exists among animals and explains the difference due to the treatments.

In the following research papers, you will see notations similar to ($P < 0.05$). This means that there is less than a 5% chance that the difference between treatments is due to the natural variation that occurs. This indicates that that there is greater than a 95% probability that the differences between treatments are the result of the treatments. You will also notice notations similar to ($P = 0.10$). This means that there is a 10% chance that the difference between treatments is due to the natural variation that occurs. This indicates that that there is a 90% probability that the differences between treatments are the result of the treatments.

In most of the papers you will see an average, or mean, reported as 25 ± 2.3. The first number is the average value for the treatment. The second number is the standard error, or the variability that occurred, and explains how accurately the mean is estimated. There is a 68% probability that the true mean will fall within 1 standard error of the listed mean and a 94% probability that the true mean will fall within 2 standard errors. For this example we are 68% certain that the true mean is between the range of 27.3 and 22.7 and 94% certain that the true mean is between 29.6 and 20.4.

Ways we decrease variability and improve the chance of measuring differences due to treatments include: having several animals in each treatment, replicating treatments several times, and using animals that are as similar as possible. The use of statistical analysis in research allows for unbiased interpretation of results. The use of statistical analysis in the research reported here increases the confidence in the results.

Editorial Committee: Dr. G. A. Perry (editor)
Betty Knutsen (word processor and formatter)

Conversion Tables

The metric system is frequently used for reporting scientific data. To aid in interpreting these data the following tables have conversions for common measurements from the metric system to the Standard English System.

Metric	English
0 C	32 Fahrenheit
1 milliliter	0.03 ounces
1 Liter	0.26 gallons
100 grams	0.22 pounds
1 kilogram	2.2 pounds
1 meter	3.28 feet

2005 South Dakota Beef Report

Range

Reproduction

SDSU Cow/Calf Teaching and Research Unit

Dick Pruitt[1], Kevin VanderWal[2], and Anna Drew[3]
Department of Animal and Range Sciences

BEEF 2005 – 01

Summary

The SDSU Cow/Calf Unit (CCU) provides cattle and facilities for numerous Animal Science and Range Science classes and a variety of research projects. The CCU also provides cattle for the SDSU Little International, Block & Bridle Club activities, numerous judging team workouts, and other activities that bring potential students to the SDSU campus. Kevin VanderWal and Anna Drew along with part-time student employees, manage the herd, collect research data, and assist with numerous beef cattle activities throughout the year.

Faculty members that have conducted or contributed to research at the CCU during the year include: Dick Pruitt, George Perry, Sandy Smart, and Jeff Clapper in the Animal and Range Sciences Department; Bill Epperson, Chris Chase, and Mike Hildreth from the Veterinary Science Department; and Vance Owens from the Plant Science Department. Studies on fenceline weaning, control of estrus and ovulation, corn germ as a source of supplemental fat before calving, extending the grazing season with small grain pasture, and interseeding legumes in grass pastures are reported in this publication.

About 130 Angus and SimAngus females are bred each spring and 100 calve starting in February. Although it is not feasible to maintain all the breeds that are important to this region, two breeds provide variation for teaching purposes and allow us to still use the herd for research where limiting variation is important. The goal of our breeding program is to produce bulls that fit into one of the following categories:

1. Low birth weight Angus bulls to breed to yearling heifers.
2. Higher growth Angus bulls (purebred and high percentage) to breed to cows.
3. SimAngus hybrid bulls for a simple crossbreeding system.

To accomplish that, proven sires are used by artificial insemination that represent below average birth weight and above average milk EPDS along with high yearling weight EPDs. In recent years, high marbling (or % IMF) and rib eye area sires have been used to increase carcass value as long as other important production traits are not sacrificed. The average expected progeny differences for the herd and sires used in 2005 are shown in Tables 1 and 2.

Each fall about 20 bred females are sold by phone auction. Yearling bulls produced are sold in a limited auction held in early April at the unit. The major goal of the sale is to provide a learning opportunity for students interested in the beef industry. Students are involved in producing the sale catalog, developing advertising, creating a promotional video, and answering questions from potential customers. Practice in communication, teamwork, and listening to customers is an important part of the process as well. Selection of sires each year is based heavily on what we learn from our customers on sale day and what has the most value to them.

On April 8, 2005 students from the CCU crew, the Seedstock Merchandising Class, and the Block & Bridle Club hosted bidders and answered questions from Colorado, Iowa, Nebraska, North Dakota, Nebraska, Minnesota and South Dakota. Table 3 shows the sale averages and range in prices. Fifty percent of the bulls sold to repeat customers. There is more information and pictures from our 2005 sale on the web at: ars.sdstate.edu/facilities/ccu.

[1] Professor
[2] Ag Research Manager/Specialist
[3] Sr. Ag Research Technician

Tables

Table 1. Expected progeny differences of Angus cows, replacement heifers and AI sires at the Cow Calf Unit.

	Angus Expected Progeny Differences (Spring 05)									
	BW	WW	YW	SC	Milk	%IMF	REA	%RP	$ Wean	$ Beef
Angus AI sires used in 2005	+2.1	+50	+93	+0.39	+28	+0.33	+0.57	+0.01	+45.57	+28.16
Angus cows	+1.7	+40	+75	+0.56	+22	+0.10	+0.15	-0.01	+23.99	+28.89
Angus replacement heifers	+1.5	+44	+82	+0.53	+25	+0.16	+0.24	+0.05	+25.76	+33.97
Avg. non-parent Angus bull in Angus Assn. database	+2.4	+37	+69	+0.32	+19	+0.09	+0.16	+0.08	+21.95	+27.82

Table 2. Expected progeny difference of SimAngus cows, replacement heifers, and Simmental AI sires at the Cow Calf Unit

	ASA Multibreed Expected Progeny Differences (Spring 05)						
	BW	WW	YW	Milk	YG	MB	REA
Simmental AI sires used in 2005	+1.9	+28	+70	+6	+0.00	+0.08	+0.24
SimAngus cows	-2.4	+19	+46	+7	+0.11	+0.22	-0.11
SimAngus replacement heifers	-2.3	+25	+59	+9	+0.17	+0.31	-0.18
Average non-parent SimAngus bull in Simmental Assn. database	-0.7	+22	+44	+5	+0.13	+0.26	-0.15

Table 3. Final bids at the 2005 SDSU Bull Sale

	Average	Range
19 Angus bulls	$3,468	$1,500 - $9,600
9 SimAngus bulls	$2,656	$2,000 - $3,300

Fenceline Weaning on Pasture and Forage Barley to Extend the Grazing Season for Replacement Heifers – a Three-year Summary[1]

Dick Pruitt[2]*, William Epperson[2†], Vance Owens[3‡] and Alexander Smart[4]*
Departments of Animal and Range Sciences*, Veterinary Science†, and Plant Science‡

BEEF 2005 – 02

Summary

In a three-year study at the SDSU Cow/Calf Teaching and Research Unit, Brookings, SD, heifer calves were allotted to two weaning management treatments in early October. The pasture-weaned group was separated from their dams and grazed a grass pasture across the fence from their dams for two weeks. Then, until early December, they grazed "Robust" barley (forage type) that had been no-till planted into oat stubble in early August. The drylot-weaned group was fed a traditional weaning diet of grass hay, corn and protein supplement from weaning until early December. Heifers received the same diet and were managed as one group from December until April. The effect of management on heifer weight gain depended on year**.** In the first two years gains for two and four weeks after weaning were affected by weaning treatment, but gains from weaning to December and April were similar. In the third year gains of heifers while grazing forage barley were less from weaning to December and April than those in dry lot. Pasture weaning appeared to cause less stress for both cows and calves, but no differences in incidence of disease were observed. Antibody titers for IBR, BVD type 1 and BVD type 2 were determined at weaning and two and four weeks after weaning to measure the development of immunity from vaccinations administered about two months prior to and at weaning. There was no overall effect of treatment on antibody titers, but there was an interaction of treatment and year for BVD type 1 at 2 weeks after weaning but not by 4 weeks. The percentage of heifers with positive titers was similar at all three sampling times. Heifers fed in drylot had more backfat, larger rib eye area, and % intramuscular fat in April. The results of this study indicate fenceline weaning on pasture combined with small grain pasture to extend the grazing system is a feasible alternative for managing replacement heifers compared to a traditional drylot weaning system. As would be expected, forage conditions as affected by year can influence performance. Weight of calves at weaning and forage conditions influence the need for supplementation.

Introduction

Some cowherd owners report that weaning calves on pasture greatly reduces the stress on the cow and the calf. The reduction in stress has potential to improve the health of weaned calves and possibly the acquisition of immunity from vaccination. It is common in southern areas of the US to graze calves on small grain pasture in the fall and winter. In South Dakota, combining pasture weaning and an extended grazing season has potential to reduce cost and labor associated with feeding, maintaining drylot facilities, and manure management. Small grains such as wheat, oats, rye, barley, and triticale are potential sources of high quality forage for calves. The objectives of this study were: 1) Evaluate fenceline weaning on pasture compared to traditional drylot weaning for calves and 2) Evaluate forage barley for pasture to extend the grazing season of weaned calves.

Materials and Methods

In each of three years, heifer calves averaging 198 days of age were allotted by breed and weight to two weaning treatments in early October. On weaning day the heifers in the pasture-weaned group were separated from their dams and allowed to graze grass pasture across the fence from their dams for two weeks. Two weeks after weaning they grazed 30 acres of forage barley until early December. The pasture consisted of "Robust" barley (forage type) that had been no-till planted into oat stubble in early August. They had access to a free choice mixture of salt, phosphorous, and

[1] This project was made possible by funds from USDA Multi-State Feed Barley Grant; Bill & Rita Larson, Fowler, CO; and the SD Ag. Exp. Station.
[2] Professor
[3] Associate Professor
[4] Assistant Professor

trace minerals. The heifers in the drylot-weaned group were transported to pens two miles from their dams and bunk fed a diet of corn, protein supplement, and grass hay (Table 1). Beginning in early December, all heifers were fed and managed as one group until yearling weights were recorded in April.

Prior to weaning (64 days the first year, 58 days the second year, and 43 days the third year) all heifers were administered a modified live virus vaccine containing IBR, BVD type 1, BVD type 2, PI_3, BRSV, as well as a Haemophilus somnus bactrin (Resvac 4/Somubac from Pfizer Animal Health). On the day of weaning, heifers were weighed and re-vaccinated with the same vaccine. At weaning and two and four weeks after weaning, a blood sample was collected from each heifer by jugular venipuncture. Using standard procedures, IBR, BVD type 1, and BVD type 2 titers were determined by the South Dakota Animal Disease Research and Diagnostic Laboratory, Brookings, SD. At two and four weeks after weaning and again in early December, all heifers were weighed following removal from feed and water overnight. For 28 days following weaning, heifer health was determined by observing for signs of depression, gauntness, eye or nose discharge, increased respiratory rate, coughing, diarrhea, or lameness.

In April, heifers were weighed after receiving the same diet and being managed as one group since December. Ultrasound images were recorded by a Centralized Ultrasound Processing Lab (CUP) certified technician. Images were interpreted by the CUP Lab, Ames, Iowa, for rib fat, intramuscular fat and rib eye area.

Data were analyzed using the general linear model (GLM) procedure of SAS and means were separated using the predicted difference (PDIFF) option. For average daily gain and weight the statistical model included weaning treatment, year, and weaning treatment x year. For ultrasound measurements the statistical model included weaning treatment, year, weaning treatment x year, percentage Angus, and age in days. A second analysis was conducted with rib fat as a covariate to determine the effect of treatment on rib eye area and % intramuscular fat. The logarithm base 2 of blood titers for IBR, BVD type 1, and BVD type 2 were analyzed with weaning treatment, year, and weaning treatment x year in the statistical model. The logarithm base 2 of blood titers at weaning was included as a covariate to analyze titers at two and four weeks after weaning. The least square means were transformed back to titers for Table 4. The percentage of calves with positive titers by treatment was analyzed by the frequency procedure (FREQ) of SAS with chi-square to determine significant differences.

Results & Discussion

The impact of weaning management on weight gain for the 4 weeks after weaning was dependent on year ($P < 0.05$ for the treatment x year interaction; Table 2). In the first year, pasture-weaned heifers gained more than the drylot group during the first two weeks after weaning ($P < 0.10$). Gains during other periods were similar, resulting in similar weights in April. Due to less favorable pasture conditions in the second year, the drylot group outgained the pasture-weaned group for two and four weeks after weaning ($P < 0.05$). Gains from weaning to December and April were not affected by management in either of the first two years. During the third year, quality and quantity of barley pasture limited gains from weaning to early December ($P < 0.05$). Heifers did not compensate from December to April, resulting in 51 lb lower weight in April ($P = 0.05$) for heifers that grazed forage barley.

It is not surprising that year affects weight gains of grazing cattle more than cattle fed grain and hay in drylot. Similar gains from weaning to December and to April during the first two years indicate that weaning on pasture followed by grazing small grains is a feasible alternative for developing replacement heifers. Research at other locations indicates that as long as heifers reach an appropriate target weight by the beginning of the breeding season, lower weight gain during early periods will not reduce reproductive performance.

Based on their performance, it would have been advisable to provide supplemental feed to heifers grazing barley during the third year to achieve weight gain similar to the drylot group. An important difference in year three was that heifers were slightly younger and almost 60 lb lighter at weaning. The pasture group was not able to make up for lower gains early after weaning. Supplementation early after weaning

is likely more important for lighter calves, particularly when forage quality and quantity limits performance. This could be important when calves are weaned earlier than 7 months of age.

The drylot-weaned group exhibited typical weaning behavior by walking the fence and bawling for about a week following weaning. The pasture-weaned group appeared to be less stressed. No bawling or walking the fence was observed. Weather conditions were near ideal to minimize stress each year, and no disease symptoms were observed for either group.

Management treatment did not affect IBR or BVD type 2 titer at any of the three sampling times (Table 3). There was a year x weaning treatment interaction (P = 0.06) for BVD type 1 titer at 2 weeks after weaning. During the second year the drylot group had a higher mean BVD type 1 titer than the pasture group (136.9 versus 73.1; P = 0.06). By four weeks, titer values were similar. It is possible that weaning management affected acquisition of immunity following vaccination. But after analyzing three years of data, the effect was not consistent. Table 4 shows the same information expressed as the percentage of heifers with positive titers. There was no effect of treatment when analyzed in this manner.

Body composition measured by ultrasonography in April is presented in Table 5. Heifers weaned on pasture had less rib fat ($P < 0.001$), smaller rib eye area ($P < 0.001$), and lower %IMF ($P = 0.02$). In a second analysis when rib fat was included in the statistical model as a covariate, the differences for rib eye area and % IMF were still important. Although it was not expected that the small difference in diets for less than three months would affect body composition as yearlings, this difference was consistent across years. Other research indicates that nutrition at a young age can affect body composition of yearlings. This may not be important for developing replacement females but could be a factor to consider when backgrounding calves intended for harvest.

Implications

Fenceline weaning on pasture followed by grazing small grain pasture is an alternative to drylot weaning for developing replacement heifers. It appears to be less stressful without detrimental affects on immunity following vaccination. Yearly differences that affect forage quality and quantity will influence gain. Calf weight at weaning and forage conditions may be important when determining the need for supplementation.

Tables

Table 1. Average daily intake of drylot heifers from weaning to early December

Grass hay, lb DM	7.3
Cracked corn, lb DM	4.1
Protein supplement, lb DM[a]	1.2
Rumensin supplement, lb DM[b]	0.9
Crude protein, lb	1.6
ME, Mcal	14.5

[a]Provided 27.4% CP and Ca, P, and trace minerals to exceed NRC (1996) requirements.
[b]To provide 100 mg monensin per head daily.

Table 2. Weaning management and heifer performance

Year	2002		2003		2004	
Weaning treatment	Drylot	Barley Pasture	Drylot	Barley Pasture	Drylot	Barley Pasture
No. heifers	23	23	21	21	26	26
Age, days	200	203	201	201	193	193
Weaning weight, lb	584	577	576	572	521	520
Average daily gain after weaning, lb[a]						
First 2 weeks	-0.52[b]	0.11[c]	0.40[d]	-0.82[e]	0.21	0.62
First 4 weeks	0.59	0.70	1.26[d]	-0.09[e]	1.07	0.70
To December	1.42	1.49	1.48	1.43	1.60[d]	0.99[e]
To April	1.96	1.96	1.87	1.78	1.98[d]	1.75[e]
April weight, lb	929	922	951	930	959[d]	908[e]

[a] There was a year x treatment interaction for ADG during all periods (P < 0.05).
[b,c] Within year, means with uncommon superscripts differ (*P* < 0.10).
[d,e] Within year, means with uncommon superscripts differ (*P* < 0.05).

Table 3. Effect of weaning management on IBR and BVD titers

Management treatment	Drylot	Pasture	Treatment P =	Treatment x year P =
No. heifers	70	70		
Age at weaning, days	198	197		
IBR titer				
Weaning	8.8	8.1	0.60	0.74
2 weeks after weaning[a]	106.4	111.6	0.78	0.85
4 weeks after weaning[a]	85.1	86.4	0.94	0.29
BVD type 1 titer				
Weaning	46.9	44.3	0.81	0.68
2 weeks after weaning[a, b]	77.8	80.3	0.87	0.06
4 weeks after weaning[a]	83.8	84.4	0.98	0.28
BVD type 2 titer				
Weaning	5.6	6.0	0.55	0.85
2 weeks after weaning[a]	7.2	6.9	0.69	0.54
4 weeks after weaning[a]	7.0	7.4	0.64	0.55

[a] The statistical model for titers at two and four weeks after weaning included the titer at weaning as a covariate.
[b] In the second year BVD type 1 titer at 2 weeks was greater for the drylot group than the pasture group (136.9 vs 73.1; P = 0.08).

Table 4. Weaning treatment and percentage of positive titers for IBR and BVD

	Drylot	Pasture	P =
IBR titer, % positive (> 4)			
weaning	62.9	57.1	0.49
2 weeks after weaning	98.6	95.7	0.31
4 weeks after weaning	94.3	92.9	0.73
BVD type 1 titer, % positive (> 8)			
weanng	84.3	81.4	0.65
2 weeks after weaning	90.0	87.1	0.60
4 weeks after weaning	90.0	85.7	0.44
BVD type 2 titer, % positive (> 8)			
weaning	12.9	15.7	0.63
2 weeks after weaning	28.6	28.6	1.00
4 weeks after weaning	15.7	25.7	0.14

Table 5. Weaning treatment and yearling ultrasound measurements

Weaning Treatment	Drylot	Pasture	Treatment P =	Treatment x Year P =
No. heifers	70	68		
Avg. age, days	408	408		
Rump fat, in.	0.29	0.29	0.61	0.64
Rib fat, in.	0.24	0.22	0.02	0.78
Ribeye area, sq. in.[a]	11.4	10.8	0.00	0.84
% Intramuscular fat[a]	4.27	3.98	0.00	0.96

[a] When rib fat was included in the model, treatment effect was still important (P < 0.06).

Effects of Weaning Date and Retained Ownership on Cow and Calf Performance and Forage Disappearance in Spring Calving Beef Systems[1]

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North Dakota State University - Dickinson Research Extension Center*, SDSU – Dept of Animal and Range Sciences†, and University of Wyoming - Dept. of Animal Science‡

BEEF 2005 - 03

Summary

Researchers in North Dakota, South Dakota and Wyoming are working together to evaluate the effect of weaning calves 75 days earlier than normal and are following the calves through finishing. This report summarizes accomplishments so far. Briefly, weaning calves 75 days early (mid-August) has improved cow weight and condition score compared to cows whose calves were weaned normally (early-November). Native range forage disappearance has tended to be lower when calves were weaned early. After weaning, backgrounded early weaned steers grew faster and were more efficient. However, early weaned steers required 61 more days on feed to reach final harvest.

Introduction

Cow/calf operations that are able to utilize early weaning of calves as part of their marketing and resource management strategies can add tremendous flexibility to their operations. The greatest concern of producers considering early weaning is selling a light calf and, as a result, losing revenue. Additional concerns may be availability and/or accessibility of facilities or operations to handle early weaned calves and apprehension to change. A number of post-weaning strategies may be useful in increasing the income from early weaned calves. Clearly it will be important to determine the decisions in the post-weaning system that have the greatest impact on net income (e.g. sale of calves at weaning versus retained ownership through backgrounding versus retained ownership through finish). These decisions have potential to add value to the calf crop as well as to forage and grain crops from the region. Other components of the ranching system will also be affected by weaning date, and these must be considered in any effort to determine the consequences of a weaning decision. Objectives of this study were to evaluate the effects of weaning date on cow performance during the fall, calf performance through backgrounding and finishing, and forage utilization.

Materials and Methods

Cow herds from the South Dakota State University Antelope Station (SDSU; 140 cows), the North Dakota State University Dickinson Research Extension Center (DREC; 88 cows), and the University of Wyoming Beef Unit (UW; 93 cows) were used in the study. At each location, spring-born calves were weaned from cows at approximately 140 days (mid-August) or 215 days of age (early-November). Cow body weight and body condition score change were monitored between the August and November weaning dates to determine impacts of weaning on cow performance.

Calf weaning weights were recorded at each location. Steer calves from SDSU and DREC were transported immediately after weaning to the NDSU Hettinger Research Extension Center for backgrounding. Steers were backgrounded either 49 (early weaned) or 54 (normal weaned) days using a diet consisting of locally grown forage and a commercial pellet consisting of regionally available co-product feedstuffs (soyhulls, wheat middlings, barley malt sprouts). Two to four weeks prior to each weaning date, calves were vaccinated against clostridial and respiratory diseases (Ultrabac 7/Somubac®-

[1] This project funded by the 4-State Ruminant Consortium.
[2] Animal Scientist
[3] Assistant Professor
[4] Professor
[5] Superintendent, Antelope Research Station

killed, Bovi-Shield 4®-modified live, One Shot®-modified live). Calves were boostered with Ultrabac 7/Somubac® and Bovi-Shield 4® at weaning. Following the 7-8 week backgrounding phase, calves were transported to a commercial feedyard for finishing. An electronic cattle management system was employed to determine final end point, based on an external fat depth of 0.40 inch. While at the feed yard, morbidity and mortality frequency and distribution was monitored. Steers from DREC and SDSU facilities were slaughtered at Excel Packing and carcass data was collected by plant personnel.

Both steers and heifers from UW were managed in a similar protocol as described for SDSU and DREC steers. Cattle were backgrounded at the UW Beef Unit, Laramie, for 43 (early weaned) and 40 (normal weaned) days, respectively. Following the backgrounding period, cattle remained at the UW Beef Unit for the experiment's finishing phase. Cattle were marketed in three groups, March 29, May 10, and May 25, 2004. Final harvest was at Swift Packing Company, Greeley, Colorado.

Grazing, backgrounding, and finishing performance were analyzed by ANOVA using a PROC GLM procedure of SAS. Since treatment by location interactions were identified, treatment means were compared within location. Animal was used as the experimental unit for the cow data and pen was used as the experimental unit for the calf data (since SDSU and DREC cattle were finished using individual cattle management, animal was the experimental unit for the finishing data at those locations).

Vegetation samples were collected at DREC to determine the magnitude of biomass disappearance among cows suckling calves from August to November (normal weaning; n=3 pasture groups) versus dry cows grazing from August to November (early weaning; n=3 pasture groups). A 640 acre pasture was subdivided into twelve 50 acre pastures in a wagon wheel configuration with central watering sites and a 23 acre center cell where cattle handling procedures were conducted. Three pen replicates per treatment were randomly assigned to half of the pastures in June where the cow-calf pairs grazed until the first weaning in mid-August. At the mid-August early weaning date, replicated groups of early and normal weaned cows were rotated and randomly assigned to the remaining six ungrazed pastures. Ungrazed pastures were sampled just prior to the mid-August rotation to estimate total available biomass and again at the end of grazing in November to estimate residual biomass. Fifty 0.25 meter samples were taken per 50 acre pasture. Forage biomass remaining after grazing compared to that measured prior to grazing was used to estimate native range forage disappearance for each weaning treatment. Growth during the August to November period was assumed to be negligible. Analysis of variance was used to evaluate weaning treatment effect on biomass disappearance with pasture as the experimental unit.

Results and Discussion

Early weaning impacted cows positively by maintaining or improving body weight ($P < 0.01$) and body condition score ($P < 0.01$) at each location (Table 1).

Normally weaned steers were heavier at the end of the backgrounding phase ($P < 0.01$) at each location (Table 2). Early weaned calves from DREC had higher ($P < 0.01$) average daily gain during backgrounding than normally weaned calves, whereas calves from SDSU had similar gains across weaning dates. In contrast, early weaned calves from UW gained less than those weaned in November ($P < 0.01$). Dry matter intake ($P < 0.05$) and F:G ($P < 0.01$) of early weaned calves were improved compared to normal weaned at SDSU and DREC.

During the finishing phase, normal weaned steers were an average 77 kg heavier on arrival ($P < 0.01$); however, final harvest weight did not differ (Table 3). On average, normal weaned steers required 61 fewer days on feed ($P < 0.01$), and SDSU's normal weaned steers were less efficient during finishing ($P < 0.01$).

Fat depth at UW was 2.75 mm greater ($P < 0.05$) for the early weaned steers. Yield and quality grades did not differ at SDSU and DREC. Hot carcass weight and rib-eye area did not differ between treatments. However, early weaned steers had greater yield ($P < 0.05$) and quality grades ($P < 0.10$) at UW that resulted when the early weaned group was fed to a higher degree of finish. Number of steers

grading Choice was low for DREC and SDSU cattle, indicating that steers finished with the electronic cattle management system needed to be on feed longer.

Morbidity was monitored based on treatment rate during the backgrounding and finishing phases of the study. Incidence of BRD was minimal among early weaned steers. However, normal weaned steers broke with BRD near the end of the backgrounding phase. Death loss was 3.95% (3 of 76). Initial feed yard pulls and re-pulls at the commercial feed yard (NDSU and SDSU) are shown in Figures 1 and 2. While steers in early weaned groups exhibited minimal BRD during backgrounding, incidence of BRD during the finishing phase for steers originating from both North and South Dakota was higher than expected.

The August weaning system utilized 72% of the available biomass when compared to the November system. Forage disappearance for cows that had calves weaned early was estimated to be 803 kg per ha, whereas forage disappearance among cows that continued to nurse their calves for an additional 75 days was estimated to be 1109 kg per ha (P = 0.15). The difference in forage utilization was attributed to calf removal.

Implications

Early weaning was advantageous to cow body condition score and early weaned calves performed adequately post-weaning. Early-weaned calves performed very well during the backgrounding phase. Early weaning resulted in sparing a significant amount of forage. Time of weaning decisions should include all of these factors and ultimately be based on net return. A beef systems economic analysis is in progress; however, the analysis is dependent upon complete summarization of the second year's data and is not included in this report.

Tables

Table 1. Body weight and condition score change among early and normal weaned cows located at the NDSU-Dickinson Research and Extension Center, SDSU- Antelope Station and UW - Beef Unit (2003)

Item	DREC Weaning period		SDSU Weaning period		UW Weaning period	
	Early	Normal	Early	Normal	Early	Normal
August cow wt., lb	1285	1332	1341	1329	1207	1242
November cow wt., lb[a]	1273	1135	1375	1281	1228	1178
Cow wt. change, lb[a]	-12	-197	36	-47	21	-65
August BCS	5.52	5.52	5.63	5.65	5.43	5.59
November BCS[a]	5.91	4.32	5.97	5.63	5.38	4.82
BCS change[a]	0.39	-1.20	0.34	-0.02	-.05	-.78
August calf wt., lb[b]	386	405	407	403	443	436
November calf wt., lb	-	543	-	582	-	607

[a]Treatments at each location differ ($P < 0.01$).
[b]Treatments at DREC location differ ($P < 0.10$).

Table 2. Summary of backgrounding performance for early and normal weaned steers at the NDSU - Dickinson Research and Extension Center (DREC), SDSU - Antelope Station and UW - Beef Unit (2003)

	DREC		SDSU		UW	
Item	Early	Normal	Early	Normal	Early	Normal
No. steers	40	38	36	35	26	23
Days on feed	49	54	49	54	43	40
Start wt., lb[a]	407	553	414	600	445	622
End wt., lb[a]	578	715	568	765	536	718
ADG, lb[b]	3.50	2.99	3.12	3.05	2.13	2.56
DM intake, lb[c]	12.0	12.5	11.7	13.2		
Feed:Gain, lb[d]	3.44	4.16	3.76	4.35		

[a]Treatments at each location differ (*P < 0.01*).
[b]Treatments at DREC and UW locations differ (*P < 0.01*).
[c]Treatments at DREC and SDSU locations differ (*P < 0.05*).
[d]Treatments at DREC and SDSU locations differ (*P < 0.01*).

Table 3. Feedlot finishing performance and carcass measurements for early and normal weaned steers from the NDSU-Dickinson Research and Extension Center (DREC), SDSU- Antelope Station and UW - Beef Unit (2003)

	DREC		SDSU		UW	
Item	Early[a]	Normal	Early	Normal	Early	Normal
Receiving wt., lb[b]	559.02	699.99	561.64	743.91	536	718
Harvest wt., lb.	1136.42	1173.5	1109.72	1174.4	1219	1229
Days at feed yard, da[b]	188.45	129.06	182.94	133.0	224	150
ADG, lb.[b]	3.08	3.69	2.99	3.22	3.08	3.42
F:G, lb.[c]	5.20	5.18	5.18	5.86		
Hot carcass wt., lb.	718.47	719.81	701.64	725.2	735	734
Rib eye area, sq. in.	12.19	12.83	12.15	12.41	11.57	12.17
Fat depth, in.[d]					.55	.44
Yield Grade[d]	2.61	2.54	2.68	2.7	2.76	2.45
Quality Grade[e]	2.95	2.78	3.00	2.8	4.95	4.38
Percent Choice, %	26.4	25.71	13.9	23.53	85.7	59.1

[a] Two steers died of bloat during finishing.
[b] Treatments at each location differ (P < 0.01).
[c] Treatments at the SDSU location differ (P < 0.01).
[d] Tratments at the UW Beef Unit differ (P < 0.05).
[e] Treatments at the UW Beef Unit differ (P < 0.10).

Figures

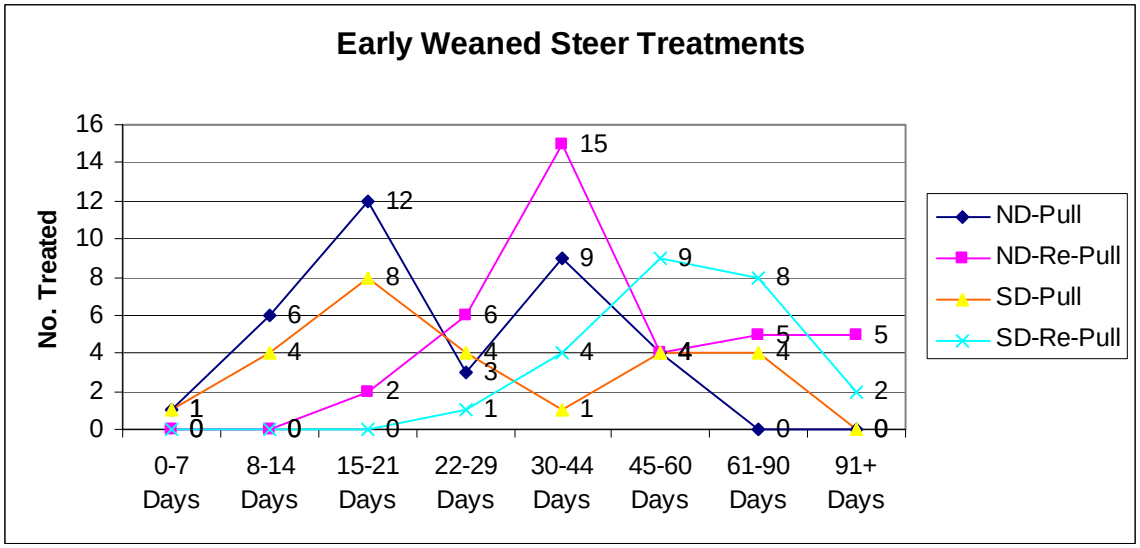

Figure 1. Distribution of BRD among early weaned steers from NDSU-Dickinson Research and Extension Center and SDSU-Antelope Station that required intervention at the feed yard (2003).

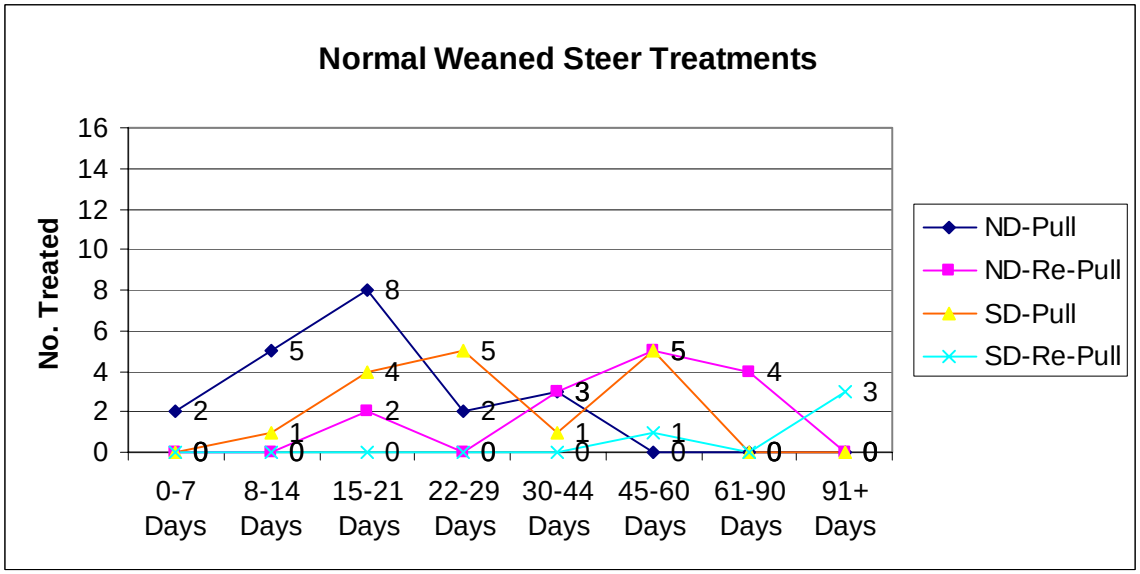

Figure 2. Distribution of BRD among normal weaned steers from NDSU-Dickinson Research and Extension Center and SDSU-Antelope Station that required intervention at the feed yard (2003).

Evaluation of Performance and Costs of Two Heifer Development Systems[1]

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BEEF 2005 – 04

Summary

Early weaned (EW) heifers must be developed for a longer period of time usually resulting in increased development costs. Developing EW heifers on native range may reduce these costs. Dried distillers grains plus solubles (DDGS) offers protein and energy that compliment native forages for developing heifers. The objective of this study was to evaluate the performance and costs of two heifer development systems in northwest South Dakota. Sixty-five nulliparous crossbred beef heifers were randomly allotted to one of two systems: 1) heifers (n=33) weaned at 132 d of age (461 lb) and developed on range with a DDGS supplement (1.8 to 6.4 lb/hd/d) from Sept. 25 to May 18 (Range); 2) heifers (n=32) weaned at 218 days of age (605 lb) and developed in a drylot with grass hay and a conventional supplement (2.6 to 3.6 lb/hd/d) from Dec. 2 to May 18 (Normal). Supplement levels were established to result in both groups of heifers reaching 65% of mature weight at breeding (863 lb). All heifers were managed similarly after May 18. Heifers were synchronized with a shot of $PGF_{2\alpha}$ and bred natural service beginning June 14. As necessary for target weights to be reached, ADG through the feeding period was greater ($P < 0.05$) for Range (1.68 lb/d) than (Normal 1.34 lb/d). Range heifers tended ($P = 0.12$) to be heavier on May 18 (859 and 830 lb, respectively) and were heavier ($P < 0.05$) at breeding (915 and 834 lb, respectively). Weight differences in May were a result of higher than expected gains by the Range heifers in the spring. From May 18 to June 14, Range heifers gained more ($P < 0.05$) than Normal (2.07 and 0.32 lb/d, respectively). Synchronized conception and overall pregnancy rates were similar ($P > 0.25$) between the Range and Normal heifers (58% vs. 50% and 91% vs. 88%, respectively). Supplement and forage costs for the Range system was similar ($122/hd) to the Normal ($117/hd). Range development provides an alternative method for developing early-weaned heifers that reduces daily costs.

Introduction

Cow-calf production systems that rely heavily on harvested and purchased feeds have less potential to be profitable (Adams et al., 1994). At the Antelope Range and Livestock Research Station near Buffalo, South Dakota, ongoing research is evaluating the effectiveness of early weaning in managing forage supplies and cow body condition in order to reduce the requirement for harvested feeds. An important part of any early weaning system is the reproductive performance and costs associated with developing heifers. Indeed, early-weaning heifers from dams results in more days that heifers must be managed and fed, potentially increasing the costs of the heifer development program. If available, forage spared by early weaning may be used in developing the early-weaned heifers.

Developing heifers on range is not a common practice in northern South Dakota due to the perception that adequate reproduction cannot be maintained in such a system. Recent reports showed that bred heifers could be managed on range with no hay during late gestation by feeding dried corn-gluten feed (Loy et al., 2004), a source of protein and fiber based energy. It is hypothesized that a similar management system could be used to develop replacement heifer calves.

Dried distillers grains plus solubles (**DDGS**) has a unique combination of fat, fiber, and protein that makes the product valuable to young beef

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female management programs. Both fat (Bellows, 1997) and undegradable intake protein (Patterson et al., 2003) supplemented to bred heifers during late gestation has been shown to increase reproductive rates. The effect of DDGS supplementation on reproduction in replacement heifers has not been well documented. Due to the low cost of both protein and energy in DDGS, the product may also be valuable in replacing expensive hay inputs in heifer development programs. Since DDGS compliments native winter range, it has promise as a supplement to heifers being developed on grass.

Materials and Methods

Sixty-five nulliparous crossbred beef heifers at the Antelope Range and Livestock Research Station, located near Buffalo, SD, were randomly allotted into one of two heifer development systems. In the first system (**Range**), heifers (n = 33) were weaned on August 12, 2003, averaging 132 days (range 149 to 93 days) of age and 395 lb (range 276 to 516 lb). Heifers were fed a weaning ration in the drylot consisting of grass hay and 3.5 lb (DM) of weaning pellet (pellet contained adequate protein, vitamins, and minerals and 66 mg/kg Decoquinate). On September 25, 2003, the heifers were turned out to native range and supplemented with DDGS (loose meal; Table 1). The DDGS was fed daily in feed bunks at rate of 1.8 to 6.4 lb/hd/d (DM basis). The feeding rate was established to result in heifers weighing approximately 65% of mature weight at breeding in June (863 lb), for an average daily gain of 1.50 lb/day during the trial (assuming 2.00 lb/day following treatments in early summer). The feeding rate changed over the winter to account for heifer size, weather conditions, expected forage quality and observed interim performance. The level of DDGS supplementation (DM basis: per hd/d) was 1.8 lb in September and increased to 3.5 lb on November 24, 4.4 lb on December 2 and 6.4 lb on February 12. The supplementation level was then decreased to 4.4 lb on April 20 and 1.0 kg on May 4. Hay was fed on two days when snow cover prevented grazing (10.4 lb/hd/d).

The second system (**Normal**), heifers (n = 32) were weaned on November 6, 2003, averaging 218 days (range 239 to 178 days) of age and 565 lb (range 418 to 662 lb). Heifers were fed the same weaning ration as the early-weaned heifers for 37 days. On December 13, immediately following the weaning period, heifers remained in the drylot and were placed on a diet consisting of ad-libitum access to grass hay (8.1% CP, 66% NDF; DM basis) and a conventional supplement fed (Table 1a) at a rate of 2.6 to 3.6 lb/hd/d (DM basis; Table 1). The supplement was fed at a rate to achieve approximately 65% of mature weight at breeding in June (863 lb), for an average daily gain of approximately 1.30 lb/day during the trial (assuming heifers would gain 2.00 lb/day following treatments in early summer). Although hay was fed ad-libitum, each hay bale was weighed to record hay disappearance.

Both treatments were terminated on May 18, 2004, when all the heifers were turned out to native range as a single group.

Heifers were weighed at weaning, the initiation of winter treatments (September 25 and December 13), at the termination of winter treatments on May 18, and at approximately 30-day intervals throughout the treatment period. Heifers were also weighed at the initiation of breeding on June 14 and at time of pregnancy determination on November 9.

On June 14, all heifers were exposed to bulls as a single group. On June 18, heifers were given an injection of $PGF_{2\alpha}$ (25 mg i.m. Lutalyse, Pfizer Animal Health, New York, NY) to synchronize estrus. Bulls were removed 5 d later, on June 23, for a 14 d period so that synchronized conception rates could be determined. Synchronized conception rates were determined by transrectal-ultrasonography 51 d after synchronization. Overall pregnancy was determined by rectal palpation 99 d after the breeding season. Two blood samples were taken 2-weeks apart prior to synchronization to determine estrous cycling status.

The effects of treatments on heifer weights and body condition scores were analyzed by ANOVA with Proc GLM of SAS (SAS Inst. Inc., Cary, NC). The effects of treatments on estrous cycling status, synchronized conception rates and pregnancy rates were analyzed by Chi-Square.

Results and Discussion

Range heifers weighed less ($P < 0.05$) at the initiation of their treatment protocol (September

25) than did Normal heifers at the initiation of their treatment protocol (December 2; Table 2). Range heifers were able to overcome their lighter initial weights by gaining 0.33 lb/d more than the Normal heifers during the experimental period ($P < 0.05$; Table 2). There was a slight difference in ADG between the Range and Normal heifers (1.34 and 1.19 for Range and Normal, respectively; $P = 0.13$) from December through February. The average daily gains between the winter months were lower for both systems than anticipated. This could be attributed to cold weather in December (avg. min. 12 ºF; avg. max. 38 ºF), January (avg. min. 5 ºF; avg. max. 23 ºF) and February (avg. min. 9 ºF; avg. max. 32 ºC). In addition, from December through February there were 44 days when snow cover was measured (average depth of 10 cm). Range heifers had higher ($P < 0.05$) ADG through March (2.13 and 1.30 for Range and Normal, respectively) and April (2.58 and 1.78 for Range and Normal, respectively; Figure 1).

Due to the greater than expected gain in the spring, the Range heifers tended ($P = 0.12$) to be heavier than the drylot heifers (859 lb and 830 lb, respectively) on May 18, the termination of treatment application. Interestingly, there was a difference ($P < 0.05$) between average daily gain of heifers from the two systems from May 18 to June 14, after treatments were applied (2.07 and 0.32 lb/d for Range and Normal, respectively). Although both groups of heifers were near their target weight of 863 lb at breeding on June 14 (Table 2), Range heifers were heavier at breeding ($P < 0.05$) than Normal heifers (Figure 2). The Normal heifers did not overcome the weight difference by November ($P < 0.05$).

There was no difference between treatments in the percentage of heifers that were estrous cycling before the start of the breeding season ($P > 0.25$; 94% and 100% for Range and Normal, respectively). Synchronized conception rates and overall pregnancy rates did not differ ($P > 0.25$) between the Range and Normal heifers (Table 2).

Supplement and forage costs for the Range heifers was similar ($122/hd) to the Normal group ($117/hd). Cost per day for the Range and Normal systems were $0.52 and $0.74, respectively (Tables 3).

Loy et al. (2004) reported that bred heifers could be maintained during the winter without hay feeding. These data show that heifer calves may also perform adequately without significant hay inputs. We observed heifers foraging through snow-cover. It is possible that the increased level of supplementation in February and March was not necessary since the heifer gains were higher than expected in the spring and early summer. It is important to note that more severe winter conditions may result in a requirement for more hay feeding to sustain performance. The improvement in gains for Range heifers compared to Normal during the early summer was higher than expected and also contributed to their weights being higher at breeding. It is not clear if this was due to physiological or behavioral differences in the heifers during the early summer months.

Implications

These results showed that early-weaned heifers developed on range with dried distiller grains supplement can achieve similar reproductive performance as normal-weaned/drylot developed heifers, but at a lower cost per day. The range system resulted in more developed young cows at a similar developmental costs as the conventional system.

