1989

1989 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

Department of Animal and Range Sciences

1989

Agricultural Experiment Station

South Dakota

Cooperative Extension Service

Beef Report

South Dakota State University, Brookings

Animal and Range Sciences Department

FACULTY

	SPECIALTY	RESPONSIBILITY
BIRKELO, Carl P.	Ruminant Nutrition	Research, Teaching
BOGGS, Donald L.	Beef Cattle Nutrition and Management	Extension
COSTELLO, William J.	Meat Science	Teaching, Research
GARTNER, F. Robert	Range Science	Research, Teaching
GEE, Dan H.	Evaluation/Marketing	Teaching
GOEHRING, Terry B.	Beef Cattle Management	Extension
HAMILTON, C. Ross	Swine Nutrition	Research, Teaching
HELD, Jeffrey E.	Sheep Nutrition and Production and Management	Extension
INSLEY, Larry W.	Beef Cattle Management and Nutrition/Horse Production	Extension, Teaching
JOHNSON, James R.	Range Science	Extension, Research
JOHNSON, Patricia S.	Range Science	Research, Teaching
LIBAL, George W.	Swine Nutrition and Management	Research, Teaching
MALES, James R.	Ruminant Nutrition	Department Head
MARSHALL, Donald M.	Animal Breeding	Research, Teaching
MCFARLAND, Douglas C.	Monogastric Nutrition and Muscle Biology	Research, Teaching
MILLER, Herley L.	Reproductive Physiology	Research, Teaching
PRITCHARD, Robbi H.	Ruminant Nutrition	Research, Teaching
PRUITT, Richard J.	Cow-Calf Management	Teaching, Research
ROMANS, John R.	Meat Science	Research, Teaching
SLYTER, A. Lowell	Reproductive Physiology/Sheep Production and Management	Research, Teaching
SOWELL, Bok F.	Range Science	Research, Teaching
THALER, Robert C.	Swine Nutrition	Extension
WAGNER, John J.	Ruminant Nutrition	Extension, Research

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South Dakota State University
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December 1989

Dear Beef Producer:

The Animal and Range Sciences Faculty and Staff are pleased to present this 1989 edition of the Beef Report. The Beef Report summarizes the activities of the department for the past year. The year 1989 has seen our beef faculty at full strength for the first time in a number of years. This has allowed us to better serve the beef industry. We have strengthened some programs and have been able to institute new programs that will allow us to better serve South Dakota's largest agricultural entity.

Don Boggs, Terry Goehring and John Thomson had a very successful series of Bull Clinics this past winter and plan to repeat these in additional locations in February 1990. The SDSU Beef Bowl was a very successful promotional event for the industry with the addition of the South Dakota Beef Industry Council's Prime Promoter banquet, the Stockgrowers' Fall Quarterly and the South Dakota Cattlemen's Fall Board meeting. The 1989 Range Beef Cow Symposium held in Rapid City was one of the most successful in the 20 years that the symposium has been held. Terry Goehring did an excellent job of organizing this event. John Wagner is planning to reinstate some innovative programs in cattle feeding that had to be put on hold while we were so shorthanded in extension faculty. Larry Insley has agreed to coordinate the preparation and publishing of extension materials so our publications are up to date and of more use to producers and county agents.

The Beef Research program continues to be very productive as shown by the articles in this publication. We continue to try to have a research program that meets the immediate needs of producers as well as being innovative and forward-thinking to generate new ideas and concepts. We are in various stages of planning and construction on much needed renovations of the Cow/Calf Teaching and Research, Beef Breeding and Beef and Sheep Nutrition (Feedlot) Units on campus. We are also in the midst of a complete turnover of personnel at the Cottonwood Station and Luke Anderson has recently joined us at the Antelope Range Livestock Station. We are excited about what the future holds for our research programs. Since I came to the department 1 1/2 years ago, I have been impressed by the enthusiasm, thought process and dedication of our research faculty to the beef industry.

The excellent teaching program in the department continues. The number of undergraduate majors is up slightly and enrollment in our courses has been quite high this year. The Beef Production class has been at capacity for both fall and spring semesters. Our graduating seniors are in high demand in a very good job market for agriculture graduates.

We want to serve the needs of the South Dakota beef industry. Let us know how we can better serve you. We are ready and willing to meet the challenge.

Sincerely,

James R. Males
Head, Department of Animal and Range Sciences

SDSU

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December 1989

Dear Friends:

Thank you for examining the 1989 South Dakota Beef Report. This report contains information concerning the nutrition, management, physiology, genetics and economics of producing beef cattle. I hope the information printed in this report helps to maintain the viability and profitability of your operation or business.

The information in this report is intended for several audiences and has several levels of application. Some articles report results that have immediate application in your farming, ranching or agri-business enterprises. Other articles report results that hopefully will lead to new discoveries that will eventually have application to beef cattle production.

There are several in vitro digestibility studies and sheep metabolism trials reported in this publication. In vitro digestion tubes and sheep are used as models for digestion and metabolism in beef cattle. These experiments are less expensive than cattle trials and are often used to screen potential treatments or products. Ultimately, results obtained from in vitro or sheep trials need to be evaluated using cattle.

The Animal and Range Sciences extension, research and teaching faculty at South Dakota State University welcome any comments, suggestions or questions that you may have concerning this report. Please feel free to contact us if you need assistance with your operation or business.

Sincerely,

John J. Wagner, Ph.D.
Extension Ruminant Nutrition Specialist

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INTERPRETING EXPERIMENTAL RESULTS

D. M. Marshall[1]
Department of Animal and Range Sciences

CATTLE 89-1

A typical experimental format involves evaluating the response caused by application of different treatments to experimental subjects (animals, carcasses, pens, pastures, etc.). The effect of a given treatment might be evaluated by comparison to a control group or to one or more other treatment groups. However, a problem with animal research (and other types as well) is that variation not due to treatments often exists among experimental subjects.