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Tables

Table 1. Nutrients in DDGS and conventional supplement (DM basis)

Item	DDGS	Conventional Supplement
Crude Protein (%)	29.7	31.0
Calcium (%)	0.06	0.37
Phosphorus (%)	0.79	1.11
Potassium (%)	1.09	1.31
Magnesium (%)	0.34	0.45
Copper (mg/kg)	6	61
Zinc (mg/kg)	99	112
Manganese (mg/kg)	18	56

Table 1a. Ingredients of conventional supplement

Item	%
Wheat Middlings	49.0
Sunmeal – 35%	30.0
Canola Meal	7.75
Feather Meal Hydrolyzed	5.0
NDM 2003	5.0
Cane Molasses	2.5
Salt	0.46
Minerals	0.16
Vitamins	0.1
Eddi 10% Premix	0.002

Table 2. Performance of heifers that were weaned in August and developed on range (Range) compared to November-weaned heifers developed in a drylot (Normal)

Treatment	Range ± SEM	Normal ± SEM
No. Head	33	32
Initial BW, lb[e]	460 ± 9.3[a]	605 ± 9.5[b]
Final BW, lb[f]	859 ± 12.9[c]	830 ± 13.1[d]
Overall ADG, lb/d[g]	1.68 ± 0.03[a]	1.34 ± 0.03[b]
% pubertal before the breeding season[h]	94	100
Synchronized Conception Rate[i]	58	50
Final Pregnancy Rate[j]	91	88

[a,b] Within a row, means with unlike superscripts differ (P < 0.05)

[c,d] Within a row, means with unlike superscripts differ (P = 0.12)

[e] Weight at the beginning of treatments
Range: 9-25-03; Normal: 12-2-03

[f] Weight at the end of treatments - both groups 5-18-04

[g] Average daily gain from initial to final weight

[h] Percent of heifer estrous cycling before the start of the breeding season

i Percent pregnant during the 10 d synchronization period to natural service

[j] overall pregnancy (34 d breeding season)

Table 3. Supplement and Forage Costs for heifers that were weaned in August and developed on range (Range) compared to November-weaned heifers developed in a drylot (Normal)

	Range[a]		**Normal[b]**	
	Total Feed (lb)	**Total Cost**	**Total Feed (lb)**	**Total Cost**
Hay	752	$27.07	65,341	$2,352.28
DDGS	36,168	$2,061.58		
Range[c]		$1,947		
Conventional Supplement			17,280	$1,382.40
	Total Cost	$4,035.65	**Total Cost**	$3,734.68
	Cost/heifer	$ 122.29	**Cost/heifer**	$116.71
	$/hd/day	**$0.52**	**$/hd/day**	**$0.74**

[a] 33 early weaned heifers developed on range and DDGS for 236 d

[b] 32 normal-weaned heifers developed in drylot and conventional supplement for 158 d

[c] Rate at $7.50/AUM

Figures

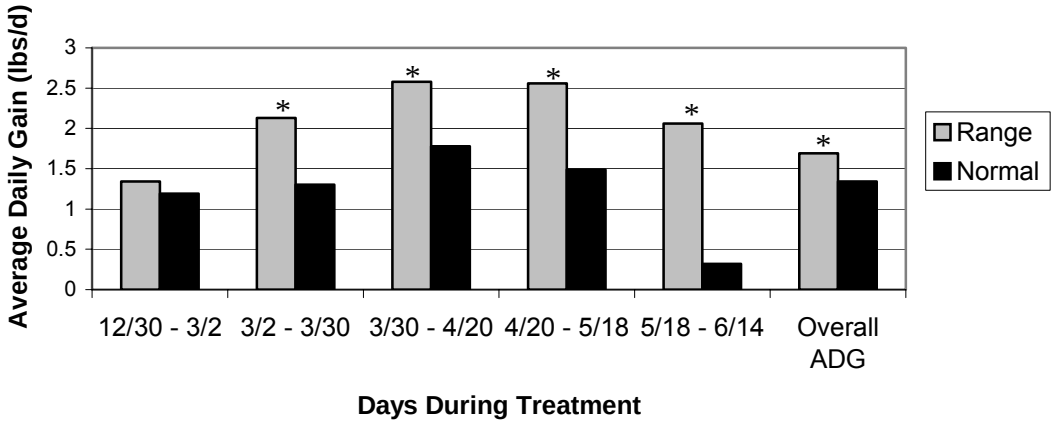

Figure 1. Average Daily Gain (lbs/d) of heifers weaned in August and developed on range (Range) compared to heifers weaned in November and developed in a drylot (Normal). (*$P < 0.05$)

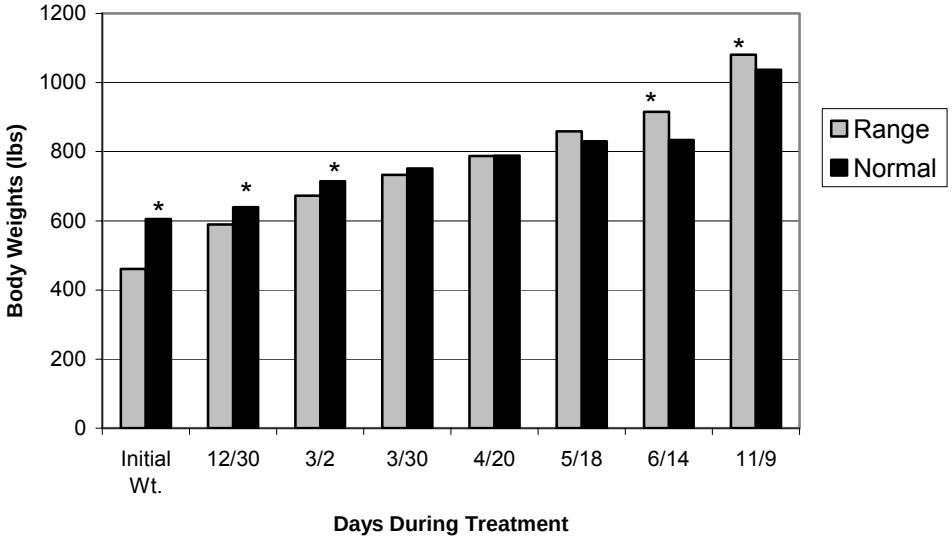

Figure 2. Body weights of heifers weaned in August and developed on range (Range) compared to heifers weaned in November and developed in a drylot (Normal). (*$P < 0.05$)

Response of Cow-calf Pairs to Water High in Sulfates[1]

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BEEF 2005 – 05

Summary

Data from our laboratory showed water sulfate levels of 3,000 ppm reduced performance and health of growing steers during summer months. In addition, water averaging 2,600 ppm in sulfates for cow-calf pairs had little impact on calf growth or milk production, but caused small reductions in cow BW and body condition score (BCS). This experiment was conducted to evaluate the effects of high sulfate water on cow and calf performance, milk production, and reproduction. Ninety-six crossbred, lactating cows (ages 2-13; average calving date of April 14) and their calves were assigned, after stratifying by age, weight, and previous winter management, to one of six pastures (16 cows/pasture). Pastures were randomly assigned to one of two water sulfate levels (three pastures/level). Treatments were low sulfate (LS) water (average 368 ± 19 ppm sulfates) or high sulfate (HS) water (average 3,045 ± 223 ppm sulfates). The HS water was created by adding sodium sulfate to the LS water. Cows grazed native range and received a conventional mineral supplement ad-libitum from June 3 to August 26, 2004. Water was provided in aluminum stock tanks. Cow 12-h milk production was estimated by the weigh-suckle-weigh method on August 7. Cows were synchronized with a single injection of prostaglandin and bred by natural service. There were no differences in cow weight or BCS change during the trial ($P > 0.15$). Twelve-hour milk production in August was higher ($P = 0.02$) for LS (9.0 lb) than HS (7.5 lb). Calf ADG tended to be higher ($P = 0.14$) for LS (2.56 lb/d) than HS (2.45 lb/d). The percentage of cows that became pregnant during the first 25 days of the breeding season was higher ($P = 0.06$) for LS (81%) than HS (64%), and final pregnancy rates (55-d breeding season) were 92% and 83%, respectively ($P = 0.20$). Sulfate levels averaging 3,045 mg/L in the drinking water of cow-calf pairs during the summer reduced cow milk production and the number of cows bred early in the breeding season.

Introduction

Our research group continues to evaluate the effects of high sulfate water on cattle, with a goal of defining critical levels of total dissolved solids (TDS) and sulfates in the drinking water. Patterson et al. (2002) reported that water with 3,000 ppm sulfates or greater reduced ADG, DMI, water intake, and gain/feed of growing steers in confinement compared to water with approximately 400 ppm sulfates. Additional work showed a quadratic decline in ADG, DMI, and gain/feed as sulfates in water for confined steers increased from approximately 400 to 4,700 ppm (Patterson et al., 2003). These reports also showed that cattle in confinement consuming water with 3,000 ppm sulfates or greater were at a higher risk of polioencephalomalacia (**PEM;** Patterson et al. 2002; 2003). Based on these studies, we have concluded that the critical level of sulfates in the water for growing cattle during the summer months is 3,000 ppm. Since water requirements increase with elevated temperatures (NRC, 1996), this critical level may be different in various environments.

Johnson and Patterson (2004) reported that water with 3,941 ppm sulfates or greater reduced performance of grazing stocker steers in South Dakota. Few health problems were observed in stocker cattle receiving the high sulfate water over that two-year study. In addition, intermediate levels of sulfates were not tested, so a "critical" level could not be determined. Patterson et al. (2004) reported that water averaging 2,600 ppm sulfates for cow-calf pairs resulted in reduced cow weights but had little impact on reproduction or calf growth. The objective of this study was to evaluate the effects of sulfates in water averaging 3,000 ppm for cow-calf pairs grazing

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native range during the summer on cow and calf performance, milk production, and cow reproduction.

Materials and Methods

The study was conducted from June 3 to August 26, 2004 at South Dakota State University's Cottonwood Range and Livestock Research Station, near Philip, SD. Ninety-six crossbred, lactating cows (ages 2-13 yr; 1281 lb) and their calves (average birth date April 14; ages 18–80 days; 181 lb) were assigned, after stratifying by age, weight, and previous winter management, to one of six pastures (16 cows/pasture). Pastures were randomly assigned to one of two water sulfate levels (three pastures/level). Treatments were low sulfate (**LS**) water or high sulfate (**HS**) water. Water was provided daily in aluminum stock tanks (round tanks; approximately 98 inches in diameter).
The LS water was from a rural water system, and the HS water was created by adding sodium sulfate to LS water to a targeted 3,000 ppm sulfate level. LS water was added to two storage tanks (one provided water for two HS pastures and one provided water for the remaining HS pasture). Sodium sulfate was added to LS water in the storage tanks during the afternoon of each day. Stock tanks were filled the following morning with either LS water or the previously-mixed HS water from the storage tanks. Samples from each water source were taken as stock tanks were being filled. Water samples were composited weekly and sent to the Water Resource Institute in Brookings, SD for sulfate analysis. A locally available commercial mineral was provided to cows in each pasture ad-libitum (13% Ca; 12% P; 13% salt; 2,000 ppm Cu; 8,000 ppm Zn).

On June 3 (trial initiation) and August 26 (trial termination), both cows and calves were weighed and cows were assigned a body condition score (**BCS**; 1-9 scale; Richards et al., 1986) by two trained technicians (to the nearest 0.5 of a BCS). Cow-calf pairs were all on LS water and grazed native range prior to trial initiation. Cows and calves were separated and not allowed access to feed or water for approximately 12 h prior to initial weight measurements. At the end of the trial, all cows and calves were placed on LS water for three days prior to final weight measurements. Cows and calves were separated and housed in a drylot without access to feed or water for approximately 12 h prior to final weight measurements.

On August 7, all cows were used to estimate twelve-hour milk production by the weigh-suckle-weigh method (Boggs et al., 1980). In brief, calves were separated from cows at approximately 0800 the day prior to measurements. Calves were returned to dams at 1800, allowed to suckle until content, and again removed. Calves were weighed the following morning at 0600, returned to dams and allowed to suckle until content, and then weighed again. The difference in calf weight prior to and post-suckling was used as an estimate of 12-h milk production. There were two calves in the LS group that did not suckle their dam, so their data were removed from analysis (LS: n = 46; HS: n = 48).

One two-year-old bull was turned into each pasture on July 2. On July 6, cows were given an injection of prostaglandin F_{2a} (25 mg i.m. ProstaMate, Phoenix, Scientific, Inc., St. Joseph, MO) to synchronize estrus. Bulls were rotated between pastures within treatment on July 29. Bulls were removed from pastures on August 26. Pregnancy was determined by rectal ultrasonagraphy 55 and 88 days following bull turnout. Pregnancies detected at 55 days were determined to be conceived in the first 25 d of the breeding season.

Water disappearance was measured by the daily change in water depth in the tank located in each pasture. This was adjusted for evaporation and precipitation using data collected at a weather station located near the experimental pastures.

Data were analyzed as completely randomized design. Cow and calf weight and cow body condition score data were analyzed by ANOVA in PROC GLM of SAS (SAS Inst. Inc., Cary, NC) with pasture as the experimental unit. Twelve-hour milk production data were analyzed by ANOVA with animal as the experimental unit. Cow pregnancy rates were analyzed by Chi-Square in PROC GENMOD of SAS, with pasture as the observation and animal as the event within observation.

Results and Discussion

Compiling all weekly water composite sample results revealed the LS water averaged 368 $\pm$ 19

ppm sulfates, and the HS treatment averaged 3,045 ± 223 ppm sulfates. The HS target of 3,000 ppm was achieved. Patterson et al. (2004) added sodium sulfate directly to stock tanks instead of storage tanks and reported that the target sulfate level of 3,000 ppm was not achieved (average 2,608 ± 408 ppm). Letting the water set in the storage tanks during the afternoon and overnight after mixing salts may have allowed more sulfates to go into solution in this experiment.

One cow from the HS treatment died two weeks prior to the end of the experiment. Diagnostics of brain tissue revealed no indication of PEM but did show high brain sodium levels.

Cow weight change from June 3 to August 26 was not different between treatments (P = 0.17; Table 1). In addition, both groups of cows maintained body condition over the experimental period (P = 0.93; Table 1). Patterson et al. (2004) showed that cows on 2,600 ppm sulfates had higher weight and body condition score loss over the summer than cows on 390 ppm sulfates. Calves in this study tended to have a lower ADG (P = 0.14) when the cow-calf pair was on HS water (Table 1), and the difference was supported by the HS cows having lower (P = 0.02) 12-h milk production than LS cows (Table 2). Patterson et al. (2004) did not report a significant effect of high sulfate water on calf performance or milk production. There was no difference in water disappearance (Table 1).

A higher (P = 0.06) percentage of cows on the LS treatment were bred in the first 25 days of the breeding season (81.3%) than were cows on the HS treatment (63.8%). This difference in early-season pregnancy could impact reproduction and weaning weights the following year. Overall pregnancy rates were not different (P = 0.20) between treatments (LS = 92%; HS = 83%).

It is not evident why results varied between this study and those reported by Patterson et al. (2004). The water in the current study was higher in sulfates and more consistent (narrower range) than Patterson el. (2004) reported. In addition, there were more two-year-old cows in the current study (34/96; 5-6/pasture) than in the former study (17/96; 2-3/pasture). Weather patterns and forage conditions are other possible reasons for differences between studies. Indeed, Johnson and Patterson (2004) reported a vegetation type by water quality interaction for ADG in yearling steers.

It is important to note that in the current study treatments were applied in a very specific and rather narrow time frame (one to four months post-calving). If the cattle were exposed to the HS water at different times, influences of physiological state and temperature may cause different responses. For example, at four to six months post-calving, calves would be expected to consume less milk (as a % of BW) and more water, which could make them more directly affected by water sulfates. Finally, the bull to cow ratio used in this study was approximately 1:16. Lower bull to cow ratios could potentially impact reproduction in high sulfate situations.

We conclude that water provided to cow-calf pairs that averaged 3,045 ppm in sulfates reduced milk production, calf gains, and the percentage of cows bred early in the breeding season.

Implications

High sulfate water had negative impacts on reproduction and calf gains. Grazing cattle receiving high sulfate water may not have the degree of reduction in gain that cattle in confinement have. Additional work should address whether the effects of high sulfate water on reproduction are due to direct of effects of the water, induced trace mineral deficiencies, or both.

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Tables

Table 1. Performance of cow-calf pairs grazing native range and supplied water with low sulfates (average 368 ppm) or high sulfates (average 3,045 ppm) during the summer (Least Squares Means)[a]

	Treatment		
Item	Low Sulfate (LS)	High Sulfate (HS)	SEM
Cow initial weight, lb	1279	1283	16.8
Cow final weight, lb	1305	1290	21.0
Cow weight change, lb	26	9	17.4
Cow initial body condition score	5.54	5.46	0.088
Cow final body condition score	5.45	5.38	0.122
Cow body condition score change	-0.09	-0.08	0.059
Calf initial weight, lb	181	181	6.8
Calf final weight, lb	397	388	8.2
Calf ADG, lb/d	2.56[b]	2.45[c]	0.042
Water Disappearance, gallons/d	18.6	18.2	0.58

[a]Trial lasted from June 3 to August 26, 2004 (84 days); Average calving date of April 14.
[b,c]Within a row, means with unlike superscripts differ (P = 0.14).

Table 2. Estimates of twelve-hour milk production using the weigh-suckle-weigh method for cow-calf pairs grazing native range and supplied water with low sulfates (average 368 ppm) or high sulfates (average 3,045 ppm) during the summer (Least Squares Means ± SEM)[a]

	Treatment	
Item	Low Sulfate (LS)[a]	High Sulfate (HS)[b]
12-h Milk, lb	9.0 ± 0.49[c]	7.5 ± 0.46[d]

[a]n = 46.
[b]n = 48.
[c,d] Within a row, means with unlike superscripts differ (P = 0.02).

Comparative Anatomy of a Presorted Pot-load of Yearling Steers

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BEEF 2005 – 06

Summary

One load (n = 72; initial BW = 745 ± 54.5) of grass-raised Angus-cross yearling steers was purchased from a sale barn in north central South Dakota. The steers were sorted into load lots by sale barn personnel from a larger group of 1200. Upon arrival, steers were used in the 4-day Feedlot Shortcourse before being weighed and appraised for visual differences. Cattle were divided (randomly) into 8 groups of 9 head each. One steer was randomly selected from each of the eight groups to make a 9th group of steers comprised of each classification. The steers were fed until they reached an average visual ribfat depth of 0.40 in. The data would show that even though cattle came from one owner, variation does exist for feedlot and carcass characteristics. This variation can affect marketing endpoints, and if not managed properly, can cause a decrease in profitability.

Introduction

Beef producers and feedlot operators are being more concerned about variation within groups of cattle. A greater concern is functionality due to an increase in the number of cattle being marketed on a "grid" pricing system. Final selling price can be reduced if a pen of cattle is marketed with a greater number of under-finished or over-finished animals which would receive discounts, or if cattle are marketed on a grid that dose not fit their type. Currently, the Choice/Select spread and discounts are historically low due to higher demand of fed cattle. Yet, one must be concerned about the number of cattle that are heavy/light or YG 4's in a pen. Trenkle (2001) showed that differences in frame size and initial backfat resulted in differences in profitability. Bruns and Pritchard (2003) summarized various research methods used to sort cattle and the costs associated with sorting. However, little work has been done to quantify the extent of variation within a group of cattle.

The objective of this study was to quantify the variation that is present within the group of cattle evaluated. The variation represented here may not exist in other pens of cattle.

Materials and Methods

Angus cross yearling steers (n = 72) were purchased from a salebarn in North Central South Dakota and hauled 255 miles to the SDSU Nutrition Unit where they were used for the SDSU Feedlot Shortcourse. Upon arrival animals were processed. Processing included vaccination against IBR, BVD, PI_3, BRSV, Haemophilus (Resvac-4, Pfizer, Eaton, PA), 7-way clostridia (Dectomax, Pfizer, Eaton, PA), and a Synovex-C implant (100 mg. progesterone and 10 mg estradiol benzoate; Fort Dodge Animal Health, Fort Dodge, IA).

Cattle were weighed and evaluated for Condition Score (CS) as defined in Table 1 and for Frame Score (FS) (Table 2) by one, experienced individual. Steers were then ranked by CS, weight, and FS and allotted to eight specific groups of 9 head each (Table 3). Pens 1-3 were the thinnest cattle and were allotted to pen by weight. Pens 4 and 5 were average CS (CS = 5) cattle broken into a light and a heavy weight group. Pens 6 and 7 (CS = 5.4 average) were fleshy cattle with Pen 6 being comprised of the larger framed half while Pen 7 were the small framed steers. Pen 8 was comprised of large framed, late maturing cattle that were thin. One steer was randomly chosen from each of the first 8 pens to fill Pen 9 with a mixed set of steers.

Steers were fed in paved outdoor pens measuring 25 ft x 25 ft, with a 25 ft fence-line feed bunk. Steers were fed twice daily and had continual access to water. A clean bunk management system was used with a series of 4 step-up diets before being switched to the finishing diet. Steers were brought up to ad libitum on the finishing diet within 20 days. The

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diet contained, on a dry matter basis, 5% oatlage, 30% high moisture corn, 56.25% whole shelled corn, 4.5% soybean meal, and 4.25% liquid supplement with urea. The diet contained 75.5% DM, 11.8% CP, and had an estimated energy content of 0.91 Mcal/lb NE_m and 0.61 Mcal/lb NE_G.

Cattle were weighed and re-implanted on d 49 with Revalor IS (16 mg Estradiol-17β and 80 mg trenbolone acetate; Intervet, Millsboro, DE).

One steer from Pen 5 was removed from the study after death due to respiratory illness. Body weight contribution to the pen mean was deleted at the time the steer was pulled due to health and deleted from the dataset. Carcass measurement data was not attainable on 6 head; 5 were pulled for plant audit (AQL) from Pens 2 and 3, and one carcass from Pen 9 was condemned due to osteomalacia.

Due to the nature of the study and the variation that existed between pens, it was decided to market the cattle in two groups, 2 weeks apart at an average visual fat depth of 0.40 in. Pens 4, 5, 6, 7, and 8 were marketed on day 126 while pens 1, 2, 3, and 9 were marketed on day 140. Cattle were hauled 125 miles to a commercial packing facility where steer identification was maintained and carcass data was obtained by university personnel. Marbling Score was assigned by an official USDA grader. Upon completion of calculating Yield Grade and Quality Grade, the following premiums and discounts were assigned to calculate a pen premium; Prime = +8.00, upper 2/3 Choice = +2.00, Select = -5.00, and Standard = -15.00, with the following Yield Grade premiums/discounts - USDA YG 1 = +3.00, YG 2 = +1.50, YG 3 and YG 4 = -14.00.

Results

The purpose of this report is to give a better understanding of the amount of variation that exists within a load of steers. Even though levels of significance were obtained between pens for various traits, these differences will not be addressed in this article. However, a discussion of the variation of performance and carcass traits will be shown.

Performance measurements are reported in Table 4. The average initial weight among pens differed by 17.7% with the lightest individual weighing 606 lb vs. the heaviest weighing 895 lb (32.3%). On day 126, the difference between the lightest pen (Pen 1, 1125 lb) and the heaviest (Pen 6, 1360 lb) narrowed to 17.3%, a reduction of 15%. When the lighter pens were fed for two more weeks, this variation was reduced further to 14%. Cumulative pen performance is shown in Table 4. The group mean for ADG, DMI, and F:G was 4.1 lb/d, 22.6 lb/d, and 5.434 lb/lb of gain. An 18% difference existed between the highest and lowest ADG, with a 24% difference in DMI, and an 11.6% difference in F:G. When evaluating pens 1-8 only, Pens 2, 3, 6, and 8 gained greater than average and also had DMI's that were greater than the average for Pens 1-8.

Carcass data is reported in Table 5. Differences for dressing percent and HCW are not well correlated. Cattle with the heavier HCWs exhibited a greater than average ribfat depth (0.49 vs. 0.35 in.) with the average ribfat for all 72 head of 0.42 in. Intramuscular fat was determined by using an Aloka 500 ultrasound machine with a 3 mHz probe. Cattle marketed in the second group, (day 140) had lower marbling compared to cattle marketed on d 126, but when fed to d 140 had caught up to those marketed on d 126.

Percent Choice and % heavy & light and % 4's are listed in Table 5. Because of the few numbers of animals per pen, and the lack of replication, these data are presented to demonstrate the variation that can exist among sorted cattle.

Implications

The data reported here gives useful information concerning the amount of variation that can be present within a semi-load of cattle. Sorting can be beneficial at the start of the finishing phase to group cattle into outcome groups. These outcome groups require different management decisions to insure maximum performance parameters are met and animal's carcasses are marketed at an optimal endpoint. In the future, larger numbers will be needed to calculate statistical parameters.

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Tables

Table 1. Condition score and frame score chart

Condition Score	
1 -	
2 -	
3 -	Outline of spine and all ribs present, experiencing slight muscle atrophy; 8% empty body fat.
4 -	Slight outline of spine; 3-5 ribs visible; outline of hips and pin bones visible; 12% empty body fat.
5 -	No visible protrusion of the spine; 1-2 ribs visible outline of hips and pin bones 16% empty body fat; < 0.10 in. of ribfat
6 -	No outline of ribs; some fat in flank and brisket; 20% empty body fat; between 0.10 - 0.20 in. ribfat.
7 -	Full look in the flank and brisket; 24% empty body fat; between 0.20 - 0.30 in. rib fat.
8 -	
9 -	
10 -	
Frame Score	
Small -	Expected to reach the Choice grade at less than 1,100 lb.
Medium -	Expected to reach the Choice grade between 1,100 and 1,250 lb.
Large -	Expected to reach the Choice grade at weights in excess of 1,250 lb.

Table 2. Mean value of one load of steers (72 head)

	Mean	Std Dev.
In Wt., lb	748	54.5
Condition	4.8	0.92
Frame	3.26	44.6
# Head thin	33	
# Head average	30	
# Head fleshy	9	

Table 3. Cattle descriptions

Pen	In Wt.	Std Dev	Condition Score[a]	Std Dev	Frame Score[b]	Std Dev	Characteristics
1	661	30.4	4.0	0.0	3.21	0.25	lightweight, thin, flighty group
2	726	20.0	4.0	0.0	3.34	0.18	Lightweight, thin
3	747	30.6	4.3	0.20	3.37	0.29	Heaviest of the thin cattle
4	736	29.7	5.0	0.09	3.28	0.36	Thin to average flesh
5	773	52.1	5.2	1.8	3.14	0.79	Average flesh
6	803	45.9	5.6	0.35	3.08	0.36	Stout, big bodied, heavy muscled
7	752	27.4	5.6	0.56	2.78	0.41	Small framed; fleshy steers
8	778	47.2	4.75	0.93	3.62	0.19	Large framed; thinner cattle
9	759	66.7	4.93	0.94	3.23	0.49	Mix of 1 steer from each of eight groups

[a] Condition score (CS) 1 - 10; description in Table 1.
[b] Frame score 1.00 = small; 2.00 = medium; 3.00 = large.

Table 4. Pen anatomy - performance data

Pen[a]	1	2	3	4	5	6	7	8	9
n =	8	8	8	8	7	8	8	8	8
In weight, lb	661	726	747	736	773	803	752	778	759
Days on feed	140	140	140	126	126	126	126	126	140
Weight, 126d, lb	1125	1262	1335	1240	1272	1360	1251	1363	1266
Weight 140d, lb	1169	1300	1383	-	-	-	-	-	1307
Change, lb	44	38	48	-	-	-	-	-	42
Cumulative performance[b]									
ADG, lb	3.6	4.1	4.5	4.0	4.0	4.4	4.0	4.3	3.9
DMI, lb	19.3	23.2	25.4	21.1	22.5	23.8	21.9	22.8	23.6
F/G	5.3	5.7	5.6	5.3	5.7	5.4	5.5	5.4	6.0

[a] Cattle type described in Table 3.
[b] Pen data used to calculate mean values.

Table 5. Pen anatomy - carcass data

Pen[a]	1	2	3	4	5	6	7	8	9
n =	6	7	7	8	7	8	8	8	7
Harvest group[b]	2	2	2	1	1	1	1	1	2
Final Wt, lb	1169	1300	1383	1240	1272	1360	1251	1363	1307
Dressing %[c]	61.3	62.4	63.2	62.3	61.6	61.4	61.5	62.1	62.5
HCW, lb[d]	688	779	840	741	752	802	739	783	816
Ribfat, in.	0.28	0.39	0.45	0.37	0.53	0.48	0.48	0.36	0.45
Ribeye area, in^2	11.6	12.8	13.2	13.6	13.5	13.5	13.0	13.9	12.6
KPH, %[e]	1.5	2.1	2.3	1.8	1.7	2.0	1.7	1.4	2.1
Yield Grade	2.6	2.9	3.1	2.4	2.9	2.9	2.8	2.4	3.1
Marbling score 126[f]	514	483	533	534	559	553	563	514	483
Marbling score 140[g]	580	548	591	-	-	-	-	-	578
Cumulative									
% Choice	66.6	71.4	85.7	87.5	71.0	62.5	87.5	62.5	85.7
% YG 1 & 2	66.6	57.1	33.0	87.5	57.1	62.5	62.5	87.5	63.0
% 4's	0	0	0	0	0	0	12.5	0	0
% Heavy or lights	0	0	0	0	0	0	0	0	0
Premium/Discount	1.00	0.50	0.67	0.50	0.57	-0.44	-0.75	-0.32	0.36

[a] Cattle type described in Table 4.
[b] Harvest group = determined by visual estimation of when cattle reach 0.40 in. backfat.
[c] Dressing % = [HCW / (Live Wt • 0.96)].
[d] HCW = Hot carcass weight.
[e] KPH = Kidney, pelvic, and heart fat.
[f] Marbling score 126 determined by use of ultrasound for Pens 1, 2, 3, 9.
[g] Marbling score 140 determined by USDA Grader.

Influence of Calcium Metabolism on Meat Tenderness in Heiferettes[1]

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BEEF 2005 – 07

Summary

Forty beef-type heiferettes (initial BW=1016 ± 93 lb) were used to evaluate the influence of dietary calcium depletion followed by dietary repletion prior to slaughter on carcass and meat quality traits. Treatments were 1.) control - feed calcium diet for duration of trial (13 hd); 2.) calcium depleted 14 days followed by one feeding of replete diet 20 h prior to slaughter (13 hd); 3.) calcium depleted 14 days followed by two feedings of repleted diet 20 h and 44 h before harvest (14 hd). Heifers were sorted on condition and weight from a larger population of 280 head. Heiferettes were fed 56 d before the initiation of the treatments. Treatments were initiated 16 d prior to slaughter. No differences in ADG or F:G were observed during this time. At harvest, no differences were found for end weight, dressing percent, hot carcass weight, backfat, ribeye area, yield grade or marbling score. Measurements of tenderness were conducted using Warner Bratzler Shear force. No differences were observed with 39% of the carcasses classified as tough (greater than 5.0 lb of shear force).

Introduction

Calcium is a macro-mineral that plays a key role as an intracellular second messenger for calpain activity. It is tightly regulated and under normal production scenarios remains between 8.5 and 10.3 mg/dl (Granner, 2000). Previous research has attempted to manipulate calcium levels by feeding pharmacological levels of Vitamin D which facilitates calcium binding protein synthesis. We have theorized that manipulation of Ca in the feedlot animal can be accomplished through dietary depletion-repletion. This is the same methodology used in the dairy industry (Green et al., 1981) to reduce the occurrence of milk fever (parturient paresis). Calcium is fed at relatively high levels in most feedlot finishing diets which minimizes the potential and success to manipulate Ca through the addition of Vitamin D. In a previous study conducted by Walsh et al. (2004), a dietary Ca depletion/repletion (CDR) approach was attempted to increase muscle Ca content at harvest and subsequently beef tenderness. The approach simply involved removing limestone from standard feedlot diets for 14 d pre-harvest and then returning limestone to the diet for the final feeding before harvest. The technique caused a substantial increase ($P < 0.01$) in serum Ca (9.3 vs. 11.9 mg/dl); an important first step to elevating intramuscular Ca. However, muscle Ca was only numerically higher due to CDR (37.3 vs. 38.6 µg/g). In an initial study, beef cuts from steers under the age of 18 months were evaluated to be very tender. In control cattle, aged (15 d) shear force values of longissimus dorsi, triceps brachii, and semimembranosus muscles were 6.2 lb, 5.8 lb, and 7.8 lb, respectively. In semimembranosus muscle aged 5 d, the shear force was reduced ($P < 0.05$) by CDR (9.4 kg vs. 8.0 kg). It was the objective of the current research project to utilize an older population of cattle that would theoretically have tough meat.

Materials and Methods

Forty beef-type heiferettes were selected from a larger population of 280 head and hauled 90 miles to the SDSU Nutrition Unit on June 7, 2004. Cattle were weighed, tagged and implanted with Synovex-H during feedlot arrival processing. Cattle were randomly assigned to one of three dietary treatments: 1.) control - feed calcium diet for duration of trial (13 hd); 2.) - calcium depleted 14 days followed by one feeding of replete diet 20 h prior to slaughter (13 hd); 3.) calcium depleted 14 days followed by two feedings of repleted diet 20 h and 44 h before harvest (14 hd). Cattle were allotted to pen and adapted to a standard finishing diet (0.91% Ca; Table 1) by a series of three step up diets which depleted the level of hay in the diet (30%, 15%, and 0%) over a 12 d period.

[1] Funding was provided by SD Beef Industry Council.
[2] Associate Professor
[3] Distinguished Professor

Harvest was targeted to optimize bodyweight and flesh for current markets (0.4" ribfat depth).

Fourteen days prior to harvest, dietary treatments were initiated by the removal of $CaCO_3$ from the supplement which reduced dietary Ca to 0.08% of the diet. At 20 h (1 feeding) and 44 h (2 feedings) prior to harvest, Ca was restored to the diet (repletion). During this time, control animals were continuously fed the 0.91% Ca diet. Blood levels of Ca were determined before harvest prior to loadout.

Standard carcass evaluations for determination of USDA Quality and Yield Grades were determined on carcasses chilled for 24 h. After grading, longissimus dorsi were removed from the carcass, sliced into a 1" thick steak and vacuum packaged for aging (7 days). After aging time, shear force was determined utilizing Werner Bratzler Shear Force.

The analysis of variance was appropriate for a completely random design study with repeated measures over time (aging). Means separations were accomplished using least square means.

Results and Discussion

Performance parameters measured every 21 days, however variation in ADG and F:G was evident from period to period due to heifers within treatments calving. Thus, performance data reported in Table 2 was divided into two periods for the trial. Period 1 0-56 d represents the time on feed prior to the treatments being implemented and period 2 56 -72 d when the treatments were administered. As expected no differences in performance were observed between the three treatments as all cattle were consuming the same ration till day 56 of the trial. Feed efficiency tended to be poorer for cattle being fed one feeding of the calcium-repleted diet as ADG was 45% lower than the controls with similar values for DMI. Two heifers from treatment two calved within 35 and 2 days of the weigh period and were 9% and 55% below the average of the group for the next weigh period. Four heifers calved during the duration of the trial. Reduction in ADG from the time of calving to the next weigh period was on average 260% with an average window of 10 days from calving to the next weight period. The reduction in gain can be attributed to these heifers calving at or very near full term.

Carcass cutability data is reported in Table 3. Data was not obtained on one carcass as it was railed out due to an infected joint. Excessive trim occurred on this carcass, so HCW and DP data were removed from the dataset. No differences were found for shrunk dressing percent [HCW/(live wt. *.96)], HCW, rib fat, loin muscle area, or yield grade. Carcass did have adequate amounts of muscle on average to meet the required rib eye area needed to maintain yield grade. Two carcasses were calculated to be YG 4's and one YG 5.

Carcass quality data is presented in Table 4. No differences were detected for quality parameters measured. Cattle were mouthed prior to shipment to determine age. Average age for all cattle was 2.4 years. Average marbling score was $Small^{18}$ or $Choice^{-}$ for all cattle. Visual estimation of carcass maturity was quantified by trained university personal. Average bone, lean and overall maturity were B^{18}, B^{28}, and B^{23}. Forty-four percent of the carcasses were A maturity, 46% B maturity and 10 % C maturity which were classified has hard bones. Thirty-three percent of the population graded choice or better with 13% selects, 44% standards and 10% commercials.

No differences were observed for Warner Bratzler shear force. Shear force values less than 7.7 lbs are considered tender and greater than 11.1 lbs are considered tough. On average shear force values neared what would be considered tough at 10.8 lbs. Carcasses classified as tender were 20.5%, with 41.0% average, and 38.5 % tough.

Serum calcium levels were not different between treatments indicating our inability to elevate serum calcium via calcium depletion repletion in this particular trial.

In previous research (Walsh, 2004) depletion for 14 days followed by feeding normal levels 16 hours before harvest resulted in elevated blood serum calcium levels. In the present study, harvest time was greater from the time calcium was brought back to normal (20 hours after one feeding and 40 hours past the 2^{nd} feeding treatment). Calcium levels may have peaked and equalized before slaughter. Additional research, concentrated on the time between calcium repletion after depletion and slaughter is necessary.

Implications

In this study, diet depletion then repletion of calcium level in the diet was unable to elevate serum calcium levels to the level to improve tenderness. The cattle population used in this study proved beneficial in producing the tougher meat, which was desired. However, differences in pregnancy and calving affected performance parameters measured.

Literature Cited

Granner, D. K. 2000. Hormones that regulate calcium metabolism. In Harpers Biochemistry. R. K. Murry, K. K. Granner, P. A. Mayes, and V. W. Rodwell, ed. 25th Ed. McGraw-Hill, New York, NY.

Walsh, T. A. 2004. The influence of calcium metabolism on beef tenderness. M.S. Thesis, South Dakota State University.

Tables

Table 1. Finishing diet on a dry matter basis

High moisture ear corn	44.0
Whole shelled corn	43.75
Dried distillers grains	8.00
Supplement	4.25
NE_m, mcal/cwt	88.7
NE_g, mcal/cwt	62.6
Crude protein, %	12.2
Calcium, %	0.612
Phosphorus	0.333

Table 2. Performance

	Control	Ca Repleted 1 Feeding	Ca Repleted 2 Feedings	SEM	P-value
n, (pens)	2	2	2		
In weight., lb	1007	994	1015	5.7	0.41
Period 1 d 0-56					
Body weight, lb	1175	1177	1196	11.9	0.76
ADG, lb	3.0	3.3	3.2	0.17	0.80
DMI, lb	23.1	23.4	24.7	2.5	0.27
F:G	7.7	7.2	7.8	0.38	0.81
Period 2 d 56-72					
Body weight, lb	1232	1207	1249	17.6	0.67
ADG, lb	3.5	1.9	3.3	0.42	0.35
DMI, lb	22.8	22.7	23.5	1.0	0.93
F:G	6.7	12.1	7.5	0.60	0.07
Cumulative, d 0 - 72					
Body weight, lb	1232	1207	1249	17.6	0.67
ADG, lb	3.1	3.0	3.2	0.21	0.87
DMI, lb	23.1	23.3	24.4	0.41	0.45
F:G	7.4	7.9	7.7	0.43	0.92

Table 3. Carcass cutability data

	Control	Ca Repleted 1 Feeding	Ca Repleted 2 Feedings	SEM	P-value
n, (head)	13	13	13		
Harvest wt., lb	1232	1207	1248	17.6	0.67
Dressing, %[a]	62.3	62.2	62.5	0.39	0.99
HCW, lb	737	723	749	12.35	0.74
Ribfat, in.	0.48	0.42	0.49	0.10	0.76
LMA, $in.^2$	12.6	13.1	12.1	0.19	0.19
Yield Grade	3.0	2.6	3.2	0.13	0.27

[a]Shrunk dressing % = HCW/(Harvest weight x 0.96)

Table 4. Carcass quality data

	Control	Ca Repleted 1 Feeding	Ca Repleted 2 Feedings	SEM	P-value
n, (head)	13	13	13		
In Wt., lb	1007	994	1015	5.7	0.41
Marbling[a]	518	514	517	15.1	0.98
Dental age, yrs[b]	2.7	2.3	2.4	0.11	0.33
Bone maturity[c]	213	222	218	10.0	0.72
Lean maturity[d]	226	222	235	8.7	0.94
Overall maturity[e]	218	226	225	8.5	0.84
Grade, No. of Head / %					
Prime	1 / 7.7	0 / 0.0	0 / 0.0		
Upper 2/3 Choice	0 / 0.0	1 / 7.7	1 / 7.7		
Choice-	2 / 15.4	3 / 23.1	5 / 38.5		
Select	2 / 15.4	2 / 15.4	1 / 7.7		
Standard	7 / 53.6	5 / 38.5	5 / 38.5		
Commercial	1 / 7.7	2 / 15.4	1 / 7.7		
Shearforce[f]	10.6	10.6	11.2	0.57	0.21
Shearforce category[g]					
Tender	3	3	2		
Average	5	6	5		
Tough	5	6	5		
Serum Calcium	98.0	95.7	96.5	0.74	0.64

[a] 500 = small[o].
[b] determined by trained individual at feedyard.
[c] 100 = A maturity; 200 = B maturity.
[d] 100 = A maturity; 200 = B maturity.
[e] 100 = A maturity; 200 = B maturity.
[f] shear force determined by Warner Bratzler shear force, lb.
[g] Tender = < 3.5 lb; average 3.6-4.9 lb; tough > 5.0 lb.

Use of Corn Co-products in Soybean Hull-based Feedlot Receiving Diets[1]

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BEEF 2005 – 08

Summary

The use of different supplemental protein sources with soybean hulls in receiving cattle diets were evaluated using 200 Angus steer calves. Diets contained either corn and soybean meal (C-SBM), or soybean hulls with soybean meal (H-SBM), dried corn gluten feed (H-DCGF) or dried distillers grains plus solubles (H-DDGS). The replacement of corn (C-SBM) with soybean hulls (H-SBM) stimulated intake within the first 14 d of the receiving period and throughout the entire growing period (52 d). Supplementing soybean hulls with corn origin protein (COP) versus soybean meal did not result in any performance differences throughout the feeding period. Within the COP sources, H-DDGS improved daily gain during the initial 28 d, while H-DCGF stimulated intake during the final 24 d on feed. This would indicate that H-DCGF may potentially have a positive impact on steer performance when fed beyond 52 d in the growing period. No differences in health status were detected; morbidity and mortality rates averaged 11.1% and 0.5%, respectively. Blood metabolite status indicated that changes in the site of protein degradability influence urea nitrogen levels, whereas H-DCGF seemed to supply greater substrate for glucose production compared to H-DDGS. The results indicate that the replacement of corn with soybean hulls is feasible from a performance stand point. Soybean hulls can be supplemented with soybean meal, dried corn gluten feed or dried distillers grains plus solubles without compromising gain performance.

Introduction

The overall costs of roughages in feedlot diets can be quite expensive, but the financial return associated with reduced morbidity and improved gain performance during the receiving period can outweigh the ingredient costs. Receiving cattle diets often contain 40% or more roughage, with valuable roughage sources considered those that are palatable and digestible by newly arrived calves. Soybean hulls are considered an excellent roughage source due to its highly digestible fiber content and palatability. Incorporation of soybean hulls seems to stimulate intake in receiving cattle, a positive attribute to a fiber source. The highly digestible fiber in combination with the increased intake has resulted in gain performances similar to rolled corn in receiving cattle diets.

The current expansion of the fuel ethanol industry in South Dakota has resulted in abundant supplies of corn co-products available to the beef industry. Many of these products are considered a valuable source of escape protein when fed in combination with corn-based diets. This study was designed to evaluate the use of corn-origin proteins in combination with soybean hulls on receiving cattle gain performance, health and blood metabolite status.

Materials and methods

Oat silage-based diets (Table 1) contained either rolled corn and soybean meal (**C-SBM**), soybean hulls and soybean meal (**H-SBM**), soybean hulls and dried corn gluten feed (Cargill Animal Feeds, Wahpeton, ND; **H-DCGF**), or soybean hulls and dried distillers grains plus solubles (**H-DDGS**). Diets were formulated to contain 11.75% CP and similar levels of Cu and Zn (2000 NRC). Grass hay (10% DM basis) replaced a portion of the oat silage on d 14 in all diets.

A single source of 200 Angus steer calves (BW = 590 ± 4 lb.) were shipped from a ranch in western South Dakota on October 28 and 30, 2003 to the SDSU research feedlot in Brookings. All steers received long-stem grass hay and access to water upon arrival. Once calves had time to rest, they were weighed, individually

[1] Funding provided by SD Corn Utilization Council.
[2] Research Associate
[3] Professor

identified and vaccinated with a 7-way clostridial vaccine and a modified live vaccine containing Infectious Bovine Rhinotracheitis Virus (IBR), Parainfluenza 3 (PI_3), Bovine Respiratory Syncytial Virus (BRSV) and *Haemophilus somnus*. All calves received a Ralgro Magnum implant (70mg Zernol; Schering-Plough) and were treated for internal and external parasites (Dectomax; Pfizer Animal Health) on d14.

Steers were blocked by weaning management into 3 groups, steers weaned 30 d prior to shipment from the home ranch (390 mi., n = 77, BW = 565 ± 5 lb.), steers weaned the day of shipment from the home ranch (390 mi., n = 79, BW = 626 ± 6 lb.), and steers weaned the day of shipment from an alternate ranch site (590 mi., n = 44, BW = 570 ± 4 lb.). Steers weaned 30 d prior to shipment were from 2 and 3 yr old dams, whereas steers weaned the day of shipment were from dams ≥4 yr old. Weights were stratified over pens within weaning group, with treatment randomly assigned to pen.

Diets were fed once per day at 1300 h, while feed refusals were quantified and sampled when feed went out of condition. Feed samples were collected and analyzed on a weekly basis for DM, CP, NDF, ADF and ash. Body weights were obtained during processing and subsequently on d 14, 28 and 52. Final BW were shrunk 4% to account for fill. Daily feed deliveries, along with feed analyses were used to determine DM disappearance and gain efficiency during interim periods.

Blood samples from the second lightest, second heaviest and middle-weight steers from each pen were collected prior to feeding on d 1, 3, 7, 14, 28 and 52. Blood samples were collected via jugular venipuncture and analyzed for plasma glucose (Sigma Diagnostics, St. Louis, MO), plasma urea nitrogen (PUN), and serum non-esterified fatty acids (NEFA; Wako Industries, Richmond, VA). Blood samples were collected to determine blood metabolite status of steers primarily during the receiving period.

Steer health was monitored on a daily basis. Morbid steers were identified based on general appearance, desire to consume feed as well as phenotypical symptoms associated with illness or lameness. Morbid steers were treated according to the South Dakota State University Research Feedlot Health protocol.

Steer performance was analyzed as a randomized complete block design using the GLM procedures of SAS. Weaning management was the blocking term and pen was the experimental unit. Blood metabolites were analyzed as repeated measures over time using GLM procedures of SAS. Weaning management was considered a random effect and treatment was tested using the steer within treatment error term. Steer was used as the experimental unit for blood metabolites. Contrasts were used to compare main effects of C-SBM vs H-SBM, H-SBM vs mean H-DCGF / H-DDGS **(COP)**, and H-DCGF vs H-DDGS.

Results and discussion

No differences were detected for morbidity or mortality during the feeding period (P > 0.10). Overall, morbidity rates were 11.1% and mortality rates were 0.50% across all treatments.

The inclusion of soybean hulls seemed to stimulate intake early during the receiving period compared to rolled corn, which continued throughout the remaining feeding period (Table 2). This response supports previous studies that showed similar intake effects. No differences were detected (P > 0.10) for ADG or gain efficiency during the initial 28 d or cumulatively. On d 3, H-SBM steers had lower plasma glucose concentrations (P < 0.05; figure 1) and tended to have lower serum NEFA concentrations (P < 0.10) compared to C-SBM steers. Plasma glucose and serum NEFA concentrations were similar between the two treatments at all other collections during the feeding period (P > 0.10). Concentrations of PUN (Figure 1) tended to be lower during d 7 for H-SBM (P < 0.10), but were not different (P > 0.10) at any other collection period compared to C-SBM. The reduced blood metabolite status of H-SBM compared to C-SBM steers early in the receiving period may indicate that the fermentation of corn in C-SBM results in greater amounts of propionate which was metabolized into glucose once absorbed. The increased intake in H-SBM early resulted in greater intake of calories, thus offsetting the glucose differences by d 7. All blood values are considered within normal physiological ranges.

When comparing the inclusion of soybean meal versus COP with soybean hulls, gain performance did not differ (P > 0.10) at any point

in the trial (table 2). There was no difference (P > 0.10) in plasma glucose (Figure 2) or NEFA concentrations at any collection period during the study. Plasma urea nitrogen (Figure 2) was similar between treatments during the first 14 d on feed, but H-SBM resulted in greater PUN concentration during d 28 and 52. The increase in PUN may reflect the combination of greater ruminal protein availability and higher levels of intake, which would result in a greater amount of rumen ammonia production. The similar gain performance in conjunction with different PUN status indicates that steers consuming COP with soybean hulls provides similar metabolizable protein even though site of degradation is likely different. This would indicate that COP is of adequate quality to ensure gain performance in receiving steers similar to soybean meal when soybean hulls make up approximately 50% of the diet.

The H-DDGS diet resulted in greater ADG (P < 0.05) during the initial 28 d, but those differences disappeared during the latter portion of the study resulting in no cumulative gain performance differences (P > 0.10). Gain efficiency tended to be greater for H-DDGS steers (P < 0.10) during d 15 to 28, which most likely resulted in the improved gain performance (P < 0.05) during the same period. Gain efficiency was similar (P > 0.10) between COP sources during all other periods and cumulatively. There were no differences in feed intake (P > 0.10) during the first 28 d, but during the last portion of the study H-DCGF stimulated greater intake. There were no differences in cumulative DM disappearance (P > 0.10), probably influenced by the first 28 d. Plasma glucose concentrations (Figure 3) were greater (P < 0.05) in H-DCGF steers at d 7, 28 and 52. The greater glucose concentrations during d 28 and 52 reflect the increased intake by those steers during the same period. Figure 3 shows that PUN concentrations are not different (P > 0.10) at any sampling time during the feeding period. The PUN concentrations would indicate that H-DCGF cattle are not degrading protein for glucose production, and that the absorbed dietary protein is probably being utilized for growth. The PUN status would also suggest that degradation rate and site were similar between protein sources. Concentration of NEFA were different on d 3 (P < 0.01), but not at any other sampling period (P > 0.10). The reason for the NEFA difference on d 3 is inconclusive at this time. Differences in corn co-product production systems seem to have minimal impact on dietary protein quality when fed with soybean hulls to newly arrived feedlot steers. Further research is warranted to determine nitrogen dynamics of soybean hulls supplemented with corn co-products.

Implications

The use of corn co-products from the dry milling ethanol industry can sustain growth rates comparable to soybean meal when fed with soybean hulls as the principle carbohydrate source. Within corn co-products, dried corn gluten feed seemed to stimulate intake later in the growing period, which may influence glucose concentrations, resulting in a more positive energy balance in those calves.

Tables

Table 1. Diet and nutrient composition[a] of receiving diets.

	Diet[b]			
Item	C-SBM	H-SBM	H-DCGF	H-DDGS
Oat silage	30.00	30.00	30.00	30.00
Grass hay	10.00	10.00	10.00	10.00
Rolled corn	48.92			
Soybean hulls		56.34	45.12	52.63
Supplement[c]				
Soybean meal	9.42	3.35		
Dried corn gluten feed			13.86	
Dried distillers grains + solubles				6.65
Trace mineralized salt	0.30	0.30	0.30	0.30
Limestone	1.35			
$ZnSO_4$[d]	0.0115	0.0083	0.0074	0.0075
$CuSO_4$[e]	0.0023			
DM, %[f]	57.36	58.87	58.79	58.92
CP, %[f]	13.55	12.93	13.12	12.87
NDF, %[f]	21.33	58.82	57.02	58.17
ADF, %[f]	13.63	41.93	37.87	40.47
Ash, %[f]	6.78	7.39	8.48	7.73

[a]Dry matter basis
[b]d1 to 13: Oat silage = 40.00%, grass hay = 0.00% DM basis.
[c]Supplement ingredients were processed into a pellet.
[d]Zinc was balanced for a minimum dietary level of 65 ppm.
[e]Copper was balanced for a minimum dietary level of 15 ppm.
[f]Based on laboratory analyses.

Table 2. Interim and cumulative feedlot performance

	Diet					Contrast[a,b]		
Item	C-SBM	H-SBM	H-DCGF	H-DDGS	SEM	1 vs 2	2 vs 3,4	3 vs 4
Initial BW, lb.	588	586	588	586	6.83	NS	NS	NS
Final BW[c], lb.	768	767	765	771	8.26	NS	NS	NS
d 1 to 14								
ADG, lb.	4.24	4.68	4.37	4.65	0.21	NS	NS	NS
DMI[d], lb/d.	11.30	11.83	12.10	12.05	0.17	0.0628	NS	NS
F/G, lb./lb.	2.67	2.59	2.81	2.64	0.25	NS	NS	NS
d 15 to 28								
ADG, lb.	3.34	3.34	3.07	3.60	0.15	NS	NS	0.0151
DMI, lb/d.	16.17	17.29	17.23	17.76	0.19	0.0038	NS	0.0938
F/G, lb./lb.	4.92	5.24	5.65	4.89	0.24	NS	NS	0.0685
d 29 to 52								
ADG, lb.	4.25	4.08	4.24	4.00	0.12	NS	NS	NS
DMI, lb/d.	20.14	21.17	21.64	20.21	0.31	0.0537	NS	0.0142
F/G, lb./lb.	4.79	5.33	5.16	5.11	0.26	NS	NS	NS
Cumulative 28-d performance								
ADG, lb.	3.76	3.96	3.72	4.11	0.12	NS	NS	0.0275
DMI, lb/d.	13.84	14.69	14.76	15.05	0.17	0.0118	NS	NS
F/G, lb./lb.	3.66	3.70	3.97	3.65	0.17	NS	NS	NS
Cumulative 52-d performance[c]								
ADG, lb.	3.38	3.42	3.35	3.48	0.07	NS	NS	NS
DMI, lb/d.	16.70	17.64	17.87	17.41	0.20	0.0139	NS	NS
F/G, lb./lb.	4.95	5.18	5.34	5.00	0.15	NS	NS	NS

[a]Contrast ID: 1 = C-SBM, 2 = H-SBM, 3 = H-DCGF, 4 = H-DDGS. LS means are presented.
[b]Orthogonal contrasts. NS = *P > 0.10.*
[c]Final BW were shrunk 4%.
[d]DMI = Dry matter disappearance.

Figures

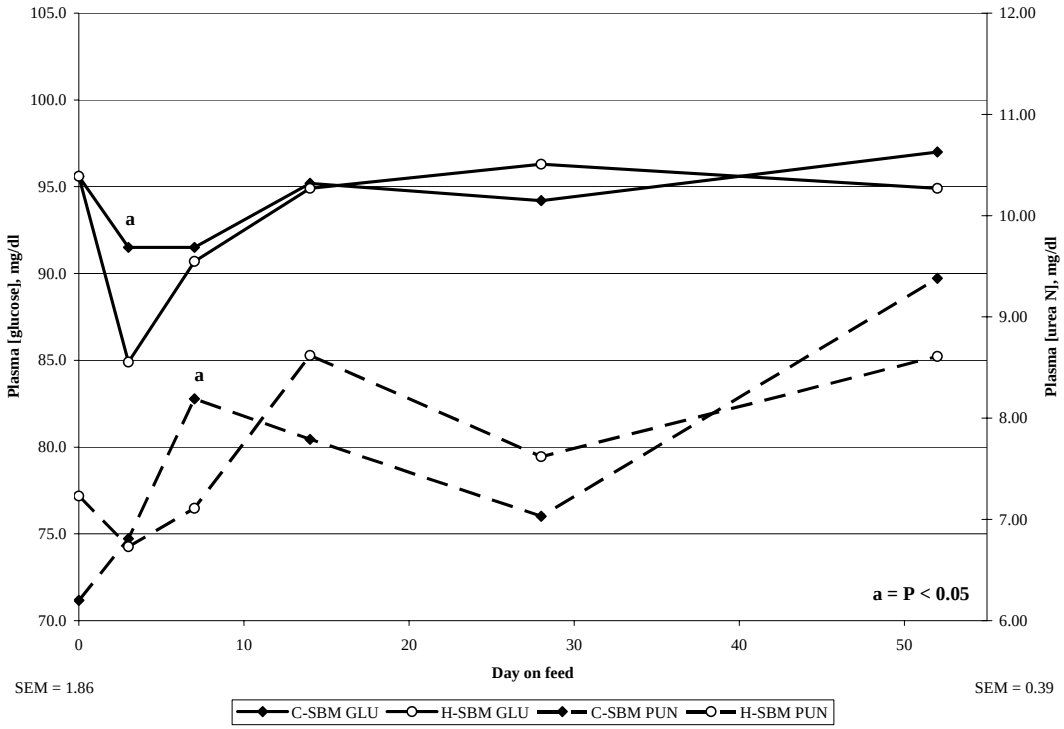

Figure 1. Comparison of plasma levels of glucose and urea nitrogen between C-SBM and H-SBM treatments.

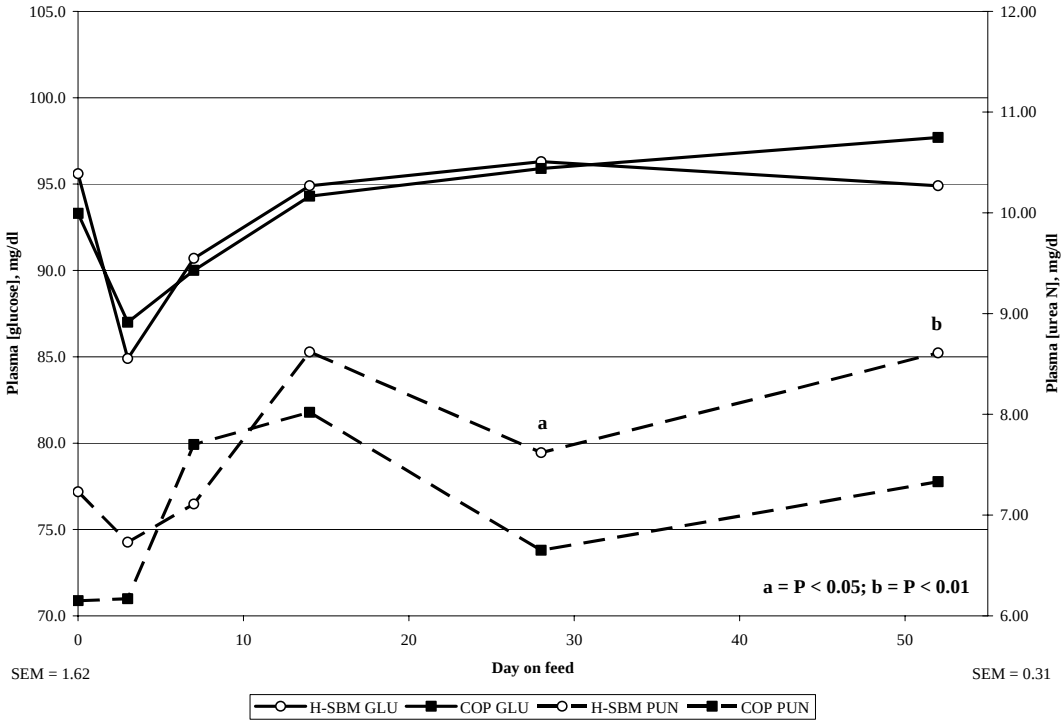

Figure 2. Comparison of plasma levels of glucose and urea nitrogen between H-SBM and H-treatments.

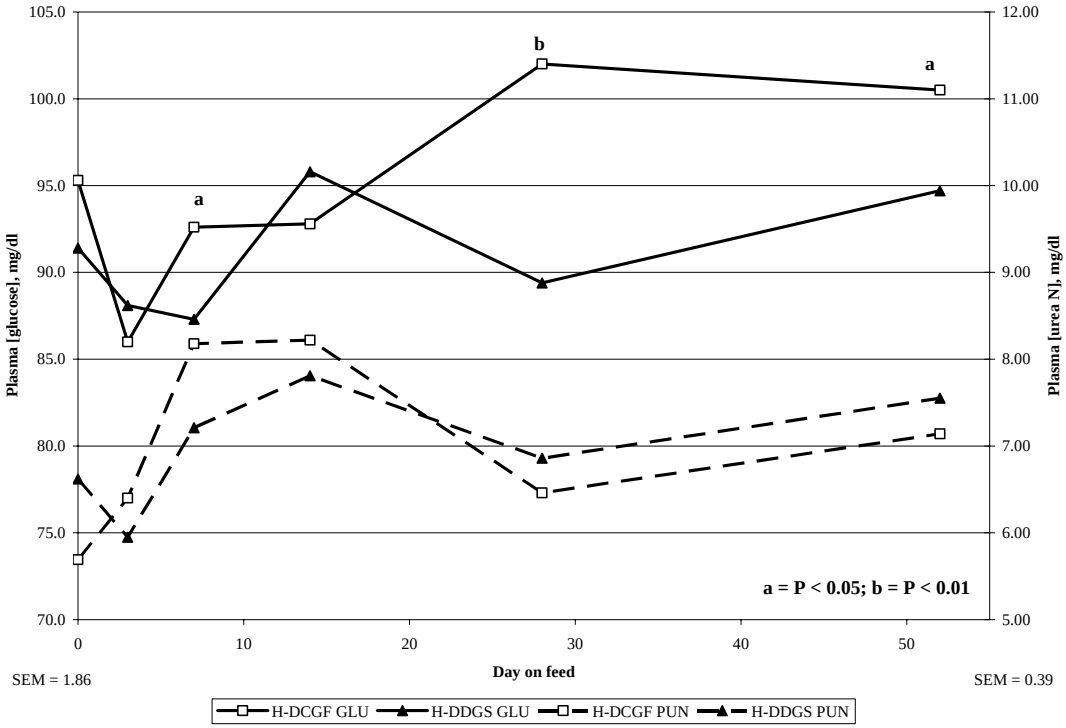

Figure 3. Comparison of plasma levels of glucose and urea nitrogen between H-DCGF and H-DDGS treatments.

Factors Affecting Profitability of the Cow-calf Enterprise in the Northern Great Plains

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BEEF 2005 – 09

Summary

One hundred and forty eight privately owned and operated cow-calf enterprises were surveyed for their production and financial performance measures and the results analyzed for factors that affected profitability. The results of these analyzes indicate that for cow-calf enterprises in the Northern Great Plains, high levels of profit are a function of lower than average investment, above average reproductive performance, lower than average total expenses, and above average market prices for calves produced. Neither high nor low levels of other biological production, geographical region, size of operation, or year were factors that explained differences in profitability. Profitability measured as Return on Assets (ROA) in the High Profit group (18.16%) was higher ($P<0.01$) than Medium or Low Profit groups and are very competitive with opportunities available in other sectors of the economy. The profit levels in the Medium and Low Profit groups (2.88% and -15.55%) are not competitive with other opportunities for investment in the economy. The long-term financial viability of the operations in these two groups would be difficult without other sources of income or investment.

Introduction

In a large, dynamic, capitalistic economy, money, energy, and people flow to where returns on the investments of money, labor, and management are the highest. The historic return on assets for businesses in our nation's economy averages 10%. With historic profit levels of 2% return on assets, cow-calf businesses have not been financially friendly environments for individuals or families. Fully one-half of the cow-calf producers in South Dakota have exited the business during the last three decades.

The response of those in leadership positions in the cattle and ranching industry and communities has largely focused on three topic areas: 1) The marketplace, especially efforts to increase consumer demand for beef, exports/imports, and industry concentration; 2) production increases; and 3) policy discussions related to taxes, federal land use, subsidies, and environmental issues. While these topic areas are certainly important, the collection of actual ranch financial and production data, and the application of analytical tools common in other businesses could provide insight and understanding into the complex problem of profitability and sustainability. This was the direction taken with this research project conducted at South Dakota State University in collaboration with faculty at Montana State University. The objectives of this study were: 1). To compare the Standardized Performance Analysis (SPA) measurements of cow-calf enterprises in the Northern Great Plains that had been categorized into high, medium, and low profit groups based on ROA. 2). To determine factors that distinguished highly profitable cow-calf enterprises from other less profitable cow-calf enterprises.

Materials and Methods

Data were collected from 148 cow-calf enterprises for fiscal years during the period of 1991-1999, according to the Standardized Performance Analysis (SPA) guidelines adopted by the National Cattlemen's Association in 1992. Owners of farms and ranches that included cow-calf enterprises were invited to participate in the SPA process in a variety of methods. Veterinarians, county agents and educators, and Bootstraps groups hosted SPA workshops. Some ranchers and farmers contacted the University system on their own through a variety

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of avenues and were invited to join scheduled workshops or were assisted with SPA on an individual basis. Participation was completely voluntary. The names of the participants have never been released and their information and privacy have been protected. The motivation of ranchers and farmers to participate was not recorded. Data collection was either done by or supervised by Dr. Edward Hamilton of South Dakota State University or Duane Griffith of Montana State University.

All participants were asked for the animal production and financial information necessary to complete a SPA analysis. Production data included: 1) breeding herd inventory and dates; 2) pregnancy test inventory and results; 3) female replacement rate; 4) the date the third mature cow in the herd calved; 5) calving distribution as defined by SPA; 6) calf death loss; and 7) weaning date and weights. The financial information came from a variety of sources including: 1) cost basis beginning and ending year balance sheets; 2) accrual adjusted income statements; 3) IRS Schedule F; and 4) depreciation schedules.

Return on Assets (ROA) was measured by annual net income divided by average total assets times 100. Net income is defined as the accrual adjusted revenues minus accrual adjusted expenses and family living expenses, plus interest expenses, but before income tax. Average total assets were calculated by averaging the beginning and ending year balance sheets. Balance sheet values were based on the financial cost of the assets or their book value. The analysis does not address the issues of deferred taxes. In this analysis, ROA at cost allows for the measurement and comparison of the return to invested capital, owner labor and management, and family living withdrawal. It is generally considered the most inclusive measurement of profitability.

The data set was divided into three profit groups. The High Profit group represented those herds with ROAs greater than one standard deviation (9.8%) above the mean ROA of 3.1% (greater than a positive 12.9%). The Low Profit herds were those with a ROA one standard deviation lower than the mean ROA (less than a negative 6.7%). The Medium Profit group represented those herds with a ROA between a negative 6.7% and a positive 12.9%. The means for all SPA variables of the High Profit, Medium Profit and Low Profit groups were compared.

Farmers and ranchers from eight states cooperated in the collection of the data (Table 1.). In order to examine the possible effects that the type of operation or geographical location within the Northern Great Plains may have on profitability, the area was divided into three regions. Region 1 represented an area from east of U.S. Highway 281 in the states of North Dakota, South Dakota, Nebraska, and Kansas, and included Minnesota and Iowa. This region was chosen to represent crop/livestock type of operations. Region 2 represented an area located from U.S. Highway 281 to the western borders of North Dakota, South Dakota, Nebraska, and Kansas and was chosen to represent range operations. Region 3 was made up of the states of Wyoming and Montana and represented ranch operations on the eastern slope of the Rocky Mountains that may have significant amounts of Federal land in their operations and operate in a more arid environment.

The experimental unit in this study was a ranch. In this report, the SPA production data are averages of ranch averages. For example, the average weaning weight of calves in the High Profit group was 513 pounds. This number was obtained by averaging the average weaning weights of the calves on the 20 ranches in the High Profit group for a production year. This is important because data reported in Table 5 cannot necessarily be used to calculate other data in the table. Means, and standard error of the means (SEM), which is a measure of the variability within the data, were calculated and compared using the General Linear Model of SAS. Means were compared on a per 100 lb of weaned calf, per cow, and per acre basis. Only results on a 100 lb of weaned calf basis are reported. This proved to be the most sensitive measure of differences in the dataset. Key SPA measures, along with other descriptive variables, were also analyzed using regression analysis to determine their impact on profitability. A list of these variables is found in Table 2.

Results and Discussion

As in any business, owners and managers of cow calf enterprises need to avoid being a low profit producer. For long-term sustainability,

achieving high levels of profit is essential. It follows that understanding the managerial behavior of the High Profit group in this sample population is important. Of the 23 SPA production measurements used to describe the cow-calf enterprise the only measurement for which High Profit enterprises were higher (P < 0.10) than Medium and Low Profit enterprises was weaning percentage. High and Medium Profit enterprises did have higher calving percentages, and weaned more pounds per cow exposed than Low Profit (P < 0.10). Medium Profit weaned heavier calves, and heavier male calves than did Low Profit (P < 0.10). There were no significant differences between High and Medium Profit operations for measures of size of operation, weaning weight, pregnancy percentage, calving percentage, female replacement rate, the measures of calving distribution, pounds of weaned calf per cow exposed, or stocking rate.

The same was not the case for the comparisons of SPA financial measurements. On a per 100 lb. of weaned calf basis (Table 3), High Profit enterprises had fewer total dollars invested than did Medium Profit (P < 0.05). They also had lower depreciation expenses (P < 0.10) and lower total expenditures (P < 0.05) than both Medium and Low Profit enterprises. High Profit enterprises also had higher revenue (P < 0.05), lower breakevens (P < 0.05), and higher net income (P < 0.01) and higher ROA (P < 0.01) than Medium and Low profit enterprises (Table 4).

High levels of profit can arise from many combinations of production and financial performance. For example, differences in ROA can be based on different levels of both financial investment, and net income. Net income is a function of quantity sold, dollars received, and total expenditures. Differences in ROA between cow-calf enterprises could be explained by any combination of assets invested, quantity produced, market value of that production, or the cost of that production. However, in this sample population, High Profit enterprises invested fewer dollars, had higher total revenue, lower total expenditures, and higher levels of net income, than Medium Profit enterprises.

It is important to note that High Profit enterprises were able to produce the same number of pounds of calf per exposed female (Table 5) at a lower breakeven (P < 0.01), and at lower level of investment (P < 0.01) than Medium or Low Profit enterprises (Table 3). This is contrary to reports that highly profitable cow-calf enterprises had higher production levels and annual expenses at least as high as average profit herds. It is important to note that differences reported by these other authors were numerical and not statistical.

Regression analysis resulted in similar results. On a per cwt. of weaned calf basis, Net Income, Owner's Equity, their interaction, and Pregnancy Percentage explained 81.27% of the variability in ROA. It can be interpreted that net income, arrived at by cost control, average production with a tendency towards high levels of reproduction, and excellent marketing, along with a strong financial position as reflected by owner's equity are key strategies for success in obtaining profitability.

Due to economies of scale, there has been speculation that larger cow-calf enterprises are more profitable than smaller operations. In this sample population, measurement of size of operation did not surface as a factor affecting profitability in regression analysis and there were no significant differences in size of operation between High, Medium, and Low Profit groups. While small operations may not be able to generate high enough levels of total income to fully cover family living and required returns to capital, they were just as efficient at converting dollars of investment into net income as large operations. This may be due to synergistic effects with other enterprises not measured by SPA. For example, the use of crop residues or the ability to depreciate equipment over multiple enterprises may compensate small operations for the loss of economies of scale when compared to larger operations.

There has also been speculation that regional differences may account for differences in profitability. While production systems in the three designated regions within this analysis vary, region was not a factor affecting profitability. This would indicate that the opportunity for profit was not determined by geographical region, but management's response to opportunities and challenges within regions.

While measurements on a per cow and per acre basis are useful and of interest, the most

sensitive unit of measure in these analyzes was on a hundred pounds of weaned calf basis. This is important because it is not only the unit of measure for marketing, but also the most inclusive measurement of productivity and efficiency.

The 18.16% ROA for High Profit herds (Table 4) in this sample population are very competitive with those of other businesses and investment opportunities in our economy. To generate $35,000.00 of family living and pay off all debt, as listed by individual operations and averaged for this study, in 10 years, the average cow-calf producer in the High Profit group would need a herd of approximately 200 beginning year breeding females. This size herd represents a very competitive opportunity for family farmers and ranchers from both an investment as well as labor perspective.

Implications

The results of these analyzes indicate that for cow-calf enterprises in the Northern Great Plains, high levels of profit are a function of lower than average levels of investment, at least average levels of biological production (with particular attention paid to measures of weaning and pregnancy percentage) achieved with lower than average total expenses, and higher than average market prices for calves produced. Neither high nor low levels of production, geographical region, size of operation, or year were factors that explained differences in profitability as expressed as ROA.

Tables

Table 1 . Location and number of participating farms and ranches

State	Number
South Dakota	43
Nebraska	68
Montana	54
Kansas	10
Wyoming	6
Iowa	6
Minnesota	3
North Dakota	1

Table 2. Variables used in regression analysis as possible factors affecting profitability

1. Avg weaning weight, lb
2. Number of beginning year breeding females
3. Pregnancy percentage
4. Weaning percentage
5. Pounds of weaned calf per cow exposed
6. Avg age at weaning, days
7. Pounds weaned per acre utilized by cow-calf enterprise
8. Total acres utilized by the cow-calf enterprise
9. Region
10. Breakeven, $ per 100 lb of weaned calf
11. Gross accrual revenue, $ per 100 lb of weaned calf
12. Total cow-calf enterprise operating costs, $ per 100 lb of weaned calf
13. Net pre-tax income, $ per 100 lb of weaned calf
14. Avg owner's equity, $ per 100 lb of weaned calf
15. Avg real estate investment, $ per 100 lb of weaned calf
16. Year

Table 3. SPA financial summary, $ per 100 lb of weaned calf for low, medium, and high profit cow-calf enterprises

	Low, n=17		Medium, n=111		High, n=20		
	Means	SEM	Means	SEM	Means	SEM	P>F
Investment							
Total assets	352.64[de]	74.37	477.62[e]	28.24	317.34[d]	64.92	.037
Total liability	113.00	36.05	148.86	13.69	95.23	31.46	.232
Avg real estate	103.12[g]	54.30	215.55[h]	20.62	114.24[g]	47.40	.039
Owner's equity	239.63	66.78	328.75	25.35	222.11	58.29	.147
Expenses							
Veterinary med	5.95[g]	0.89	3.95[h]	0.33	3.46[h]	.74	.077
Depreciation	17.98[g]	3.01	11.11[h]	1.11	6.15[i]	2.50	.013
Interest	7.16	2.24	8.54	0.85	6.77	1.95	.638
Labor & Mgt.	9.98	2.86	7.38	1.05	5.84	2.37	.538
Purchased feed	15.78	3.75	13.97	1.38	9.97	3.11	.416
Inventory Adj.	26.28[a]	6.19	1.28[b]	2.28	-2.41[b]	5.14	.001
Total expenses	145.52[d]	9.79	82.38[e]	3.71	60.92[f]	8.54	.001
Revenue							
Calf revenue	83.18[gh]	7.89	76.28[g]	3.04	92.96[h]	6.98	.083
Non-calf revenue	5.75	5.46	14.86	2.07	19.50	4.77	.161
Total revenue	88.92[d]	8.90	91.14[d]	3.38	112.45[e]	7.77	.038
Profit							
Breakeven	136.43[d]	9.28	66.05[e]	3.52	40.63[f]	8.10	.001
Net income	-56.63[a]	6.84	8.78[b]	2.60	51.53[c]	5.97	.001

[abc] Means within the same row with different superscripts differ (P < 0.01).
[def] Means within the same row with different superscripts differ (P < 0.05).
[ghi] Means within the same row with different superscripts differ (P < 0.10).
Note: The experimental unit in this analysis is a ranch. Data in the table cannot necessarily be used to generate other data.

Table 4. SPA financial summary, owner's equity and ROA for low, medium, and high profit cow-calf enterprises, %

	Low, n=17		Medium, n=111		High, n=20		
	Means	SEM	Means	SEM	Means	SEM	P>F
Owner's equity	67.95	2.24	68.83	.85	69.99	1.96	.741
ROA	-15.55[a]	1.28	2.88[b]	0.49	18.16[c]	1.12	.001

[abc] Means within the same row with different superscripts differ (*P < 0.01*).

Table 5. SPA production summary for low, medium, and high profit cow-calf enterprises

	Low, n=17		Medium, n=111		High, n=20		
	Mean	SEM	Means	SEM	Mean	SEM	P>F
Cow-Calf enterprise summary							
Total adjusted exposed females	490	182	535	69	486	159	0.942
Beginning fiscal year breeding females	469	176	519	67	474	154	0.940
Total acre	10,646	5,844	12,933	2,179	11,708	4,940	0.921
Acre/exposed female	21.74	17.29	24.21	7.41	24.21	14.82	0.468
Reproduction performance measures based on exposed females							
Avg beginning calving day of year	70	6	58	2	58	5	0.952
Days in breeding season	79	13	89	5	90	11	0.749
Pregnancy percentage	90.88	1.17	93.03	0.46	94.13	0.99	0.104
Pregnancy loss percentage	3.17	2.50	3.11	0.99	3.02	2.12	0.999
Calving Percentage	88[a]	1.80	92[b]	0.68	94[b]	1.57	0.061
Calf death loss percentage	2.98	0.96	3.42	0.36	2.37	0.84	0.501
Calf crop or weaning %	83[a]	1.91	87[a]	0.73	90[b]	1.67	0.029
Female replacement rate, %	15.99	5.04	20.28	1.90	19.32	4.36	0.725
Calving performance measures based on calves born							
Calf death loss rate, %	5.42	1.09	5.05	0.42	3.69	0.10	0.379
% calves born d 1 - 21	52.22	4.32	57.06	1.70	58.96	3.78	0.481
% calves born d 1 – 42	81.84	1.99	84.61	1.34	86.51	2.98	0.353
% calves born d 1 – 63 d	95.45	1.99	95.92	0.90	95.45	1.99	0.626
% calves born 63+ d	4.79	2.43	4.09	0.96	4.43	2.13	0.960
Production performance measures, pound							
Avg age at weaning, d	200	7	199	3	198	6	0.963
Avg weaning weight, male	499[a]	16	536[b]	6	513[ab]	15	0.056
Avg weaning weight heifer	487	15	517	6	504	13	0.133
Avg weaning weight calf	493[a]	15	525[b]	6	507[ab]	13	0.082
Lb. weaned/exposed female	413[a]	18	455[b]	7	455[ab]	15	0.078
Lb. weaned/acre used by the cow-calf enterprise	39.3	9.8	41.1	3.6	33.9	8.9	0.727

[a, b] Means within the same row with different superscripts differ ($P < 0.10$).

Note: The experimental unit in this analysis is a ranch. Data in the table cannot necessarily be used to generate other data.

Effect of Harvest Method on the Nutrient Composition of Baled Cornstalks[1]

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BEEF 2005 - 10

Summary

This experiment was conducted to determine the effect of chopping corn residue prior to baling on the nutrient composition of cornstalk bales. One dryland corn field planted with a single variety of corn was used. After harvest, one half of the field was chopped with a stalk chopper. The remaining half was not chopped. Each half of the field was then raked into windrows, baled, and wrapped with plastic netting. Ten round bales were harvested from each half of the field (chopped and not chopped). Three core samples were then collected from each bale and pooled for analysis. Pooled samples were dried and analyzed for crude protein, crude fat, ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), neutral detergent insoluble nitrogen (NDIN), lignin, calcium (Ca) and phosphorus (P). Total digestible nutrients were then calculated from the analyses. Neutral detergent insoluble nitrogen was greater ($P < 0.01$) in chopped cornstalks than in cornstalks that had not been chopped. Calcium concentrations were greater ($P < 0.05$) and phosphorus concentrations tended to be greater ($P < 0.10$) in chopped cornstalks than in those that had not been chopped. The remaining nutrients were not affected by processing. Chopping cornstalks prior to baling did not negatively affect their nutritional value for beef cattle. However, because of differences in varieties, growing conditions, and agronomic practices, caution should be exercised in extrapolating these results.

Introduction

Crop residues are a critical resource for beef cattle production systems throughout the Upper Midwest. Without question, the most economical means of harvesting crop residue is by grazing. However, because of unpredictable fall and winter weather or management challenges (fencing, water supply, etc.), many producers elect to bale at least a portion of their available crop residue.

Agronomic practices can be variable for corn producers in the Upper Midwest. Tillage practices range from conventional tillage to no tillage and multiple other variations. Consequently, residue management can vary accordingly. The desired amount and particle size of the crop residue can vary dramatically.

Variation in the nutrient composition of different parts of a corn plant has been clearly documented (Fernadez-Rivera and Klopfenstein, 1989; Rasby et al., 1998). Since cattle will select the highest quality diet available, processing residue likely has minimal impact on animal performance when corn residue is grazed. However, when cornstalks are harvested mechanically, the effect of processing is not well documented. This experiment was designed to determine if chopping corn residue prior to harvest negatively affects the nutrient composition of cornstalk bales.

Materials and Methods

One dryland corn field planted with a single variety was used for this experiment. After harvest, one half of the field was chopped with a stalk chopper. The remaining half was not chopped. Each half of the field was then raked into windrows, baled, and wrapped with plastic netting. Ten round bales were baled on each half of the field (chopped and not chopped). Three core samples were then collected from each bale using a Penn State Forage Sampler and pooled for analysis.

Each pooled sample was dried at 105°C for 3 hr (NFTA Method 2.2.2.5) and ground. Ground samples were analyzed for crude protein (AOAC Official Method 990.03), crude fat (AOAC Official Method 2003.05), ash (AOAC Official Method 942.05), ADF (AOAC Official Method 973.18), NDF (AOAC Official Method 2002.04), neutral detergent insoluble nitrogen, lignin (AOAC

[1] The author thanks the Southeast Research Farm for their financial support of this research.
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Official Method 973.18, Ca (AOAC Official Method 968.08), and P (AOAC Official Method 931.01). Total digestible nutrients were then calculated (NRC, 2001).

Data were analyzed as a completely randomized design using the GLM procedure of SAS (SAS, 1999). Significance was declared at $P < 0.05$.

Results and Discussion

Neutral detergent insoluble nitrogen was greater ($P < 0.01$) in chopped cornstalks than in cornstalks that had not been chopped (Table 1). Calcium concentrations were greater ($P < 0.05$) and phosphorus concentrations tended to be greater ($P < 0.10$) in chopped cornstalks than in those that had not been chopped (Table 1). The remaining nutrients were not affected by processing (Table 1). Total ash content of the bales was not different (Table 1). Therefore these differences are not likely related to soil contamination. Rather, it is possible that Ca and P are found in greater concentration in the stem, but analyses of individual parts of the cornstalk were not performed.

Implications

Based on these findings, chopping cornstalks prior to harvest did not negatively affect their nutritional value for beef cattle. However, caution should be exercised when extrapolating these results. There is potential for significant variation in the nutrient composition of various components of the cornstalk (husk, leaf, and stem) based on growing conditions and variety. Further research is required to better quantify the effect of chopping cornstalks prior to harvest on nutrient composition

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Tables

Table 1. Effect of processing prior to harvest on nutrient composition of baled cornstalks

	Harvest Method		
Item	Chopped	Not chopped	SEM[a]
Dry matter, %	79.0	81.2	1.04
Crude protein, %	5.4	5.5	0.18
Fat, %	0.79	0.81	0.10
Ash, %	21.3	23.0	1.48
ADF, %	68.2	67.6	1.20
NDF, %	100.0	98.2	1.77
NDIN[b], %	0.59	0.41	0.03
Lignin, %	6.8	6.7	0.19
Ca[c], %	0.52	0.45	0.02
P[d], %	0.17	0.15	0.01
TDN, %	40.9	39.5	0.68

[a]SEM = standard error of the mean.
[b]Means differ ($P < 0.01$).
[c]Means differ ($P < 0.05$).
[d]Means differ ($P < 0.10$).

Corn Germ as a Source of Supplemental Fat for Cows in Late Gestation[1]

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BEEF 2005 – 11

Summary

To evaluate corn germ as a source of supplemental fat, 217 two to twelve-year-old cows receiving grass hay free choice were supplemented with either 2.75 lb of corn germ (dry basis) or an equal amount of crude protein from soybean meal (0.80 lb dry matter) starting approximately 50 days prior to the first expected calving. Cows were removed from treatment the day they calved and where managed as a group through the breeding season. Supplement treatment did not affect cow weight change or body condition score. Corn germ did not improve any measure of reproduction, including the percentage of cows cycling or conceiving in the first 21 days of the breeding season or the days from calving to the onset of cyclicity or conception. Calf performance, calf health or indicators of colostrum absorption (total serum protein or IgG) were not influenced by supplement treatment. The results were similar whether all age groups were included in the analysis or when only data for the two and three year old cows were included in the data set. Under the conditions of this study there was no advantage to feeding a source of supplemental fat from corn germ during late gestation.

Introduction

Several studies have shown dietary fat to influence ovarian activity and hormones associated with reproduction. Studies at other locations have demonstrated that providing supplemental fat during late gestation may improve pregnancy rate, increase cow body weight and improve calf vigor, health and weaning weight. The response has not been consistent in all studies and may be dependant on the source of fat. The objective of this study was to evaluate corn germ as a source of supplemental fat for cows in late gestation.

Materials and Methods

This study was conducted during two years at location 1 and one year at location 2. Within location and year, pregnant cows from two to twelve years of age were allotted by age group (2, 3, 4 and greater than 4 years old), breed and projected calving date to two treatments starting approximately 50 days prior to the first expected calving. At location 1, two-year-olds had been bred to start calving 21 days prior to the rest of the cowherd so they started on trial prior to the rest of the cowherd. At location 2 all age groups were bred to start calving on the same day and started on trial the same day. During the treatment period, all cows received grass hay free choice (Table 1 and 2). Cows on the corn germ treatment received 2.75 lb of corn germ dry matter per head and cows in the control group received 0.80 lb of soybean meal dry matter to provide an equal daily amount of crude protein as the corn germ treatment.

At the beginning of each trial and prior to the first scheduled calving, cows were weighed on two consecutive days following an overnight shrink away from feed and water. Fat thickness between the 12th and 13th rib was measured by ultrasonography and cows were assigned a body condition score (1 – 9 with 1 being extremely thin and 9 being obese; Pruitt and Momont, 1988) by 2 people. Within 24 hours of calving, cows were assigned condition scores by the same two people, weighed, removed from the treatments and managed as one group (within location) through the breeding season until weaning in the fall. Cows grazed a common pasture, within location, starting approximately 14 days prior to the breeding season until weaning time.

[1] This study was possible through funds provided by Minnesota Corn Processors, Marshall, MN; Bill & Rita Larson, Fowler, CO; and the SD Ag Exp Station.
[2] Professor
[3] Associate Professor
[4] Assistant Professor

Starting four weeks prior to the beginning of the breeding season blood samples were collected by jugular veni-puncture weekly and analyzed for serum progesterone by radioimmunoassay. Onset of cyclicity was defined as: 1) the date of the first of two consecutive weekly samples with great than 1 ng progesterone/mL of serum; 2) the date of a sample >1 ng progesterone/mL of serum followed by an observed estrus within 14 days; or 3) the date of the first observed estrus without a preceding sample >1 ng progesterone/mL of serum. At the beginning of the breeding season cows were observed for estrus at least twice daily for 7 days and artificially inseminated (AI) approximately 12 hours after standing estrus. Cows not inseminated were then administered an injection of prostaglandin $F_{2\alpha}$ to synchronize estrus. At location 1, heat detection and AI continued for 30 days and then cows were exposed to a bull for 30 days. At location 2, heat detection and AI continued for 7 days and then cows were exposed to a bull for 45 days. Pregnancy was determined by transrectal ultrasonography. Conception date was determined using a combination of breeding records, calving date and ultrasonography (when calving date was not available).

Calves were weighed within 24 hours of birth, at weaning and at about a year of age. Calves were observed daily for symptoms of disease and treatments were recorded.

Blood samples were collected from the calves by jugular veni-puncture between 24 and 48 hours after birth. Serum was separated the following day after centrifuging at 1500x g for 25 minutes and frozen. Total serum protein was measured by refractometry, which has been shown to be an accurate measure of total protein, which is closely correlated with the amount of immunoglobulin in serum and plasma. IgG was determined by radioimmunoassay.

Statistical analysis. Since cows were fed as a group within each location, treatment and year, feeding group were defined as: 1) year 1, location 1; 2) year 2, location 1; and 3) year 2, location 2. Cows producing twins were deleted from the data set and only cows that weaned a calf were included in the analysis.

Cow weight, average daily gain, condition score, rib fat, calving date and days from calving to onset of cycling and conception were analyzed using Proc GLM of SAS. Independent variables in the statistical model included treatment (corn germ and soybean meal), feeding group and treatment x feeding group. Treatment x feeding group served as the error term. Means were separated by the PDIFF option of SAS.

Calf weights, average daily gain, total serum protein and IgG were analyzed using Proc GLM of SAS. Independent variables included: treatment (corn germ and soybean meal), feeding group, treatment x feeding group, percentage Angus of the dam and calf sex. The error term to test treatment effects was treatment x feeding group. Means were separated using the PDIFF option of SAS.

Percentage cycling in the first 21 days of the breeding season, percentage conceiving in the first 21 days of the breeding season and overall pregnancy rate were analyzed with Proc GENMOD of SAS. Independent variables were treatment, cow age group and treatment x cow age group.

The first set of analyses included all cows. Since young, thin cows are more likely to show a reproductive response to nutritional treatments, a second analysis was performed with only 2 and 3 year old cows in the data set.

Results and Discussion

Cow weight and average daily gain were not affected by supplement treatment (Table 3). The higher fat content of corn germ makes it a higher energy feed than soybean meal. But the fat content also has the potential to decrease the digestibility of the grass hay and reduce hay intake. The similar weight gains between the treatment groups indicate that the total energy available to each of the treatment groups was similar.

The cows receiving soybean meal before calving had a higher percentage conceiving in the first 21 days of the breeding season than those receiving corn germ (Table 4). No other measure of reproductive performance was affected by treatment. Researchers in Miles City, Montana reported inconsistent responses to supplemental fat fed in late gestation to first calf heifers (Bellows et al., 2001). They concluded that when pasture forage quality and quantity prior to and during the breeding season was limited, supplemental fat in late gestation

resulted in a beneficial response to reproduction. When weather conditions resulted in abundant high quality forage, they found not reproductive response to supplemental fat in late gestation. In our study pasture forage prior to and during the breeding season was not limiting.

Supplemental treatment did not affect calf birth weight (Table 5). Similar mean values for total serum protein and IgG of calves from blood samples taken 24 to 48 hours after birth indicate that corn germ did not increase passive immunity of the calf from colostrum. Analysis of health records indicated a very low incidence of calf disease symptoms and there was no effect of supplement treatment on the percentage of calves requiring treatment prior to weaning or from weaning to yearling time.

Typically two and three year old cows are thinner at the beginning of the breeding season, require more days from calving to the first postpartum estrus and have lower pregnancy rate. Management that has potential to improve reproductive performance is more likely to affect young cows than mature cows, so the results from two and three year old cows and their calves are presented in Tables 6 through 8. The results are not different than when the analysis included all age groups.

Implications

Under the conditions of this study supplemental fat in the form of corn germ during late gestation did not have a beneficial effect on cow reproductive performance or calf performance. Under these conditions, additional expense to provide supplemental fat during late gestation would not be justified. It is possible that under conditions where calf disease is a problem, supplemental fat could be beneficial.

Tables

Table 1. Feed Analysis

	Corn germ	Soybean meal	Grass hay
Location 1, Year 1			
% dry matter	93.7	89.2	84.9
% crude protein[a]	12.4	49.4	9.4
% crude fat[a]	38.6	2.0	2.2
% NDF[a]			63.4
% ADF[a]			42.1
Location 1, Year 2			
% dry matter	92.9	89.1	89.4
% crude protein[a]	12.4	49.3	9.4
% crude fat[a]	47.6	1.4	
% NDF[a]			62.8
% ADF[a]			41.4
Location 2, Year 2			
% dry matter	92.9	89.1	83.6
% crude protein[a]	12.4	49.3	10.4
% crude fat[a]	47.6	1.4	
% NDF[a]			62.0
% ADF[a]			40.2

[a]dry matter basis

Table 2. Feed intake.

Treatment	No. cows	Dry matter disappearance, lb per cow daily: Grass hay	Corn germ	Soybean meal	Total	Supplemental fat: Lb per cow daily	% of daily dry matter
Location 1, Year 1							
Corn germ	52	19.3	2.75		22.1	1.06	4.82
Soybean meal	50	20.2		0.80	21.0	0.02	0.08
Location 1 Year 2							
Corn germ	49	20.5	2.74		23.3	1.31	5.61
Soybean meal	50	24.2		0.80	25.0	0.01	0.04
Location 2, Year 2							
Corn germ	37	20.9	2.73		23.6	1.30	5.50
Soybean meal	37	25.1		0.82	25.9	0.01	0.04

Table 3. Performance of all cow age groups.