For example, suppose that animals receiving ration A grow faster than animals receiving ration B. Was the observed difference in growth rates actually due to differences in the rations or to other factors (i.e., genetics, age, sex, etc.) or some of each? Statistical analyses evaluate the amount of variation between treatment groups relative to the amount of variation within treatment groups. In addition, variation caused by factors other than treatments can sometimes be eliminated by the statistical analysis.

The statement "the difference was statistically significant ($P = .05$)" indicates the probability of a difference of that magnitude occurring from chance rather than from the research treatment is about 5%.

A correlation coefficient provides an indication of the relationship between two factors and can range from -1 to +1. A strong, positive correlation (close to 1) indicates that as one factor increases the other factor tends to increase, also. For example, several studies have shown a positive correlation between cow milk yield and calf weaning weight. A strong negative correlation (close to -1) indicates that as one factor increases the other factor tends to decrease. A correlation near zero indicates the two factors are unrelated.

Several of the reports in this publication refer to least squares means. In balanced experimental designs, least squares means are often the same as the simple raw means. However, when numbers of experimental subjects are not evenly distributed across treatments, adjustments to the means are needed. Appropriate adjustments are made by least squares procedures. In addition, least squares means are sometimes adjusted for extraneous sources of variation through a so-called analysis of variance.

Means (averages), correlations and other statistics presented in research results are sometimes followed by ± some figure known as the standard error. The standard error provides an indication of the possible error with which the statistic was measured. The size of the standard error of a treatment mean depends on the animal to animal variation within a treatment group and on the number of animals in the group.

All other factors being equal, the greater the number of animals and(or) replications per treatment, the smaller the difference required to achieve a given value for probability of significance. Stated another way, increasing the number of animals or replications increases the likelihood of detecting differences due to treatments when such differences do indeed exist.

Several of the research reports in this publication contain statistical terminology. Although such terms might be unfamiliar to some readers, the statistical analyses allow for more appropriate interpretation of results and make the reports more useful.

[1]Assistant Professor.

SDSU PUREBRED BEEF HERDS

R. J. Pruitt[1], R. H. Haigh[2] and K. E. Vander Wal[3]
Department of Animal and Range Sciences

CATTLE 89-2

A herd of purebred Angus and Simmental cows is maintained at the Cow-Calf Teaching and Research Unit near the SDSU campus. Cattle maintained at this unit are used for teaching, research and extension activities. Current reproductive physiology research under the direction of Dr. Herley Miller is reported elsewhere in this publication. In addition to use in the classroom, cattle are used for the annual SDSU Little International, field days and numerous 4-H, FFA and other educational events. In addition to providing research information and an opportunity for education, this herd provides a stimulus for interactions between students and faculty and an avenue for communication between faculty and producers in the region.

In 1990 approximately 50 Angus and 50 Simmental females will calve to some of the elite bulls of the industry as indicated by National Sire Summary information. The average expected progeny differences (EPD's) for the AI sires used in 1989, the cow herd and the 1989 calf crop are reported in Table 1. In addition to extensive AI, limited embryo transfer is being used to improve our purebred herd.

It is unfeasible to maintain a herd with all of the breeds that are important to South Dakota and surrounding states. We have two breeds that are distinctly different with well established breed association performance records programs that are also quite different. To maximize the herd's value as a teaching resource a wide variety of sires that represent differences in calving ease, growth rate, maternal value and mature size within their respective breed are used. This enables us to provide examples of the genetic

TABLE 1. EXPECTED PROGENY DIFFERENCES

	AI sires used in 1989	Cow herd	1989 replacement heifers
Angus			
Birth weight	+ 3.9	+ 4.2	+ 4.7
Weaning weight	+ 33.3	+ 20.9	+ 24.6
Milk	+ 11.4	+ 5.1	+ 5.4
Combined maternal index	+ 28.0	+ 15.5	+ 17.7
Yearling weight	+ 58.9	+ 35.9	
Simmental			
Calving ease	100.0	97.2	96.9
Birth weight	- .4	+ .8	- .4
Weaning weight	+ 11.7	+ 9.1	+ 11.7
Yearling weight	+ 25.6	+ 17.5	+ 19.3
Maternal calving ease	103.9	103.7	103.0
Maternal weaning weight	+ 11.1	+ 7.9	+ 9.0
Maternal milk	+ 5.2	+ 3.4	+ 3.1

[1]Associate Professor.
[2]Manager, Cow-Calf Teaching and Research Unit.
[3]Assistant Manager, Cow-Calf Teaching and Research Unit.

differences that are useful to the commercial beef cattle industry in this region. Tables 2 and 3 show information on some sires that have been used recently. Development of expected progeny differences (EPD's) by most breed associations are a great asset to the commercial cow-calf producer in matching genetics to a specific environment and set of resources. Understanding how to use the information currently available to accomplish this is a real challenge to the beef industry. Although more complicated than the traditional idea of determining an ideal type that fits all situations, these are important concepts to understand for students who will be involved in the seedstock and commercial cow business in the future.

TABLE 2. EXPECTED PROGENY DIFFERENCES OF SOME RECENTLY USED ANGUS SIRES

	Birth weight	Weaning weight	Maternal Milk	Maternal Combined index	Yearling weight
High milk, high growth sire	+6.1	+40.1	+14.4	+34.5	+68.1
Low birth weight, high milk, above average growth sire	- .4	+15.4	+14.6	+22.3	+40.8
Moderate birth weight, high growth, average milk sire	+3.1	+33.9	+ 4.1	+21.1	+66.3

TABLE 3. EXPECTED PROGENY DIFFERENCES OF SOME RECENTLY USED SIMMENTAL SIRES

	Calving ease index 1st calf	Birth weight	Weaning weight	Yearling weight	Maternal Calving ease 1st calf	Maternal Weaning weight	Maternal Milk
High growth, moderate birth weight sire	98.3	+ .7	+24.6	+37.0	95.3	+14.4	+ 2.1
Calving ease, high maternal, above average growth sire	102.2	-1.5	+ 4.8	+10.7	108.5	+14.2	+11.8

In the recent past, yearling bulls produced have been used in other SDSU crossbred research herds with some bulls offered for sale. Table 4 shows information on the 1988 steer calves produced in a rotational crossbreeding program at the SDSU Range and Livestock Research Station. These steers were sired by young Angus and Simmental bulls produced in our purebred herd or by some of the same AI sires used to produce them.