	Corn Germ	SE	Soybean Meal	SE	Probability
No. of females	127		128		
Avg. days on treatment	56.8		56.0		
Avg. calving date	3/20		3/20		
Weight, lb					
Initial	1374	31	1386	31	0.79
Prior to the start of calving	1403	22	1398	22	0.87
Post-calving	1324	12	1326	12	0.90
Cow ADG from initial weight, lb					
Prior to the start of calving	0.78	0.29	0.35	0.29	0.35
To post-calving	-1.12	0.42	-1.20	0.42	0.90
To weaning	-0.02	0.23	-0.05	0.24	0.93
Condition score					
Initial	6.2	0.1	6.2	0.1	0.99
Prior to the start of calving	6.2	0.1	6.2	0.1	0.87
Post-calving	6.1	0.1	6.1	0.1	0.94
Ribfat, in.	0.22	0.02	0.21	0.02	0.70

Table 4. Reproductive performance of all cow age groups.

	Corn Germ	SE	Soybean Meal	SE	Probability
No. of females	127		127		
Cycling before the start of the breeding season, %	36.2		38.1		0.76
Cycling by day 21 of the breeding season, %	92.9		94.5		0.61
Calving to cycling, days	66.9	8.9	68.4	9.1	0.91
Conception in first 21 days of breeding season, %	62.2		74.2		0.04
Calving to conception, days	88.4	2.3	88.1	2.3	0.97
% pregnant	92.6		94.3		0.58

Table 5. Calf performance and health for all cow age groups.

	Corn Germ	SE	Soybean Meal	SE	Probability
No. of calves	129		130		
Birth weight, lb	87.6	3.0	85.9	3.0	0.71
Age at weaning, lb	189	8	191	8	0.89
ADG birth to weaning, lb	2.51	0.12	2.49	0.12	0.90
Weaning weight, lb	564	38	562	38	0.97
Total serum protein 24-48 h after birth, g/dl	6.6	0.2	6.6	0.2	0.95
No. of calves[a]	88		86		
IgG, 24-48 h after birth, mg/dl	4951	323	5444	335	0.38
No. of calves	127		127		
Calves treated from birth to weaning, %	2.4		2.4		1.00
Calves treated from weaning to yearling, %	5.7		5.1		0.85
Calves treated from birth to yearling, %	7.6		6.8		0.82
No. of yearlings	117		122		
ADG from weaning to yearling, lb	2.56	0.02	2.59	0.03	0.53

[a]Calves at location 1 only.

Table 6. Performance of 2 and 3 year old cows.

	Corn Germ	SE	Soybean Meal	SE	Probability
No. of females	57		58		
Avg. days on treatment	55.9		56.5		
Avg. calving date	3/15		3/17		1.00
Weight, lb					
Initial	1249	20	1254	19	0.88
Prior to the start of calving	1278	16	1267	15	0.64
Post-calving	1205	15	1205	14.2	0.98
Cow ADG from initial weight, lb					
Prior to the start of calving	0.76	0.25	0.41	0.24	0.36
To post-calving	-1.02	0.40	-0.92	0.38	0.87
To weaning	0.08	0.23	0.10	0.23	0.95
Condition score					
Initial	6.1	0.2	6.1	0.2	0.99
Prior to the start of calving	6.0	0.2	6.0	0.2	0.99
Post-calving	6.0	0.2	6.0	0.2	0.83
Ribfat, in	0.20	0.02	0.19	0.02	0.65

Table 7. Reproductive performance of 2 and 3 year old cows.

	Corn Germ	SE	Soybean Meal	SE	Probability
No. of females	58		55		
Cycling before the start of the breeding season, %	24.1		30.9		0.89
Cycling by day 21 of the breeding season, %	87.9		89.3		0.89
Calving to cycling, days	71.8	9.1	74.9	9.0	0.82
Conception in first 21 days of breeding season, %	62.1		73.2		0.20
Calving to conception, days	87.3	4.7	92.6	4.5	0.46
% pregnant	92.9		96.4		0.41

Table 8. Performance of calves from 2 and 3 year old cows

	Corn Germ	SE	Soybean Meal	SE	Probability
No. of calves	58		56		
Birth weight, lb	82.8	3.0	82.4	2.7	0.93
ADG to summer wt., lb	2.42	0.10	2.40	0.09	0.84
Age at weaning, lb	188	9	192	9	0.77
ADG birth to weaning, lb	2.38	0.13	2.35	0.12	0.89
Weaning weight, lb	532	43	536	40	0.95
Total serum protein 24-48 hr after birth, g/dl	6.40	0.11	6.47	0.10	0.65
No. of calves (location 1 only)	42		38		
IgG, 24-48 h after birth, mg/dl	4337	86	4572	90	0.17
No. of yearlings	43		49		
ADG from weaning to yearling, lb	2.45	0.09	2.58	0.08	0.31

Composition and Nutritive Value of Corn Fractions and Ethanol Co-products Resulting from a New Dry-milling Process[1]

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BEEF 2005 - 12

Summary

The development of a new dry-milling process for the production of corn ethanol has resulted in new feedstuffs. This process fractionates the corn kernel prior to fermentation. Pre-fermentation fractions include bran, germ, and endosperm. Post-fermentation fractions include dried distillers grains (DDG) and condensed distiller solubles (syrup). Proximate analysis was conducted on these fractions along with the parent corn sample. Equations were used to predict TDN and undegradable intake protein (UIP). These feeds differ substantially from historical dried distiller's grains with solubles (DDGS). Feeding experiments will be necessary to confirm the results of the predicted feed values.

Introduction

A dry-milling process that involves fractioning the corn kernel prior to fermentation in the course of ethanol production results in three fractions: bran, germ, and endosperm. Currently, only the endosperm fraction is fermented for ethanol production. Post-fermentation products include dried distillers grains (DDG) and condensed distiller solubles (syrup). These fractions, along with the parent corn sample, were used to determine nutrient values.

Materials and Methods

Four fermentation runs were used in this study. Samples were collected June 16-20, 2004. Ethanol plant personnel collected samples from each fermentation run, for each fraction, over a period of 10 h. Sampling occurred every 2 h. At the end of each sampling period, samples were frozen at the plant. These samples were transported to South Dakota State University Ruminant Nutrition Laboratory for processing and analyses.

Samples were allowed to thaw in a refrigerator. Solid samples were composited by fraction for each fermentation run by collecting equal weights (as-is basis) and mixing for 2 min in a bowl-type mixer. The liquid samples were composited by collecting equal volume and mixing for 2 min in a high-speed blender.

Dry matters were determined on all solid fractions by drying at 60°C until no further water loss occurred. Dry matters of the liquid fractions were determined by freezing samples at -80°C and lyophilizing them. Corn, germ, bran, and DDG samples were then ground to pass through a 1 mm screen.

Proximate analysis was performed on each composite sample. The DDG, germ, and bran fractions were subjected to a crude protein fractionation assay as outlined by Licitra et al. (1996) to predict percent undegradable intake protein (UIP). Mineral concentrations of all samples were determined by inductively coupled plasma spectrophotometry (Olsen Biochemistry Labs, SDSU).

The TDN values were calculated using a model for forages and concentrates ($TDN=(TD_{cp}xCP)+((EE-1)x2.25)+[(0.98x(100-NDF_n-CP-ash-(EE-1)-1)]+0.75x\{(NDF_n-Lig)x[1-(Lig/NDF_n)^{0.667}]\}-7$; Weiss et al., 1992). The UIP values were estimated using Dairy Cattle NRC (2001) equation for calculating rumen undegradable protein. Rate of digestion (K_d; B_1=150, B_2=6, B_3=0.5%/h) and rate of passage (K_p=2.5%/h) of CP fractions were taken from dried distiller's grains with solubles (DDGS) values published in Beef Cattle NRC (2000).

[1] This study funded in part by the U.S. Department of Energy.
[2] Graduate Student
[3] Distinguished Professor
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Results and Discussion

Research conducted on four regional ethanol plants reported CP, NDF, and fat of DDGS to be 33.3%, 42.7%, and 13.1%, respectively (Holt and Pritchard, 2004). Because only endosperm was fermented, the new DDG was higher in CP, and lower in NDF and fat than conventional DDGS. Germ was a dry, flowable, relatively high fat, and high TDN feedstuff. Bran provides a primary source of NDF with TDN and CP content comparable to corn. Syrup was a liquid feed source that could be used to condition diets while adding CP and fat.

Bran-cake, currently being used to market the bran and syrup fractions, is combined in a 1:1 mix on a wet basis (78% bran, 22% syrup, DMB). Bran-cake composition suggests it could be fed much the same way as corn gluten feed. Based upon our analyses, bran-cake would be 58% DM, 30% NDF, 12% CP, 38% UIP, 7.5% EE, 3% OM, 0.5% P, and 90% TDN.

Phosphorus was also a consideration when evaluating this fractionation process. TDN:P ratios on corn, germ, bran, and bran-cake were 293, 78, 209, and 180, respectively. The CP:P ratios on conventional DDGS and new DDG were 36 and 97, respectively. The TDN:P and CP:P are important considerations for farm operations where manure application is controlled by soil and manure P levels. Producers that feed new DDG as a CP source instead of conventional DDGS will lower their dietary P input.

Implications

New DDG will be used exclusively as a CP supplement as opposed to conventional DDGS being used as a protein and energy supplement. New DDG allows operations to use a product with similar particle size and density to conventional DDGS, but is higher in CP and lower in EE and P.

Germ can be used as a protein and energy supplement to replace concentrates (corn and SBM) in feedlot and dairy diets. This product could allow producers to add a dry, solid form of fat to diets, increasing the caloric density of the diet. Producers that use germ as an energy source should consider their farm-feedlot P balance since the addition of germ to diets will increase the amount of P accumulation in the manure.

Bran-cake composition suggests it could be fed much like corn gluten feed in finishing and dairy diets to provide energy without adding starch.

Feeding experiments will be necessary to confirm the results of predicted feed values reported in this paper.

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Tables

Table 1. Type and description of samples taken from new dry-mill ethanol procedure

Fraction	Description
Corn	Parent corn sample taken prior to fractionation
Bran	Seed coat of corn kernel
Germ	Reproductive fraction of corn kernel
Endosperm	Starch fraction of corn kernel
DDG	Solid residue from fermentation of endosperm
Syrup	Liquid residue from fermentation of endosperm

Table 2. Laboratory assays

Assay	Method
Dry Matter (DM)	60°C oven, AOAC Official Method 4.1.03
Crude Protein (CP)	Kjeldahl Method, AOAC Official Method 954.01
Neutral Detergent Fiber (NDF)	Goering, H.K. and P.J. Van Soest. 1970. in:Forage Fiver Analyses. (USDA, Agric. Handbk. No. 379 Jacket No. 389-598)
Acid Detergent Fiber (ADF)	Goering, H.K. and P.J. Van Soest. 1970. In:Forage Fiver Analyses. (USDA, Agric. Handbk. No. 379 Jacket No. 389-598)
CP Fractionation	Licitra et al. 1996. In: Anim. Feed Sci. Technol. 57:347–358
Ash	500°C Muffle Furnace, AOAC Official Method 942.05
Ether Extract	Soxhlet Fat Extraction methods, AOAC
Lignin	H_2SO_4 Lignin, AOAC Official Method 973.18
Minerals	Inductively coupled plasma spectrophotometry, AOAC official method 985.01 and 999.10

Table 3. Composition of new dry-milling process co-products

	Corn		Bran		Germ		Endosperm		DDG		Syrup	
Item	Mean [c]	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv
DM, %	92.0	0.2	90.1	0.1	91.3	0.1	89.6	0.2	89.1	1.5	25.5	1.0
GE, Mcal/kg	4.18	0.2	4.48	1.4	4.99	0.7	3.82	0.1	4.62	0.6	4.98	0.9
TDN, % [a]	--	--	87.8	1.9	103.2	1.7	--	--	84.2	1.6	99.7	1.4
NDF, %	10.8	6.9	38.1	4.5	17.8	6.6	4.2	11.7	23.8	1.9	--	--
ADF, %	2.4	4.5	9.3	5.1	5.6	9.7	1.1	6.4	8.4	14.8	--	--
Lignin, %	--	--	0.6	5.8	1.0	26.4	--	--	1.5	40.5	--	--
CP, %	8.4	1.8	9.4	2.5	14.5	0.9	7.8	2.0	42.5	0.4	20.6	5.1
UIP, % of CP [b]	--	--	40.9	1.1	34.1	1.5	--	--	41.0	2.0	--	--
EE, %	3.9	1.1	5.7	18.0	18.1	5.3	--	--	2.6	23.5	14.0	7.8
Ash, %	1.3	2.9	2.1	2.8	5.5	3.1	0.7	3.0	2.1	10.2	7.3	1.7

[a] Values are predicted using Weiss' equation. (Anim. Feed Sci. Technol. 39:95) Note: No liquid feeds were used to derive this equation (syrup).

[b] Values are predicted using Dairy Cattle NRC equation for ruminally undegraded feed CP (RUP).

[c] Values represent means of four different fermentation runs.

Table 4. Mineral composition of new dry-milling process co-products

	Corn		Bran		Germ		Endosperm		DDG		Syrup	
Item	Mean [a]	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv
Ca, %	--		0.02	14.5	0.02	2.3	--		0.01	8.4	0.03	7.9
P, %	0.28	5.2	0.42	6.7	1.33	4.5	0.14	2.6	0.44	3.3	0.97	2.8
Mg, %	0.12	3.3	0.18	6.0	0.55	2.3	0.06	2.0	0.14	3.6	0.44	2.2
K, %	0.39	3.1	0.62	4.4	1.37	3.4	0.23	2.0	0.49	0.6	1.7	1.2
Na, %	--		--		--		--		0.12	12.9	0.41	9.7
S, %	0.13	2.5	0.13	2.7	0.20	1.1	0.1	1.8	0.83	4.9	0.79	2.5
Cu, ppm	--		3.94	7.6	12	9.7	--		--		4.6	14.3
Fe, ppm	84	2.9	94	7.3	117	2.7	53	10.2	127	6.7	174	7.2
Mn, ppm	5	1.9	13	2.7	24	1.7	2	4.9	8	6.2	19	1.5
Zn, ppm	21	2.0	38	5.2	93	3.1	9	2.1	42	4.8	59	6.7
Mo, ppm	0	27.5	1	2.3	2	9.9	0	12.6	1	2.9	2	4.5

[a] Values represent means of four different fermentation runs.

Effects of Feeding Varying Concentrations of Dry Distiller's Grains with Solubles to Finishing Steers on Feedlot Performance, Nutrient Management and Odorant Emissions[1]

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Summary

A study was conducted to determine the effects of feeding varying concentrations of dried distillers grains with solubles (DDGS) to finishing steers on feedlot performance, nutrient management, and odorant emissions. Prior to initiation of the trial, 192 steers (initial BW = 826 ± 18 lb) were blocked by receiving date, weighed, and randomly allotted to 16 dirt floor pens (48.2 ft x 113.8 ft; 5% slope). Pens were then randomly assigned to one of four dietary treatments. The control diet (CON) contained 82% cracked corn, 10% alfalfa hay, 4% molasses, 3.2% supplement, and 0.8% urea. In the remaining three treatment diets, all of the urea and portions of the cracked corn were removed and replaced with DDGS at 15% (15% DDGS), 25% (25% DDGS), and 35% (35% DDGS) of the diet DM. The diets were formulated to be isocaloric and to provide similar levels of crude protein (CP) for CON and 15% DDGS (13.2 and 13.3% CP, respectively) and a stepwise increase in CP for 25% and 35% DDGS (15.4 and 17.6%, respectively). Analysis of weekly feed samples collected throughout the trial determined that the CP concentrations were 11.4, 12.2, 14.3, and 16.5% for CON, 15% DDGS, 25% DDGS, and 35% DDGS, respectively.

Cumulative dry matter intake (DMI) was greater ($P < 0.05$) and ADG tended ($P < 0.10$) to be greater for cattle consuming the 25% DDGS treatment compared to CON with 15% DDGS and 35% DDGS being intermediate (DMI = 23.7, 24.1, 24.8 and 24.1 lb/d and ADG = 4.25, 4.39, 4.55, and 4.45 lb for CON, 15%, 25%, and 35% DDGS, respectively). Dry matter intake responded quadratically ($P < 0.05$) as the level of DDGS in the diet increased. Steers fed DDGS also tended to consume more dry matter than steers fed the control diet ($P < 0.07$). There were no differences in final weight between treatments.

Dressing percent and backfat increased ($P < 0.05$) and hot carcass weight and yield grade tended ($P < 0.10$) to increase in a linear fashion as level of DDGS in the diets increased. No differences were detected between treatments for marbling, kidney, pelvic, and heart fat, or ribeye area.

Air samples were collected via wind tunnel at 3 locations per pen over a 3-d period prior to animal introduction and on d 78 to 80. Hydrogen sulfide levels were greatest ($P < 0.05$) in pens containing cattle fed the 35% DDGS treatment compared to pens with cattle consuming the remaining treatments. No differences in odor characteristics were detected between treatments.

Pen floor core samples (7 per pen) were taken prior to animal introduction and upon completion of the trial. No differences were found for nitrogen (N), phosphorus (P), potassium, organic matter, pH or salt concentrations. Manure samples collected from pens scrapings were weighed and analyzed for dry matter, ammonia-N, Kjedahl-N, and Olsen-P. Ammonia-N and Olsen-P increased in a linear fashion ($P < 0.05$) as the levels of DDGS in the diets increased.

Dried distiller's grains with solubles can be included in feedlot finishing diets at up to 35% of DMI without negatively affecting performance. However, animal performance is maximal when DDGS is included at 25% of DMI. Changes in carcass characteristics with increasing DDGS levels may affect days on feed needed to reach

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optimum terminal endpoint. Hydrogen sulfide emissions from pen floors may increase as the level of DDGS in the diet increases. However, when the feedlot is the sole source of H_2S, the impact of increased H_2S on odor or human health is negligible. General odor detection is not affected by feeding DDGS.

Introduction

Distillers grains are becoming increasingly more prevalent as a feed ingredient in the diets of growing and finishing cattle. Previous research suggests that DDGS can substitute for corn in finishing diets, up to approximately 20% of the diet DM, without sacrificing animal performance.

Gordon et al. (2002), in a heifer feeding experiment utilizing DDGS levels of 0, 15, 30, 45, 60, and 75%, found that average daily gain, feed efficiency, and dry matter intake all peaked in the 15% DDGS treatment and declined as the level of DDGS increased to 75%. Hot carcass weights of heifers fed by Gordon et al. (2002) peaked at 15% DDGS and decreases as the level of DDGS increased. Mateo et al. (2004) reported no differences in HCW or dressing percentage in cattle fed 20 and 40% DDGS rations, but marbling scores were greater from steers fed 20% DDGS compared to those fed 40% DDGS.

Odor has become, and will continue to be, an issue of concern for livestock operations. Unfortunately, odor is difficult to quantify in practice. Dose-response relationships have been recognized for ammonia, hydrogen sulfide (H_2S), and dust as potentially detrimental to human health (Nicolai and Pohl, 2005).

Additionally, H_2S can be detected by the human nose at levels as low as 0.5 ppb (Tamminga, 1992).

Manure has been and should continue to be utilized as a fertilizer and soil amendment. However, crops require approximately 5:1 nitrogen (N) to phosphorus (P) ratio and manure typically contains approximately 2:1 N to P ratio as a result of N volatilization (Erickson et al., 1998). Historically, manure has been applied based on N concentration of the manure and the N requirement of the crops. However, given the ratio of N to P in manure, this practice could become an environmental concern. Regulatory agencies have recognized this concern and have begun implementation of P-based land application regulations. Therefore, an understanding of how dietary manipulation can affect the P concentrations in manure is of great importance to feedlot managers.

This trial was designed to determine the effect of increasing levels of DDGS in feedlot diets on performance and carcass characteristics of yearling steers, odorant emissions from feedlot pens, and nutrient concentrations in manure and soil.

Materials and Methods

This experiment was conducted at the South Dakota State University (SDSU) Southeast Research Farm near Beresford, SD. One hundred ninety-two steers (initial BW = 826 ± 18 lb) received on two separate dates were weighed, blocked by receiving date, and randomly allotted to 16 dirt floor pens (48.2 ft x 113.8 ft; 5% slope). The pens were then randomly assigned to one of four dietary treatments. The control diet (CON) contained cracked corn, alfalfa hay, molasses, supplement, and urea. In the remaining three diets, all of the urea and portions of the cracked corn were removed and replaced with DDGS at 15% (15% DDGS), 25% (25% DDGS), and 35% (35% DDGS) of the diet DM (Table 1). The diets were formulated to provide similar levels of crude protein (CP) for CON and 15% DDGS (13.2 and 13.3% CP, respectively) and a stepwise increase in CP for 25% and 35% DDGS (15.4 and 17.6%, respectively). Analysis of weekly feed samples collected throughout the trial determined that the CP concentrations were 11.4, 12.2, 14.3, and 16.5% for CON, 15% DDGS, 25% DDGS, and 35% DDGS, respectively. All steers were vaccinated at the beginning of the trial and received a Revalor© IS (80mg trenbolone acetate and 16mg estradiol) implant on day 28. Diets were mixed daily and delivered in the morning. Steers were fed the finishing diet on day one at 14.6 lb dry matter (DM) and intakes were increased in a step-wise manner over a four-week period until animals were allowed to consume feed *ad libitum.* Feed ingredients and treatment diets were sampled weekly, frozen immediately, and stored at –20^{O} C for later analysis of chemical composition. Steers were fed until they had approximately 0.4 in. backfat, by visual appraisal, at which time they were sent to a commercial packing plant and carcass data was collected.

Wind tunnel samples (9 L) were taken from three locations on each pen floor over three days prior to animal introduction and on d 76-78. Sample locations were predetermined with location A and B being approximately 20 ft back from the bunks and 16 ft from each sides fence line, respectively. Location C was located in the center of each pen both by length and width. Samples were taken in the pens by day and location, i.e. on the first day of sampling, location A was sampled in all 16 pens; on day two location B; and on day three location C. Samples were collected in Tedlar® bags and shipped overnight to the University of Minnesota, Department of Biosystems and Agricultural Engineering, St. Paul, MN for analysis via dynamic triangular forced-choice olfactometry. Samples were analyzed using the Ac'scent International Olfactometer (St. Croix Sensory, Stillwater, MN,). Briefly, air samples were diluted and presented to a trained sensory panel along with two filtered air samples in three separate air streams. Intensity of odor was calculated by determining the concentration of the odor samples at which the panelists could distinguish it from the other filtered air samples. Hydrogen sulfide gas was analyzed at the time of odor sampling from air collected in each individual bag. It was quantified using a Jerome® meter calibrated to detect H_2S at levels as low as 1 part per billion (ppb).

Soil samples were taken from pen floors prior to animal introduction as well as after manure removal. Soil cores (0-6 in) were taken from seven locations in each pen, pooled within pen, and chemically analyzed for organic matter (OM), nitrate nitrogen (NO_3-N), ammonia nitrogen (NH_4-N), Kjeldahl nitrogen (Kjedahl-N), Olsen phosphorus (Olsen-P), pH, salts and potassium (K) (Table 7). Manure removed from pens after animal removal was weighed wet, sub-sampled, and analyzed for DM, Olsen-P, NH_4-N, and Kjedahl-N (Table 5).

Performance, carcass, soil, and odor data were analyzed as a randomized complete block using the GLM procedure of SAS (2002) with pen as the experimental unit When the model was significant ($P < 0.05$), treatment means were separated using least significant differences. Orthogonal contrasts were performed to compare control vs distillers treatments and to test for linear and quadratic effects.

Results and Discussion

Over the 105-d experiment, cattle fed 25% DDGS consumed more ($P < 0.05$) dry matter than cattle fed the CON diet (Table 2). Dry matter intake of steers fed 15% and 35% DDGS was intermediate but not different than that of steers fed CON or 25% DDGS. Dry matter intake increased quadratically as the level of DDGS in the diet increased ($P < 0.05$). Steers fed DDGS consumed more feed than steers fed the CON diet ($P < 0.10$). Average daily gain tended ($P < 0.10$) to be greater for cattle fed 25% DDGS than CON cattle. Average daily gain of steers fed 15% and 35% DDGS was intermediate but not different than that of steers fed CON or 25% DDGS. Feed efficiency (gain:feed) was not affected by treatment.

Carcass data are reported in Table 3. Hot carcass weights and Yield Grades were greater ($P < 0.05$) for 35% DDGS vs CON with 15% and 25% DDGS being intermediate but not different than that of steers fed CON or 35% DDGS. Backfat tended ($P < 0.10$) to be greater for 35% DDGS vs CON with 15% and 25% DDGS being intermediate but not different than that of steers fed CON or 35% DDGS. Dressing percentage was lower ($P < 0.05$) for steers fed CON than those fed 15% or 35% DDGS, but was not different than those fed 25% DDGS. Steers fed 35% DDGS had greater dressing percent than steers fed CON or 25% DDGS but were not different than those fed 15% DDGS. Dressing percent and backfat increased ($P < 0.05$) and hot carcass weight and Yield Grade tended ($P < 0.10$) to increase in a linear fashion as level of DDGS in the diets increased. Increasing the level of DDGS did not affect ribeye area, kidney, pelvic, and heart fat, or marbling score.

Hydrogen sulfide was detected at higher ($P < 0.05$) levels in the 35% DDGS treatment (Table 4). The Occupational Safety and Health Administration (OSHA) limits workplace hydrogen sulfide at 2000 ppb over an eight-hour workday (Agency for Toxic Substances and Disease Registry, 1999). The highest reading from any one sample in this study was 13 ppb. In areas where odor may be a public concern, it should be noted that H_2S can be detected by the human nose at levels as low as 0.5 ppb (Tamminga, 1992). The levels in this study are below levels of concern from a human health perspective; however H_2S should be considered a contributor to malodors. A trained panel was

unable to detect differences in odor produced between the test diets, and as a whole, odors were near or below the threshold for detection by the panel.

Since manure can be used as a fertilizer and crops require approximately 5:1 nitrogen to phosphorus ratio, understanding the concentration of N and P in the manure is critical. Because manure typically contains approximately 2:1 N to P ratio as a result of N volatilization (Erickson et al., 1998), excess P can become a potential environmental concern. In this study, increasing levels of DDGS significantly ($P < 0.05$) increased ammonia –N and Olsen-P in manure removed from pens (Table 5). These results agree with previous work (Geisert et al., 2005) that demonstrates an increase in fecal P as the P content of the ration increases. Increase in concentration of P in livestock manure is of notable importance as regulations pertaining to manure P distribution on cropland are becoming increasingly stringent. Some caution must be used as this is a small dataset for making such decisions, but an example of how manure application may be affected by increasing dietary DDGS can be found in Table 6. Based on this experiment more than a 75% increase in corn acreage would be needed for manure application to account for the increase in P between control and 35% distillers diets.

Pen floor soil analysis (Table 7) showed no differences for OM, NO_3-N, NH_4-N, Kjedahl-N, Olsen-P, pH, salts, and K between pens before or after animal introduction. There was, however, a trend ($P < 0.15$) for the 35% DDGS treatment to increase Olsen- P and NH_4-N between initial and final core sampling periods. Previous research from the University of Nebraska suggests that diets formulated to contain lower P concentrations can result in lower P levels in core samples from pens where manure has been removed (Erickson et al., 2000).

Pen soil contamination and leeching from feedlot pens are generally not environmental concerns in permitted feedlots, due to regulations guiding pen construction methods, compaction, and slope. There is a concern with down slope areas where runoff tends to pool and settle allowing N to move vertically through the soil profile. Interesting to note in this study is that even with the clay pen construction and 5% slope, the higher manure N and P concentrations were able to penetrate the soil, at least to the 6 in. test depth. Rainfall during the trial (11.7 in.) may have pooled as a result of manure buildup in the pens. This pooling may have contributed to the increased infiltration of N and P into the pen floors.

Implications

Dried distillers grains with solubles are a suitable feed ingredient for finishing steers based on performance and carcass traits. From this study, inclusion of up to 35% DDGS was not detrimental to animal performance; however, performance was maximized at 25% DDGS. Increasing levels of DDGS appears to increase subcutaneous fat deposition. As such careful attention should be paid to days on feed and terminal endpoints. Inclusion appears to have no noteworthy effects on odor emission from the feedlot. However, increasing levels of DDGS does affect the nutrient composition of manure, which may limit its use, particularly in states where manure application is currently regulated under a P-based management system.

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Tables

Table 1. Composition of finishing diets

	Treatment			
Item, % DM	CON	15% DDGS	25% DDGS	35% DDGS
Alfalfa hay	10.0	10.0	10.0	10.0
DDGS	-	15.0	25.0	35.0
Dry rolled corn	82.0	67.0	57.0	47.0
Molasses	4.0	4.0	4.0	4.0
Supplement				
Ground corn	1.93	2.35	2.35	2.35
Urea	0.83	-	-	-
Limestone	0.58	1.00	1.00	1.00
TM salt	0.57	0.57	0.57	0.57
Premix[a]	0.08	0.08	0.08	0.08
Nutrient composition				
Dry Matter, %	87.9	87.8	88.8	89.0
Ash, %	9.7	9.6	9.2	8.9
CP, %	11.4	12.2	14.3	16.5
NDF, %[b]	14.4	18.9	21.8	24.9
ADF, %[b]	6.8	8.1	8.9	9.7
Fat, %	4.7	5.8	6.5	7.3
P, %[c]	0.29	0.37	0.42	0.47

[a] Provides:18 g/ton monensin; 10 mg Cu, 9.2 IU Vitamin E, and 2,200 IU Vitamin A per kg total diet DM.

[b] Derived from assay values for alfalfa and DDGS and NRC (1996) tabular values for remaining dietary ingredients.

[c] Derived from tabular values for feeds used (NRC, 1996).

Table 2. Performance of finishing steers fed increasing levels of dried distillers grains with solubles[a]

	Treatment					Contrasts		
						---------- *P* –value ----------		
Item	CON	15% DDGS	25% DDGS	35% DDGS	SEM	CON vs. DDGS	Linear	Quadratic
Initial Weight, lb	829	828	826	823	3.35	0.426	0.232	0.757
d 0-28								
ADG, lb/d	3.35[j]	3.82[k]	3.74[jk]	3.59[jk]	0.17	0.094	0.475	0.096
DMI, lb/d	18.45[f]	18.49[g]	18.56[h]	18.61[i]	0.01	0.000	0.000	0.631
Gain:Feed	0.182[j]	0.207[k]	0.201[jk]	0.193[jk]	0.009	0.114	0.574	0.097
Feed:Gain	5.55[j]	4.88[k]	4.96[jk]	5.23[jk]	0.240	0.096	0.490	0.086
d 28-56								
ADG, lb/d	5.16[j]	4.33[k]	4.87[jk]	5.08[jk]	0.27	0.225	0.659	0.085
DMI, lb/d	24.81[b]	24.75[b]	24.96[c]	25.26[d]	0.10	0.161	0.009	0.122
Gain:Feed	0.208[j]	0.175[k]	0.195[jk]	0.201[jk]	0.010	0.180	0.843	0.097
Feed:Gain	4.84[j]	5.77[k]	5.12[jk]	5.05[jk]	0.296	0.202	0.818	0.127
d 56-84								
ADG, lb/d	3.47[b]	4.87[c]	5.19[c]	4.59[c]	0.23	0.001	0.007	0.002
DMI, lb/d	25.75[f]	26.85[fg]	28.68[g]	26.40[f]	0.56	0.043	0.116	0.017
Gain:Feed	0.135[b]	0.182[c]	0.181[c]	0.174[c]	0.006	0.000	0.004	0.002
Feed:Gain	7.46[b]	5.53[c]	5.54[c]	5.87[c]	0.220	0.000	0.002	0.001
d 84-105								
ADG, lb/d	5.03[j]	4.41[jk]	4.12[k]	4.35[jk]	0.32	0.082	0.142	0.219
DMI, lb/d	26.54	27.06	27.69	26.48	0.61	0.472	0.802	0.195
Gain:Feed	0.190[j]	0.164[jk]	0.149[k]	0.165[jk]	0.013	0.069	0.146	0.130
Feed:Gain	5.29[j]	6.31[jk]	6.79[k]	6.13[jk]	0.500	0.087	0.207	0.130
Final Weight, lb	1275	1289	1303	1290	11.97	0.204	0.278	0.284
Cumulative (d 0-105)								
ADG, lb/d	4.25[j]	4.39[jk]	4.55[k]	4.45[jk]	0.10	0.106	0.124	0.269
DMI, lb/d	23.74[f]	24.13[fg]	24.81[g]	24.06[fg]	0.25	0.070	0.130	0.048
Gain:Feed	0.179	0.182	0.184	0.185	0.003	0.262	0.223	0.822
Feed:Gain	5.59	5.50	5.46	5.42	0.096	0.272	0.238	0.830

[a] All calculations based on computed 3% BW shrink.
[b,c,d,e] Means with different superscripts differ ($P < 0.01$).
[f,g,h,i] Means with different superscripts differ ($P < 0.05$).
[j,k] Means with different superscripts differ ($P < 0.10$).

Table 3. Carcass characteristics of finishing steers fed increasing levels of dried distillers grains with solubles

	Treatment					Contrasts		
						----------*P* – value----------		
Item	CON	15% DDGS	25% DDGS	35% DDGS	SEM	CON vs. DDGS	Linear	Quadratic
HCW, lb	787.8[a]	804.9[ab]	809.4[ab]	811.5[b]	4.22	0.033	0.054	0.377
Shrunk dress, %	60.0[a]	60.6[bc]	60.2[ab]	61.0[c]	0.11	0.011	0.017	0.866
Marbling score[f]	537	518	530	510	6.25	0.213	0.284	0.969
KPH fat, %	2.12	2.16	2.03	2.11	0.04	0.951	0.620	0.837
Backfat, in.	0.45[d]	0.46[de]	0.47[de]	0.51[e]	0.01	0.345	0.010	0.411
REA, in^2.	13.1	13.1	13.1	13.1	0.10	0.919	0.979	0.904
Yield grade	2.84[a]	2.96[ab]	2.96[ab]	3.15[b]	0.05	0.120	0.059	0.747

[a,b,c] Means with different superscripts differ ($P < 0.05$).
[d,e] Means with different superscripts differ ($P < 0.10$).
[f] Small[0]=500, Modest[0]=600.

Table 4. Effects of feeding increasing levels of dried distillers grains with solubles on hydrogen sulfide (H_2S) and odor detection[a]

	Treatment				
Item	CON	15% DDGS	25% DDGS	35% DDGS	SEM
H_2S, ppb					
Initial[b]	0.00	0.00	0.08	0.01	0.028
On trial[c]	0.67[e]	0.56[e]	0.81[e]	2.22[f]	0.355
Difference	0.666[e]	0.556[e]	0.722[e]	2.223[f]	0.360
Odor Detection, OU[d]					
Initial[b]	30.5	30.5	36.1	36.5	3.092
On trial[c]	35.7	26.7	32.2	36.3	3.701
Difference	4.17	-3.67	-5.13	0.33	4.860

[a] Stocking density on monoslope pens 450 ft^2/hd.
[b] Samples taken prior to animal introduction (June 21,23-24).
[c] Samples taken at d78-80 (Oct. 4-6).
[d] Odor Units (OU).
[e,f] Means with different superscripts differ ($P < 0.05$).

Table 5. Manure scraping nutrient compositions

	Treatment			
Item	CON	15% DDGS	25% DDGS	35% DDGS
lb removed[a]	10,223	11,151	10,661	10,616
DM, %	65	67	65	67
NH_4, ppm	241[b]	411[b,c]	764[c]	1304[d]
Kjedahl-N, %	0.2	0.2	0.2	0.1
Olsen-P, ppm	710[b]	860[c]	1013[d]	1163[e]

[a] Calculated from study animals; four pens per treatment containing 12 head per pen, feed 105 d.
[b,c,d,e] Means with different superscripts differ ($P < 0.05$).

Table 6. Calculated crop production for manure phosphorus utilization

	Treatment			
Item	CON	15% DDGS	25% DDGS	35% DDGS
P_2O_5, lb / hd[a]	178.29	246.60	265.30	315.26
Corn, bu[b]	509.4	704.6	758.0	900.7
Acres of corn[c]	3.92	5.42	5.83	6.93
Soybean, bu[b]	231.55	320.26	344.55	409.43
Acres of soybeans[d]	5.79	8.01	8.61	10.24
Alfalfa, ton[b]	14.86	20.55	22.11	26.27
Acres of alfalfa[e]	6.46	8.93	9.61	11.42

[a] Calculated from study animals; four pens per treatment, 12 head per pen, fed 105 d.
[b] Represent production needed to utilize manure P without soil loading or depletion.
[c] Based on average production of 130 bushels per acre.
[d] Based on average production of 40 bushels per acre.
[e] Based on average production of 2.3 tons per acre.

Table 7. Composition of soil core samples taken from pen floor.

	Initial[a]				Final[b]				Difference			
	CON	15% DDGS	25% DDGS	35% DDGS	CON	15% DDGS	25% DDGS	35% DDGS	CON	15% DDGS	25% DDGS	35% DDGS
OM, %	6.2	7.5	6.5	6.5	8.6	8.3	8.1	7.7	2.4	0.8	1.6	1.2
NO_3-N, ppm	45.5	45.0	39.5	44.8	113.0	136.7	120.8	127.6	67.5	91.7	81.3	82.9
Olsen-P, ppm	425.0	485.0	417.5	357.5	430.0	428.8	425.0	452.5	5.0[c]	-56.3[c]	7.5[c]	95.0[d]
K, ppm	3407.5	3367.5	3500.0	3387.5	4090.0	4225.0	4637.5	4240.0	682.5	857.5	1137.5	852.5
pH	8.0	8.1	8.1	8.1	8.1	8.0	8.1	8.0	0.08	-0.15	-0.08	-0.15
Salt, mmho/cm	2.9	2.7	2.7	2.6	3.6	3.8	3.9	3.8	0.7	1.1	1.2	1.2
NH_4, ppm	9.5	13.3	6.5	2.8	66.9	38.3	59.6	97.1	57.4[e]	25.1[e]	53.1[e]	94.3[f]
Kjedahl-N, %	0.56	0.68	0.57	0.54	0.62	0.68	0.66	0.64	0.05	0.00	0.08	0.08

[a] Prior to animal introduction.
[b] After animal removal and pen scraping.
[c,d] Values within column lacking common superscripts tend to be different ($P < 0.11$).
[e,f] Values within column lacking common superscripts tend to be different ($P < 0.14$).

Effectiveness of Dried Distillers Grains with Solubles as a Replacement for Oilseed Meal in Supplements for Cattle Consuming Poor Quality Forage[1]

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Summary

A two-year study was conducted at the South Dakota State University Southeast Research Farm in Beresford, SD, to determine the effects of feeding supplemental dried distillers grains with solubles (DDGS) on the performance of mid-gestation and non-gestating, non-lactating beef cows. Ninety-six gestating beef cows (initial BW = 1276.4 ± 22.2; initial BCS = 4.7 ± 0.09) and 96 non-gestating, non-lactating beef cows (initial BW = 1214.0 ± 20.8; initial BCS = 5.4 ± 0.10) were used for year 1 and year 2, respectively. Cows were stratified by weight and allocated to one of 15 pens. Pens were then randomly assigned to one of three treatment supplements: 1) sunflower meal (SFM), 2) a 50:50 combination of SFM and dried distillers grains plus solubles (COMB), or 3) dried distillers grains plus solubles (DDGS). Supplements were formulated to be isocaloric and isonitrogenous, but provide decreasing levels of degradable intake protein (DIP; 332.6, 256.5, 206.8 g/d year 1, 338.1, 284.9, 232.2 g/d year 2). All cows received a basal diet of ground corn stalks and were allowed *ad libitum* access to a salt-mineral block. Cows were fed treatment diets for 70 days. Weights were taken on day -1, 0, 35, 69, and 70. Body condition scores (BCS) were determined on day 0 and 70. Ultrasound fat dept was determined at the 12th rib and on the rump on day 0 and 70. Weight change tended ($P < 0.06$) to be affected by a treatment by year interaction. In year 1, cows consuming the SFM supplement gained more weight than cows consuming any of the other treatments. However, in year two, gain was not affected by treatment. Treatment had no effect on BCS or ultrasound fat depth at the 12th rib or rump. Small and inconsistent differences in performance and the lack of differences in body condition between treatments suggest that DDGS can replace an oilseed meal in protein supplements without affecting animal performance. Supplementing DDGS as a sole protein source for cows consuming poor-quality forage is a viable management alternative for producers.

Introduction

The expansion of the ethanol industry has increased the availability of co-products for livestock feed. Utilization of these co-products in beef cattle diets could be a means for producers to reduce the cost of production without sacrificing animal performance. Use of DDGS in cattle diets has become an increasingly common practice in modern feedlots and dairies. A large body of research has identified optimum inclusion rates for each industry. However, research on the use of DDGS in poor-quality forage diets is limited.

Beef producers who rely on crop residue, dormant range or other poor-quality forages for winter feed may be able to reduce their cost of production by utilizing dried distillers grains with solubles (DDGS) as a crude protein (CP) source rather than a more expensive oilseed meals or commercial protein supplements. Dried distillers grains with solubles contain approximately 30% CP. Approximately 45% of the CP is degradable in the rumen and the other 55% is undegradable intake protein (UIP), or escape protein. This balance of rumen degradable and undegradable protein makes DDGS suitable for beef cow diets. Young and high producing females require more escape protein to help meet their metabolizable

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protein requirements. However, if the supply of rumen degradable protein is inadequate, fiber digestion may be reduced. Fortunately for beef producers, ruminants recycle nitrogen. Nitrogen in the bloodstream can re-enter the rumen environment in the form of urea either directly across the rumen wall or as a component of saliva. The extent of recycling that occurs in beef cows on low-protein diets is not well documented. This experiment was designed to determine if DDGS could be used to replace sunflower meal (SFM), on a CP basis, in the diets of beef cows consuming poor-quality forages.

Materials and Methods

Ninety-six gestating beef cows (initial BW = 1276.4 ± 22.2; initial BCS = 4.7 ± 0.09) and 96 non-gestating, non-lactating beef cows (initial BW = 1214.0 ± 20.8; initial BCS = 5.4 ± 0.10) were used for year 1 and year 2, respectively. Animals were stratified by weight and assigned to one of fifteen pens. Pens were then randomly assigned to one of three treatment supplements: 1) SFM, 2) a 50:50 combination of SFM and DDGS (COMB), or 3) DDGS (Table 1). Supplements were formulated to be isocaloric and isonitrogenous, but provide decreasing levels of degradable intake protein (Table 1). All cows received a basal diet of ground corn stalks (CS) and were allowed *ad libitum* access to a salt-mineral block. Cows were fed there allotted supplement first and then allowed free access to the basal forage. Cows were weighed on d -1, 0, 35, 69, and 70. Consecutive weights at the initiation (d -1 and 0) and conclusion (d 69 and 70) of the experiment were averaged to determine initial and final weights. On day 0 and 70 body conditioned scores (BCS) were determined by averaging the estimates of three experienced individuals. Fat depth at the 12th rib and rump were determined by ultrasound on d 0 and 70. Feed samples were taken weekly, frozen immediately, and stored at –20^{o}C prior to analysis. Samples were later dried at 60^{o}C for a minimum of 24 hours and ground through a Wiley Mill (Aurthur H. Thomas, Philadelphia, PA) fitted with a 1mm screen. Feed samples were assayed for Kjeldahl N (Macro-Kjeldahl N; AOAC, 1995), ADF and NDF (Goering and Van Soest, 1990), and UIP (Klopfenstein et al., 2001) (Table 2).

Daily feed allocations were recorded and orts were collected and weighed weekly or as needed. All data were analyzed with pen as the experimental unit using the GLM procedure of SAS (1999 SAS Inst., Inc., Cary, NC). When treatment x year interactions were not significant ($P > 0.05$), data were pooled across years. Significance was declared at $P < 0.05$.

Results

Weight change tended to be influenced by a treatment x year interaction ($P < 0.06$; Table 3). In year 1, cows supplemented with SFM gained more weight than cows supplemented with DDGS or COMB. However in year 2, performance was not affected by treatment. Intake of cornstalks, supplement, and mineral are reported in Table 4. Intake of corn stalks did not differ between treatments for year 1. In year 2, cows fed the COMB treatment had greater ($P < 0.05$) intake of corn stalks than cows fed the DDGS treatment but did not differ from the SFM treatment. Cows fed the SFM treatment had intermediate CS intake which did not differ from COMB or DDGS. In year 1, supplement intake was greater for cows fed the SFM treatment than for cows fed DDGS but did not differ from those cows fed the COMB treatment. Supplement intake did not differ between cows fed DDGS and COMB. No significant difference was noted between treatments for mineral intake in year 1. In year 2, supplement intake was greatest ($P < 0.05$) for cows consuming SFM and lowest for cows fed DDGS. Supplement intake of cows fed COMB was intermediate. In year 2, no difference was found between treatments for mineral intake. Treatment had no affect on BCS (Table 5) or ultrasound fat depth at the 12th rib or rump (Table 6).

Discussion

In the first year of the experiment, cows consuming SFM gained more weight than cows consuming DDGS or COMB. However, this response was not observed in year 2. The difference in weight gain between years is likely a result of the difference in physiological state (gestating vs. non-gestating, non-lactating) of the cows used in each year. Cows in late gestation would experience greater weight gain as a result of fetal development and have higher nutritional requirements than open cows. The reason for increased performance of cows in the SFM treatment is unclear. Samples were collected for analysis of diet digestibility, but results were not available at the time of

publication. However, given the similar intake of CS across treatments, it is unlikely that diet digestibility was substantially different between treatments. Differences in the intake of treatment supplements were not unexpected. To facilitate provision of an isocaloric and isonitrogenous supplement, cows fed SFM and COMB received slightly more DM per day than cows fed DDGS. Inconsistent responses in gain and the lack of differences in BCS and ultrasound fat depth suggests that DDGS can replace oilseed meals on a crude protein basis without affecting animal performance. These data agree with the findings of Stalker et al. (2004) who observed no difference in performance of heifers fed DDGS with increasing levels of urea to correct a deficiency in degradable intake protein.