Information provided to bull buyers include birth weight, weaning weight, yearling weight, scrotal circumference, frame score and expected progeny differences (EPD's). EPD's currently calculated by most breed associations offer the most accurate method of selecting young bulls for calving ease, growth rate and productivity of their daughters. Frame scores are provided as an objective measurement related to mature size that can be used to increase or decrease the weight at a desired grade and mature size of the progeny produced, whichever is desirable for a given situation. Scrotal circumference of yearling bulls is the most useful objective selection tool currently available to select for improved reproductive performance of a bull's daughters because of its relationship to age at puberty. If you are interested in receiving performance information and a price list for bulls available in April, 1990, contact Ron Haigh, Kevin Vander Wal or Dick Pruitt of the Animal and Range Sciences Department.

TABLE 4. CROSSBRED STEERS FROM THE SDSU RANGE AND LIVESTOCK RESEARCH STATION

Number of steer calves	57	head
Actual weaning weight	614	lb
Age at weaning	199	days
Age at slaughter	391	days
Slaughter weight (shrunk)	1140	lb
Hot carcass weight	693	lb
Fat thickness	.39	inches
Rib eye area	12.3	square inches
Yield grade distribution		
1	9.7	%
2	69.0	%
3	21.8	%
Quality grade distribution		
Choice	78	%
Select	22	%

HYDROLYZED FEATHER MEAL SUPPLEMENTATION FOR LACTATING RANGE COWS

P. A. Momont[1], R. J. Pruitt[2] and J. Cantrell[3]
Department of Animal and Range Sciences

CATTLE 89-3

Summary

Sixty-eight cows calving in March and April grazing dormant winter range were used to evaluate hydrolyzed feather meal[4] as a protein supplement during early lactation. Within a week after calving cows were fed either a soybean meal or feather meal-corn supplement that provided approximately .83 lb crude protein per cow daily. Cow weight and condition score changes from calving until early May and percentage of cows cycling at the beginning of the breeding season in early June were similar between supplement groups. Calf average daily gains from birth until May were not affected by supplement fed to cows. In this study, supplementing lactating cows with hydrolyzed feather meal resulted in similar performance as supplementing with soybean meal.

(Key Words: Hydrolyzed Feather Meal, Range Cows, Lactation.)

Introduction

Research conducted with dairy cattle would suggest that methionine, a sulfur-containing amino acid, is one of the first limiting amino acids for milk production. Supplementing lactating cows with a protein source that provided this limiting amino acid to the small intestine may increase milk levels and improve reproductive performance. Hydrolyzed feather meal is 85 to 95% crude protein and high in the sulfur-containing amino acids methionine and cystine. Feather meal is also relatively undegraded (70% rumen bypass) in the rumen and it could be expected that a greater percentage of those amino acids would be presented intact to the small intestine where they could be absorbed and used for milk synthesis. The objective of this study was to evaluate hydrolyzed feather meal as a protein supplement for mature beef cows grazing native range during early lactation.

Materials and Methods

Sixty-eight mature Simmental x Angus cows grazing native range at the SDSU Range and Livestock Research Station near Cottonwood were fed either a soybean meal or hydrolyzed feather meal-corn supplement (Table 1) during early lactation. Supplements were formulated to provide .83 lb crude protein per cow daily and were balanced for energy, calcium, phosphorus, potassium and sulfur. Actual nutrient composition of supplements as determined by laboratory analysis are reported in Table 2. Equal amounts of prairie grass hay were fed to cows on each treatment when weather prevented grazing. Cows calved from March 11 to April 18. Within a week after calving, cows were weighed (after overnight feed and water removal), condition scored (1-9, 1 = severely emaciated) and allotted by calving date to one of the two supplemental treatments. Pasture groups were rotated every 10 to 15 days over the treatment period. In early May shrunk weights (after overnight night feed and water removal) on two consecutive days and cow condition scores were recorded. Calves were weighed at birth, in early May and at weaning in late October. Two blood samples taken 8 days apart from cows in early June were used to determine cyclic activity. Cows with greater than 1.0 ng progesterone per ml of serum (determined by radioimmunoassay) in either sample were considered to be cycling. Pregnancy was determined by rectal palpation in late October.

Data were analyzed by least squares procedures using General Linear Model procedure (GLM) of the Statistical Analysis System (SAS). Treatment and calf sex were included in each model as main effects.

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[1]Graduate Assistant.
[2]Associate Professor.
[3]Former Superintendent, Range and Livestock Research Station, Cottonwood.
[4]Thanks to Central Bi-Products, Redwood Falls, MN, for donating the hydrolyzed feather meal.

TABLE 1. SUPPLEMENTS FED LACTATING COWS[a]

Ingredient	Soybean meal	Feather meal
Soybean meal	93.0	--
Corn	--	48.0
Hydrolyzed feather meal	--	39.0
Liquid molasses	5.0	5.0
Na2SO4	1.0	--
Binder[b]	1.0	5.0
Potassium chloride	--	2.5
Dicalcium phosphate	--	.5

[a] Percent, as fed basis.
[b] Bentonite based.

TABLE 2. POUNDS OF NUTRIENTS PROVIDED LACTATING COWS[a]

	Supplement	
Item	Soybean meal	Feather meal
Dry matter, %	86.50	89.65
Crude protein	.77	.82
Calcium	.0069	.0077
Phosphorus	.0104	.0075
Potassium	.0413	.0361
Sulfur	.0106	.0160
Methionine + cystine	.0258	.0571
Mcal ME[b]	2.37	2.40

[a] Lb per head daily.
[b] Calculated values.

Calving date was included in each model as a covariate.

Results and Discussion

Cows fed feather meal supplements had similar (P = .33) early lactation weight and condition score changes compared to cows supplemented with soybean meal (Table 3). No differences (P = .53) in the percentage of cows cycling at the beginning of the breeding season in early June or percentage of cows pregnant in late October (P = .90) were observed for the different supplement groups. Hydrolyzed feather meal did not appear to increase cow milk production as indicated by calf weight gains during early lactation or adjusted calf weaning weights in late October (P = .40 and .53, respectively).

Potential benefits in increased cow and/or calf weight gains or cow reproductive performance by feeding a bypass protein high in sulfur containing amino acids were not observed in this study.

TABLE 3. EFFECTS OF SUPPLEMENT ON COW PERFORMANCE

Item	Supplement: Soybean meal	Supplement: Feather meal
No. of cows	32	36
Cow weight following calving, lb	1152	1165
Cow condition score at calving	5.5	5.5
Cow weight change, lb		
Calving - 5/5/89	-50	-57
Cow condition score, 5/5/89	5.0	4.9
Percent cows cycling, 6/7/89	86.2	90.6
Percent cows pregnant, 10/25/89	91.9	91.1
Calf weight change, lb/day		
Birth - 5/5/89	2.50	2.42
Calf weaning weight[a]	627	621

[a] Weight adjusted for sex and age of calf.

EFFECT OF LATE SEASON PROTEIN AND ENERGY SUPPLEMENTATION ON PERFORMANCE OF YEARLING STEERS GRAZING MIXED NATIVE RANGE OR COOL SEASON, CRESTED WHEATGRASS PASTURES

J. J. Wagner[1], P. S. Johnson[1] and J. Cantrell[2]
Department of Animal and Range Sciences

CATTLE 89-4

Summary

Seventy-two yearling, black baldy steers were utilized in a grazing experiment to study the effect of late summer, early fall protein (2.33 lb, 40% all natural, fed each Monday, Wednesday and Friday) or energy (4.4 lb corn fed daily) supplementation on average daily gain. Two pasture types, mixed native range and crested wheatgrass, were also examined. Cattle were purchased in May as part of a larger group and gained an average of 2.16 lb per head daily prior to initiation of the study on September 9, 1988. Average daily gain was significantly greater (P = .012) for cattle grazing crested wheatgrass than for steers grazing native range (1.38 vs .62 lb per head daily, respectively). Differences in daily gain due to supplement fed were not statistically significant (P = .298). Daily gains for the control, corn and protein group across both pasture types were .77, 1.02 and 1.22 lb per head daily, respectively.

(Key Words: Yearling Steers, Protein Supplementation, Energy Supplementation, Native Range, Crested Wheatgrass.)

Introduction

Performance by yearling cattle grazing native ranges and introduced pastures is related to several factors, including growth potential of the cattle, forage quality and availability, and type and level of supplementation. Cattle performance is typically greatest early in the grazing season and markedly lower during late summer and early fall. This reduction in performance is due to an increase in the energy requirements of the cattle combined with a decline in forage quality and/or availability.

Providing limited amounts of protein supplement during late summer and early fall to cattle grazing warm season grasses has been shown to improve both forage digestibility and intake and thus performance. It is not clear, however, whether protein supplementation of cattle grazing cool season grasses in fall would result in similar improvements in performance. Providing supplemental energy to pasture cattle has been shown to result in a substitution of supplement for forage. This substitution effect may be desirable when forage quantity is limited.

The objectives of this research were to (1) compare performance of cattle grazing either native range (having both warm and cool season grass components) or crested wheatgrass (a cool season grass) in late summer and fall and (2) determine differences in cattle performance due to either protein or energy supplementation. Data presented in this report represent the second year of an ongoing study.

Materials and Methods

This study was conducted at the Range and Livestock Research Station near Cottonwood, South Dakota. On September 9, 1988, 72 yearling, black baldy steers (734 lb) were randomly allotted to six native and six crested wheatgrass pastures. These steers were purchased in western Nebraska as part of a larger (125 head) group in early May at an average weight of 540 lb. The cattle grazed experimental pastures during summer 1988, with an average gain of 2.16 lb per head daily.

Six steers were utilized in each pasture. Stocking rates were light in order to avoid limiting forage availability during the study. Cattle in two of the native and two of the crested wheatgrass pastures were fed 2.33 lb of a 40% all natural protein supplement per head each Monday, Wednesday and Friday. Cattle in two native and two of the crested wheatgrass pastures were fed 4.4 lb of whole shelled corn daily. Both

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[2]Former Superintendent, Range and Livestock Research Station, Cottonwood.

supplements provided equal crude protein to the cattle per week. Cattle in the remaining two native and two crested wheatgrass pastures received no supplemental protein or energy and served as the control group. Cattle in each of the supplemented pastures were fed their supplement allotment as a group in feed bunks. All cattle, including controls, were offered salt and mineral supplements free choice. Cattle were individually weighed at the beginning of the study (September 9), at 28 days and again at 56 days following an overnight withdrawal of feed and water.

On September 29, forage samples were hand clipped from all pastures. Samples were collected of each of the major forage species and subsequently analyzed for crude protein, acid detergent fiber (ADF) and neutral detergent fiber (NDF).

Results and Discussion

Late season performance of yearling steers is shown in Table 1. Cattle grazing crested wheatgrass gained more weight (P = .012) than cattle grazing native range (1.38 vs .62 lb per head daily). Crested wheatgrass is a cool season forage and is generally of higher quality than the native grasses (western wheatgrass, blue grama and buffalograss) during late summer and early fall (Table 2).

The interaction between treatment and pasture type was not significant. Differences in daily gain due to treatment were not statistically significant (P = .298). Average daily gain of cattle on the control, corn and protein treatments were .77, 1.02 and 1.22 lb per head daily, respectively. For cattle grazing native range, conversion of supplement to added gain was 8:1 and 1.64:1 for the corn and protein treatments, respectively. For cattle grazing crested wheatgrass pastures, corn supplementation did not improve daily gains over the control group. Cattle fed protein supplement gained 1.59 lb per head daily compared with 1.30 and 1.26 lb per head daily for the control and corn fed cattle, respectively. Conversion of protein supplement to added gain was 3.45:1 for cattle grazing crested wheatgrass.