Implications

Results of these experiments suggest that DDGS can effectively replace sunflower meal on a crude protein basis without sacrificing animal performance. This provides beef producers with an economical management alternative for winter supplementation for cattle on poor-quality forages.

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Tables

Table 1. Composition and nutrient profile of treatment supplements

	Year 1			Year 2		
Ingredient	SFM	COMB	DDGS	SFM	COMB	DDGS
	---------- lb DM/d ----------					
DDGS	-	1.49	2.97	-	1.57	3.15
SFM	2.85	1.43	-	3.5	1.75	-
Soy oil	0.35	0.17	-	0.35	0.17	-
	---------- % of diet DM ----------					
DM	90.1	87.6	84.9	90.6	90.3	89.9
CP	26.7	28.6	30.8	24.0	27.9	32.6
	---------- % of CP ----------					
DIP	88.0	71.7	63.2	88.0	71.6	63.2

Table 2. Chemical composition of individual feed ingredients

Analysis	Year 1			Year 2		
	SFM	CS	DDGS	SFM	CS	DDGS
	---------- %DM ----------					
CP	29.7	3.31	30.8	26.4	3.58	32.6
DM	89.1	87.3	84.9	89.8	81.8	89.9
ASH	5.49	4.95	3.93	9.34	9.39	3.36
OM	94.5	95.1	96.1	90.7	90.61	95.6
ADF	28.3	47.2	14.8	38.7	53.6	13.4
NDF	44.1	79.8	42.6	38.7	88.2	42.4

Table 3. Cow weights and weight changes

	Year 1				Year 2			
	SFM	COMB	DDGS	SEM	SFM	COMB	DDGS	SEM
	---------- lb ----------							
Initial	1286.1	1285.5	1293.3	10.7	1194.2	1212.9	1215.4	10.7
Final	1355.6	1332.4	1341.2	13.0	1197.8	1231.7	1234.8	13.0
Change	69.5[b]	46.9[a]	47.9[a]	8.6	3.6	18.8	19.4	8.6

[a,b] Means with uncommon superscripts differ ($P < 0.10$).

Table 4. Intake

Ingredient	Year 1				Year 2			
	SFM	COMB	DDGS	SEM	SFM	COMB	DDGS	SEM
	---------- lb/d DM ----------							
Corn Stalks	28.0	28.2	28.6	0.03	18.6[c,d]	19.0[d]	17.6[c]	0.00
Supplement[a]	3.23[d]	3.19[c,d]	3.15[c]	0.03	3.26[e]	2.99[d]	2.79[c]	0.00
Mineral[b]	0.79	0.86	0.81	0.03	0.62	0.62	0.53	0.00

[a] Supplements were formulated for different intake levels.
[b] Mineral was provided as a free choice block.
[c,d,e] Means within a row under each year with uncommon superscripts differ ($P < 0.05$).

Table 5. Body condition scores and changes

	SFM	COMB	DDGS	SEM
Initial	5.04	5.02	5.09	0.05
Final	5.15	5.15	5.22	10.07
Change	0.11	0.13	0.03	0.08

Table 6. Ultrasound rib and rump fat depth and changes

	SFM	COMB	DDGS	SEM
12^{th} rib fat	---------- in. ----------			
Initial	0.13	0.14	0.12	0.01
Final	0.13	0.14	0.12	0.01
Change	0.00	0.00	0.00	0.00
Rump fat	---------- in. ----------			
Initial	0.22	0.22	0.22	0.02
Final	0.22	0.21	0.21	0.02
Change	- 0.02	- 0.01	- 0.01	0.00

Evaluation of Dried Distillers Grains with Solubles as a Feedstuff for Heifers in the Last Trimester of Gestation[1]

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Beef 2005 - 15

Summary

Ninety-six crossbred heifers were used in an experiment to evaluate the effect of dried distillers grains plus solubles (DDGS), fed in the last trimester of gestation, on heifer performance and reproduction.

Animals were blocked by previous heifer development strategy (Antelope Research Station range developed = **ANT 1**; Antelope Research Station dry lot developed = **ANT 2**; Cottonwood research station = **CTW**), stratified by expected calving date, body weight and body condition score, and randomly allotted to one of twelve pens. Each pen was randomly assigned to one of two treatments (6 pens/treatment; 4 pens per block). Treatments were 1) dried distillers grains and grass hay **(DDGS)** or 2) soybean hulls and grass hay **(SBH).** Treatments were applied during the last-trimester of gestation. Diets were developed utilizing the 1996 NRC computer model and designed to meet nutrient requirements at 240 days of gestation under thermo-neutral conditions. Treatment diets offered similar amounts of NEm each day based on assumptions of the energy content of SBH and DDGS (assumed SBH = 80% TDN and DDGS = 88% TDN). Heifers fed the DDGS had a greater ($P<0.01$) increase in body weight and a heavier ($P=0.03$) final weight compared to the heifers fed SBH. Body condition score was not affected by diet. Calf birth weights were similar for both the DDGS and SBH treatments with a mean birth weight of 87.0 lbs ± 5.3lb and 85.0 lbs ± 3.4lbs respectively. Treatment had no effect on calving ease or calf vigor scores. These results suggest that in limit fed situations DDGS and SBH can both be supplemented at 40 percent of the diet with no negative affects on cow performance, calf birth weight, or calving difficulty.

Introduction

It is well known that one of the major causes of failed reproductive performance in cow-calf operations is nutritional inadequacies. This is usually most evident when rebreeding 2 year olds. Two-year-old heifers must raise a calf and become pregnant while still growing. The goal is finding a balance between economically available feedstuffs that will meet the nutritional requirements of the young cow and fit the management of the operation, while maintaining the productivity of the cow. Researchers have looked at supplementing fat or UIP (undegradable intake protein) as ways to increase the energy density of the diet or to meet the metabolizable protein (MP) requirements respectively, of pre-partum cows, to remediate nutritional stresses and increase subsequent reproduction. There is little documentation of fat and MP used together as a way to meet nutritional needs during gestation and the impact this may have on performance and reproduction. Patterson et al. (2001) in Nebraska noted an increase in pregnancy rate in bred heifers supplemented to meet MP requirements over heifers supplemented to meet CP requirements without a change in body weight or body condition over the winter feeding period. Studies looking at fat supplementation have had mixed results on cow performance and subsequent reproduction (Staples, 1998).

The nutritional demands of a lactating animal are very high, to increase body weight and body condition score during this period is often cost prohibitive. Obtaining optimum body condition before calving is more economical from both feed cost and reproductive stand points.

[1] Funding for this study was provided by the SD Corn Utilization Council.
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Over the last several years by-product feeds have received much attention because of their increased availability to livestock producers as a supplemental nutrition source for cattle. Corn distillers dried grains is a widely available by-product feed for South Dakota livestock producers. Distillers dried grains are an excellent source of energy with a TDN value at least that of corn with 12% fat and are also high in protein (33% CP) with 60% of the CP as UIP (Loy, 2003;Lardy, 2003; Holt, 2004).

The objective of this experiment is to evaluate dried distillers grains plus solubles (DDGS) as a feedstuff for heifers in the last trimester of gestation.

Materials and Methods

This study was conducted at the SDSU Cottonwood Range and Livestock Research Station, Philip, SD, (winter 2005) and used 96 crossbred pregnant first calf heifers (average weight 1119 lb) in a randomized complete block design. Animals were blocked by previous heifer development strategy (Antelope Research Station range developed= **ANT 1**; Antelope Research Station dry lot developed= **ANT 2**; Cottonwood research station=**CTW**), stratified by expected calving date (ANT 1= April 9; ANT 2= April 6; CTW= March 31), body weight and body condition score (BCS), and randomly allotted to one of twelve pens. Each pen was randomly assigned to one of two treatments (6 pens/treatment; 4 pens per block). Treatments were 1) dried distillers grains and grass hay **(DDGS)** or 2) soybean hulls and grass hay **(SBH).** Treatments were applied during the last-trimester of gestation.

Diets were delivered once daily in concrete bunks in each dry lot pen where heifers were housed. Heifers were fed 9.0 lbs/d ground grass hay top dressed with either SBH (7.25lb/d) or DDGS (6.6lb/d) for the respective treatments along with 0.69 lb/d supplement designed for each respective treatment (Table 1). Diets were developed using the 1996 NRC computer model and designed to meet nutrient requirements at 240 days of gestation under thermo-neutral conditions. Diets offered similar amounts of NEm each day based on assumptions of the energy content of SBH and DDGS (assumed SBH = 80% TDN and DDGS = 88% TDN; Table 2). Diets were limit fed at a constant rate throughout the study and were designed to meet or exceed requirements for degradable intake protein (DIP), crude protein (CP), vitamins, and minerals. The nutrient balances at ~240 days of gestation are listed in Table 3.

Initial body weights and body condition scores (BCS) were taken on two consecutive days (Dec 29 and 30) following an overnight fast from feed and water. During initial processing animals were treated for parasites with Ivermectin©. Heifers were adjusted to the treatment over a four day period (day -4 to -1). The adjustment period utilized a two-day two-level hay step down (80% & 67% of the diet DM, respectively). Body weights and BCS were determined each month during the feeding period. Final weights were taken March 10 and 11 prior to first scheduled calving date. Within 24 hrs of calving, heifers and calves were weighed, assigned a calving ease and calf vigor score, and removed from treatment.

Initial body weight and BCS, final body weight and BCS, changes in body weight and BCS, calf birth weight, and calving ease and calf vigor scores were analyzed by analysis of variance using the GLM procedures of SAS with pen as the experimental unit. When a significant effect of treatment was detected ($P<0.05$) means were separated using least significant differences.

Results and Discussion

Both the DDGS and SBH treatment animals had positive weight gains during the experiment. Heifers on the DDGS treatment had a greater ($P<0.01$) increase in weight and a heavier ($P=0.03$) final weight compared to the SBH treatment animals. Body condition was similar between treatments at the initiation and termination of the experimental period (Table 4). Most of the weight change could be attributed to fetal growth (approximately 74lbs; NRC, 1996) and would explain the lack of BCS change. The BCS results are similar to those found by Patterson et al. (2001), in which supplemented UIP did not have a significant impact on BCS but did have a positive impact on subsequent reproduction. Both diets effectively met the maintenance requirements of the heifers while successfully supporting fetal growth and development.

It is important to note that both diets were provided to the animals in a limit fed situation. Limit feeding

will decrease the rate of passage of feed and result in increased diet digestibility. Limit feeding can also lower maintenance requirements. Although both diets were fed to result in similar energy values, the heifers on DDGS slightly out-performed the SBH treatment. The level of DDGS fed in this trial was safe and efficacious. There were no documented health concerns, and no animals were removed from treatment prior to the end of the feeding period.

Calf birth weights were similar for both the DDGS and SBH treatments (Table 5). Treatment had no effect on the calving ease or the calf vigor (Table 5) scores. There have been concerns regarding supplemental fat provided in late gestation causing increased calf birth weights. The calf birth weight results in this study would be similar to those reported by Hess et al. (2002) in which they concluded that higher dietary fat levels fed in late gestation did not impact calf birth weight.

Implications

Based on the results it is apparent that dried distillers grains with soluble are as effective as soybean hulls as a forage replacement at this critical production period to meet the nutritional needs for heifers. These results suggest that in limit fed situations DDGS and SBH can both be supplemented at 40 percent of the diet with no negative affects on cow performance, calf birth weight, or calving difficulty.

Continuing Research

Further analysis of blood samples taken from animals both pre- and postpartum will further answer questions regarding the implications fat and UIP supplied by the DDGS treatment may have on metabolic status of the animal postpartum and on subsequent reproductive performance. Further analysis of these factors as well as calf weaning weights may provide additional insight in to economic value of utilizing distillers grains as a protein and energy source in late gestation.

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Tables

Table 1. Composition of rations (DM basis)

	Diet			
Item	DDGS		SBH	
Ingredient	Lb[a]	% of Diet	Lb[a]	% of Diet
Grass hay	9.00	55	9.00	53
Dried distillers grains + solubles	6.60	41	-	-
Soybean hulls	-	-	7.25	43
Supplement	0.69	4	0.69	4
Total	16.29	100	16.94	100

[a]Pounds per head daily.

Table 2. Nutrient composition of distillers dried grain plus solubles (DDGS) and soybean hull (SBH) treatment diets fed to heifers pre-partum (winter 2005)

Nutrients	DDGS Diet	Soy Hull Diet
DM Intake, lb	16.3	16.9
NE_m, Mcal/d[a]	11.8	11.8
NE_m, Mcal/lb[a]	0.72	0.70
CP, lb/d[a]	2.92	2.06
CP, %[a]	17.9	12.2
Dietary fat	6.0	2.1
Cost, $/d[a]	0.88	0.93

[a] Dry matter basis.

Table 3. Nutrient balance for distillers dried grains plus solubles (DDGS) and soybean hull (SBH) diets based on animal requirements at ~240 days of gestation

Nutrient Balance (240 d of gestation)	DDGS	SBH
NE_m balance, Mcal/d	0.0	0.0
DIP balance, g/d	+121	+96
MP balance, g/d	+331	+44
CP balance, g/d	+599	+208

Model in NRC Level 1, 2000.

Table 4. Weight and body condition score (BCS) of heifers fed distillers dried grains plus solubles (DDGS) and soybean hull (SBH) treatments at 40% of the diet dry matter during the last trimester of gestation

Item	DDGS	SBH	SEM[d]
Initial wt., lb	1117	1130	1.37
Final wt., lb	1249[a]	1230[b]	4.75
Wt. change, lb.	132[a]	110[b]	3.76
Initial BCS[c]	5.94	5.88	0.04
Final BCS[c]	5.96	5.84	0.07
BCS change[c]	0.02	-0.04	0.06

[ab] Means within rows (dried distillers grains plus solubles vs. soybean hulls) having different superscripts are different ($P < 0.01$).
[c] Body condition score.
[d] Standard error of the mean.

Table 5. Calving ease and calf vigor scores, and birth weight for distillers dried grains plus solubles (DDGS) and soybean hull (SBH) treatments

Item	DDGS	SBH	SEM[c]
Calving ease[a]	1.22	1.22	0.14
Calf vigor[b]	1.42	1.20	0.20
Birth wt, lb	87.0	85.0	1.48

[a] Calving ease score: 1 = no assistance, 2= easy pull, 3=hard pull requiring calf jack, 4 = caesarian section, 5 = malpresentation.
[b] Calf vigor score: 1 = nursing w/o assistance, 2 = assisted nursing but calf lives at least 1 week, 3 = calf dead within 1 week, 4 = calf dead within 24 hours of birth, 5 = calf dead at birth.
[c] Standard error of the mean.

Relative Efficiency of Natural Feeding Programs Using Germ or Bran Cake from a Dry Milling Process[1]

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BEEF 2005 - 16

Summary

This experiment was designed to evaluate the potential of using high-fat ethanol co-products in cattle feeding programs that exclude implants and ionophores. Four treatments included: 1) Positive Control, implanted steers fed a typical diet that included 29g/T monensin; 2) Control Diet fed to non-implanted steers; 3) 14% Germ, no implant or ionophore; and 4) 30% Bran Cake, no implant, no ionophore. After a 110 d finishing period, the breakeven (B/E) fed cattle price increased $3.04/cwt when an implant was not used on the Control diet. The Germ diet resulted in comparable performance as the Control diet fed to non-implanted steers. The Bran Cake diet resulted in lower ($P < 0.05$) ADG and higher ($P < 0.05$) feed/gain than the Control diet (2) although DMI were similar. Most of the performance loss associated with the Bran Cake diet occurred late in the feeding period. The substitution of bran for corn results in an apparent lower dietary NE value. A substantial reduction in feed price would be necessary for this Bran Cake diet to be a cost effective means of producing antibiotic-free beef. There was no evidence of bloat or digestive disorder in the higher fat-no ionophore diets.

Introduction

There is a steady growth of branded beef programs with production criteria that prohibit the use of growth promotant implants and/or antibiotics. Ionophores may be excluded in some programs under the antibiotic criteria. There are ample data available to allow one to calculate fed cattle premiums necessary to offset unrealized performance when implants and ionophores are not used. Rather than repeat those experiments, this study was designed to provide a cursory comparison of alternative feeding programs.

A basic premise behind the alternative diets used here was that it may be beneficial to increase the caloric intake as fat when ionophores are not used. The substitution of fat for starch would reduce the amount of starch fermentation, acid production, and bloat potential of the diet. The fat source would need to be a cost effective source of energy that could be easily handled in small to medium-sized feedlots located in the northern plains.

Two relatively new co-products of dry milling ethanol production were chosen as fat sources. The germ used is a free flowing dry (94% DM) product containing 16% CP and 20% fat. The bran cake used is a composite of corn bran and syrup. This material was 52% DM, 12% CP, and 11% fat. These products were substituted for corn at 14% or 30% of the diet to provide 5.1% total fat.

It is important to recognize that the comparisons reported are comparisons of conceptual production options. These data do not lend themselves to be used to determine the energy values of the co-products or to calculate responses to ionophores.

Materials and Methods

Steers (156 hd; Initial BW 866 lb.) were selected from a larger group of steers previously used in a backgrounding study. Steers were allotted to 20 pens of 7 or 8 hd such that the range of body weight was stratified within all pens. The experiment included four treatments: 1) Positive Control - implanted steers fed a typical finishing diet (including monensin and tylosin); 2) Non-implanted - These steers were fed the same typical finishing diet; 3) Germ - no implants, no ionophore, 14% germ; and 4) Bran Cake - no implants, no ionophores, 30% bran cake. The objective was to increase dietary fat from 2.7% in the control diet to 5.1% in Germ and Bran Cake diets. Complete diet formulations and compositions are reported in Table 1. The

[1] This study funded in part by USDA-ARS.
[2] Distinguished Professor
[3] Professor

implant used in Treatment 1 was Revalor-S, administered on d 12.

For adaptation, all initial diets contained 50% corn silage. Germ and Bran Cake were included at 7 and 15% where appropriate in the initial diets. Four diets were used during the step-up period, reaching the fourth (final) diet at d 19. At d 104, oat hay replaced a diminished supply of oat silage at equal dry matter contribution to the diet. Steers were fed twice daily.

Individual body weights were determined prior to morning feeding at days 0, 28, 56, 84, and 110. All interim performance data were based on these unshrunk weights. A carcass weight basis final body weight, used for calculating cumulative performance was determined as hot carcass weight ÷ 0.625. Feed ingredients were sampled weekly for determination of dry matter and crude protein content. These dry matter values were applied to feed batching records to calculate DMI. Intakes were summarized at weekly intervals.

Two batches of germ and bran cake were received for this experiment. Germ was stored in a hopper-bottom bulk bin. Bran cake was piled on a concrete slab.

Data were analyzed using procedures appropriate for a completely random designed experiment. Means separations were accomplished using a Fishers T test.

Results and Discussion

Three animals were removed from the experiment. Reasons included a stag, pneumonia, and a non-performer, none of which should be attributed to treatments.

The implanted steers fed the Control diet had higher ADG, lower feed/gain, heavier final weights, and produced heavier carcasses ($P < 0.05$) than the other systems. The importance of this treatment in this experiment is to provide a benchmark or reference point for evaluating the economics of the other treatments. This short version of production costs [yardage 30¢/d, feed $120/T (DMB), and feeder steer at $100/cwt] applied to production rates in Table 3 resulted in a breakeven market price of $84.39/cwt. Doing the same calculation for Treatment 2 resulted in a breakeven of $87.43/cwt. This assumed no premium was paid for feeders certified for an implant-free program. There also was no Quality Grade premium applied since this implant caused no Quality Grade depression as used in this study.

Treatments 2 and 3 resulted in similar performance. The substitution of germ for the ionophore, SBM, and corn resulted in similar ADG and carcass weight. There was a trend ($P < 0.10$) toward slightly higher DMI when feeding germ. Since growth was similar on these diets, the application of production data would be to calculate the competitive price of the Germ diet. Compared to the $120/T Control diet, a comparable breakeven is achieved if the Germ diet cost is $116.50/T. There is no ionophore cost and less supplemental CP cost in the Germ diet, which is sufficient to meet or exceed savings required. Actual benefits would be dependent on the price of germ.

Steers fed the Bran Cake diet grew more slowly ($P < 0.05$) and less efficiently ($P < 0.05$) than those fed the Control or Germ diets. If this diet could be formulated at $120/T, the B/E selling price on the steers would increase to $89.47/cwt. There was no additional savings in supplemental CP to be had over the Germ diet. To match the B/E of the Germ treatment, diet cost would have to be reduced to $75.52/T. The performance drag due to Bran Cake was most pronounced from 85 to 110 d on feed. Feed efficiency differences would be more pronounced in lower energy feeds as cattle approach harvest flesh and body weight. This period also coincides with feeding of the second load of Bran Cake (days 82 to 110). It was not apparent that the feeding quality of the Bran Cake changed, but that possibility cannot be ruled out.

The original premise of this experiment was to determine if using ethanol co-products to add fat to finishing diets would offset the advantages provided by ionophores in typical diets. Using this dry milling germ product containing 20% fat at 14% of the diet appeared to adequately replace SBM, corn, and monensin. There was no evidence of an increased prevalence of bloat, acidosis, or coccidiosis on either co-product diet. The bran cake product was not suitable for this purpose.

Tables

Table 1. Final diets formulations and composition[a]

	Treatment[b]		
	1 and 2	3	4
Oat silage, %[c]	10.00	10.00	10.00
Whole shelled corn, %	78.81	67.16	51.47
Germ	-	14.00	-
Bran cake	-	-	30.00
SBM[d]	9.20	6.20	6.20
Urea[d]	0.30	0.30	0.30
Limestone[d]	1.44	2.09	1.78
Trace mineralized salt[d]	0.25	0.25	0.25
DM[e]	79	79	67
CP[e]	12.4	12.4	12.4
NDF[e]	14	16	19
Ca[e]	0.57	0.78	0.68
P[e]	0.32	0.45	0.39

[a] DM basis.
[b] Treatment 1 = Positive Control; 2 = Non-implanted Control; 3 = Germ, non-implanted, no ionophore; and 4 = Bran Cake, non-implanted, no ionophore.
[c] Replaced with oat hay day 105.
[d] Incorporated into pelleted supplement fortified with Vitamins A and E, $ZnSO_4$, and $CuSO_4$. Diet 1 and 2 provided 29g/T monensin.
[e] Tabular values.

Table 2. Interim performance by treatment

	Treatment[a]				
	1	2	3	4	SEM
Initial BW, lb	870	867	868	861	5.3
d 28 BW	1001[b]	987[bc]	974[c]	968[c]	8.4
1 to 28d					
ADG	4.69[b]	4.31[bc]	3.79[c]	3.83[c]	0.214
DMI	18.67[f]	18.70[f]	19.05[e]	18.71[f]	0.113
F/G	4.01[b]	4.39[bc]	5.09[c]	4.90[c]	0.252
d 56 BW, lb	1117[b]	1086[c]	1084[c]	1065[d]	6.3
29 to 56d					
ADG	4.15[e]	3.54[f]	3.94[ef]	3.44[f]	0.212
DMI	24.85	24.53	24.91	24.49	0.245
F/G	6.03[e]	6.98[ef]	6.37[ef]	7.30[f]	0.337
d 84 BW, lb	1236[b]	1195[c]	1185[cd]	1174[d]	6.2
57 to 84d					
ADG	4.26	3.87	3.60	3.91	0.211
DMI	26.68[b]	26.35[b]	27.36[c]	26.51[b]	0.229
F/G	6.33[e]	6.86[ef]	7.65[f]	6.85[ef]	0.350
d 110 BW, lb	1321[b]	1283[c]	1274[c]	1243[d]	6.1
85 to 110d					
ADG	3.27[ef]	3.40[e]	3.43[e]	2.65[f]	0.237
DMI	27.64	27.68	28.95	28.29	0.481
F/G	8.86[ef]	8.19[e]	8.50[e]	10.97[f]	0.760

[a] Treatment 1 = Positive Control; 2 = Non-implanted Control; 3 = Germ, non-implanted, no ionophore; and 4 = Bran Cake, non-implanted, no ionophore.
[b,c,d] Means without common superscripts differ ($P < 0.05$).
[e,f] Means without common superscripts differ ($P < 0.10$).

Table 3. Cumulative steer performance and carcass traits by treatment

	Treatment[a]				
	1	2	3	4	SEM
110d - Cumulative					
Final BW, lb[b]	1264[d]	1216[e]	1214[e]	1180[f]	4.9
ADG	3.59[d]	3.18[e]	3.14[e]	2.89[f]	0.045
DMI	24.40[h]	24.25[h]	25.00[g]	24.43[h]	0.196
F/G	6.80[d]	7.65[e]	7.95[e]	8.45[f]	0.131
Carcass wt., lb	790[d]	760[e]	758[e]	743[f]	4.5
Ribfat, in.	0.52	0.49	0.49	0.48	0.020
REA, in^2	12.2	12.1	12.3	12.0	0.11
KPH, %	2.33[h]	2.20[gh]	2.28[h]	2.02[g]	0.082
Marbling[c]	5.5	5.6	5.5	5.3	0.15
Yield Grade	3.34[g]	3.19[gh]	3.11[h]	3.05[h]	0.077
≥ Choice, %	76	65	64	64	

[a] Treatment 1 = Positive Control; 2 = Non-implanted Control; 3 = Germ, non-implanted, no ionophore; and 4 = Bran Cake, non-implanted, no ionophore.
[b] Calculated as hot carcass weight ÷ 0.625.
[c] 4.0 = Slight[o]; 5.0 = Small[o].
[d,e,f] Means differ $P < 0.05$.
[g,h] Means differ P < 0.10

Effect of High-sulfate Water on Trace Mineral Status of Beef Steers[1]

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BEEF 2005 - 17

Summary

Two experiments were conducted to determine the effect of high-sulfate water on the performance, health, and mineral status of growing steers. The first experiment was conducted from June 20 to September 12, 2001, at the South Dakota State University (SDSU) Cottonwood Range and Livestock Research Station. Eighty-one crossbred steers (initial BW = 700 lb) were stratified by weight and randomly assigned to 12 dry-lot pens (6 or 7 steers/pen). Pens were then randomly assigned to one of three water quality treatments: 1) rural water (404 ppm sulfate), 2) well water (3087 ppm sulfate), and 3) stock dam water (3947ppm sulfate). Steers were fed a diet consisting of grass hay and pelleted wheat middlings. The second experiment was conducted from May 23 to September 4, 2002, at the SDSU Cottonwood Range and Livestock Research Station. Eighty-four crossbred steers (initial BW = 640 lb) were stratified by weight and randomly assigned to 12 dry-lot pens (7 steers/pen). Pens were then randomly assigned to one of four water quality treatments: 1) 1000, 2) 3000, 3) 5000, and 4) 7000 ppm total dissolved solids. These treatment levels were created by mixing water of varying quality from three different natural sources. Steers were fed a diet consisting of grass hay and pelleted wheat middlings. In both experiments, initial and final liver biopsy samples were collected. Liver samples were analyzed for copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn). In both experiments, initial liver Cu concentrations were not different between treatments. Provision of high-sulfate water reduced liver Cu concentrations in experiment 1 ($P < 0.01$) and 2 ($P < 0.01$). Liver Fe, Mn, Mo, and Zn were not affected by treatment. Results of these two experiments clearly demonstrate the dramatic impact that high-sulfate water can have on liver Cu stores in growing cattle.

Introduction

High-sulfate water is not a new concern for beef producers in the Upper Great Plains. Ranchers and cattle feeders alike have been dealing with water quality issues for quite some time. Previous research has clearly documented the detrimental effects of high-sulfate water on the health and performance of cattle (Weeth and Capps, 1972; Patterson et al., 2003; Patterson et al., 2004).

Previous research has also clearly documented the detrimental effects of dietary sulfur (S) and molybdenum (Mo) on the copper (Cu) status in sheep (Suttle, 1974) and cattle (Wittenberg and Boila, 1988). Minimal research has been conducted to examine the effect of high-sulfate water on the trace mineral status of beef cattle. Marked reductions in liver Cu have been observed in suckling calves, that, together with their dams, consumed water containing nearly 950 ppm sulfate (Cameron et al., 1989) and growing cattle consuming water formulated to contain 1500 ppm sulfate (Wright et al., 2000). In certain areas of South Dakota the sulfate levels of available water (surface or well) may be well in excess of 3000 ppm. These experiments were designed to determine the effect of high-sulfate water on the trace mineral status of growing steers.

Materials and Methods

Two experiments were conducted to determine the effect of high-sulfate water on the performance, health, and mineral status of growing steers. Performance and health data are reported elsewhere (Patterson et al., 2003; Patterson et al., 2004). The first experiment was conducted from June 20 to September 12, 2001, at the South Dakota State University (SDSU) Cottonwood Range and Livestock Research Station. Eighty-one crossbred steers (initial BW

[1] The authors acknowledge Dr. Connie Larson and Zinpro Corporation, Eden Prairie, MN, for financial support of this project.
[2] Assistant Professor

= 700 lb), purchased from local auction markets, were stratified by weight and randomly assigned to 12 dry-lot pens (6 or 7 steers/pen). Pens were then randomly assigned to one of four water quality treatments: 1) rural water, 2) well water, 3) stock dam water, and 4) stock dam water, then switched to extremely high-sulfate water late in the summer. Sulfate levels associated with each treatment can be found in Table 1. Since actual total dissolved solids and sulfate measurements were less than anticipated, treatments 3 and 4 were combined for analysis (total of 6 pens). From June 20 to July 19, steers were fed a diet consisting of grass hay and pelleted wheat middlings (14.3% CP, 0.38 Mcal/lb NEg DM basis). Mineral composition of the feed ingredients can be found in Table 2. On July 20 the proportions of grass hay and wheat middlings were altered to improve animal performance. From July 20 to the end of the experiment the diet contained 14.9% CP, 0.42 Mcal/lb, and 0.19% S. Cattle had *ad libitum* access to white salt. Supplemental minerals, including Cu, were not provided.

The second experiment was conducted from May 23 to September 4, 2002, at the SDSU Cottonwood Range and Livestock Research Station. Eighty-four crossbred steers (initial BW = 640 lb), purchased from local auction markets, were stratified by weight and randomly assigned to 12 dry-lot pens (7 steers/pen). Pens were then randomly assigned to one of four water quality treatments: 1) 1000, 2) 3000, 3) 5000, and 4) 7000 ppm total dissolved solids. These treatment levels were created by mixing water of varying quality from three different natural sources. Actual average sulfate concentrations of each targeted water treatment can be found in Table 3. Throughout the experiment, steers were fed a diet consisting of grass hay and pelleted wheat middlings (15.7% CP, 0.44 Mcal/lb NEg DM basis). Mineral composition of the feed ingredients can be found in Table 2. Cattle had *ad libitum* access to white salt and limestone (36% Ca) was top-dressed at a rate of 0.15 lb/hd/d; however, other supplemental minerals, including Cu, were not provided.

Water sulfate concentrations were determined using ion chromatography by the SDSU Water Resource Institute, Brookings, SD. Water sulfate concentrations from 2001 and 2002 are reported in Tables 1 and 3, respectively. Complete results from the water analyses are reported elsewhere (Patterson et al., 2003; Patterson et al., 2004).

Mineral concentrations in feed samples were analyzed using inductively coupled plasma-optical emission spectroscopy by Servi-Tech Laboratories, Hastings, NE.

Liver biopsies were collected from each steer on d 0 and 84 in experiment 1 and d 0 and 104 in experiment 2 using the true-cut technique described by Pearson and Craig (1980), as modified by Engle and Spears (2000). Following collection, samples were stored on ice during transport, then frozen and stored at -20°C prior to analyses. Ten liver samples per treatment (n = 30 in experiment 1; n = 40 in experiment 2) were randomly selected for trace mineral analysis. Frozen samples were then sent to Michigan State University Diagnostic Center for Population and Animal Health, Lansing, MI, for analysis of trace mineral concentration using inductively coupled plasma-atomic emission spectroscopy as described by Braselton et al. (1997).

Initial and final liver trace mineral concentrations and the associated change were analyzed as a completely randomized design using the Proc GLM procedure of SAS (SAS Institute, Cary, NC). Animal was used as the experimental unit. Significance was declared at $P < 0.05$.

Results

Liver trace mineral concentrations from experiment 1 can be found in Table 4. Initial liver copper concentrations were not different between treatments. However, steers that consumed well or dam water (3087 and 3947 ppm sulfate, respectively) had lower ($P < 0.01$) final liver copper concentrations than steers that consumed rural water (404 ppm sulfate). Final liver iron concentrations were greater ($P < 0.01$) in steers that consumed dam water compared to those that consumed rural water. Treatment had no effect on liver manganese, molybdenum, or zinc concentrations.

Liver trace mineral concentrations from experiment 2 can be found in Table 5. Initial liver copper concentrations were not different between treatments. However, steers that consumed water formulated to contain 3000, 5000, or 7000 ppm TDS had lower ($P < 0.01$) final liver copper stores than steers that consumed water formulated to contain 1000 ppm TDS. Treatment had no effect on liver iron,

manganese, molybdenum, or zinc concentrations.

Discussion

In these experiments, consumption of high-sulfate water resulted in precipitous declines in liver Cu stores in growing cattle. In the first experiment, the steers had an average initial liver copper concentration of 78.9 ppm. This concentration would be considered adequate to marginally deficient (Puls, 1994). Cattle that consumed the high-sulfate water had liver copper concentrations of 26.3 and 35.2 ppm, concentrations that would be considered deficient (Puls, 1994).

In the second experiment, the steers had an average initial liver copper concentration of only 35.8 ppm. This concentration would be considered borderline deficient (Puls, 1994). Cattle that consumed high-sulfate water had final liver Cu concentrations of 24.8, 7.7, and 6.5 ppm. The dramatic effect of high-sulfate water, in the presence of dietary Mo, is clearly illustrated by these findings and agrees with previous research in growing cattle (Wright et al., 2000) and suckling calves (Cameron et al., 1989). Provision of S and Mo as dry ingredients has also reduced liver Cu concentrations in growing cattle (Arthington et al., 1996).

The reason for the increase in liver Fe in the first year is unclear. It may be possible that the dam water contained higher levels of Fe; however, the Fe concentration in the water was not analyzed.

The lack of effect of high-sulfate water on the liver concentrations of other minerals is not unexpected. While the interactions of S, Mo, and Cu have been investigated extensively and clearly documented, interactions of S and other trace minerals analyzed in this experiment (manganese and zinc), have not been reported.

Implications

The dramatic effects of high-sulfate water on the health and performance of beef cattle has been clearly documented. However, while nutritionists have known for some time that high-sulfate water can interfere with Cu absorption and metabolism, only recently has the extent of that interference been documented. Producers in areas where high-sulfate water is prevalent should test their water sources routinely as part of their management strategy. Challenges associated with high-sulfate water can often be overcome with alterations to grazing management, water development, and appropriate supplementation strategies.

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Tables

Table 1. Sulfate concentrations of water from different sources over time in 2001[a]

	Water Source		
Date	Rural	Well	Dam
	---------- ppm[b] ----------		
June 20	421	3165	3167
July 17	374	3096	3766
July 30	410	3174	3667
August 13	404	3120	4107
August 28	421	3044	4359
September 10	394	2920	4603
Mean	404	3087	3947

[a]Adapted from Patterson et al. (2003).
[b]ppm = parts per million.

Table 2. Mineral composition of feed ingredients used in 2001 and 2002

	2001		2002	
	Grass hay	Wheat middlings	Grass hay	Wheat middlings
	---------- % of DM ----------			
Calcium	0.82	0.11	0.89	0.10
Magnesium	0.24	0.52	0.17	0.50
Phosphorus	0.17	1.23	0.12	1.21
Potassium	2.20	1.45	1.76	1.25
Sulfur	0.17	0.22	0.15	0.20
	---------- ppm[a] (DM basis) ----------			
Copper	7.0	13.0	6.5	12.0
Iron	276	183	95	153
Manganese	59	166	54	153
Molybdenum	4.9	1.4	3.4	
Zinc	23	108	22	101

[a]ppm = parts per million.

Table 3. Actual sulfate concentrations of targeted water treatments in 2002[a]

	Target total dissolved solids, ppm[b]			
	1000	3000	5000	7000
Sulfate	441	1725	2919	4654

[a]Adapted from Patterson et al. (2004).
[b]ppm = parts per million.

Table 4. Effect of poor quality water on liver mineral status in beef steers (2001)

Source/ sulfate	Initial			Final		
	Rural/ 404	Well/ 3087	Dam/ 3947	Rural/ 404	Well/ 3087	Dam/ 3947
	ppm[a] (DM basis)					
Cu	81.0	70.2	85.5	84.8[b]	26.3[c]	35.2[c]
Fe	268.0	281.0	304.0	257.7[b]	286.4[bc]	331.6[c]
Mn	9.1	8.5	8.8	10.0	10.7	11.3
Mo	3.1	2.9	2.9	3.2	3.1	2.9
Zn	96.1	107.9	113.5	84.6	89.8	94.0

[a]ppm = parts per million.
[b,c]Means within a row under one heading (e.g. Initial or Final) without common superscripts differ (*P < 0.01*).

Table 5. Effect of poor quality water on liver mineral status in beef steers (2002)

TDS[a]/ sulfate	Initial				Final			
	1000/ 441	3000/ 1725	5000/ 2919	7000/ 4654	1000/ 441	3000/ 1725	5000/ 2919	7000/ 4654
	ppm[b] (DM basis)							
Cu	30.9	56.8	27.4	28.7	56.8[c]	24.8[d]	7.7[d]	6.5[d]
Fe	448.0	466.0	437.0	470.0	364.0	280.0	317.0	418.0
Mn	8.8	9.8	9.9	9.8	8.9	9.9	9.9	9.6
Mo	3.4	3.6	3.7	3.8	2.9	3.3	3.2	2.9
Zn	123.3	135.8	128.3	146.8	83.7	88.9	85.0	131.3

[a]TDS = target total dissolved solids.
[b]ppm = parts per million.
[c,d]Means within a row under one heading (e.g. Initial or Final) without common superscripts differ (*P < 0.01*).

Effect of Feeding Schedule on Tympanic Temperature of Steer Calves During Winter[1]

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BEEF 2005 - 18

Summary

Angus steer calves (n=135) were used in a 55d feedlot growing study to investigate the effects of feeding schedule on tympanic temperature response when limit feeding. Steers were fed a high moisture ear corn diet (58 Mcal/cwt NEg) at 0900h (AM), 1500h (PM) or 50% at 0900h and 50% at 1500h (SPLIT) to allow for 2.50lb ADG. Climatic data were collected at 30 min intervals throughout the study via an on site automated weather station. Tympanic temperatures (TT) were collected every 30 min (5 steers/trt) for 5d (d44 to d48). Mean ambient temperature during the 5d TT collection period was -6.5^{0}F (-23.1 to 9.1^{0}F). After 55d, BW (802, 808 and 802lb), ADG (2.56, 2.67 and 2.52lb) and feed efficiency (5.73, 5.52 and 5.87) did not differ (P>.10) between AM, PM and SPLIT respectively, but followed rankings of previous research. Diurnal TT patterns were assessed by separating the day into three periods based on mean hourly wind chills (44.2, 17.8 and 7.5^{0}F) for Period 1 (0800 to 1600h), Period 2 (1630 to 2100h) and Period 3 (2130 to 0730h) respectively. Peak TT occurred during Period 2 for AM (102.4^{0}F) and Period 3 for PM (103.2^{0}F). SPLIT fed steers exhibited TT peaks of 103.9^{0}F or greater in each period. These data indicate that by adjusting feeding schedule it is possible to alter the time at which peak TT may occur, so that peak TT coincides with colder periods of the day. Elevated TT across all periods for SPLIT suggests that these steers may have increased metabolic rate to maintain normal TT during extreme cold. Additional research is needed to explain the changes in TT and how feeding times may impact energy partitioning.

Introduction

In the Northern plains of the United States the average January temperature is below 32^{0}F. These cold weather conditions present challenges for young feedlot animals. The acclimation of feedlot animals to winter conditions occurs generally at the cost of an increase in resting metabolic rate, which is required to maintain body temperature. As a consequence less feed energy is available for growth. Feed intake is increased during chronic cold exposure when animals have unlimited access to feed, and this may compensate in part for the increased energy requirement (Scott et al., 1993). Restricting feed intake of high energy diets has been researched. Most of this research has been focused on restricting intake of high energy diets as an alternative management practice to full feeding high roughage diets during the growing phase (Loerch, 1990; Sip and Pritchard, 1991). These studies reported improved feed efficiency and reduced cost of gain for limit-fed cattle compared to those fed ad libitium. Under cold exposure it may be possible to better utilize heat of fermentation by altering feeding time when cattle are limit-fed to help maintain body temperature. The objective of this study was to determine the effect of feeding schedule on tympanic temperature responses of limit-fed growing feedlot steers during winter.

Materials and Methods

Angus steer calves (n=135) from a single source were used in the 55 d growing study. Steers were blocked by weight and randomly assigned to one of three feeding schedules; feed delivered once daily at approximately 0900h (AM); feed delivered once daily at approximately 1500h (PM) or feed delivered twice daily at approximately 0900 and 1500h (SPLIT).

All steers had previously been vaccinated against IBR, BVD, PI_3, BRSV, Haemophilus

[1] This project funded by the SD Ag Experiment Station and the Beef Nutrition Center.
[2] Post Doctorate
[3] Distinguished Professor

(Resvac-4, Pfizer, Exton, PA), 7-way clostridia (Ultrabac-7, Pfizer, Exton, PA) and treated for parasites (Cydectin, Fort Dodge Animal Health, Fort Dodge, IA). All steers were allowed 28 days in a receiving program prior to the initiation of this study. Individual body weights were recorded at the start of the study and all steers were implanted (Synovex S, Fort Dodge Animal Health, Fort Dodge, IA) at that time. Interim body weights were collected on all steers every 14 d and a final body weight was recorded on d 55.

Steers were limit-fed a high moisture ear corn diet (58 Mcal/cwt NEg) to allow for 2.5lb ADG (Table 1.). Calculations of NEg required were derived using NRC equations and tabular values for ingredients. Dry matter intake was adjusted every 14 d for corresponding changes in body weight.

Tympanic temperature loggers were placed into 5 randomly selected steers per treatment. Tympanic temperature readings were recorded every 30 minutes to the loggers for 5 consecutive days (d 44 to d 48). The loggers were then retrieved and the data were downloaded to a computer for analysis. Diurnal TT patterns were assessed by separating the day into three time periods based on mean hourly wind chills (44.2, 17.8 and 7.5^0F) for Period 1 (0800 to 1600h), Period 2 (1630 to 2100h) and Period 3 (2130 to 0730h) respectively.

Weather information was collected throughout the 55 d growing study via a wireless weather station (Davis Instruments, CA) located centrally within the feedlot facility. Ambient temperature (^{0}F), Black globe temperature (^{0}F) and wind speed (mi/h) were recorded every 30 min. The black globe thermometer consists of a 6-inch sphere of copper painted matte black on the outside. A temperature sensor is inserted into the globe and is centered at the midpoint of the globe. The purpose of the black globe thermometer is to combine the thermal effects of the radiation from the sun and hot surfaces in the environment into a single reading. Wind chill temperature was calculated based on the NOAA's National Weather Service equation, substituting black globe temperature for ambient temperature.

$$\text{Wind Chill } (^0\text{F}) = 35.74 + 0.6125T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where; T – Black globe temperature (^{0}F)
V – Wind speed (mph)

All data were compared using methods appropriate for a completely randomized block design using the GLM procedure of SAS (1996).

Results and Discussion

During the 55 d growing study ambient temperature ranged from -23 to 55^0F, with a mean of 17.2^0F (Table 2.). Mean black globe temperature was 20^0F and ranged from -24 to 67^0F, while wind speed ranged from 0 mph to 20 mph with a mean of 4.1 mph. Mean wind chill was 16.1^0F and ranged from -28 to 67^0F. During the 5 d tympanic temperature collection period (d44 to d48) mean ambient temperature was -6.5^0F (-23 to 9^0F), while mean wind chill was -5.2^0F (-28 to 28^0F)(Figure 1).

Initial body weights and final body weights did not differ ($P < 0.05$) between treatment groups (Table 3.). However, body weights at d 28 were greater ($P > 0.05$) for PM than AM or SPLIT treatment groups. This trend was also observed at d 14 and d 42 where body weights were greater ($P < 0.1$) for PM than AM or SPLIT treatment groups. Numerical rankings of ADG and F:G were consistent with these other production variables but were not different (*$P > 0.10$*). Maintenance energy requirements over the 55 d growing study were 5.6 and 7.6% higher for AM and SPLIT treatment groups compared to PM. This may, in part, explain the improvements in performance.

Diurnal TT patterns were assessed by separating the day into three time periods based on mean hourly wind chills (44.2, 17.8 and 7.5^0F) for Period 1 (0800 to 1600h), Period 2 (1630 to 2100h) and Period 3 (2130 to 0730h) respectively. During the daytime hours (Period 1), peak TT was highest (*$P < 0.0001$*) for SPLIT (104.0^0F), lowest for AM (102.0^0F) with PM (102.2^0F) being intermediate (Figure 2). Similar rankings occurred in Period 2 (early evening). However, a small increase in TT for AM (102.4^0F) and a similar decrease for SPLIT (103.9^0F) was observed with colder temperatures, compared to an increase of 0.9^0F for PM (103.1^0F). During the coldest portion of the day (Period 3), AM treatment group had a lower TT (*$P < 0.0001$*), than PM and SPLIT treatment groups (101.8, 103.2 and 104.3^0F, respectively). This would suggest that AM fed

cattle are not able to maintain TT during the colder late evening/early morning hours. PM fed cattle were able to maintain a higher body temperature by possibly taking advantage of heat generated from fermentation. SPLIT fed cattle tended to maintain an abnormally high TT throughout all three periods. This may suggest that SPLIT fed cattle attempt to compensate for failure to maintain normal TT by increasing metabolism which in turn raises body temperature above normal levels.