Data published by Oklahoma researchers suggest that protein supplementation improves forage digestibility and stimulates forage intake, thereby improving performance of pasture cattle during late summer and early fall. Performance of cattle in this preliminary study agrees with this suggestion. However, lack of statistical significance prevents conclusions from being drawn. This study will be repeated to increase the number of replications per treatment group and to examine the effect of year on the response to supplementation.

TABLE 1. AVERAGE DAILY GAINS OF YEARLING STEERS, LB/DAY

	Treatment[a]			
Pasture type	Control	Corn	Protein	Average[b]
Native	.24	.79	.85	.62
Crested wheatgrass	1.30	1.26	1.59	1.38
Average	.77	1.02	1.22	

[a] Standard error of the mean = .26.
[b] Native vs crested wheatgrass, P = .012.

TABLE 2. CRUDE PROTEIN, ACID DETERGENT AND NEUTRAL DETERGENT FIBER CONTENT OF GRASSES IN EXPERIMENTAL PASTURES

Grass[b]	Crude protein, %	Acid detergent fiber, %	Neutral detergent fiber, %
Crested wheatgrass	6.96	39.94	71.30
Western wheatgrass	4.19	46.50	75.28
Shortgrass[c]	5.06	45.09	78.67

[a] Dry matter basis.
[b] Samples from each pasture collected on September 29, 1988.
[c] Primarily buffalograss and blue grama.

MODERATE VERSUS HIGH PROTEIN DIETS FOR FINISHING YEARLING STEERS

J. J. Wagner[1] and R. Hanson[2]

CATTLE 89-5

Summary

Sixty-four yearling crossbred steers (864 lb) were utilized to study moderate versus high protein finishing diets. Diets were formulated to contain 11.25 or 12.25% crude protein on a dry matter basis. Differences observed for all performance and carcass traits were not significant. Steers on the 11.25 and 12.25% crude protein diets consumed 22.29 and 22.26 lb dry matter per head daily, gained 2.83 and 2.90 lb per head daily and required 7.91 and 7.69 lb dry matter per pound of gain, respectively. Diets formulated to contain 11.25% crude protein appear adequate for finishing heavy yearlings.

(Key Words: Feedlot, Yearling Steers, Protein Levels, Finishing Diets.)

Introduction

The National Research Council (1984) suggested that the protein requirement of 900-lb, large framed finishing steers gaining 3 lb per head daily is approximately 9.8% of diet dry matter. Throughout most of the feedlot industry, finishing diets of 12% crude protein or greater are common.

Feeding high protein levels in the finishing diet is believed to result in improved dry matter digestion and intake, greater average daily gain and improved feed efficiency. However, protein is generally expensive to add to feedlot diets. Reducing dietary protein levels from 12.25% to 11.25% could result in a savings of $.70 to $5.00 per ton of ration dry matter depending upon source and price of protein. This corresponds to $1.12 to $8.00 per head assuming similar performance of 400-lb gain and 8:1 feed conversion for both dietary protein levels.

The objective of this trial was to determine the effect of reducing the protein level in a finishing diet from 12.25 to 11.25% of dry matter on feedlot performance and carcass characteristics.

Materials and Methods

Sixty-four yearling crossbred steers that had been grown for 46 days on a 70% concentrate, 30% roughage diet to about 864 lb were randomly allotted to eight pens and finished using one of two experimental diets (Table 1). Diets were formulated to contain either 11.25 or 12.25% crude protein on a dry matter basis. Soybean meal was used as the source of supplemental protein.

Steers were weighed and implanted with Ralgro[3] following an overnight withdrawal (16 hours) of feed and water. Steers were weighed again after 28 days on feed and on the morning prior to slaughter. Interim weight was obtained following overnight withdrawal of water only. Final weight was obtained after a 16-hour withdrawal of feed and water. All cattle were slaughtered on the same day after 75% of all the cattle on the study reached an anticipated choice grade. Carcass data were obtained 24 hours post-slaughter.

Results and Discussion

Bunk samples were collected each 28 days and composited by treatment. Crude protein contents of the moderate and high protein diet as determined by Kjeldahl analysis were 11.12 and 12.70% of dry matter, respectively. Thus, a wider range in dietary crude protein content appeared to have been fed than was anticipated.

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[1]Assistant Professor.
[2]Cattle Manager, Southeast South Dakota Experiment Farm.
[3]Product of IMC-Pitman Moore, Inc., Terre Haute, IN.

TABLE 1. EXPERIMENTAL DIETS FED TO STEERS

Item	Diet: Moderate protein	High protein
Ingredient[a]		
Whole shelled corn	38.79	37.79
Ground high moisture corn	38.79	37.79
Alfalfa-grass hay	4.22	4.09
Corn silage	12.64	12.28
Supplement		
Soybean meal	3.53	6.01
Limestone	1.07	1.08
Trace mineralized salt	.50	.50
Beet molasses	.13	.26
Dicalcium phosphate	.17	.12
Vitamin ADE premix	.05	.05
Rumensin 60	.02	.02
Potassium chloride	.11	.01
Nutrient composition[b]		
Crude protein	11.25	12.25
NEm, Mcal/cwt	91.60	91.60
NEg, Mcal/cwt	62.00	62.00
Calcium	.50	.50
Phosphorus	.32	.32
Potassium	.65	.65
Vitamin A, IU/lb	1500.00	1500.00

[a] Percentage of dry matter.
[b] Percentage of dry matter unless stated otherwise. Calculated values from feed analysis or book value for individual feed commodities.

The length of the finishing period for all cattle was 91 days. Daily dry matter intake, average daily gain and feed/gain were not affected by dietary crude protein level (Table 2). Cattle fed the 11.25 and 12.25% crude protein diets consumed 22.28 and 22.26 lb of dry matter daily, gained 2.83 and 2.90 lb per head daily and converted feed at 7.91 and 7.69 lb dry matter per pound of gain, respectively.

Carcass traits were not influenced by level of crude protein (Table 3). About 88% of the cattle in this study graded choice or higher. Carcasses carried about .46 in. fat at the 12th rib, had about 13.4 $in.^2$ rib eyes and were yield grade 2.