Implications

The data collected from this study indicate that by adjusting feeding schedule it is possible to alter the time at which peak TT may occur, so that peak TT coincides with colder periods of the day. Elevated TT across all periods for SPLIT suggests that these steers may have increased their metabolic rate to maintain normal TT during extreme cold. Additional research is required to explain how changes in feeding schedules may influence energy partitioning.

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Tables

Table 1. Diet Formulation[ab]

High moisture ear corn, %	82.83
SBM[c], %	13.00
Wheat midds[c], %	2.16
Limestone[c], %	1.30
TM Salt[c], %	0.30
Zinc Sulfate[c], %	0.008
Copper Sulfate[c], %	0.003
Potassium Chloride[c], %	0.4
CP, %	12.87
NDF, %	25.12
NEm, Mcal/lb	0.88
NEg, Mcal/lb	0.58

[a] DM basis.
[b] 23g/T monensin, 1000IU/lb Vit A and 10IU/lb Vit E was provided in the diet.
[c] Provided as pelletted supplement.

Table 2. Mean daily (± SD) climatic conditions during the study

Item	Average	Minimum	Maximum	SD
Period 1 (d 1-14)				
Ambient temperature, ^{0}F	28.67	5.8	47.7	7.96
Wind chill[a], ^{0}F	28.52	1.24	67	11.70
Wind speed, mph	4.02	0	20	3.82
Black globe temperature, ^{0}F	31.43	4	67	11.40
Period 2 (d 15-28)				
Ambient temperature, ^{0}F	15.81	-10	46.4	13.34
Wind chill[a], ^{0}F	13.71	-19.32	61.96	15.92
Wind speed, mph	4.39	0	20	3.94
Black globe temperature, ^{0}F	18.48	-13	62	15.58
Period 3 (d 29-42)				
Ambient temperature, ^{0}F	13.34	-7.2	54.8	12.02
Wind chill[a], ^{0}F	12.05	-18.99	61.3	14.95
Wind speed, mph	3.82	0	17	3.54
Black globe temperature, ^{0}F	16.31	-8	63	13.70
Period 4 (d 43-55)				
Ambient temperature, ^{0}F	10.4	-23	42.1	16.28
Wind chill[a], ^{0}F	9.58	-28.13	67	18.71
Wind speed, mph	4.31	0	18	4.27
Black globe temperature, ^{0}F	14.46	-24	67	18.16
Overall (d 1-55)				
Ambient temperature, ^{0}F	17.18	-23	54.8	14.47
Wind chill[a], ^{0}F	16.08	-28.13	67	17.18
Wind speed, mph	4.13	0	20	3.90
Black globe temperature, ^{0}F	20.27	-24	67	16.04

[a]Wind Chill (^{0}F) = 35.74 + 0.6125T – 35.75($V^{0.16}$) + 0.4275T($V^{0.16}$), where; T – Black globe temperature (^{0}F), V – Wind speed (mph).

Table 3. Performance data

	AM	PM	SPLIT	sem
Initial BW, lb	661	662	663	1.3
Day 1-14				
BW (day 14), lb	716[c]	724[d]	720[cd]	2.1
DMI, lb	14	14	14	
ADG, lb	3.94	4.44	4.02	0.16
F/G	3.55	3.16	3.49	0.132
Day 15-28				
BW (day 28), lb	750[a]	761[b]	756[ab]	2.5
DMI, lb	14.6	14.7	14.7	0.05
ADG, lb	2.46	2.68	2.62	0.174
F/G	6.17	5.51	5.67	0.399
Day 29-42				
BW (day 42), lb	793[c]	803[d]	798[cd]	3
DMI, lb	14.9	14.9	14.9	
ADG, lb	3.05	3.00	2.99	0.164
F/G	4.92	5.03	5.03	0.293
Day 43-55				
BW (day 55), lb	835	842	835	3.1
DMI, lb	15.4	15.4	15.4	
ADG, lb	3.24	2.97	2.87	0.183
F/G	4.77	5.2	5.5	0.349
Day 1-55				
BW (day 55), lb[e]	802	808	802	2.93
DMI, lb	14.7	14.7	14.7	
ADG, lb	2.56	2.67	2.52	0.069
F/G	5.73	5.52	5.87	0.165

[ab]Means within a row with different superscripts are different (*P < 0.05*).

[cd]Means within a row with different superscripts are different (*P < 0.10*);

[e]4% shrink applied.

Figures

Figure 1. Mean hourly ambient temperature (^{0}F) and wind chill (^{0}F) during the 5 d TT collection period[a]

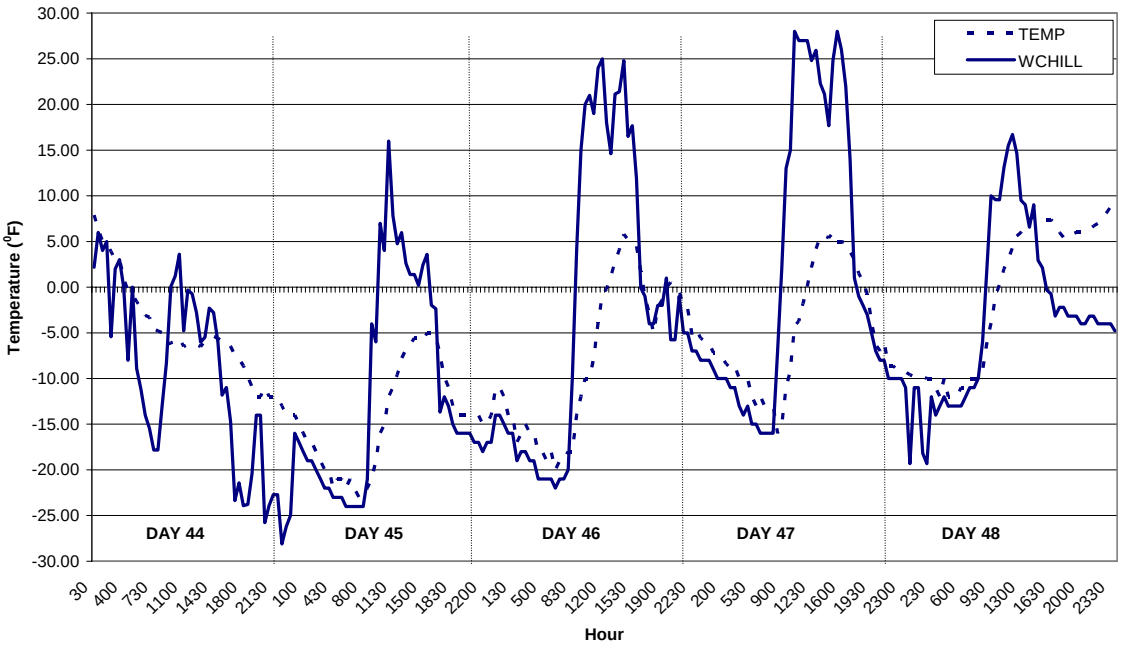
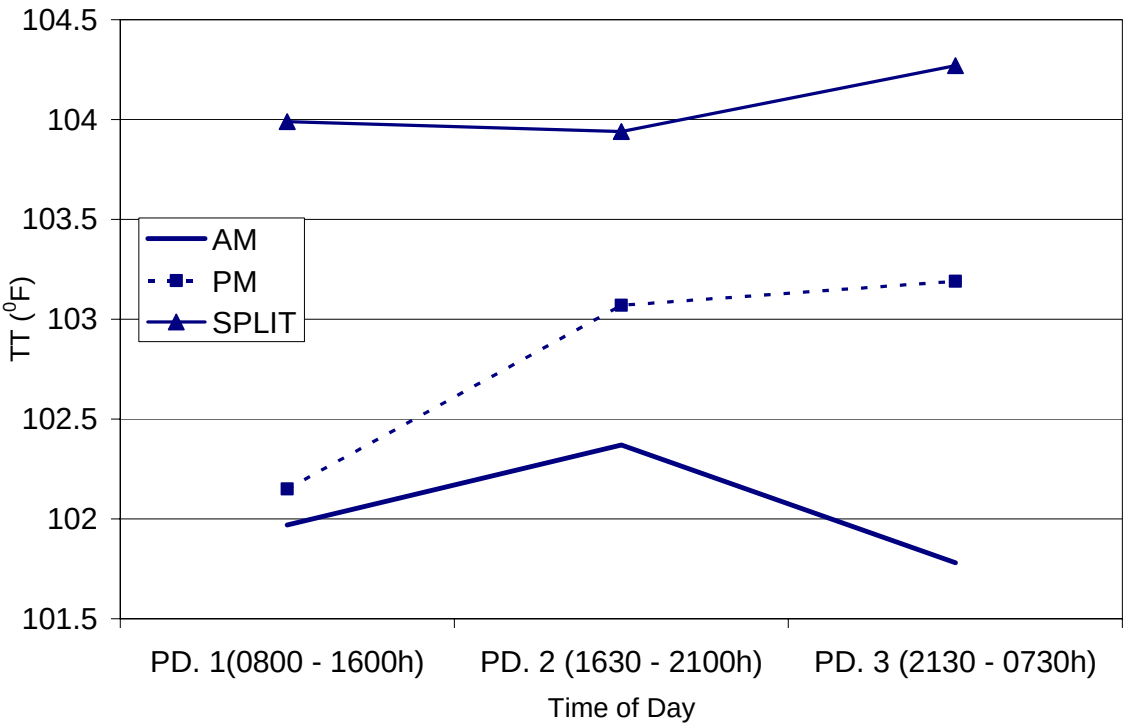


Figure 2. Peak TT during the collection period.



Intravenous Ghrelin Infusion Affects Plasma Growth Hormone Concentrations, Dry Matter Disappearance, and Length of Time Spent Feeding[1]

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Summary

Six steers (915 ± 37.8 kg) were used in a crossover design to determine the effects of intravenous infusion of bovine ghrelin (BGR) on plasma growth hormone (GH) concentrations, length of time spent feeding, and dry matter disappearance per unit of metabolic weight. Steers were fed individually once daily (0800 h) and allowed to consume ad libitum until 2000 h when feed was removed. Daily feed allotment was sufficient to result in ≥ 10% feed refusal. Serial blood samples were collected from steers fitted with an indwelling jugular catheter at 15-min intervals from 0600 h through 1800 h. Harvested plasma was assayed for ghrelin and GH concentrations. Saline (SAL) or BGR was infused via jugular catheter at 1200 h and 1400 h. Treatment infusion times were selected on the basis of the observation that steers did not consistently feed at these times. Exogenous BGR was infused to achieve a plasma concentration of 1000 pg/mL. This dosage was chosen on the basis of previous research that indicated a peak ghrelin concentration of 1000 pg/mL for fasting steers. Steers were allowed 5 d to adjust between treatment periods and then treatments were switched between steer groups and the sampling period repeated. Compared to SAL steers, average plasma ghrelin concentration was elevated ($P \leq 0.0001$) at the first post-infusion sampling for BGR steers at both infusion. Bovine ghrelin infusion resulted in elevated ($P \leq 0.005$) plasma GH concentrations compared to SAL steers after the first infusion. The second infusion of BGR resulted in numerically higher GH concentrations, but this difference was not statistically different from SAL steers or baseline concentrations. Both plasma ghrelin and GH concentrations returned to baseline 30 min post-BGR infusion. Length of time spent feeding ($P = 0.03$) and dry matter disappearance per unit of metabolic body weight ($P = 0.05$) for the combined infusion times were increased for steers infused with BGR. Bovine ghrelin is a compound that has the potential to elevate plasma GH concentrations and to increase length of time spent feeding and dry matter disappearance per unit of metabolic body weight.

Introduction

Feeding cattle properly is an intricate part of any successful beef cattle operation. Feed costs account for 40 to 50 percent of the total on-farm costs of beef production, and Miller et al. (2001) reported that 50 percent of the herd-to-herd variation in profitability among beef cow/calf operations can be attributed to variation in feed costs. Additionally, dramatic fluctuations in feed intake can cause metabolic acidosis or inefficient production of meat, whereas inadequate feed intake can result in ketosis (Baile and Della-Fera, 1981). Voluntary feed intake is often compromised during stress associated with stage of production and temperature extremes (Baile and Della-Fera, 1981). In rodents, ghrelin has been reported to influence energy metabolism, increase growth hormone (GH) secretion, and stimulate feed intake, all of which contribute to the growth and the nutritional status of an animal (Tshöp et al. 2000). Ghrelin is a peptide hormone synthesized by the abomasumal and ruminal tissues of cattle (Hayashida et al., 2001 and Gentry et al., 2003, respectively). Ghrelin has been reported to stimulate feed intake through neuropeptides found in the appetite center of the hypothalamus (Tshöp et al. 2000; Inui, 2001; Shintani et al., 2001; and Nakazato et al., 2001). As feed intake contributes greatly to the nutritional status of cattle and therefore animal well-being and economic viability of an operation, this experiment was designed to

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study the influence of ghrelin on plasma GH concentrations, length of time spent feeding, and dry matter disappearance (as a indicator of feed intake) in beef cattle. The long-term goal of this research is to understand more thoroughly the regulation of feed intake to minimize economic loss and maximize animal well-being during nutritionally critical stages of production such as weaning, parturition, lactation, or temperature extremes.

Materials and Methods

Animals and treatments. Six steers (915 ± 37.8 lb) were used in a crossover design to determine the effects of intravenous infusion of bovine ghrelin (BGR) on plasma growth hormone (GH) concentrations, length of time spent feeding, and dry matter (DM) disappearance. Steers were acclimated to a climate-controlled facility and a specific feeding schedule during a 10-d pre-treatment adaptation period. Steers were fed individually once daily (0800 h) and allowed to consume ad libitum until 2000 h when feed was removed. Prior to entering the climate-controlled facility, steers were acclimated to a common finishing diet that was fed throughout the experiment (Table 1). Once in the climate-controlled facility, daily feed allotment for each steer was sufficient for ≥ 10% feed refusal to result. Each feeding apparatus was attached to a digital load cell capable of relaying weight differences to a computer. Feeder weight data were logged at 20-sec intervals. Volatility of logged weights indicated that an animal was feeding, whereas a consistently stable weight indicated that the animal was not feeding. The difference between a stable weight prior to and following a volatile weight period was used to calculate DM disappearance during a feeding period. Dry matter disappearance was recorded two days prior to treatment, the day of treatment, and one day following treatment. These data were used to calculate length of time spent feeding and dry matter disappearance per unit of metabolic body weight.

Plasma sample collection. Steers were fitted with an indwelling jugular catheter following the adaptation period. Steers were allowed a minimum of 12 h to recover between catheterization and initiation of the sampling / treatment period. Surgical procedures for this experiment were approved by the South Dakota State University Institutional Animal Care and Use Committee prior to the initiation of this experiment. Serial blood samples were collected from indwelling jugular catheters at 15-min intervals from 0600 h through 1800 h, on treatment day. Plasma was assayed for ghrelin and GH using radioimmunoassay procedures. During the sampling period, saline (SAL) or BGR was infused via jugular catheter at 1200 h and 1400 h. The catheter was then flushed with 5 mL of saline to ensure that BGR had been flushed from the catheter. Treatment infusion times were selected based on the observation that steers did not consistently consume feed during this time period. Therefore, steers were in a satiated state when BGR was administered. Exogenous BGR was infused to achieve a plasma concentration of 1000 pg/mL. This dosage was chosen on the basis of previous research that indicated a peak BGR concentration of 1000 pg/mL for fasting steers (Wertz et al., 2004). This model allowed for determining if the fasting concentration of ghrelin was adequate to stimulate feeding in a satiated steer. Steers were allowed a 5-d rest between the first and second treatment periods, and then treatments were switched between steer groups and the sampling / treatment period was repeated.

Statistical Analyses. Two steers were removed from the experiment because of catheter malfunction during a treatment period, therefore statistical analyses were performed on data from four steers that completed both treatment periods. Plasma ghrelin and GH concentrations were analyzed statistically as repeated measures in time using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Differences in plasma ghrelin and GH concentrations that resulted from treatment at specific time points were separated using least squares means. Dry matter disappearance and length of feeding period data were analyzed as crossover design using the MIXED procedure of SAS. Differences in DM disappearance or length of time spent feeding that resulted from treatment were separated using least squares means.

Results

The first post-infusion blood sample was collected 15 min after treatment infusion or at approximately the first half-life for ghrelin. Compared to SAL steers, average plasma ghrelin concentration was elevated ($P \leq 0.0001$) at the first post-infusion sampling for BGR steers after both the 1200 and 1400 h infusion times

(Figure 1). The time by treatment interaction tended (P = 0.12) to be significant for the effects of ghrelin infusion on GH concentrations. Bovine ghrelin infusion resulted in elevated ($P \leq 0.005$) plasma GH concentrations at the initial sampling after the first infusion time (1200 h) compared to SAL steers (Figure 2). The second infusion of BGR resulted in numerically higher GH concentrations, but concentrations were not statistically different from SAL steers. The magnitude of GH elevation following the second BGR infusion (1400 h) was less ($P \leq 0.0001$) when compared to the first infusion time. A clear explanation for this response cannot be established from data collected from this trial however, the attenuated GH response to BGR infusion may suggest a feedback mechanism or mechanisms in response to repeated BGR surges. Both plasma ghrelin and GH concentrations returned to concentrations similar to baseline by 30 min post-BGR infusion and were not different from that of SAL steers.

Dry matter disappearance and length time spent feeding were quantified for the first hour following each infusion (Infusion 1: 1200 to 1300 or Infusion 2: 1400 to 1500) because this time period corresponded with the time that ghrelin was elevated in the plasma (Table 2). Data for the two post-infusion periods were combined so that DM disappearance and length time spent feeding could be evaluated for the entire treatment period. Dry matter disappearance and length time spent feeding also were calculated for the entire day of treatment. Numerically, DM disappearance and time spent feeding were greater BGR steers ($P \leq 0.47$), however, the increase was not significantly different than SAL steers except for the combined post-infusion periods. For the combined post-infusion periods, BGR steers spent an average of 11.7 min more time feeding (P = 0.03), and DM disappearance was an average of 9.4 g/kg of metabolic body weight greater (P = 0.05) compared to SAL steers. Because DM disappearance was not significantly different following a single BGR infusion but was significantly increased when data for the individual infusions were combined, a single BGR infusion may not be sufficient to alter feeding but multiple or perhaps sustained elevation of ghrelin may be necessary to attain an increase in DM disappearance.

Exogenous BGR administered intravenously to finishing steers results in a transient increase in plasma GH concentration. Additionally, these data suggest that when plasma ghrelin concentrations are elevated that steers spend more time feeding and consume more feed. However, the effects on feed intake are not sustained beyond the treatment period.

Implications

These data indicate that bovine ghrelin can stimulate steers to consume feed. During critical production situations when feed intake can be compromised, ghrelin treatment may be a means of stimulating feed intake to offset poor performance and animal well-being associated with compromised feed intake. However, these data indicate that increased dry matter disappearance is detectable only during the ghrelin infusion, and therefore may require multiple intravenous infusions or an alternate means of sustained release to be efficacious. More research is needed to evaluate the effects of sustained ghrelin administration on dry matter disappearance, animal production, and animal well-being.

Acknowledgement

The authors would like to thank Sandy Smart for his help with the statistical analyses, and Taia Huls and Abby Bartosh for their help with sample collection.

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Tables

Table 1. Experimental diet composition

Ingredient	%, Dry Matter Basis
Corn	75.0
Grass hay	11.0
Wheat midds	7.52
Soybean meal	4.66
Urea	0.42
Limestone	1.23
Vitamin A [a]	0.007
Vitamin E [b]	0.005
Trace mineral salts [c]	0.100
$ZnSO_4$ [d]	0.006
Rumensin [e]	0.019
Calculated Nutrient Composition	
NEm, Mcals/lb	0.92
NEg, Mcals/lb	0.62
CP, %	13.0

[a] 30,000 IU/g.
[b] 500 IU/g.
[c] NaCl 94.0-98.5%, Zn 0.35%, Fe 0.20%, Co 0.005%, Mn 0.20%, Cu 0.30%, I 0.007%.
[d] 35.54% Zn.
[e] Formulated to contain 30 g/Ton

Table 2. Effects of intravenous ghrelin or saline injection on length of time spent feeding and dry matter disappearance for finishing beef steers

	Ghrelin	Saline	SE	$P \leq$
Number of Animals	4	4	----	----
After first infusion, 1200 to 1300				
Time spent feeding, min	10.0	3.8	3.5	0.33
Dry matter disappearance, g/kg MBW [a]	6.9	2.2	2.3	0.29
After second infusion, 1400 to 1500				
Time spent feeding, min	19.0	13.5	4.0	0.44
Dry matter disappearance, g/kg MBW	13.8	9.3	3.6	0.47
Combined post-infusion				
Time spent feeding, min	29.0	17.3	1.4	0.03
Dry matter disappearance, g/kg MBW	20.7	11.3	1.6	0.05
Entire treatment day				
Time spent feeding, min	136	124	5.9	0.28
Dry matter disappearance, g/kg MBW	93.6	84.4	5.4	0.37

[a] MBW = metabolic body weight = body weight ($kg^{0.75}$)

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Figures

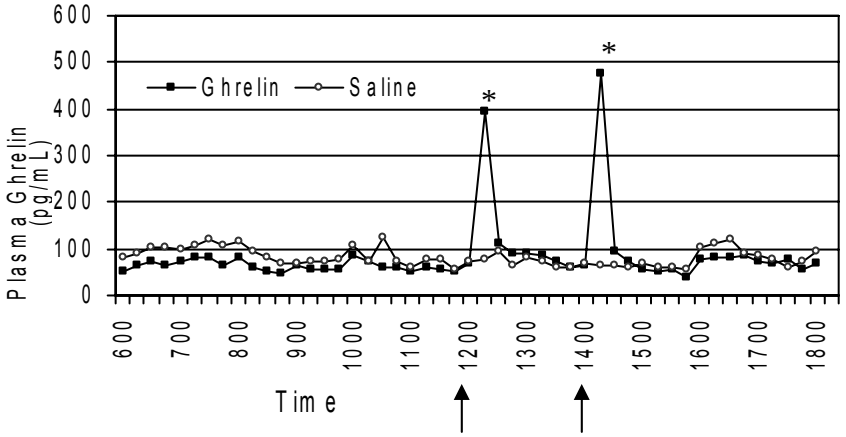

Figure 1. Plasma ghrelin concentrations for beef steers intravenously infused with ghrelin or saline. Arrows indicate infusion times. * Plasma ghrelin concentration was elevated ($P \leq 0.0001$) following intravenous infusion of ghrelin. Plasma ghrelin concentrations returned to baseline concentrations and similar to saline-treated steers by 30 min. post infusion.

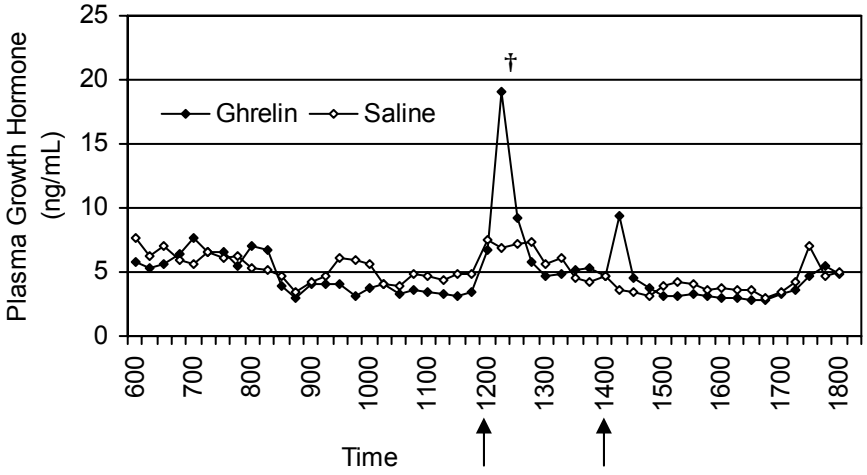

Figure 2. Plasma growth hormone concentrations for beef steers intravenously infused with ghrelin or saline. Arrows indicate infusion times. † Intravenous ghrelin infusion resulted in elevated ($P \leq 0.005$) plasma growth hormone (GH) concentrations following the first infusion. Plasma GH was not significantly different than baseline concentrations or saline-treated steers after second infusion.

Effect of Grazing, Mowing, or Herbicide on Leafy Spurge Control[1]

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BEEF 2005 – 20

Introduction

Leafy spurge (*euphorbia esula* L.) is an herbaceous perennial which is deep rooted and can reproduce by seeds and rhizomes. First introduced into North America in the 1800's from Europe, it now covers 25 states in the USA and several provinces in Canada. It is a major concern in North Dakota, South Dakota, Wyoming, Montana, and Nebraska. Leafy spurge is considered a noxious weed that is extremely competitive, establishing itself in pastureland and roadsides. Bangsund et al. (1997) estimated that by 2005, uncontrolled leafy spurge acres would reach 18.5 million in the Northern Great Plains. The cost of leafy spurge is estimated to be in the 100's of millions of dollars due to lost grazing through a reduction of available AUM's (animal unit months) and treatment costs which may not be economically feasible. This is impart due to the fact that cattle avoid eating leafy spurge because of post-ingestive negative feedbacks from plant toxins (Kronberg et al., 1993) and avoid grazing in areas where leafy spurge canopy cover is high, thus reducing grass production and utilization (Hein and Miller, 1992).

Do to the high costs of herbicides and their ineffective control in the long-term (Lym and Messersmith, 1985), biological controls such as sheep and goats as well as the flea beetle have become more popular tools in controlling leafy spurge (Bangsund et al., 2000). In a pasture setting sheep and goats readily graze forbs and do not experience the build up of toxins that cattle do, making small ruminants ideal biological controls for leafy spurge.

The object of this trial was to measure the effectiveness of various control methods on leafy spurge.

Methods

The study site was located on a heavily leafy spurge infested pasture located 4 miles north of Brookings, SD. The topography and climate is characterized by rolling hills with an annual precipitation of 22.8 inches with an average temperature during the growing months (April – September) of a high of 73°F and a low of 48°F. Vegetation was dominated by predominately cool-season grasses such as smooth bromegrass (*Bromus inermis* Leyss. subsp. *inermis*), Kentucky bluegrass (*Poa pratensis* L.), quackgrass [*Elytrigia repens* (L.) Desv. ex Nevski] and leafy spurge.

The study was initiated in June of 2004. Experimental design was a randomized complete block design with four replications. Treatments were applied to 16 x 16 ft plots. Treatments consisted of 1) Control (only measurements taken from the plot site), 2) Mow – plot mowed and grass removed to simulate haying, 3) Graze – plot grazed with sheep at a stocking rate of 6.8 AUM/acre, and 4) Herbicide – plot sprayed with a 2% solution of Grazon (picloram, 2.3 oz/1.05 qt and 2-4-D 8 .5 oz/1.05 qt; Dow Agro Sciences, Indianapolis, IN) using a hand-held sprayer.

Estimates of grass and leafy spurge biomass and leafy spurge stem density were made prior to treatment application (June 2004, Year 1) and one year after treatments were applied (June 2005, Year 2) by clipping vegetation from four 0.19.5 in.^{2} quadrats per plot. Grass and leafy spurge were hand separated and the number of leafy spurge stems was counted. Samples were dried in a forced air oven at 140°F for 72 hours and weighed.

Analysis of variance was used to analyze treatment effects from biomass and stem density estimates from Year 1, Year 2, and the difference of Year 1 from Year 2. A randomized complete block model was calculated using PROC GLM (SAS, 1999). Least square means

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and standard errors were calculated using the LSMEANS statement and separated using the PDIFF option (SAS, 1999). Mean comparisons were considered significantly different at $P \leq 0.05$.

Results and Discussion

Estimates of leafy spurge and grass biomass and leafy spurge stem density from plots prior to treatment application in Year 1 were similar (Table 1). Grass yield averaged 2300 lb/acre while leafy spurge contributed to 40% of the total herbage biomass. Productive cool-season pasture in Brookings County, SD without leafy spurge can yield 6000 lb/acre in late June (Smart unpublished data). In Year 2, herbicide treatment reduced ($P < 0.01$) leafy spurge biomass compared to the control (Table 1). This was a result of smaller stems since stem density was not significantly different in Year 2 (Table 1). Mow and graze treatments did not reduce leafy spurge biomass compared to the control. The difference between Year 1 from Year 2 resulted in an 850 lb/acre decrease ($P < 0.01$) in leafy spurge biomass, however, grass production did not increase compared to the control (Table 2). Leafy spurge density decreased ($P < 0.01$) by 6 plants per ft^2. Mow and graze treatments did not differ from the control.

Leafy spurge stem densities in this study were at levels that would hinder grazing utilization by cattle (Hein and Miller, 1992). Our results are typical of other herbicide studies, in that leafy spurge is reduced but not eradicated with herbicide application (Lym and Messersmith, 1985). The lack of reduction in leafy spurge biomass or stem density using mow and graze is also typical of first year results (Lacey and Sheley, 1996). Strategies that combine treatments may be more effective in reducing leafy spurge. Lacey and Sheley (1996) showed that sheep grazing in combination with picloram was more effective than either one alone.

Implications

Use of herbicide to control leafy spurge is a promising way to suppress leafy spurge in the first year of treatment. However, costs associated with this form of treatment may not be economically feasible for large infestations. Future research will focus on grazing strategies throughout the growing season in combination with herbicide treatment to suppress the growth of leafy spurge with analysis of the costs associated with the treatments.

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Table 1. Leafy spurge and grass biomass and leafy spurge stem density from Brookings, SD

	Year 1			Year 2		
Treatment	Leafy Spurge, lb/acre	Grass, lb/acre	Leafy Spurge, No. of stems/ft^2	Leafy Spurge, lb/acre	Grass lb/acre	Leafy Spurge, No. of stems/ft^2
Control	1440	2370	13	1640[a]	2660	12
Mow	1390	2370	11	1470[a]	2020	13
Graze	1450	2440	12	1530[a]	2790	11
Herbicide	1870	2070	15	1030[b]	2350	9
Std Error	162	207	1.3	90	160	1.7
LSD	519	661	4.1	288	514	5.3

[a,b] Means with different superscripts within a column differ $P < 0.01$.

Table 2. Change in leafy spurge and grass biomass and leafy spurge plant density from Year 1 to Year 2 near Brookings, SD

Treatment	Leafy Spurge, lb/acre	Grass lb/acre	Leafy Spurge No. of Stems/ft^2
Control	210[a]	290	-0.4[a]
Mow	90[a]	-350	2.0[a]
Graze	80[a]	300	-0.6[a]
Herbicide	-850[b]	280	-6.1[b]
Std Error	138	256	1.1
LSD	441	820	3.4

[a,b] Means with different superscripts within a column differ $P < 0.01$.

Sod Suppression Techniques for Legume Interseeding[1]

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BEEF 2005 - 21

Summary

Sod suppression is necessary for successful establishment of legumes interseeded into existing pasture; however such techniques vary in their effectiveness, cost, and management. Sod suppression experiments for legume interseeding into cool-season pasture were conducted at South Dakota State University's Cow-Calf Unit located near Brookings, SD in 2003 to 2005. We evaluated (i) spring burn, (ii) field cultivator or disk, (iii) herbicide, (iv) heavy fall and spring graze, and (v) a control with no sod suppression. Legume species were alfalfa, birdsfoot trefoil, and kura clover. Sod suppression techniques enhanced the success of legume interseeding. In this study, the grazing equaled or was better than herbicide as a sod suppression technique. Field cultivating, disking or spring burning did not enhance the success of legume establishment. Alfalfa had a greater establishment in the drier year of 2003. Birdsfoot trefoil had greater establishment in the wetter year of 2004. Kura clover was not successful in establishment. Costs of sod suppression techniques varied from $0 per acre (grazing) to $13.30 per acre (herbicide). Management of sod suppression techniques is important to provide a long enough window for legumes to establish with minimal competition from existing grass. Managers can choose the sod suppression technique and legume that fits their resources, skills, and comfort level to achieve successful legume interseeding.

Introduction

Legumes grown in combination with grass pasture have been shown to be very beneficial for increased livestock production. Forage legumes can reduce annual nitrogen fertilizer application through their ability to fix nitrogen (Alexander and McCloud, 1962). Estimates of nitrogen fixation for forage legumes in grass pasture range from 70 to 100 lb N per acre (Matches, 1989; Burton and DeVane, 1992). Forage nutritive value of cool-season grass pastures has been shown to improve when forage legumes are grown in the sward because nutritive value of legumes tends to be higher than grasses (Sanderson and Wedin, 1989; Ullerich et al., 2002). Grass-legume pastures have been shown to provide a more uniform seasonal distribution of forage than grass pastures (Sheaffer et al., 1990; Gerrish, 1991; Belsky and Wright, 1994). All of these factors are responsible for better animal performance on grass-legume pasture versus pure grass pasture. An extensive review of grazing studies in the temperate northern USA has shown higher average daily gain on grass-legume pastures (1.43 lb per day) versus pure grass pasture (1.30 lb per day), even when nitrogen fertilizer was added (Burns and Bagley, 1996). Unfortunately, successful establishment practices and stand persistence are not fully understood, especially under diverse management systems. A better understanding of these factors and how they govern the complex establishment process will improve our knowledge of legume-grass pasture resources.

The suppression of existing vegetation with herbicides and the development of new planting methods have greatly increased the success of inter-seeding legumes (Moshier and Penner 1978; Olsen et al., 1981; Cuomo et al., 2001; Seguin et al., 2001). Establishment success is still limited by seedling vigor, lack of moisture, high temperatures, low fertility, low pH, diseases, and winter-killing (Vough et al., 1995). It is clear from various studies (Kunelius et al., 1982; Cuomo et al., 2001; Seguin et al., 2001) that competition from existing vegetation is the main constraint to establishment. Costs, performance, and effects on the environment are reasons why alternative methods to herbicides are desirable to control existing grass

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competition. These may not always be as successful as herbicides (Kunelius et al., 1982). Very little is known about the use of burning or grazing as sod suppression techniques to interseed legumes. The objectives of this study were to examine the establishment success and economics of four sod suppression techniques for the establishment of legumes in smooth bromegrass (*Bromus inermis* Leyss.)/Kentucky bluegrass (*Poa pratensis* L.) dominated pastures in eastern South Dakota.

Materials and Methods

Two experiments were conducted from 2002 through 2005 at South Dakota State University's Cow-Calf Unit located near Brookings, SD. The pasture vegetation was dominated by smooth bromegrass and Kentucky bluegrass with minor amounts of intermediate wheatgrass [*Elytrigia intermedia* (Host) Nevski subsp. *intermedia*] and quackgrass [*Elytrigia repens* (L.) Desv. ex Nevski] on a Fordtown-Spottswood loam soil (Fine-loamy over sandy, mixed Pachic Udic Haploborolls). Climate is continental with a monthly mean maximum temperature of 82°F occurring in July and a monthly mean minimum temperature of 11°F in January from a 30 yr (1975-2004) average (USDC, 2004). Average annual precipitation is 23.2 in with June being the wettest month and 79% of the annual precipitation occurring between April and September (USDC, 2004).

The experimental design was a randomized complete block with four replications for both experiments. Treatments were arranged in a split plot design with sod suppression method as the whole plot and legume species as the subplot. Whole plot experimental units were 20 x 44 ft in Experiment I and 20 x 28 ft in Experiment II. Subplot experimental units were plots 12 x 20 ft. Alleyways 4 ft wide separated each subplot. In Experiment I, sod suppression treatments were (i) spring burn conducted immediately after seeding, (ii) field cultivate with 6 in sweeps spaced 9 in apart that dug approximately 4 in deep immediately prior to seeding, (iii) herbicide application of glyphosate [isopropyl amine of N-(phosphono-methyl) glycine] at 0.5 lb of active ingredient per acre applied immediately after seeding, (iv) heavy fall and spring graze, and (v) a control with no sod suppression. Beginning graze dates for the heavy fall and spring graze treatment were 26 August 2002 and 16 May 2003. Grazed plots in the fall were stocked with two beef heifers weighing approximately 1000 lb for 1 day by fencing a 40 x 40 ft area (56 animal unit days, AUD pre acre) to achieve a residual vegetation height of < 2 in. The same areas were grazed in the spring with a cow-calf pair weighing approximately 1400 lb for 2 d (78 AUD per acre). In Experiment II, sod suppression treatments were (i) spring burn conducted immediately after seeding, (ii) disk approximately 4 in. deep immediately prior to seeding, (iii) herbicide application of glyphosate at 0.5 lb of active ingredient per acre applied immediately after seeding, (iv) heavy fall and spring graze, and (v) a control with no sod suppression. Beginning graze dates for the heavy fall and spring graze treatment were 4 September 2003 and 30 April 2004. Grazed plots in the fall were stocked with a beef heifer weighing approximately 1000 lb for 1 d (28 AUD per acre). The same areas were grazed in the spring after seeding with a cow-calf pair weighing approximately 1400 lb for 2 d (78 AUD per acre). Both experiments were fenced after seeding and no defoliation occurred until July of the second year.

Seeding date for Experiment I and Experiment II was 16 May 2003 and 30 April 2004, respectively. In Experiment I, seeding rate for 'Ameristand 403+Z' alfalfa (*Medicago sativa* L.), 'Norcen' birdsfoot trefoil (*Lotus corniculatus* L.), and 'Endura' kura clover (*Trifolium ambiguum* Bieb.) was 10, 10, and 12 lb per acre respectively. In Experiment II, Ameristand 403+z alfalfa and Norcen birdsfoot trefoil were seeded at 10 lb per acre each. Plots were seeded with an 8 row, 5 ft wide Truax FlexII No-till drill (Truax Company Inc., New Hope, MN).

Stand counts were collected in late June during the establishment year and one year after establishment in mid-May for each experiment. Stand data were collected from the middle 4 rows of the drill pass using a 24 x 30 in frame divided into 20 squares. Eight samples were taken from each subplot. Frequency of occurrence for each subplot was calculated by tallying the number of squares that contained live-rooted plants of planted species and divided by 160. Plant density was estimated by assuming that presence of one rooted plant per 20, 6 x 6 in, squares or 5% occurrence equaled 0.2 plants per ft^2. Herbage biomass was estimated one year after establishment on 4 June 2004 in Experiment I and on 11 July 2005

in Experiment II by clipping vegetation near the soil surface from four 3.9-ft square frames per subplot. Samples were dried in a forced air oven at 140°F for 72 hours. Samples were weighed and yield was calculated.

Frequency of occurrence during the year of establishment, one year after establishment, and biomass were analyzed separately for each experiment using analysis of variance procedures. A split plot model was calculated using PROC MIXED (SAS, 1999). Sod suppression treatment and species were considered fixed effects and block and block x sod suppression treatment were considered random effects. Least square means and standard errors were calculated using the LSMEANS statement and separated using the PDIFF option (SAS, 1999). Mean comparisons were considered significantly different at $P \leq 0.05$.

Results and Discussion

Climate

Establishment year temperatures for each experiment during the growing season were slightly below the 30-yr average (Table 1) and very favorable for establishment of cool-season species. The daily maximum temperature during this period reached > 90°F only 16 and 4 times, in 2003 and 2004, respectively (data not shown). Precipitation was 4.5 in below the 30-yr normal in 2003, but was 1.8 in above normal in 2004. Precipitation was very timely in 2004 with twice the normal precipitation falling in May and above normal precipitation in July (Table 1). Both years were below normal in August and September precipitation was above normal.

Sod Suppression

To equate the frequency of occurrence to a density measurement (plants per ft^2) in this study, one multiplies the frequency of occurrence x 20 squares divided by 5 ft^2. A 25% frequency of occurrences equals 1 plant per ft^2 which we considered an acceptable stand. The success of species establishment varied across different sod suppression techniques as indicated by a significant ($P < 0.01$) sod suppression by species interaction for frequency of occurrence during the year of establishment in Experiment I, Experiment II, and one year after establishment in Experiment I but not in Experiment II. Since the rankings of species remained constant among sod suppression treatments in both experiments, the presence of the interactions would not be expected to change the conclusions drawn from the different sod suppression techniques used for these species.

Fall and spring graze treatment had the greatest ($P = 0.05$) legume frequency of occurrence during the year of establishment in Experiment I (Table 2). Field cultivate had the second greatest legume frequency of occurrence followed by burn, herbicide and no sod suppression. In Experiment II, fall and spring graze, herbicide, and no sod suppression treatment had the greatest ($P = 0.05$) frequency of occurrence of legumes during the establishment year (Table 2). Frequency of occurrence was less ($P = 0.05$) in burn and disk treatments.

Estimated plant density during the year of establishment for fall and spring graze treatment averaged approximately 3 plants per ft^2 over both experiments. Similar graze treatments by Seguin et al. (2001) produced plant density of clover species (*Trifolium* spp.) equal to herbicide or mowed + fall graze suppressed sod. Uneven surfaces due to tillage or black surface caused by burning may have provided unfavorable characteristics that caused poorer emergence or seedling death in the field cultivate/disk or burn treatments compared to graze or herbicide treatments. It is unclear why the frequency of occurrence of legumes in the herbicide treatment was similar to no sod suppression in Experiment I and II. Cuomo et al. (2001) reported legume stands of < 1% without herbicide sod suppression. Favorable precipitation in 2004 may have benefited the legumes in the no sod suppression plots. Another explanation may be the timing of when stand counts were taken. In this study, stand counts were made mid-summer approximately 2 months after seeding whereas Cuomo et al. (2001) reported stand counts in the fall during the year of establishment.

A better measure of stand establishment success comes from the frequency of occurrence of legumes measured one year after establishment. In Experiment I, only the fall and spring graze treatment had a frequency of occurrence near that of an acceptable stand (≥ 1 plant per ft^2; Table 2). None of the other sod suppression treatments had greater frequency of occurrence of legumes than no sod suppression.

In Experiment II, fall and spring graze, herbicide, and burn sod suppression treatments had the greatest frequency of occurrence of legumes a year later (Table 2). The other treatments were similar to no sod suppression, but produced acceptable stands.

Species

In Experiment I, alfalfa had a higher (P< 0.01) frequency of occurrence during the year of establishment than birdsfoot trefoil or kura clover (Table 3). Similar to the findings of Cuomo et al. (2001), kura clover had the least (P< 0.01) frequency occurrence, probably a result of poor seedling vigor (Lucas et al., 1980; Scott, 1985). In Experiment II, birdsfoot trefoil had a higher (P< 0.01) frequency of occurrence during the establishment year than alfalfa. We attribute these differences to precipitation during the year of establishment (Table 1). Alfalfa is known for its drought tolerance and need for well drained soils (Barnes and Sheaffer, 1995). During Experiment II, precipitation in May was twice that of Experiment I, which could have resulted in wetter conditions more favorable for birdsfoot trefoil seedlings (Beuselinck and Grant, 1995). Frequency of occurrence the year after establishment was greatest for alfalfa in Experiment I and greatest for birdsfoot trefoil in Experiment II (Table 3). In Experiment I, stand counts one year after establishment were less than reported by Cuomo et al. (2001) for the same species. In Experiment II, birdsfoot trefoil stands were greater than those reported by Cuomo et al. (2001), which we attributed to favorable moisture conditions.

Costs and Management

Costs of sod suppression treatments were estimated from various sources. Burn treatment was estimated at $2 per acre from Ortman et al. (1996). Cost of tillage operation (field cultivate or disk) was estimated at $4.60 per acre (Lazarus and Selley, 2004). Herbicide cost was estimated at $13.30 per acre from an herbicide price list by Wrage et al. (2002), including a custom application fee of $6.50 per acre (Volga Coop, personal communication). Cost of heavy fall and spring graze was $0 per acre, because it was assumed that fencing and water would be in place and rotation of cattle to pastures would be part of the overall grazing system for an operation.

Clearly, from a cost savings perspective, heavy fall and spring grazing was the least expensive followed by burning, tillage, and herbicide. From a management standpoint, burning requires a familiarity and a level of comfort to be able to use as a sod suppression technique. The window of opportunity can be narrow because certain environmental conditions have to be favorable to allow for a burn (Masters et al., 1990). A burn permit may be required which takes additional time to obtain.

Heavy fall and spring grazing requires a high stock density and monitoring efforts from the manager to achieve defoliation of vegetation of <2 in. stubble height. For example, in our study stocking rates ranged from 28 to 78 AUD per acre (approximately 20 to 55 cows weighing 1400 lb grazing one acre for one day) to achieve the desired level of defoliation in the fall and spring. There could be a loss of animal performance in order to achieve this level of defoliation because quantity of forage may be inadequate as stubble height decreases. If the size of the pasture renovation project is quite large (> 80 acres) it could take considerably more animals or a longer grazing period to achieve the desired level of defoliation. Minimizing the time it takes to achieve the desired defoliation will minimize any loss in animal performance.

Tillage using a disk or field cultivator is relatively risk free and management issues are few. Both implements are readily available. Excessive precipitation in the spring or conflicts with other farming operations are most likely timing issues associated with tillage. Management issues to consider for herbicide are timing of application and correct rates. Whether done by the operator or hired by custom applicator, these issues are not trivial. If herbicide application is too early, the effective window of sod suppression may be shortened and could result in poor stand establishment. If the application of herbicide is too late, it could kill emerging legume seedlings. The correct herbicide rate is critical in providing a long window of sod suppression for legume establishment, but not carrying over into the next year and thereby potentially reducing forage production. All of these sod suppression techniques are designed to reduce the competition of existing grass to allow the legume seedling a chance to establish. Increased weeds and reduced yield can be negative carryover effects of sod suppression a year after application. In Experiment I, heavy fall and spring graze was the only treatment to

significantly (P = 0.10) reduce forage yield one year following establishment (Table 4). However, in Experiment II there was no reduction in biomass from sod suppression treatments. Seguin et al. (2001) showed mixed results of herbicide reducing herbage yield one year after establishment, however grazing did not reduce herbage yield. If pasture yield is a concern, providing a spring or fall grazing deferment may improve plant vigor enough to restore the pasture's productivity.