This study indicates that heavy yearling cattle previously fed a high plane of nutrition may be finished satisfactorily on 11.12% crude protein diets. Formulating diets to contain greater amounts of crude protein will likely not result in improved performance.

TABLE 2. PERFORMANCE OF STEERS FED DIFFERENT LEVELS OF CRUDE PROTEIN[a]

Item	Crude protein percentage 11.25	12.25	SE[b]
Initial wt., lb[c]	853	876	9.21
Day 1-28			
Dry matter intake, lb/head/day	21.90	21.70	.10
Average daily gain, lb/head/day	4.90	4.77	.12
Feed/gain	4.47	4.55	.11
Day 1-91			
Dry matter intake, lb/head/day	22.28	22.26	.16
Average daily gain, lb/head/day	2.83	2.90	.11
Feed/gain	7.91	7.69	.30

[a] Least squares means adjusted for initial weight.
[b] Standard error of the mean.
[c] Raw mean.

TABLE 3. CARCASS CHARACTERISTICS OF STEERS FED DIFFERENT LEVELS OF CRUDE PROTEIN[a]

Item	Crude protein percentage 11.25	12.25	SE[b]
Hot carcass wt., lb	716	725	6.10
Dressing percentage, %	63.86	64.24	.36
Fat thickness, in.	.45	.48	.02
Rib eye area, $in.^2$	13.30	13.53	.23
Kidney, heart and pelvic fat, %	2.74	2.49	.16
Marbling score, units[c]	5.33	5.35	.06
Percentage choice, %	87.50	88.83	6.95
Yield grade, units	2.08	2.05	.10

[a] Least squares means adjusted for initial weight.
[b] Standard error of the mean.
[c] 5 = small; 6 = modest.

FROST DAMAGED, IMMATURE SOYBEANS FOR RUMINANT DIETS

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CATTLE 89-6

Summary

The potential for including freeze damaged, immature soybeans (FDIS) into corn based diets for ruminant animals was evaluated in a series of experiments. No differences in feeding value were evident for FDIS and normal soybeans except due to oil content. Oil content of soybeans depressed dry matter and particularly fiber digestion of corn silage fed to lambs ($P<.05$). Nitrogen digestion and retention were also reduced ($P<.10$) by feeding raw soybeans. The effect on N utilization appeared to be due to trypsin inhibitor activity, since this did not occur when soybean meal + oil supplements were fed. Nitrogen, dry matter and gross energy utilization decreased dramatically ($P<.05$) when FDIS increased from 14 to 21% of corn silage diets. Use of FDIS in corn silage diets should be restricted to no more than 15% of diet dry matter.

(Key Words: Ruminant, Lambs, Soybeans, Fiber, Energy, Nitrogen Digestibility.)

Introduction

Frost damaged, immature soybeans (FDIS) are prevalent in northern soybean production areas. Poor processing and storage characteristics of damaged soybeans prompt producers to feed them quickly. Antinutritional factors and high oil content may create problems with dietary nutrient utilization when FDIS are incorporated into ruminant diets. Earlier in vitro fermentation studies showed that FDIS could be successfully added to high concentrate diets without detrimental effects at 20% additions. However, FDIS depressed fiber utilization in vitro when added to corn silage substrates. This research attempted to separate effects due to raw soybean antinutritional factors, oil content and maturity of frost damaged, immature soybeans fed to lambs and to determine the maximum practical incorporation level of FDIS in corn silage based diets.

Materials and Methods

Exp. 1. Twenty Hampshire ram lambs (106 lb) were used to evaluate and differentiate oil and antinutritional factor effects of FDIS on in vivo nitrogen metabolism and digestibility of dry matter, crude protein and ADF. Lambs were allotted to four treatments, soybean meal (SBM), soybean meal + oil (SBO), mature raw soybeans (MSB) and FDIS supplements in a 75% corn silage diet (Table 1). Diets were formulated to contain 14% crude protein. Equal amounts of $CaCO_3$ were added to each diet to minimize differences due to formation of calcium fatty acid soaps. Lasalocid was fed at 1 mg/kg body weight as a coccidiostat.

Dry matter intake was held constant at 2.17 lb per head per day for all lambs. Lambs were adapted to diets 21 days prior to placement in metabolism stalls. A 7-day adjustment to stalls preceded two consecutive 4-day collection periods. Total feces, urine and feed refusals were collected and frozen prior to analysis. Analysis included Kjeldahl-N determination of all samples and ADF and dry matter content determination of feed feces and orts. Single degree of freedom orthogonal contrasts were utilized throughout the experiment to separate differences due to oil content, soybean maturity and antinutritional factor effects of FDIS.

Exp. 2. Four, ruminally fistulated crossbred wethers (150 lb) were fed diets similar to those used in Exp. 1 at 1,480 grams per head per day to determine FDIS antinutritional, oil and maturity effects on ruminal fermentation. Wethers were allotted in a split plot Latin square design with ruminal samples collected at 0, 3, 6, 12 and 24 hours postfeeding as the split plot.

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TABLE 1. FORMULATION FOR DIETS USED IN EXPERIMENTS 1 AND 2

	Treatment[a]			
Ingredient	SBM	SBO	FDIS	MSB
Corn silage, %	75.0	75.0	75.0	75.0
Corn, #2, %	12.0	7.4	2.1	6.6
SBM, %	12.1	13.1	0.0	0.0
FDIS[b], %	0.0	0.0	22.1	0.0
MSB[c], %	0.0	0.0	0.0	16.9
Oil, %	0.0	3.7	0.0	.8
Trace mineral salt[d], %	.3	.3	.3	.3
$CaCO_3$, %	.6	.6	.6	.6
Vitamins A, D, E[e], %	.005	.005	.005	.005
Lasalocid, mg/head/day	50	50	50	50

[a] SBM = soybean meal, SBO = soybean meal + oil, FDIS = frost damaged immature soybeans and MSB = mature raw soybeans.
[b] FDIS, 32% crude protein, 16.81% ether extract.
[c] MSB, 39.3% crude protein, 17.87% ether extract.
[d] Contains 97% NaCl, .007% I, .24% Mn, .24% Fe, .05% Mg, .032 Cu, .011% Co, .032% Zn and .50% Ca.
[e] Contains 2,200,000 IU/kg vitamin A; 1,100,000 IU/kg vitamin D_3 and 2,200 IU/kg vitamin E.