Implications

Sod suppression techniques enhance the success of legume interseeding. Burn-down herbicides are commonly recommended to control the competition from the existing grass sod for legumes seedlings to establish. We showed that alternative physical techniques such as spring burning, field cultivating or disking, and heavy fall and spring grazing are also effective. In this study the performance of sod suppression techniques such as grazing equaled or were better than herbicide. Costs of such treatments vary from $0 per acre (grazing) to $13.30 per acre (herbicide). Management of sod suppression treatments is important to provide a long enough window for legumes to establish with minimal competition from existing grass. Managers can choose the sod suppression technique and legume that fits their resources, skills, and comfort level to achieve successful legume interseeding.

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Tables

Table 1. Average maximum monthly temperature and monthly precipitation for May through September for Brookings, SD.

	Year		
Month	2003	2004	30-yr mean
	Mean Maximum Temperature		
	---------- °F ----------		
May	65	65	68
June	75	73	77
July	82	79	82
Aug.	83	70	79
Sep.	75	75	71
	Precipitation		
	---------- inches ----------		
May	2.7	6.2	2.9
June	3.3	2.7	4.3
July	2.8	4.4	3.2
Aug.	2.2	0.9	3.0
Sep.	3.5	6.2	2.7
Annual	18.7	25.0	23.2

Table 2. Frequency of occurrence of interseeded legumes into smooth bromegrass/Kentucky bluegrass pasture using sod suppression treatments near Brookings, SD.

	Establishment year		Year after establishment	
Sod suppression	Experiment I	Experiment II	Experiment I	Experiment II
	---------- Frequency of occurrence % ----------			
Burn	45[c]	53[c]	10[b]	48[ab]
Field cultivate/disk	55[b]	55[bc]	6[b]	32[b]
Fall and spring graze	64[a]	76[a]	23[a]	60[a]
Herbicide	39[cd]	75[a]	5[b]	62[a]
No suppression	38[d]	68[ab]	<1[b]	24[b]
LSD (0.05)	13.9	13.6	10.8	24.6

[a, b ,c ,d] Means within a column followed by similar letters are not statistically different (*P< 0.05*).

Table 3. Frequency of occurrence of alfalfa, birdsfoot trefoil, and kura clover interseeded into smooth bromegrass/Kentucky bluegrass pasture averaged over sod suppression treatments near Brookings, SD

	Establishment year		Year after establishment	
Species	Experiment I	Experiment II	Experiment I	Experiment II
	---------- Frequency of occurrence % ----------			
Alfalfa	77[a]	55[b]	22[a]	38[b]
Birdsfoot trefoil	54[b]	75[a]	5[b]	52[a]
Kura clover	13[c]		<1[b]	
LSD (0.05)	6.2	8.4	8.1	8.5

[a, b ,c ,d] Means within a column followed by similar letters are not statistically different (*P< 0.05*).

Table 4. Herbage biomass one year after establishment in Experiment I (4 June 2004) and Experiment II (11 July 2005) near Brookings, SD.

Sod suppression	Experiment I	Experiment II
	---------- lb per acre ----------	
Burn	2090[ab]	4180
Field cultivate/disk	2140[ab]	3840
Fall and spring graze	1810[b]	4080
Herbicide	2290[ab]	3930
No suppression	2460[a]	3720
LSD (0.05)	480	725

[a, b] Means within a column followed by similar letters are not statistically different (*P< 0.05)*.

Forecasting Forage Yield on Clayey Ecological Sites in Western South Dakota using Weather Data[1]

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Summary

The ability to forecast annual forage yield from weather data would be useful for making appropriate adjustments to stocking rates in order to achieve or maintain desired plant communities. Our objective was to determine the relationship between weather variables and annual forage yield from three distinct plant communities on clayey ecological sites in western South Dakota. Forage yield and weather data were collected from 1945 through 1960 at the Cottonwood Range and Livestock Research Station, in western South Dakota. Pastures stocked at 0.25, 0.40, and 0.60 AUM/acre from 1942 to 1960 developed into western wheatgrass-dominated, western wheatgrass-shortgrass co-dominated, and shortgrass dominated plant communities, respectively. Forage data were compiled from previously reported data and raw data. Spring (April-June) precipitation, the last calendar day that the minimum temperature was 30°F or below, and previous year's spring precipitation were best predictors (R^2 = 0.81) of forage yield in western wheatgrass dominated plant communities. Spring precipitation and the last calendar day that the minimum temperature was 30°F or below were best predictors (R^2 = 0.69) of forage yield in western wheatgrass-shortgrass co-dominated plant communities. Spring precipitation was the best predictor (R^2 = 0.52) of forage yield in shortgrass dominated plant communities. In western South Dakota, managers of these plant communities can make reliable estimates of annual forage yield by the end of June using precipitation and temperature measurements.

Introduction

The ability to forecast annual forage yield from weather data would be useful for making appropriate adjustments to stocking rates in order to achieve or maintain desired plant communities. Identifying the key weather variables that determine forage yield would help managers focus their attention on what to measure and when to make grazing decisions. Stocking rate decisions are critical in determining long-range sustainability and productivity of range ecosystems and ultimately the financial success of ranches. Over-stocking of rangeland has led to increased soil bulk density, increased runoff of water and sediment, reduced soil cover, reduced infiltration, and increased weedy forbs and woody plant species. All of these factors and others lead to a shift in species composition and to less productive vegetation which negatively impacts animal production management opportunities. Therefore enhancing the grassland manager's sensitivity to seasonal influences of weather patterns on forage production will enable managers to make stocking rate adjustments.

In a South Dakota agricultural experiment station bulletin (Johnson et al. 1951), the authors recognized that spring precipitation (April, May, and June) influenced total forage growth more than summer precipitation. Since the warm-season grasses consisted mainly of shortgrasses such as blue grama and buffalograss, late summer rainfall did little to increase the season's total forage production because the cool-season forages had already produced the majority of their biomass for that year. Heitschmidt (2004) confirmed this by examining 15 sites in the northern Great Plains and found that 91% of the annual forage was produced by July 1.

At the Cottonwood Range and Livestock Research Station from 1942 to 1960 different

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summer stocking rates were used to develop three distinct plant communities: western wheatgrass-dominated (historically referred to as excellent range condition), western wheatgass-shortgrass co-dominated (historically referred to as good range condition), and shortgrass dominated (historically referred to as fair range condition). The major tools for determining stocking rates have been condition of range site compared to its ecological potential and annual precipitation. Forecasting annual forage yield from spring weather data would help range managers make mid-season adjustments to stocking rates in order to achieve or maintain desired plant communities. Our objective was to determine the relationship between weather variables and annual forage yield by early summer from three distinct plant communities in western South Dakota.

Materials and Methods

Site Description

This study was conducted at South Dakota State University's Range and Livestock Research Station near Cottonwood, South Dakota. The research station is located in the Northern Great Plains mixed-grass prairie, approximately 75 miles east of Rapid City. Topography of the research station is gently sloping with long, rolling hills and relatively flat-topped ridges. The long-term average annual precipitation from 1909 to 2002 is 16 inches, 77% of which falls from April to September (High Plains Regional Climate Center, 2003). Predominant soil of the experimental pastures is clay developed over the Pierre shale formation. Predominant ecological site classification is Clayey. Vegetation is typical of mixed-grass prairie. Dominant species on native pastures are the cool-season mid-grass, western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Love) and warm-season shortgrasses, blue grama (*Bouteloua gracilis* [H.B.K.] Lag. Ex Griffiths) and buffalograss (*Buchloe dactyloides* [Nutt.] Engelm.). Long-term differential season-long stocking has resulted in the development of three distinct plant communities (Table 1).

Weather Variables

Weather data were collected from the weather station at the research station headquarters approximately 1 mile from experimental pastures. Variables measured were daily minimum and maximum temperature and daily precipitation. From these variables, monthly mean minimum and maximum temperatures were calculated. Three accumulated growing degree day (GDD) indexes were calculated each year using the following equation:

$$GDD = \sum \text{from March 15 to April 30, May 31, or June 30}[(T_{max} + T_{min})/2 - T_{base}]$$

where T_{max}, T_{min}, T_{base} are daily maximum temperature, daily minimum temperature, and base temperature of 40°F, respectively. The last spring calendar day when the daily minimum temperature was below 30°F and the number of times the minimum daily temperature reached below 32°F after April 1 were calculated for each year. Precipitation was summed by month, growing season, and year. Previous spring (April-June), fall (September-December), and annual (January-December) precipitation were calculated for each year. Number and amount of precipitation received in daily rain event size classes from <0.24 in, 0.24 to 0.59 in, 0.63 to 1.18 in, and >1.18 in were summed from April to October for each year, respectively.

Grazing History

In the late 1930s, an experimental plan was developed by researchers to collect data on summer grazing of mixed-grass rangeland at three stocking rates (light, moderate, and heavy) at the Cottonwood station. In 1939 and 1941, rangeland was surveyed, fenced, and water sources were developed for two pastures at each stocking rate treatment (Johnson et al. 1951). Pasture sizes were 180, 133, and 80 acres for the light, moderate, and heavy stocking treatments, respectively. From 1942-1967, pastures were stocked at 0.25, 0.40, and 0.61 AUM/acre for the light, moderate, and heavy stocking rates, respectively (Lewis et al. 1983). During 1942 through 1950 pastures were grazed from May through November by Hereford cows at fixed stocking rates. In 1951, a put-and-take stocking method (the use of variable animal numbers during a grazing period or grazing season, with a periodic adjustment in animal numbers in an attempt to maintain desired sward management, i.e. degree of defoliation; Glossary of Terms in Range Management 1998) was put in place to achieve better control over forage utilization. Utilization (estimated by visual inspection and by clipping outside and inside protected cages) for the light, moderate, and heavy grazing intensities was aimed at 25, 45, and 65%, respectively. In 1953 pastures were stocked with 2-year old Hereford cows and their

performance was monitored through 1959. In 1960, yearling steers were grazed on the pastures at the three stocking rates.

Forage Yield

From 1942 to 1951, forage yield was estimated in each pasture using three movable grazing exclosures (Johnson et al. 1951). At the beginning of each grazing season, grazing exclosures were relocated to different areas within the pasture to estimate the current year's forage yield. Within each exclosure, three 9-ft^2 plots were hand clipped at crown level using grass shears approximately June 15 and August 15 to estimate peak standing biomass of the cool-and-warm-season forages. Forage was air dried and weighed.

During 1952-1954 forage production was estimated by placing two movable grazing exclosures on each of eight different areas based on soil and topography within each pasture (Lewis et al. 1956). At the beginning of each grazing season, grazing exclosures were relocated to different areas within the pasture to estimate current year's forage production. Within each exclosure, three 2-ft^2 plots were clipped in June and August. In 1952 and 1953, medium height grasses were clipped to a 1 in stubble height and short grasses were clipped to crown height. In 1955 all grasses were clipped just above the first leaf. The clipped vegetation was dried in a forced air oven at 140^{o}F for 72 hours and weighed.

From 1956 to 1960, 11 to 21 movable grazing exclosures were located on each pasture to estimate forage yield based on soil and topography. As before, exclosures were moved to new locations within each pasture at the beginning of each year. Within each exclosure, two 2-ft^2 plots were clipped to near ground level with grass shears in June and August to estimate peak standing biomass for cool- and warm-season forages. Clipped vegetation was dried in a forced air oven at 140^{o}F for 72 hours and weighed.

Statistical Analysis

The association between approximately 60 weather variables and annual forage yield from 1945 to1960 was determined using correlation analysis [PROC CORR (SAS 1999)]. Variables that had the strongest correlation with forage yield were used to develop separate prediction equations for each plant community using multivariate, stepwise regression procedures [PROC REG (SAS 1999)]. Data from 1942-1944 were not included in the analysis because grazing treatment effects had not achieved the desired plant communities until 1945 (Johnson et al. 1951).

Results and Discussion

Western Wheatgrass Dominated Plant Communities

Forecasting annual forage yield by the end of June in western wheatgrass dominated plant communities was related best to cumulative spring (April-June) precipitation, the last spring calendar day when the daily minimum temperature was below 30^{o}F, and spring precipitation from the previous year. When forage production in western wheatgrass dominated plant communities was predicted using only a spring precipitation variable, none of the models had an $R^2 > 0.22$. The inability of any single precipitation variable to explain a large portion of the variation in forage yield may be related to the complex dynamics of western wheatgrass dominated plant communities (Table 1). For example, forage yield for the western wheatgrass dominated plant community was highly variable as expressed by its coefficient of variation of 33%. In particular, deviation of annual forage yield from the long-term average did not coincide with similar deviations in spring precipitation. For instance, forage yield was 900 lb/acre above the long-term average in 1949 when spring precipitation was approximately 2.8 in below normal.

When the last spring calendar day when the daily minimum temperature was below 30^{o}F was added to the model, the fraction of variation explained increased (R^2 = 0.47, P = 0.02). Pastures with western wheatgrass dominated plant communities have more cool-season mid-grasses and less warm-season shortgrasses than shortgrass dominated plant communities (Table 1). Partial R^2 attributed to spring precipitation and the last spring calendar day when the daily minimum temperature was below 30^{o}F was 0.21 (P = 0.08) and 0.25 (P = 0.03), respectively. Cool-season grasses such as western wheatgrass typically start growing in mid-April and peak in production by the end of June in the Northern Great Plains (White 1983). Cold temperatures, especially those below 32^{o}F rupture plant cell walls and damage meristem tissue in plants (Pearce and McDonald 1978). Fructans that provide chill tolerance decreases

dramatically in the spring when plants are concurrently developing stem structure (Gonzalez et al. 1990). Therefore, grass plants in a rapid growth phase would be more susceptible to freezing temperatures. As a result, plant dry weight has been reduced after being subjected to low temperatures (Humphreys and Eagles 1988).

When spring (April-June) precipitation from the previous year was added to the model the proportion of variation explained by the model increased to 82% (Table 2). Partial R^2 attributed to spring precipitation, the last spring calendar day when the daily minimum temperature was below 30°F, and spring precipitation of the previous year were 0.12 ($P = 0.07$), 0.19 ($P = 0.01$), and 0.51 ($P < 0.01$), respectively. One reason that spring precipitation was highly correlated ($r = 0.71$, $P < 0.01$) to annual forage production may be due to the fact that 48% of the annual precipitation falls between April-June (HPRCC 2003). The effect of precipitation from the previous year often had a lag effect on current year forage yield. For instance, forage yield was above the 16-year mean in 1949 when current spring precipitation was below normal, but because previous spring precipitation was above normal, there may have been abundant soil moisture for good growth that increased plant vigor in terms of roots and shoot buds for next year's season. Similarly, in 1951 forage yield was 850 lb/acre below the 16 year mean when spring precipitation was only 1.34 in below average, but because spring precipitation the previous year, 1950, was 57% below average, soil moisture and plant vigor was probably reduced in 1951. Favorable spring growing conditions (i.e. moderate temperature and adequate soil moisture) and light grazing are necessary to maintain western wheatgrass dominated plant communities.

Western Wheatgrass-Shortgrass Co-dominated Plant Communities

Forecasting annual forage yield by the end of June in western wheatgrass-shortgrass co-dominated plant communities was related best to cumulative spring precipitation of April-June and the last spring calendar day when the daily minimum temperature was below 30°F (Table 2). When forage yield was predicted by spring precipitation alone, the R^2 was 0.34. Since these plant communities are co-dominated by western wheatgrass and shortgrasses (Table 1), an explanation may be that some spring moisture is used by the cool-season grasses and some is stored in the soil and used later in the growing season for the warm-season shortgrasses. Sala et al. (1992) hypothesized that larger precipitation events tend to wet the soil to depths beyond the influence of evaporation and the more frequently a wet day follows a wet day (small or large rainfall events) the greater the probability that some water will seep deeper into the soil and remain for a longer period. Spring rainfall at Cottonwood followed this pattern. For example, 86% of the rain events were 0.59 in or less and accounted for 54% of the amount of precipitation during April-June. Only 14% of rainfall events were >0.59 in but accounted for 46% of the precipitation during April-June. Of the rain events that occurred during this period, 45% occurred following the day after a previous rain and 70% of them occurred no more than 2 days after a previous rain.

When the last spring calendar day when the daily minimum temperature was below 30°F was added to the cumulative spring precipitation, the model explained more variation in forage yield (Table 2). Partial R^2 attributed to spring precipitation and the last spring calendar day when the daily minimum temperature was below 30°F were 0.33 ($P = 0.02$) and 0.36 ($P < 0.01$), respectively. The relationship between the last spring calendar day when the daily minimum temperature was below 30°F and forage yield in western wheatgrass-shortgrass co-dominated plant communities would be similar to that previously discussed for western wheatgrass dominated plant communities. Previous spring, fall, or annual precipitation was not significantly related to current annual forage yield. This may be related to the rooting depth of warm-season shortgrasses such as blue grama and buffalograss. Blue grama has been shown to have more than 70% of its root biomass in the top 4 in of soil (Coffin and Lauenroth 1991), whereas a greater proportion of western wheatgrass root system is at lower depths (Coupland and Johnson 1965, Weaver 1958).

Shortgrass Dominated Plant Communities

Forecasting annual forage yield by the end of June in shortgrass dominated plant communities was related best to cumulative spring precipitation of April-June (Table 2). Brown and Trlica (1977) showed that blue grama dominated range in eastern Colorado had two production peaks, one in late-July and one in early-

September. The strong relationship between spring precipitation (r = 0.72, P = <0.01) and forage yield in our study indicates that soil moisture was probably being stored, as described by Sala et al. (1992), for warm-season shortgrass production later in the growing season.

Forage yield in shortgrass dominated plant communities was not related to the last spring calendar day when the daily minimum temperature was below 30°F. Since the major species of these plant communities were warm-season and given that the last spring calendar day when the daily minimum temperature was below 30°F averaged May 2 and ranged from April 6 to May 23, the last spring calendar day when the daily minimum temperature was below 30°F would not affect warm-season dominated pastures because the warm-season grasses would not have begun their rapid growth phase until June (Dickinson and Dodd 1976). In addition, forage yield in shortgrass dominated plant communities was not related to spring, fall or annual precipitation received in the previous year. Since these plant communities were dominated by warm-season shortgrasses, which have short root systems, soil moisture stored from the previous year may have been deeper in the soil profile and therefore out of the reach of most of the root system.

Implications

The ability to explain 52-82% of the variation in forage yield from these pastures, which varied in their degree of composition and complexity, using climatic information is important. However, compared to monocultures, the fraction of variation in forage yield explained by climatic variables was less. For example, Currie and Peterson (1966) were able to explain 88% of the variation in crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.] yield from April precipitation, because much of the annual growth of crested wheatgrass was completed by the end of April (Currie and Peterson 1966). Sneva and Hyder (1962) also demonstrated that forage yields from seeded ranges could be predicted accurately (R^2 = 0.80 to 0.94) with crop-year precipitation. Forage yields from native rangeland have been predicted but, with less accuracy (Dahl 1963, Lauenroth and Sala 1992, Smoliak 1956, Sneva and Hyder 1962). It is likely that native rangeland, with greater species diversity and longer duration of forage production would be less predictable from a relatively small number of climatic variables compared to seeded pasture.

Key variables derived from this long-term data set offer a reasonable explanation for the main factors that influence forage yield on these diverse plant communities in clayey ecological sites in western South Dakota. In the western South Dakota mixed-grass prairie, April, May, and June precipitation events, the last spring calendar day when the daily minimum temperature was below 30°F, and spring precipitation from the previous year were useful in forecasting current annual forage yield by July 1. The usefulness is in the ability of managers to make stocking rate adjustments for the rest of the growing season. If forage is going to be below average then strategies, such as early weaning or de-stocking might be necessary to avoid over utilizing forage resources. Likewise, if forage yield is going to be above normal, forage could be stockpiled for winter grazing or more animals could be grazed for a longer period of time.

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Tables

Table 1. Percent species composition, based on biomass, and standard deviation in parenthesis from western wheatgrass dominated (WW), western wheatgrass-shortgrass co-dominated (WWSG), and shortgrass dominated (SG) plant communities averaged over 1952-1960 at the SDSU Cottonwood Range and Livestock Research Station, Cottonwood, SD.

	Plant Community		
Species	WW	WWSG	SG
	---------- % Composition ----------		
Blue grama	14 (15)	22 (18)	17 (18)
Buffalograss	22 (22)	45 (24)	63 (22)
Western wheatgrass	39 (24)	17 (13)	9 (11)
Other[1]	15 (NA)	16 (NA)	11 (NA)

[1]Other is calculated by difference, standard deviation not available.

Table 2. Prediction equations of forage yield from weather variables in western wheatgrass dominated (WW), western wheatgrass-shortgrass co-dominated (WWSG), and shortgrass dominated (SG) plant communities from 1945-1960 at the SDSU Cottonwood Range and Livestock Research Station, Cottonwood, SD.

Plant Community	Variables[1]	Prediction equation[2]	R-square	P-value
WW	S, PS, DOY	Y = 2464 + 120(S) + 153(PS) – 22(DOY)	0.81	<0.01
WWSG	S, DOY	Y = 2717 + 117(S) – 19(DOY)	0.69	<0.01
SG	S	Y = 519 + 84(S)	0.52	<0.01

[1]S equals cumulative precipitation (in) for April-June; PS equals previous year's spring (April-June) cumulative precipitation (in); DOY equals the last spring calendar day when the daily minimum temperature was below 30°F.
[2]Y equals forage yield (lb/acre).

Spring Drought Effects on Rangeland Forage Yield from Clayey Ecological Sites in Western South Dakota [1]

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Summary

Understanding the historical influence of seasonal precipitation, especially spring precipitation, and stocking rate on forage yield would be desirable for planning purposes. The objectives of this study were to examine the historical precipitation pattern and how it influenced forage yield on pastures that were stocked at light, moderate, and heavy stocking rates for 15 years at the Cottonwood Range and Livestock Research Station in western South Dakota. Weather data from 1909 to 2004 at the station were analyzed to determine the frequency of occurrence of below (≤75 of mean), normal, and above normal (>125% of mean) spring precipitation (April, May, June). Additional data from the station provided for an examination of the relationships between weather and forage yield from pastures grazed at three stocking rates. Forage yield and precipitation data were collected from 1945 to 1960 from pastures continuously grazed from May to November at 0.25, 0.40, and 0.60 AUM/acre. Analysis of variance was used to test influence of spring precipitation (spring drought and non-spring drought) and stocking rate (light, moderate, and heavy) on forage yield. Below normal, normal, and above normal spring precipitation occurred 29, 48, and 23% of the time, respectively. Forage yield in spring drought years was 420 lb/ac less ($P < 0.01$) than in non-spring drought years. Lightly stocked pastures had 38 and 71% more ($P < 0.01$) forage than moderate and heavily stocked pastures. Spring droughts reduced forage yield ($P < 0.01$) in light, moderate, and heavily stocked pastures by 20, 27, and 35%, respectively. Forage yield from lightly stocked pastures during spring droughts was similar to heavily stocked pastures in non-spring drought years. Our study indicates that spring precipitation should guide stocking rate decisions made during the growing season. Light and moderate stocking rates reduce the impact of spring drought on forage yield more than heavy stocking rates.

Introduction

Anticipating low rainfall and having the flexibility to respond has been common advice from rangeland management professionals and ranchers who have successfully weathered previous droughts. Properly managing rangeland resources requires an acceptance that droughts occur and willingness to plan based on this certainty. The Society of Range Management (1974) glossary stated that drought is “prolonged dry weather, generally when precipitation is less than three-quarters of the average annual amount”. However, annual precipitation may not be related to yield because the distribution does not always overlap the growing season. In the northern mixed-grass prairie of the Great Plains the amount of spring precipitation during April, May, and June is the most important indicator of current year’s forage production (Smart et al., 2005). Johnson et al. (1951) recognized this phenomenon and also noticed that summer precipitation was below 75% of normal 6 out of 7 years. Since the warm-season grasses on these ecological sites consisted mainly of shortgrasses, such as blue grama and buffalograss, late summer rainfall did little to increase growing season forage production because the cool-season forages had already produced the majority of their biomass for that year. In Heitschmidt’s (2004) review of results from 15 experiments in the northern Great Plains, 91% of the annual forage was produced by July 1. An historical data set from the Cottonwood Range and Livestock Research Station provided for an examination of the relationships between weather and forage yield from pastures grazed at three stocking rates. The objectives of this study were to

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examine the historical precipitation pattern and how it influenced forage yield on pastures that were stocked at light, moderate, and heavy stocking rates for 15 years.

Materials and Methods

Site Description

This study was conducted at South Dakota State University's Range and Livestock Research Station near Cottonwood, South Dakota. The research station is located in the Northern Great Plains mixed-grass prairie, approximately 75 miles east of Rapid City, SD. Topography of the research station is gently sloping with long, rolling hills and relatively flat-topped ridges. Long-term average annual precipitation from 1909 to 2002 is 16 inches, 77% of which falls between April and September (USDC 2004). Predominant soil of the experimental pastures is clay developed over the Pierre shale formation. Predominant ecological site classification is Clayey. Vegetation is typical of a mixed-grass prairie. Dominant species on native pastures are the cool-season mid-grass, western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Love) and warm-season shortgrasses, blue grama (*Bouteloua gracilis* [H.B.K.] Lag. Ex Griffiths) and buffalograss (*Buchloe dactyloides* [Nutt.] Engelm.).

Weather Variables

Precipitation data were collected at the research station headquarters approximately 1 mile from experimental pastures from 1909 to 2004. Spring precipitation was the sum of April, May, and June rainfall. The frequency of years with normal or above normal spring-rainfall that occurred between below normal spring-rainfall years was calculated. The overall mean spring precipitation was calculated over the 95 year period. Spring precipitation was categorized into below normal (≤75% of mean), normal (>75% but ≤125% of mean), and above normal (>125% of mean).

Grazing History

In the late 1930s, an experimental plan was developed by South Dakota State University to collect data on summer grazing of mixed-grass rangeland at three stocking rates (light, moderate, and heavy) at the Cottonwood Station. From 1939 to 1941, rangeland was surveyed, fenced, and water sources were developed to provide two pastures at each stocking rate (Johnson et al. 1951). Pasture sizes were 180, 133, and 80 acres for light, moderate, and heavy stocking treatments, respectively. From 1942-1960, pastures were stocked at 0.25, 0.40, and 0.60 AUM/acre for light, moderate, and heavy stocking rates, respectively (Lewis et al., 1983). During 1942 through 1950 pastures were grazed from May through November by cows with calves (*Bos tarus* L.) at fixed stocking rates. This grazing pattern resulted in distinct plant communities. In 1951, a put-and-take stocking method was put in place to achieve better control over forage utilization and maintain distinct plant communities. This method entails the use of variable animal numbers during a grazing period or grazing season, with a periodic adjustment in animal numbers to maintain desired degree of defoliation (SRM, 1998). Utilization for the light, moderate, and heavy grazing intensities estimated by visual inspection and by clipping outside and inside protected cages, was targeted at 25, 45, and 65%, respectively. In 1953 pastures were stocked with 2-year old cow-calf pairs. In 1960 yearling steers were grazed on the pastures at the three stocking rates.

Forage Yield

Forage yield data were available for 15 years. From 1942 to 1951, forage yield was estimated in each pasture using three movable grazing exclosures (Johnson et al. 1951). At the beginning of each grazing season, grazing exclosures were relocated to different areas within the pasture to estimate the annual forage yield. Within each exclosure, three 9-ft^2 plots were hand clipped at crown level using grass shears approximately June 15 and August 15 to estimate peak standing biomass of the cool-and-warm-season forages. Samples were air dried and weighed.

In 1952-1954 forage production was estimated by placing two movable grazing exclosures on each of eight different areas based on soil and topography within each pasture (Lewis et al. 1956). At the beginning of each grazing season, grazing exclosures were relocated to different areas within the pasture to estimate annual forage production. Within each exclosure, three 2-ft^2 plots were clipped in June and August. In 1952 and 1953, medium height grasses were clipped to a 1 in stubble height and short grasses were clipped to crown height. In 1955 all grasses were clipped just above the first leaf.

Clipped vegetation was dried in a forced air oven at 140°F for 72 hours and weighed.

From 1956 to 1960, 11 to 21 movable grazing exclosures were located on each pasture to estimate forage yield based on soil and topography. As before, exclosures were moved to new locations within each pasture at the beginning of each year. Within each exclosure, two 2-ft^2 plots were clipped to near ground level with grass shears in June and August to estimate peak standing biomass for cool- and warm-season forages. Clipped vegetation was dried in a forced air oven at 140°F for 72 hours and weighed.

Statistical Analysis

Analysis of variance was used to test the effects of spring precipitation (spring drought and no spring drought), stocking rate (light, moderate, and heavy) and the spring precipitation x stocking rate interaction on forage yield from 15 years of data using SAS (1999). Year was considered replication and pasture was the experimental unit. Mean treatment differences were considered significant at $P = 0.10$ level. Data from 1942-1944 were not included in the analysis because grazing treatment effects had not achieved the desired plant communities until 1945 (Johnson et al. 1951).

Results and Discussion

Weather

The cumulative spring precipitation data for the months of April, May, and June from 1909 to 2004 at the Cottonwood Range and Livestock Station near Philip, SD are presented in Fig. 1. As expected, spring precipitation was highly variable over the 95 years. Below normal (≤75% of mean), normal, and above normal (>125% of mean) occurred 29, 48, and 23% of the time, respectively. During the decades of 1910's through 1950's, below normal spring precipitation occurred nearly 40% of the time while only occurring 15% of the time from 1960's to 1990's (Fig. 1).

The occurrence of past events provides insight about what kind of spring-rainfall might be expected given current rainfall patterns. Information about the occurrence of events such as the number of years of favorable spring-rainfall between spring-drought years is an informative use of this historical data. The occurrence and frequency of favorable spring-rainfall years between spring-drought years were calculated (Table 1). Consecutive spring droughts, which are represented by zero favorable spring-rainfall years between spring-drought years, occurred 33% of the time. Fifty-one percent of the favorable spring-rainfall years lasted from 1 to 4 years. Only 16% of the favorable spring-rainfall years lasted more than 7 years (Table 1). The use of this historical data can be illustrated in the following example. Prior to 2002, favorable spring growing conditions had occurred seven years in a row in at Cottonwood. Expecting an eighth consecutive year of above normal or normal spring rainfall was unlikely based on the historical data. Ranchers and rangeland resource professionals should have been expecting a drought. Realizing that consecutive spring droughts occurred 33% of the time, the risk of reduced forage production was great. Knowing and understanding historic precipitation patterns is a critical first step to a prudent management response.

Impact on Forage Resources

The impact that spring drought can have on forage yield is dramatic. At the Cottonwood Station, forage yield averaged 420 lb/ac less during years with below normal spring precipitation than in normal or above normal years (Table 2). This translates to an average decrease of 0.18 AUM/acre. Stocking higher in normal and above normal spring-rainfall years can result in lower forage carryover into subsequent years, compounding the effects of drought. Stocking for the average forage yield would give the flexibility to hay excess forage in an above spring-rainfall year. Since the majority of the forage is produced by July 1 decisions to de-stock by selling off cattle or weaning early to adjust grazing pressure can be fit into a management plan.

Stocking rate had a greater effect on forage yield than spring drought (Table 2). Forage yield from moderate and heavy stocking averaged 500 and 750 lb/ac less than lightly stocked pastures. In addition, spring droughts reduced forage production on light, moderate, and heavily stocked pastures by 20, 27, and 35%, respectively. Also, during spring droughts, lightly stocked pastures had 1.9 times more forage than heavily stocked pastures. During non-spring drought years, heavily stocked pastures had the same forage yield as did lightly stocked pastures in spring drought years (Table 2). If stocking rates are not adjusted during

drought years, grazing pressure is dramatically increased. The mixed-grass plant community can shift from western wheatgrass dominated to western wheatgrass-shortgrass co-dominate to shortgrass dominated relatively quickly. Johnson et al. (1951) found this happened in less than 5 years. It is also true that plant communities can shift in the opposite direction in years with above normal spring precipitation and lower stocking rates. How long it takes to move from shortgrass dominated to western wheatgrass-shortgrass co-dominated or western wheatgrass dominated plant communities is unknown. The ability to predict forage yield and make appropriate stocking rate adjustments is necessary to sustain plant communities dominated by western wheatgrass. The merits of deferred rotation at proper stocking rates for improving range condition in the Northern Great Plains are well known (Rogler, 1951, Sampson 1951, Smoliak 1960). Klipple and Bement (1961) argued that light grazing is an economically feasible method for improving deteriorated rangeland.

Implications

At the Cottonwood Station, our study found that below normal, normal, and above normal spring precipitation occurred 29, 48, and 23% of the time. The frequency of 1 to 4 favorable spring moisture years between spring drought years was 51%. Consecutive spring droughts occurred during 33% of the 95-year period. Historical precipitation patterns are a useful guide for planning. Forage yield in moderate and heavily stocked pastures was 72 and 58% less than lightly stocked pastures. Forage yield in heavily stocked pastures was 1.9 times less than lightly stocked pastures during spring droughts. During spring drought, lightly stocked pastures had the same forage yield as heavily stocked pastures in non-spring drought years. Our study indicates that spring precipitation is a useful management tool for stocking rate decisions made during the growing season. Light and moderate stocking rates reduce the impact of spring drought on forage yield more than heavy stocking rates.

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Tables

Table 1. Number and frequency of normal or above normal spring (cumulative April, May, and June) rainfall years between years having below normal spring rainfall at South Dakota State University's Cottonwood Range and Livestock Station from 1909 to 2004.

Normal or above normal spring rainfall years between years having below normal spring rainfall	Times occurred	
Event	No.	%
0	9	33
1	5	18
2	3	11
3	4	15
4	2	7
5	0	-
6	0	-
7	1	4
8	1	4
9	1	4
10	0	-
11	0	-
12	0	-
13	1	4
Total	27	100

Table 2. Forage yield from pastures stocked season-long (May-November) at light, moderate, and heavy stocking rates during years with spring-droughts (≤5.7 inches, ≤75% of mean) and no spring-droughts (>5.7 inches) of April through June precipitation from 1945 to 1960 at the Cottonwood Range and Livestock Station near Philip, SD.

	Spring Precipitation (April-June)[2]		
Stocking rate[1]	Spring drought	Non spring drought	Mean[3]
	---------- lb/ac ----------		
Light	1590[ab]	2000[a]	1800[j]
Moderate	1100[bc]	1510[b]	1300[k]
Heavy	840[c]	1280[b]	1050[k]
Mean[4]	1180[y]	1600[z]	

[1]Stocking rates for light, moderate, and heavy grazing were 0.25, 0.40, 0.60 AUM/ac, respectively.
[2]Means within a row and column followed by different letters (a, b, c) are significantly different (*P < 0.10)*.
[3]Means within a column followed by different letters (j, k) are significantly different (*P < 0.10*).
[4]Means within a row followed by different letters (y,z) are significantly different (*P < 0.10*).

Figures

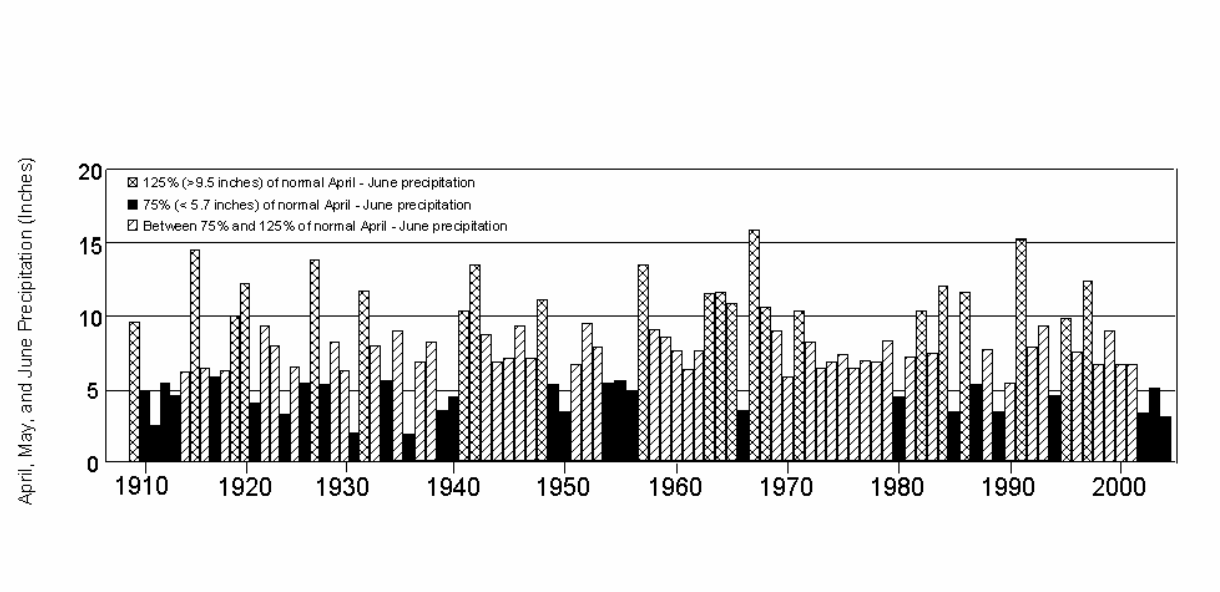

Figure 1. Cumulative precipitation for April, May, and June from 1909 to 2004 for the Cottonwood Range and Livestock Station, located 75 miles east of Rapid City, South Dakota in the mixed-grass prairie. Mean precipitation for April, May, and June is 7.6 inches (USDC 2004).

Comparison of the Efficiency and Accuracy of Three Estrous Detection Methods to Indicate Ovulation in Beef Cattle [1]

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Summary

The ability to successfully artificially inseminate cattle requires determining the appropriate time to inseminate. Therefore, detection of standing estrus is a major factor in the success or failure of most artificial insemination programs. The objective of these experiments was to determine the efficiency and accuracy of three estrous detection methods (visual, penile deviated bull, and Estrus Alert estrous detection aids) to determine if animals were going to ovulate. Fifty-three postpartum beef cows were synchronized with an injection of gonadotropin releasing hormone (**GnRH**) followed by an injection of prostaglandin F_2 (PG) seven days later. Estrus was monitored for 72 hours following the PG injection by visual estrus detection and Estrus Alert estrous detection aids. Thirty-seven beef heifers were synchronized with an injection of GnRH and insertion of a Controlled Internal Drug Releasing (**CIDR**) device on day 0. On day 7 an injection of PG was administered and the CIDR was removed from half the heifers on day 7 and the remaining heifers on day 14. Estrus was monitored for 5 days following CIDR removal by visual estrus detection, a penile deviated bull, and the Estrus Alert estrous detection aids. Ovulation was determined in all animals by transrectal ultrasonography between 48 and 96 hours after the onset of standing estrus. The percentage of animals detected in standing estrus and the percentage correctly identified as going to ovulate was similar (*P > 0.78*) among all three methods. In summary, intensive visual estrus detection, a marker animal, or proper use of estrous detection aids can correctly identify the majority of animals that will ovulate.

Introduction

Reproductive failure is a major factor effecting the production and economic efficiencies of dairy and beef operations (Bellows et al., 2002). Furthermore, the success of any breeding program requires detecting the animals that are ready to be bred and inseminating them at the correct time prior to ovulation. With natural service, the herd bull detects when cows should be inseminated, but when artificial insemination is used the herdsman must now decide when cows are ready to be inseminated. Therefore, failing to detect estrus and incorrect detection of estrus can result in significant economic losses (Heersche and Nebel, 1994).

Currently, detection of standing estrus is the best indicator of ovulation in cattle. Fertilization rates following natural service or artificial insemination in cattle range from 89 to 100% when ovulation occurs (Kidder et al., 1954; Bearden et al., 1956; Diskin and Sreenan, 1980; Maurer and Chenault, 1983; Gayerie de Abreu et al., 1984). Furthermore, timing of insemination plays a role in the success of any breeding program. Saacke et al., (2000) reported that when insemination occurs before the onset of standing estrus (>30 hrs before ovulation), fertilization rates are low but embryo quality is high; however, when insemination occurs >12 hours after the initiation of estrus (<18 hours before ovulation), fertilization rates are high but embryo quality is low. Therefore several aids have been developed to assist in the detection of standing estrus in cattle. The objective of these experiments were to compare the efficiency and accuracy of intensive visual estrus detection, a penile deviated bull, and the Estrus Alert estrous detection aid, to determine when animals are ready to ovulate.

[1] The author would like to thank A. Drew, C. Moret, K. Vander Wal, and all the SDSU Beef Breeding and Cow-Calf Units' staff for their assistance in conducting this research. This research was funded by the South Dakota State University Experiment Station, and products were donated by Pfizer (CIDR and Lutalyse; New York), and Phoenix Scientific (Ovacyst and Prostamate; St. Joseph, MO), and Western Point, Inc. (Estrus Alert; Merrifield, MN).
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Material and Methods

Experimental Design

Postpartum multiparous (3 to 13 years old) Angus-crossed beef cows (n = 53) at the South Dakota State Uniersity Beef Breeding Unit were injected with gonadotropin releasing hormone (**GnRH**, 100 μg as 2 mL of Ovacyst i.m.; Phoenix Scientific St. Joseph, MO) on day 0, and prostaglandin $F_{2\alpha}$ (PG; 25 mg as 5 mL of Prostamate i.m., Phoenix Scientific, St. Joseph, MO) on day 7. Estrus Alert patches (Western Point, Inc. Merrifield, MN) were placed on the tailhead at the time of PG administration on day 7. Estrus was detected for 72 hours by 1) visual observation every three hours and 2) the amount of activation of an Estrus Alert estrous detection aid. All cows were examined by transrectal ultrasonography 48 to 96 hours after the onset of estrus to determine if ovulation had occurred.

Angus and Angus-cross beef heifers (n = 37) at the South Dakota State Uniersity Cow-Calf Unit were injected with GnRH (100 μg as 2 mL of Ovacyst i.m.; Phoenix Scientific St. Joseph, MO) and a Controlled Internal Drug Release (CIDR; Pfizer, New York, NY) was inserted into the vagina on day 0. Estrus Alert patches (Western Point, Inc. Merrifield, MN) were placed on the tailhead at the time of GnRH administration on day 0. On day 7 all heifers received an injection of $PGF_{2\alpha}$ (25 mg as 5 mL of Lutalyse i.m., Pfizer, New York, NY), and CIDR were removed on day 7 or 14. Estrus was detected for five days following CIDR removal by 1) visual observation three times daily for at least 30 minutes, 2) a penile deviated bull, and 3) the amount of activation of an Estrus Alert estrous detection aid. All heifers were examined by transrectal ultrasonography between 48 and 96 hours after the onset of estrus to determine if ovulation had occurred.

Determination of Standing Estrus

Animals were classified as 1) in standing estrus, 2) suspect, or 3) not in estrus. By visual detection, animals were classified as in standing estrus when they stood to be mounted by another animal and did not try to move. When animals would not stand to be mounted, but exhibited secondary signs of standing estrus (i.e. congregating, mounting other animals, clear mucus from vagina, nervous and restless, or roughed up tailhead) animals were classified as suspect, and animals that showed no signs of estrus were classified as being not in estrus. By penile deviated bull, animals were classified in standing estrus if they stood to be mounted by the bull. When animals would not stand to be mounted, but the bull continued to try to mount them, they were classified as suspect. When the bull showed no interest in the animal they were classified as not in estrus. By the Estrus Alert estrous detection aid, animals were classified in standing estrus when the patch had been completely activated (Figure 1a). When the patch was partially activated animals were classified as suspect (Figure 1b), and as not in estrus when the patch had no signs of activation (Figure 1c).

Efficiency and Accuracy

The efficiency of each estrous detection method was determined by the percentage of animals that ovulated and were detected in standing estrus (the number of animals detected in standing estrus and ovulated divided by the number of animals that ovulated multiplied by 100). The accuracy of each estrous detection method to predict ovulation was determined by the percentage of animals detected in standing estrus that did ovulate and the animals not detected in standing estrus that did not ovulate (identified correctly), and by the percentage of animals detected in standing estrus that did not ovulate and the animals not detected in standing estrus that did ovulate (identified incorrectly).

Statistical Analysis

The percentage of animals detected in standing estrus, and the percentage of cows correctly (detected in standing estrus and ovulated, not detected in estrus and did not ovulate) and incorrectly (detected in standing estrus and did not ovulate, not detected in standing estrus and did ovulate) identified by each estrous detection method were analyzed using categorical data modeling in SAS (Proc Catmod). The preceding variables were analyzed for an effect of treatment.

Results

The number of animals that ovulated, as determined by transrectal ultrasonography are shown in Table 1. Seventy-four animals ovulated following estrus synchronization (37 cows and 37 heifers). The number of animals detected in standing estrus, suspect, or not in standing estrus by visual observation, by the penile deviated bull, and by the Estrus Alert

estrus detection aids, are shown in Table 1. There was no difference (*P > 0.65*) in the efficiency of estrous detection among the three estrous detection methods (91%, 92%, and 89% for visual observation, penile deviated bull, and Estrus Alert patches; respectively).

Of the 53 postpartum beef cows, one cow ovulated but was never detected in standing estrus by either visual observation or the Estrus Alert patches. However, two cows were detected in standing estrus by both visual observation and the Estrus Alert patches but did not ovulate. Among the 37 heifers two heifers ovulated but were never detected in standing estrus by visual observation, a penile deviated bull, or the Estrus Alert patches. One heifer was detected in standing estrus by visual observation and the penile deviated bull and did ovulate, but was not detected in standing estrus by the Estrus Alert patches.

The percentage of animals identified correctly by each of the three estrous detection methods did not differ (*P* > 0.79). The percentage of cows correctly determined to be in standing estrus and going to ovulate also did not differ (*P > 0.31*) among estrous detection methods (Table 2). A similar (*P > 0.87)* number of animals were determined to be suspect by intensive visual observation, a penile deviated bull, and by the Estrus Alert patches (2, 1, and 2, respectively).