Wethers were adapted to diets for 7 days before sampling, then switched to the next treatment after sampling. Ruminal liquor was strained through eight layers of cheese cloth and subsampled for determination of ruminal ammonia and VFA concentrations. Aliquot samples for VFA determination were acidified with 1 ml of 25% (v/v) metaphosphoric acid. All samples were frozen at -10 °C until analysis.

Exp. 3. Twenty crossbred wether lambs (66 lb) were assigned to treatments containing 0, 7, 14 or 21% FDIS substitution for corn and SBM in 75% corn silage diets (Table 2). The experiment was designed to determine the maximum allowable levels of dietary FDIS before detrimental effects to N or fiber utilization occur. Nitrogen content of the diets was maintained at 2.72% (Table 3). Equal amounts of $CaCO_3$ were added to each diet to prevent differences caused by insoluble fatty acid soap formation. Lasalocid was fed at 1 mg/kg body weight as a coccidiostat. Feces and urine were collected similarly as Exp. 1 to determine crude protein, ADF, ether extract and gross energy digestibilities and N retention. Gross energy was determined by bomb calorimetry.

Results and Discussion

In Exp. 1, soybean meal maintained higher ($P<.001$) dry matter, crude protein and ADF digestibilities than oil containing treatments (SBO, FDIS and MSB, Table 4). Soybean antinutritional factors reduced ($P<.07$) crude protein digestibility and were additive to oil content effects. N retention and protein biological value (N retained/N absorbed) were reduced ($P<.07$) when raw soybeans were added to the diet. Adding oil did not affect N retention or biological value. No differences in dry matter, crude protein or ADF digestibilities, N retention or protein biological value were detected due to soybean maturity. It appears that oil content of raw soybeans depressed digestibility of feed components while in the rumen (dry matter, ADF and crude protein digestibilities), whereas antinutritional factors reduced uptake of nitrogen from the small intestine. When oil was added to SBM, ADF digestibility was lower than when diets contained soybeans. This likely is not due to antinutritional factors as inferred by the statistical analysis. Reduced ADF disappearance may have occurred because added oil was more effective in depressing bacterial fermentation than oil contained in soybean seeds.

In Exp. 2 total ruminal VFA concentrations were unaffected by oil or antinutritional factors (Table 5). A slight reduction ($P<.001$) in butyrate and a slight increase ($P<.05$) in isobutyrate and isovalerate concentrations were noted for oil containing treatments. Ruminal NH_3-N concentrations were reduced ($P<.001$) when oil containing diets were fed, but antinutritional

TABLE 2. FORMULATION FOR DIETS USED IN EXPERIMENT 3

Ingredient	Diet 0% FDIS	7% FDIS	14% FDIS	21% FDIS
Corn silage, %	75.0	75.0	75.0	75.0
Corn, #2, %	7.3	4.8	2.3	1.0
SBM, %	16.7	12.2	7.7	3.0
FDIS[a], %	0.0	7.0	14.0	21.0
Trace mineral salt[b], %	.3	.3	.3	.3
$CaCO_3$, %	.7	.7	.7	.7
Vitamins A, D, E[c], %	.005	.005	.005	.005
Lasalocid, mg/head/day	30	30	30	30

[a] FDIS, 32.0% crude protein, 16.81% ether extract.
[b] Contains 97% NaCl, .007% I, .24% Mn, .24% Fe, .05% Mg, .032 Cu, .011% Co, .032% Zn and .50% Ca.
[c] Contains 2,200,000 IU/kg vitamin A; 1,100,000 IU/kg vitamin D_3 and 2,200 IU/kg vitamin E.

TABLE 3. COMPOSITION OF DIETS (EXP. 3)

Item	Diet[a] 0% FDIS	7% FDIS	14% FDIS	21% FDIS
Nitrogen, %	2.28	2.27	2.32	2.31
ADF, %	20.73	21.20	22.18	22.99
Ether extract, %	3.16	4.37	5.50	6.48
Gross energy, Mcal/kg	4.388	4.473	4.520	4.608
Dry matter intake, g/head/day[b]	722.60	766.96	728.68	689.31

[a] Level of FDIS in diet.
[b] Least squares means.

TABLE 4. EFFECT OF SOYBEAN PROTEIN SUPPLEMENTS ON UTILIZATION OF A CORN SILAGE DIET BY LAMBS (EXP. 1)

Item	Treatment[a] SBM	SBO	FDIS	MSB	SEM
Digestible					
Dry matter, %[b]	75.7	69.6	68.8	67.8	.89
Crude protein, %[bc]	76.8	72.4	70.4	69.3	1.05
ADF, %[b]	59.6	45.4	49.6	47.2	1.28
N retention, g/day[c]	6.1	6.7	5.1	5.4	.56
B.V., %[c]	36.5	40.8	33.0	35.1	2.72

[a] SBM = soybean meal, SBO = soybean meal + oil, FDIS = frost damaged immature soybeans, MSB = mature raw soybeans.
[b] Oil effect, SBM vs others (P<.001).
[c] Inhibitor effect, SBO vs FDIS and MSB (P<.07).