Discussion

Detection of standing estrus can be one of the time consuming herd management chores related to estrous synchronization and artificial insemination. However, the success of any breeding program requires detecting the animals that are ready to be bred and inseminating them at the correct time prior to ovulation. Therefore, failing to detect estrus and incorrect detection of estrus can result in significant economic losses (Heersche and Nebel, 1994). Furthermore, using continuous monitoring of over 500 animals exhibiting natural estrus in 3 separate studies indicated that greater than 55% of cows initiated standing estrus from 6 p.m. to 6 a.m. (Hurnik and King, 1987; Xu et al., 1998; Perry unpublished data). The efficiency of each of the methods of estrous detection tested was 89% or greater. Indicating that each of the methods used can very effectively determine which animals have been or are in standing estrus even when visual observation is difficult. These efficiencies are very similar to efficiencies reported for grazing dairy cows (visual with tail paint 98% and the HeatWatch electronic estrous detection system 91%) over a 6 week breeding season (Xu et al., 1998).

In both the heifer and cow groups there were animals that ovulated without being detected in standing estrus. Similar results have been reported in peripubertal heifers where 7% and 25% of heifers had a silent or nonstanding estrus, respectively (Morrow et al., 1976). Following treatment with a CIDR or MGA along to induce estrous cycles in anestrous cows 25% and 43% of cows ovulated without exhibiting signs of standing estrus, respectively (Perry et al., 2004). Furthermore, detection of standing estrus prior to the first postpartum ovulation has ranged from 20% to 50% depending on the frequency of estrus detection (see review by Wettemann, 1980).

In the present study there was no difference in the accuracy of three estrous detection methods used and all were greater than 90%. Inseminating animals detected in estrus with any of these methods would result in the majority of the animals getting inseminated around the time of ovulation. Furthermore, similar pregnancy rates have been reported for once daily insemination and twice daily insemination when animals have been detected in standing estrus (Nebel et al., 1994; Graves et al., 1997). However, the timing of insemination after the onset of standing estrus can influence fertilization rates and embryo quality (Dalton et al., 2001). When insemination occurs before the onset of standing estrus (>30 hrs before ovulation), fertilization rates are low but embryo quality is high; however, when insemination occurs >12 hours after the initiation of estrus (<18 hours before ovulation), fertilization rates are high but embryo quality is low (Saacke et al., 2000). Inseminating cattle approximately 12 hours after the onset of standing estrus should result in the best fertility with good fertilization rates and good embryo quality (Saacke et al., 2000; Dalton et al., 2001).

Implications

Detection of standing estrus can be one of the most time-consuming chores related to estrous synchronization and artificial insemination. However, the success of any artificial insemination program requires detecting the

animals that are ready to be bred (standing estrus) and inseminating them at the correct time. Several estrous detection aids have been developed to assist with this time consuming chore. These estrus detection aids can very effectively determine which cows are or have been in standing estrus, therefore relieving the time required to visually observe cattle for standing estrus. However, increased visual observation in addition to the use of estrous detection aids could improve fertility by detecting the most possible number of animals ready to be inseminated and indicating the most appropriate time for insemination.

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Tables

Table 1. Number of animals detected in standing estrus, suspect, or not in standing estrus by visual observation, a penile deviated bull, or the Estrus Alert patch

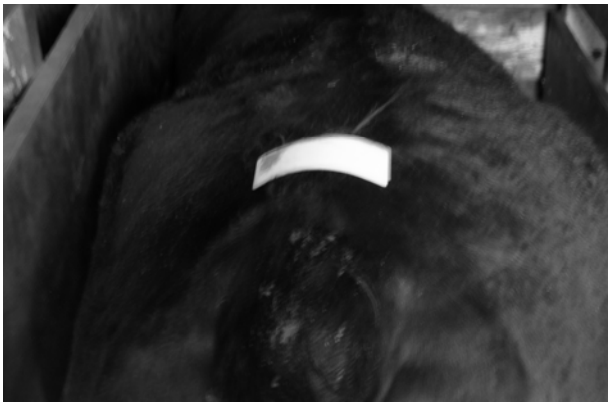
	Visual	Penile Deviated Bull	Estrus Alert
Standing Estrus (cows;heifers)[a]	69 (35;34)	34 (0; 34)	68 (35;33)
Suspect (cows;heifers)[b]	2 (0;2)	1 (0;1)	2 (0;2)
Not in standing estrus (cows;heifers)[c]	19 (17;2)	2 (0;2)	20 (17;3)
Ovulated (cows;heifers)[d]	74 (37;37)	37 (0;37)	74 (37;37)
Efficiency[e]	91% (67/74)	92% (34/37)	89% (66/74)

[a]Number of animals determined to be in standing estrus by each estrous detection method.
[b]Number of animals that indicated signs of standing estrus but did not fully meet the requirements of standing estrus.
[c]Number of animals determined to not be in standing estrus by each estrous detection method.
[d]Number of animals that each method was used on that actually ovulated as determined by transrectal ultrasonography.
[d]The number of animals detected in standing estrus and ovulated divided by the number of animals that ovulated multiplied by 100.

Table 2. The accuracy of visual estrous detection, a penile deviated bull, and the Estrus Alert estrus detection aid

	Visual	Penile Deviated Bull	Estrus Alert
Percent identified correctly[a]	92% (83/90)	92% (34/37)	91% (82/90)
Percent identified incorrectly[b]	8% (7/90)	8% (3/37)	9% (8/90)
Percent suspect[c]	2% (2/90)	3% (1/37)	2% (2/90)
Percent identified in standing estrus that ovulated[d]	97% (67/69)	100% (34/34)	97% (66/68)
Percent identified in standing estrus that ovulated (including suspect animals)[e]	97% (69/71)	100% (35/35)	97% (68/70)

[a]The number of animals detected in standing estrus and ovulated plus the number of animals determined not to be in standing estrus and not ovulating divided by the total number of animals X 100.
[b]The number of animals detected in standing estrus and did not ovulated plus the number of animals determined not to be in standing estrus and did ovulate divided by the total number of animals X 100.
[c]The number of animals that indicated signs of standing estrus but did not fully meet the requirements of standing estrus divided by the total number of animals X 100.
[d]The number of animals detected in standing estrus and ovulated divided by the total number of animals detected in standing estrus X 100.
[e]The number of animals detected in standing estrus or suspect and ovulated divided by the total number of animals detected in standing estrus and suspect X 100.



A

B

C

Figure 1. Examples of an Estrus Alert patch on an animal that was in standing estrus (A), a patch on an animal classified as suspect (B), and a patch on an animal classified as not in standing estrus.

Effect of Using CIDRs for Seven Days Before the Introduction of Bulls on the Proportion of Cows Conceiving Early in the Breeding Season[1]

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BEEF 2005 - 25

Summary

Cows that conceive earlier in the breeding season wean calves that are older and heavier at weaning. Therefore, the objective of this study was to determine the ability of a CIDR to increase the proportion of cows that conceived early during a natural service breeding season. Two hundred twenty-two postpartum beef cows were allotted to one of two treatments: 1) cows were treated with a CIDR for 7 days before bulls were introduced (n = 100), 2) cows were not treated and served as a control (n = 122). Seven days before bulls were introduced to the herd CIDRs were inserted into the CIDR treated cows, and were removed the day bulls were placed with the herd. The percentage of CIDR treated cows that conceived during the first 14 days of the breeding season tended (P = 0.08) to be greater compared to the control group. Beginning on day 21 of the breeding season a similar (P > 0.35) percentage of CIDR treated and control cows had conceived. In summary, a CIDR alone tended to increase the proportion of cows that conceived during the first 14 days of the breeding season.

Introduction

Synchronizing estrus is an effective way to maximize the use of time and labor required to detect standing estrus in cattle. However, estrous synchronization can also benefit overall herd management. Cows that are synchronized: 1) exhibit standing estrus at a predicted time, 2) conceive earlier in the breeding season, and 3) wean calves that are older and heavier at weaning. In addition certain estrous synchronization protocols can induce non-cycling cows to begin estrous cycles. This will decrease the anestrous postpartum interval and allow for more chances for cows to conceive during a defined breeding season.

The anestrous postpartum interval is a major contributing factor to cows failing to become pregnant and calving on a yearly interval. A short luteal phase can further delay the interval from calving to conception and usually occurs following the first postpartum ovulation. Treatment with a controlled internal drug-releasing device (**CIDR**) can induce ovulation in postpartum anestrous cows and eliminate the occurrence of short estrus cycles (Perry et al., 2004). Therefore, many estrous synchronization protocols have included the use of a CIDR. Estrous synchronization can be an effective method of increasing the proportion of animals bred early in the breeding season resulting in a shorter calving season, and a more uniform calf crop. Cows that conceived to a synchronized estrus calved 13 days earlier and weaned calves 21 pounds heavier than nonsynchronized females (Schafer et al., 1990).

The time and labor required to detect estrus often makes AI impractical (Britt, 1987), and current surveys indicate that fewer than 5% of beef cows in the United States are bred by AI and estrous synchronization is only used by half of the producers that utilize AI (Corah and Kiracofe, 1989; NAHMS, 1994). Therefore, the objective of this study was to determine the ability of a CIDR alone to get more cows bred by natural service early in the breeding season.

Materials and Methods

Postpartum multiparous (3 to 11 years old) angus based beef cows located on a ranch in eastern South Dakota were divided into two treatment groups based on age, days postpartum, and body condition score. Treatments consisted of 1: untreated late calving cows (between 27 and 68 days postpartum; n =

[1] This research was funded by the South Dakota State University Experiment Station and products were donated by Pfizer (New York).
[2] Assistant Professor

122), and 2: synchronized late calving cows (between 27 and 69 days postpartum; n = 100). Synchronized cows had a Controlled Internal Drug Release (CIDR; Pfizer, New York, New York) inserted into the vagina on day -7 and removed on day 0. All cows were placed with fertile bulls (n = 9) that had successfully passed a breeding soundness exam on day 0 at a bull to cow ratio of 1:25. All cows were managed as a single group throughout the breeding season. Pregnancy and fetal age were determined by transrectal ultrasonography on day 58 and 120 using an Aloka 500V ultrasound with a 5 MHz linear probe (Aloka, Wallingford, CT). Five CIDR treated cows and 3 control cows lost ear tags during the breeding season and were therefore removed from the analysis.

Differences between treatments in the percentage of animals pregnant on day 7, 14, 21, and 28 of the breeding season were analyzed using chi-square analysis in SAS (Proc Freq). Differences between treatments in the day of conception were determined by analysis of variance in SAS (Proc GLM). When the F statistic was significant ($P < 0.05$), mean separation was performed using least significant differences (Means ± SEM).

Results and Discussion

In the present study there was a tendency (P = 0.08) for a greater percentage of CIDR treated cows to have become pregnant during the first 14 days of the breeding season compared to control cows (Figure 1). When pregnancy was determined on day 58 of the breeding season CIDR treated cows tended (P = 0.08) to be bred earlier compared to control cows (45 days vs. 43 days, respectively). When CIDRs were used in anestrous postpartum cows, a greater percentage of CIDR-treated cows had exhibited standing estrus on day 2 after CIDR removal compared with control-treated cows, but beginning on day 14 after CIDR removal no significant difference was detected between CIDR- and control-treated cows (Perry et al., 2004). Furthermore, the percentage of CIDR-treated cows that ovulated was greater than the percentage of control-treated cows that ovulated beginning on day 4 after CIDR removal, but beginning on day 18 after CIDR removal, the cumulative percentage of CIDR- and control-treated cows that had ovulated did not differ (Perry et al., 2004).

By day 21 and 28 of the breeding season a similar percentage (P > 0.35) of CIDR treated and control cows had become pregnant (Figure 1). Since the bovine estrous cycle is 21 days, beginning on day 21 of the breeding season all cows that had begun estrous cycles have had one opportunity for become pregnant. Therefore, the greatest benefit of estrous synchronization with natural service is likely the ability to get more cows pregnant during the first few days of the breeding season. Cows that exhibit estrus early in the breeding season may have additional chances to conceive during a defined breeding season. During a 65-day breeding season, cows that cycle naturally have only three chances to conceive, but cows that are synchronized and show estrus the first few days of the breeding season have an additional chance to conceive. However, in the present study, this did not result in greater breeding season pregnancy rates.

When cows are synchronized and bred by natural service, the time required to detect estrus is not a concern, since the bull will be detecting the cows that exhibit estrus, however management considerations should be made for the serving capacity of the bull. Healy et al., (1993) reported a tendency (P < 0.10) for pregnancy rates over a 28-day synchronized breeding season to be reduced when a bull to female ratio of 1:50 (77%) was used compared to a bull to female ratio of 1:16 (84%), but no difference was detected between a bull to female ratio of 1:16 and 1:25 (84% and 83%, respectively). In the present study a bull to female ratio of 1:22 was used.

Implications

Using a CIDR for 7 days before the beginning of the breeding season tended to result in more cows conceiving in the first 14 days of the breeding season and having an earlier day of conception compared to control treated cows.

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Figures

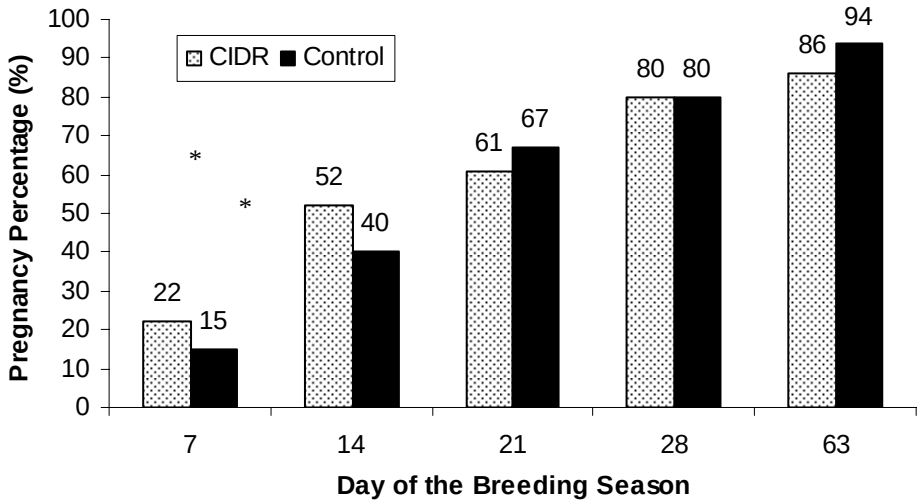

Figure 1. Effect of treatment on cumulative percentage of cows pregnant by day of the breeding season (d 0 = day bulls were introduced into the herd). **P = 0.08*

Effect of Ovulatory Follicle Size and Standing Estrus on Circulating Hormone Concentrations and Interval to Ovulation[1]

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BEEF 2005 - 26

Summary

In postpartum cows, ovulatory follicle size at time of insemination (GnRH/TAI) influenced pregnancy rates following TAI, but had no effect on pregnancy rates when cows spontaneously ovulated. Furthermore, cows that exhibited estrus (± 24 h of GnRH/TAI) had higher pregnancy rates compared to cows not in estrus. The objective was to assess the relationship between ovulatory follicle size and estradiol concentrations, timing of the LH surge, timing of ovulation, and subsequent progesterone concentrations. Cows were synchronized with the CO-Synch (n = 64; induced ovulation) or the Select Synch (n = 20; spontaneous ovulation) protocol. Cows that exhibited estrus and were induced to ovulate medium (11.5-14 mm) or large (>14) follicles had preovulatory concentrations of estradiol similar (*P > 0.05*) to cows that spontaneously ovulated and higher (*P* < 0.05) than cows not exhibiting estrus. Cows not exhibiting estrus had lower (*P < 0.05*) preovulatory concentrations of estradiol compared to cows that spontaneously ovulated. There was no effect (*P > 0.36*) of follicle size or estrus on concentrations of LH. Among cows induced to ovulate, cows detected in estrus had a shorter (*P < 0.01*) interval from GnRH to the LH surge and ovulation compared to cows not exhibiting estrus. Cows that spontaneously ovulated had an intermediate interval from onset of estrus to the LH surge, but a shorter (*P = 0.02*) interval to ovulation compared to cows not exhibiting estrus. Cows that ovulated medium follicles had a longer (*P = 0.03*) interval to ovulation compared to cows that ovulated large follicles, with cows that ovulated small follicles (≤ 11 mm) intermediate. The rate at which concentrations of progesterone increased following ovulation was similar (*P* > 0.30) among cows that spontaneously ovulated, cows detected in estrus and cows not detected in estrus and induced to ovulate medium and large follicles. Concentrations of progesterone were lower in cows not detected in estrus and induced to ovulate small follicle compared to cows not detected in estrus and induced to ovulate medium or large follicles (*P < 0.08*), cows that spontaneously ovulated (*P < 0.07*), and cows detected in estrus and induced to ovulate medium follicles (*P < 0.01*). In summary, concentrations of estradiol, timing of the LH surge, timing of ovulation, and rate subsequent progesterone rose could explain the increased pregnancy rates in cows that exhibit estrus and are induced to ovulate compared to cows that do not exhibit estrus.

Introduction

Most fixed-time insemination protocols utilize gonadotropin-releasing hormone (**GnRH**) to induce ovulation. Gonadotropin-releasing hormone administered nine days before insemination (day -9) induces ovulation, corpus luteum (**CL**) formation, and initiates a new follicular wave. Two days before insemination (day -2) prostaglandin $F_{2\alpha}$ (**$PGF_{2\alpha}$**) is administered to induce luteolysis, and GnRH is administered to induce ovulation of the preovulatory follicle around the time of insemination (day 0). Insemination is performed at the time of the second GnRH injection (Geary and Whittier, 1998) or 16 to 24 hours after the second GnRH injection (Pursley et al., 1998).

Bovine follicles achieve ovulatory capacity at approximately 10 mm, however a larger dose of LH was required to induce ovulation of a 10 mm follicle compared to larger follicles (Sartori et al., 2001). Furthermore, a decrease in pregnancy rates (Lamb et al., 2001; Perry et al., 2005) and an increase in embryonic mortality (Perry et al.,

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[2] Assistant Professor

2005) occurred in postpartum cows when small follicles were induced to ovulate following a fixed-time AI protocol. However, in postpartum beef cows ovulatory follicle size had no effect on fertility when ovulation occurred spontaneously following detection in standing estrus (Perry et al., 2005). Therefore, the objectives of this study were to assess the relationships between ovulatory follicle size and circulating concentrations of estradiol and LH and timing of ovulation.

Materials and Methods

Experimental Design

Postpartum multiparous (3 to 13 years old) Angus-crossed beef cows at the South Dakota State Uniersity Beef Breeding Unit were synchronized with the CO-Synch (Induced ovulation; n = 64) or the Select Synch (Spontaneous ovulation; n = 20) synchronization protocol in 4 replicates. Cows were injected with GnRH (100 μg as 2 mL of Ovasynch i.m.; Pheniox Scientific, St. Joseph Missouri) on day -9, and $PGF_{2\alpha}$ (25 mg as 5 mL of Prostamate i.m., Pheniox Scientific, St. Joseph Missouri) on day -2 (Select-Synch). Forty-eight hours after $PGF_{2\alpha}$ (day 0) cows in the CO-Synch group received GnRH (Ovasynch; 100 μg i.m.). Cows in each replicate were maintained as a single group and calves were allowed to suckle without restriction throughout the experiment.

Blood samples were collected by venipuncture into 10 mL Vacutainer tubes (Fisher Scientific, Pittsburgh, PA) every three hours from day -2 through day 2 and daily from day 2 through day 21. Blood was allowed to coagulate at room temperature, stored at 4°C for 24 hours, and centrifuged at 1,200 x *g* for 30 minutes. Serum was harvested and stored at -20°C until analysis was performed. Serum concentrations of progesterone, estradiol, and LH were analyzed in all samples by radioimmunoassay (**RIA**). Intra- and interassay coefficients of variation were 3.2% and 7.0%, 4.0% and 15.4%, 5.0% and 6.8%, for progesterone, estradiol and LH respectively.

Ovaries of all cows were examined by transrectal ultrasonography to characterize follicular development and to determine time of ovulation (day -2, day 0, and every four hour from 20 hours after GnRH or standing estrus through ovulation) using an Aloka 500V ultrasound with a 7.5 MHz linear probe (Aloka, Wallingford, CT). All follicles ≥ 8 mm in diameter were recorded. Follicle size was determined by averaging follicular diameter at the widest point and at a right angle to the first measurement using the internal calipers on the Aloka 500V. Ovulation was defined as the disappearance of a large follicle from an ovary.

Differences between follicle size groups in timing of ovulation and timing of LH surge were determined by analysis of variance in SAS (SAS Inst. Inc., Cary, NC). When the F statistic was significant ($P < 0.05$), mean separation was performed using least significant differences (Means ± SEM, Snedecor and Cochran, 1989). Circulating concentrations of progesterone, estradiol-17□, and LH were analyzed by analysis of variance for repeated measures in SAS (proc mixed, Littell et al., 1998). The statistical model consisted of follicle size and standing estrus, time, and their interactions. The effect of follicle size or standing estrus was analyzed using animal within treatment as the error term, and effects of time and any interaction were analyzed using the residual as the error term.

Results

There was an affect of treatment ($P < 0.01$), time ($P < 0.01$), and a treatment by time interaction ($P < 0.01$) on preovulatory concentrations of estradiol (Figure 1). More specifically, cows that did not exhibit estrus and were induced to ovulate small (≤11 mm) or medium (11.5-14 mm) follicles had lower ($P < 0.05$) preovulatory concentrations of estradiol compared cows that spontaneously ovulated. Cows not detected in standing estrus and induced to ovulate small or medium follicles also had lower ($P < 0.05$) preovulatory concentrations of estradiol compared to cows that exhibited estrus and were induced to ovulate small, medium, or large (> 14 mm) follicles. Cows not detected in standing estrus and induced to ovulate large follicles had lower ($P < 0.05$) preovulatory concentrations of estradiol compared to cows detected in standing estrus and induced to ovulate medium or large follicles and similar ($P > 0.05$) preovulatory concentrations of estradiol to cows detected in standing estrus and induced to ovulate small follicles. Preovulatory concentrations of estradiol did not differ ($P > 0.05$) among cows that exhibited estrus and were induced to ovulate and cows that spontaneously ovulated.

There were no detectable differences (*P* > *0.36*) among groups on circulating concentrations of LH (Figure 2). However, among cows induced to ovulate, cows that exhibited estrus had a shorter (*P* < *0.01*) interval from GnRH to the LH surge compared to cows not exhibiting estrus (Table 1). The interval from the onset of estrus until the LH surge was intermediate for cows that spontaneously ovulated. Estrus and follicle size also affected the interval from GnRH or onset of estrus to ovulation. Cows that did not exhibit estrus and were induced to ovulate had a longer interval to ovulation compared to cows that exhibited estrus and were induced to ovulate (*P* < *0.01*) and cows that spontaneously ovulated (*P* = *0.02*; Table 1). Furthermore, cows that ovulated medium follicles had a longer (*P* = 0.03) interval to ovulation compared to cows that ovulated large follicles (Table 1). Interval to ovulation was intermediate for cows that ovulated small follicles (≤ 11 mm).

There was a tendency (*P = 0.10*) for a treatment by time interaction of subsequent concentrations of progesterone (Figure 3). However, cows not detected in standing estrus and induced to ovulate small follicles had a slower rise in progesterone compared to cows not detected in standing estrus and induced to ovulate medium (*P = 0.05*) or large (P = *0.08*) follicles , cows that spontaneously ovulated (*P = 0.06*), and cows detected in standing estrus and induced to ovulate medium follicles (*P < 0.01*). There were no differences detected (*P > 0.30*) in the rate at which progesterone increased among cows not detected in standing estrus and induced to ovulate medium and large follicles, cows that spontaneously ovulated, and cows that were detected in standing estrus and induced to ovulate.

Discussion

The efficiency of timed-insemination protocols is dependent on precisely controlling the timing of ovulation, and for pregnancy to be maintained a proper uterine environment and adequate progesterone production by the subsequent CL must occur. In the present study, ovulation was induced by an injection of GnRH, however the interval from the GnRH injection until ovulation was influenced by both the ovulatory follicle size and if the animal had exhibited standing estrus. A longer interval from the GnRH injection (insemination) until ovulation could lead to decreased fertility. Sacke et al., (2000) reported that when insemination occurs before the onset of standing estrus (>30 hrs before ovulation), fertilization rates are low, but when insemination occurs >12 hours after the initiation of estrus (<18 hours before ovulation), fertilization rates are high. Furthermore, the timing of insemination after the onset of standing estrus can not only influenced fertilization rates but also influenced embryo quality (Dalton et al., 2001).

Preovulatory concentrations of estradiol may also play an important role in both preparing the uterus for pregnancy and in preparing follicular cells for luteal formation and function. Previous reports have shown cows that exhibit standing estrus around (± 24 hours) of fixed-time insemination had significantly higher pregnancy rates compared to cows that did not exhibit standing estrus (Perry et al., 2005). In the present study cows that were induced to ovulate and were detected in standing estrus had higher preovulatory concentrations of estradiol compared to cows not detected in standing estrus and induced to ovulate. In postpartum beef cows, preovulatory concentrations of estradiol-17β were lower preceding a short compared to a normal length luteal phase (Sheffel et al., 1982; Garcia-Winder et al., 1986; Garverick et al., 1988; Braden et al., 1989). Furthermore, reduced concentrations of estradiol-17β during the preovulatory period have been associated with decreased numbers of endometrial progesterone receptors during the early luteal phase (Zollers et al., 1993). Ovulation of follicles producing suboptimal preovulatory concentrations of estradiol may result in reduced numbers of endometrial progesterone receptors. Consequently, pregnancy maintenance may be decreased due to inadequate response of the endometrium to progesterone. Furthermore, ovariectomized ewes that did not receive an injection of estrogen corresponding with initiation of estrus before embryo transfer had decreased embryo survival (Miller and Moore, 1976), uterine weight, uterine protein, RNA to DNA ratio, and the rate of protein synthesis (Miller et al., 1977).

In addition to playing a role in preparing the uterus for pregnancy, increased preovulatory concentrations of estradiol likely plays a role in luteal progesterone production. Luteinized human granulosa cells secreted more progesterone when they were collected from follicles having increased follicular fluid

concentrations of estradiol compared to granulosa collected from follicles that had lower concentrations of estradiol (McNatty et al., 1979). In dairy cows, ovulation of small follicles resulted in the development of a smaller CL and lower serum progesterone concentrations (Vasconcelos et al., 2001). Furthermore, premature stimulation of ovulation by intrafollicular injections of LH or FSH reduced subsequent luteal progesterone secretion in ewes (Murdoch et al., 1983), and induced ovulation of small ovine follicles resulted in formation of small CL that had fewer large luteal-granulosa cells (Murdoch and Van Kirk, 1998). A decrease in CL size and progesterone production is believed to be related to a reduction in the number of granulosa cells present at the time of ovulation. Granulosa cells are generally believed to differentiate into large luteal cells (Smith et al., 1994) and approximately 80% of progesterone secreted by ovine corpora lutea is believed to be secreted by large luteal cells (Niswender et al., 1985). Therefore, a decrease in the number of granulosa/large luteal cells could influence circulating concentrations of progesterone.

Previous studies have reported cows treated with GnRH following detection in standing estrus had an LH surge of greater amplitude than cows that had a spontaneously induced LH surge (Kaim et al., 2003), and a GnRH-induced LH surge is of shorter duration when cows were not detected in standing estrus compared to cows that spontaneously initiated surge (Chenault et al., 1990). In the present study no differences were detected among treatments in serum concentrations of LH during the LH surge. This is likely due to a sample being collected only once every three hours in the present study.

Luteal progesterone secretion is required for maintenance of pregnancy (McDonald et al., 1952) and stimulates endometrial secretions (Geisert et al., 1992) as well as embryonic growth/development (Garrett et al., 1988; Mann et al., 1996). In previous studies cows induced to ovulate smaller follicles had significantly lower concentrations of progesterone beginning on day 9 after insemination and a slower rise in progesterone following insemination (Perry et al., 2005), and cows with normal developing embryos had higher concentrations of progesterone on days 3 and 6 after insemination compared to cows with degenerating embryos (Maurer and Echternkemp, 1982). In the present study there was a tendency for treatment to influence concentrations of progesterone, and cows not detected in standing estrus and induced to ovulate small follicle had a slower rise in progesterone following ovulation compared to cows not detected in standing estrus and induced to ovulate medium or large, cows that spontaneously ovulated, and cows detected in standing estrus and ovulated medium follicles. The rate at which concentrations of progesterone increase following ovulation can likely influence pregnancy rates. Cows that had an earlier rise in progesterone had embryos that were more advanced developmentally, produced more interferon τ (INF-τ) and were capable of inhibiting the $PGF_{2\alpha}$ release on day 16 after breeding, but cows that had a delayed rise in progesterone had less developed embryos, produced less IFN-τ, and were not capable of inhibiting the $PGF_{2\alpha}$ release on day 16 (Kerbler et al., 1997; Mann et al., 1999; Mann and Lamming, 2001). Furthermore, luteal progesterone secretion has been associated with fertility in cattle by stimulating endometrial secretions (Geisert et al., 1992). Endometrial secretions include nutrients, growth factors, immunosuppressive agents, enzymes, ions, and steroids contribute to early conceptus growth/survival (Geisert et al., 1992; Gray et al., 2001).

Implications

The most efficient and economical method for genetic improvement of economically important traits in the beef industry is artificial insemination with semen from genetically superior sires. However, cows induced to ovulate that have not been detected in standing estrus have decreased pregnancy rates compared to cows induced to ovulate that have exhibited standing estrus. This decrease in pregnancy rates might result from decreased preovulatory concentrations of estradiol, increased interval from GnRH until ovulation, or decrease rate of increase in subsequent concentrations of progesterone when cows that have not exhibited standing estrus are induced to ovulate.

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Tables

Table 1. Effect of standing estrus and follicle size on interval to LH surge and ovulation

	Estrus Status			Follicle Size (mm)		
	Standing Induced[a]	Not Standing Induced[b]	Spontaneous[c]	≤ 11[d]	11.5 to 14[e]	> 14[f]
Interval to LH surge (h)[g]	0.0 ± 0.79[x]	2.65 ± 0.71[y]	0.81 ± 1.76[xy]	1.6 ± 1.15	1.9 ± 0.74	0.14 ± 1.23
Interval to ovulation (h)[h]	25.75 ± 0.85[x]	28.97 ± 0.82[y]	25.83 ± 1.11[x]	26.5 ± 1.2[xy]	28.2 ± 0.6[x]	25.8 ± 0.9[y]

[a]Cow detected in standing estrus and inducted to ovulate
[b]Cow not detected in standing estrus and induced to ovulate
[c]Cow detected in standing estrus and spontaneously ovulated
[d]Cows that ovulated (induced or spontaneous) follicles ≤ 11 mm in diameter
[e]Cows that ovulated (induced or spontaneous) follicles 11.5 to 14 mm in diameter
[f]Cows that ovulated (induced or spontaneous) follicles > 14 mm in diameter
[g]Interval from GnRH injection (induced ovulation) or onset of standing estrus (spontaneous ovulation) to the onset of the LH surge
[h]Interval from GnRH injection (induced ovulation) or onset of standing estrus (spontaneous ovulation) to ovulation
[xy]Means within a row and category (estrus status or Follicle size) having different superscripts are different ($P \leq 0.03$)

Figures

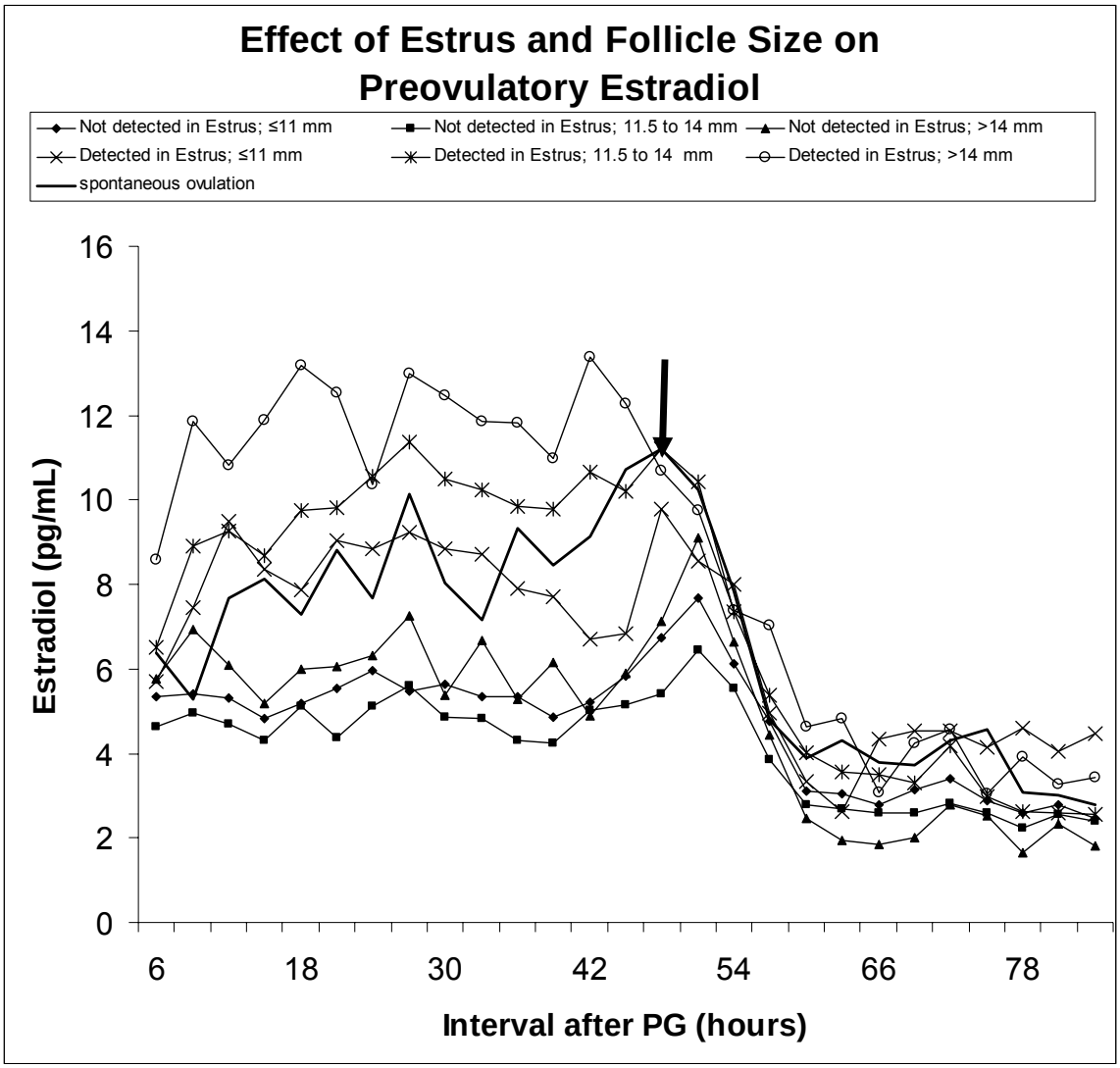


Figure 1. Influence of standing estrus and ovulatory follicle size on preovulatory concentrations of estradiol. Timing of the second GnRH injection for cows treated with the CO-Synch protocol is indicated by the arrow. (Treatment $P < 0.01$; Day $P < 0.01$; Treatment x Day $P < 0.01$).

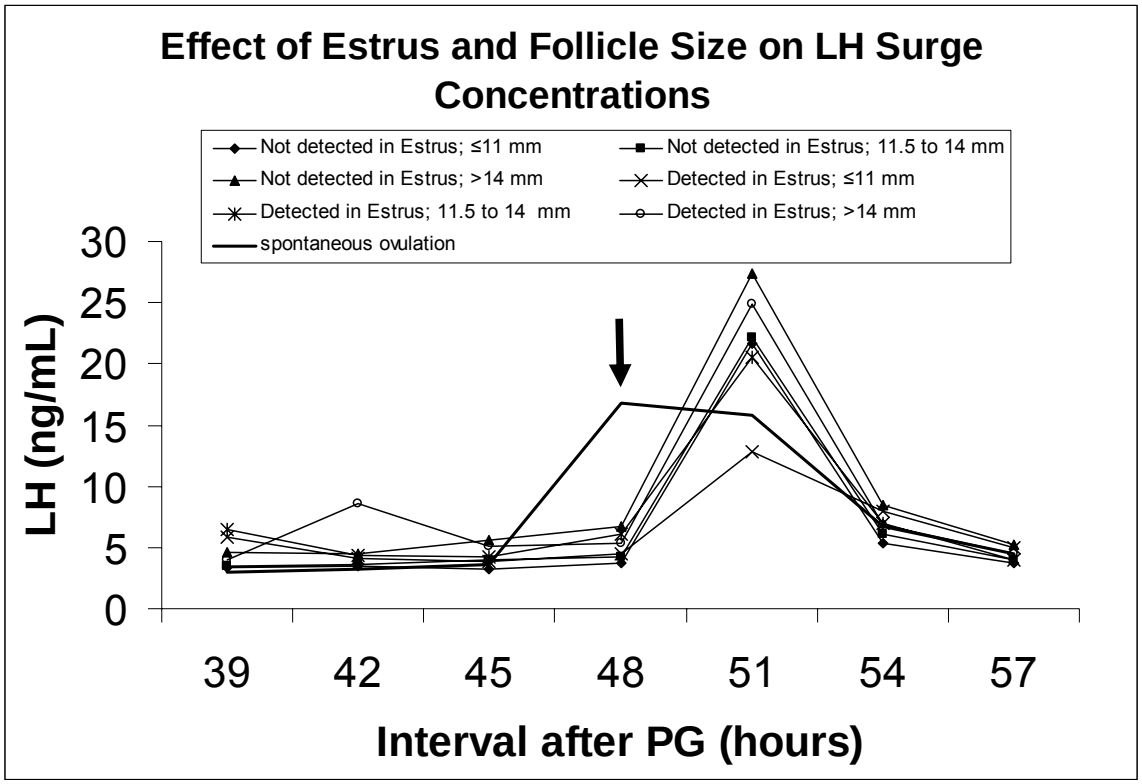


Figure 2. Influence of standing estrus and ovulatory follicle size on concentrations of LH. Timing of the second GnRH injection for cows treated with the CO-Synch protocol is indicated by the arrow. (Treatment $P = 0.74$; Day $P < 0.01$; Treatment x Day $P = 0.77$)

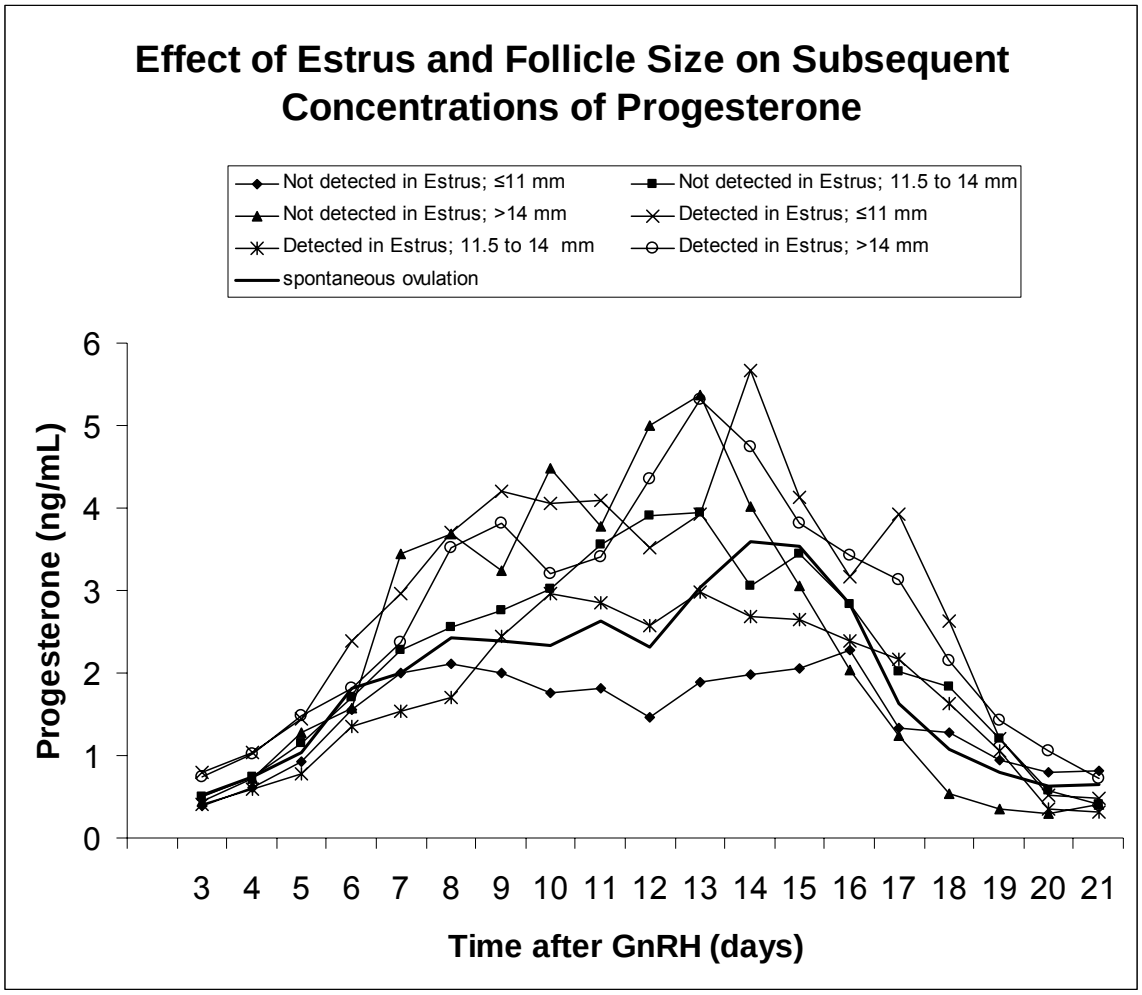
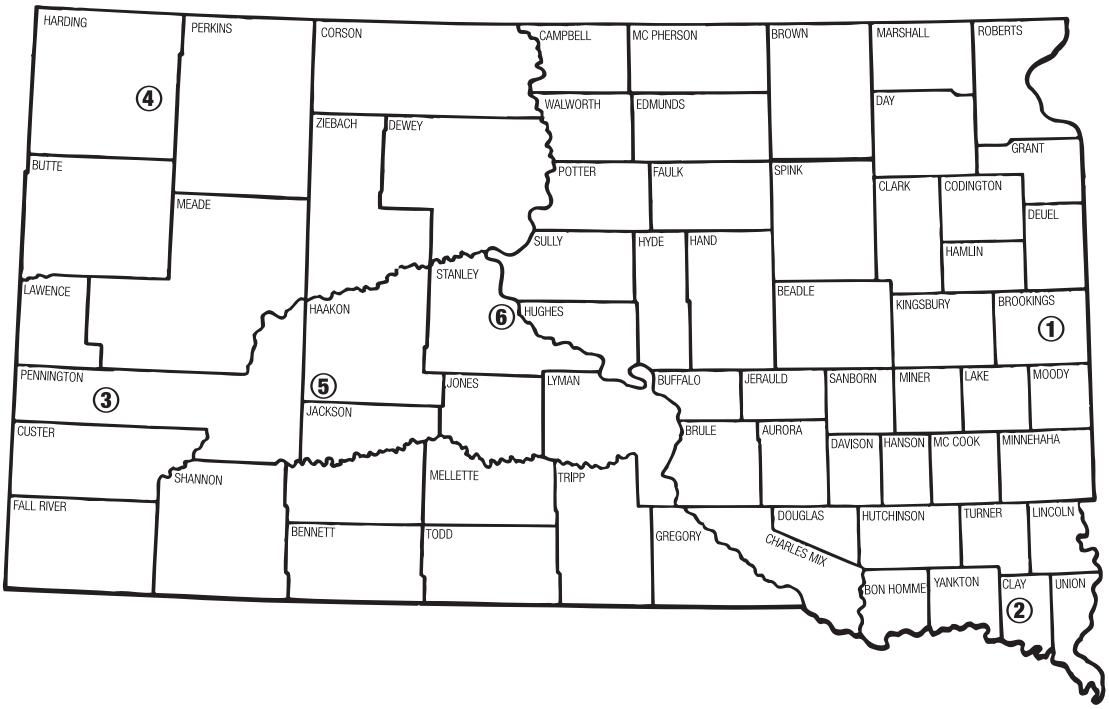


Figure 3. Influence of standing estrus and ovulatory follicle size on postovulatory concentrations of progesterone. (Treatment $P = 0.59$; Day $P < 0.01$; Treatment x Day $P = 0.10$)

Animal and Range Sciences
Research and Extension Units



1. Brookings: SDSU campus, Agricultural Experiment Station,
   Cooperative Extension Service

2. Beresford: Southeast South Dakota Research Farm
   Beef cattle nutrition
   Swine nutrition and management

3. Rapid City: West River Ag Research and Extension Center
   Research and Extension staff in Animal & Range Sciences,
   Plant Science, Economics, 4-H, and
   Extension administration

4. Buffalo: Antelope Range Livestock Station
   Beef cattle breeding and range beef herd management
   Sheep nutrition, management, and breeding

5. Philip: Range and Livestock Research Station
   Range beef nutrition and herd management
   Range management

6. Ft. Pierre: Hughes-Stanley County Extension Office
   Area beef and 4-H Extension specialists

These research and Extension units are geographically spaced across South Dakota to help solve problems, bring the results of livestock and range research to users, enhance the statewide teaching effectiveness of the Animal & Range Sciences Department staff, and maintain a close and productive relationship with South Dakota producers and the agribusiness community.

The state of South Dakota is our campus, our research lab, our classroom