TABLE 5. EFFECT OF SOYBEAN PROTEIN SUPPLEMENTS ON RUMINAL VFA AND NH_3-N CONCENTRATIONS (EXP. 2)[a]

Item	Treatment[b]				SEM
	SBM	SBO	FDIS	MSB	
Acetate, μM/ml	41.4	41.2	41.1	37.8	3.2
Propionate, μM/ml	13.1	12.2	12.3	13.0	1.6
Butyrate, μM/ml[c]	6.5	5.8	5.2	5.7	.4
Isobutyrate, μM/ml[cd]	.67	.76	.80	.80	.03
Valerate, μM/ml[d]	.65	.93	.69	.65	.21
Isovalerate, μM/ml[c]	1.13	1.57	1.65	1.59	.18
Total VFA, μM/ml	63.4	62.5	61.7	59.6	4.4
A/P ratio	3.4	3.5	3.9	4.1	1.0
NH_3-N, mg/dl[c]	15.42	14.06	13.42	12.17	1.37

[a] Mean of 0, 3, 6, 12 and 24 hours postprandial samples.
[b] SBM = soybean meal, SBO = soybean meal + oil, FDIS = frost damaged immature soybeans, MSB = mature raw soybeans.
[c] Oil effect (P<.001), SBM vs SBO, FDIS and MSB.
[d] Inhibitor effect (P<.05), SBO vs FDIS and MSB.

factors did not reduce NH_3-N concentration over time. Ruminal NH_3-N peaked for all treatments at 3 hours postfeeding but was higher when SBM was fed (Table 6). By 12 hours postfeeding, ruminal NH_3-N for SBM returned to baseline levels, while SBO, FDIS and MSB maintained higher (P<.01) NH_3-N concentrations than SBM. No differences in ruminal VFA or NH_3-N concentrations were found between FDIS or MSB. Since NH_3-N concentrations are in part a result of proteolytic rates, it appears that oil depressed the rate of protein degradation in the rumen. Antinutritional factors seemed to also reduce ruminal protein fermentation but did not affect VFA concentrations.

In Exp. 3, adding FDIS to corn silage diets caused a linear depression (P<.05) in dry matter and ADF digestion (Table 7). Approximately half of the decrease in dry matter disappearance could be attributed to reduced ADF digestibility. Gross energy digestion decreased quadratically (P<.001) due to a marked reduction as diets increased from 14 to 21% FDIS. N digestion tended to be reduced (P<.11) by increasing dietary FDIS. This was due to the reduction in N digestion that occurred in the 21% FDIS diet. N retention also appeared lower when this diet was fed. Fiber and N digestibility data indicate FDIS should not be fed at levels as high as 21% of corn silage diets.

Raw soybeans increased the ether extract and gross energy content of the diets (Table 3). Digestion of ether extract was unaffected by FDIS concentration. However, daily digestible energy intake was not increased by feeding the more energy dense diets. It appears that with a mixed grain-roughage diet like corn silage the negative effects of oil content and trypsin inhibitor activity limit use of soybeans in ruminant diets.

TABLE 6. EFFECT OF SOYBEAN PROTEIN SUPPLEMENTS ON RUMINAL AMMONIA CONCENTRATION WITH TIME (EXP. 2)

	Treatment[a]				
Time	SBM	SBO	FDIS	MSB	SEM
0	9.30	11.55	12.90	12.45	1.18
3[b]	30.05	19.77	18.52	17.14	2.57
6	18.29	16.31	11.63	8.39	3.05
12[bc]	9.25	10.07	14.05	12.27	.65
24	10.19	12.37	10.01	10.61	.93

[a] SBM = soybean meal, SBO = soybean meal + oil, FDIS = frost damaged immature soybeans, MSB = mature raw soybeans.
[b] Oil effect ($P<.01$), SBM vs SBO, FDIS and MSB.
[c] Inhibitor effect ($P<.01$), SBO vs FDIS and MSB.

TABLE 7. EFFECTS OF FDIS ON UTILIZATION OF CORN SILAGE DIETS BY LAMBS (EXP. 3)[a]

	Diet[b]			
Item	0% FDIS	7% FDIS	14% FDIS	21% FDIS
Percent digestibility				
Dry matter[c]	74.06	68.61	67.11	62.63
Nitrogen	68.49	68.88	68.47	53.39
ADF[c]	47.06	41.56	35.26	24.17
Ether extract	85.50	84.68	87.58	84.94
Gross energy[d]	69.50	66.69	62.63	49.24
N retention, g/head/day	14.99	17.70	11.67	.72

[a] Least squares means.
[b] Level of FDIS.
[c] Linear effect ($P<.001$).
[d] Quadratic effect ($P<.0001$).

ALTERNATE DAY SUPPLEMENTATION OF HIGH ESCAPE COMPARED TO LOW ESCAPE PROTEIN FED WITH CORN STALKS

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CATTLE 89-7

Summary

A study was conducted using four ruminally fistulated wethers to compare ruminal fermentation characteristics of corn gluten meal (high escape) and soybean meal (low escape) supplements to corn stalks. Supplements were fed at 24 or 48-hour intervals. Ruminal ammonia nitrogen (RNH_3-N) concentrations were affected ($P<.05$) by treatment and treatment by hour interactions occurred. Soybean meal fed at 48-hour intervals (SBM48) resulted in the highest mean and peak RNH_3-N concentrations, as expected due to the quantity of rumen degradable protein fed. Soybean meal fed at 24-hour intervals (SBM24) caused higher ($P<.05$) RNH_3-N concentration than corn gluten meal fed at 24-hour intervals (CGM24) but not CGM48. Total VFA concentrations averaged over time were not affected ($P>.10$) by type of protein supplement. Treatment by hour interactions were observed ($P<.05$) for total VFA, because SBM24 resulted in higher VFA concentrations at several points in the 48-hour sampling period. The ratios of acetate:propionate: butyrate were similar, 74:18:7, 74:18:7, 74:18:8 and 74:18:8 for SBM24, SBM48, CGM24 and CGM48, respectively. Ruminal fluid pH values were within the range of 6.2 to 7.0 normally associated with predominantly roughage diets. Alternate day supplementation with CGM48 allows for adequate ruminal fermentation and a more constant RNH_3-N concentration than SBM48.

(Key Words: Soybean Meal, Corn Gluten Meal, Corn Stalks, Rumen Fermentation, Ammonia, Volatile Fatty Acids.)

Introduction

Alternate day protein supplementation is a common practice of livestock production. Frequency of supplementation gives rise to concerns of appropriate protein source and feeding levels. There have been satisfactory responses to protein supplementation every other day, every third day, twice weekly or even once weekly, but the response depends on the protein type.

Feeding a readily rumen degradable protein source (low escape) can lead to increased urinary nitrogen excretion and therefore less efficient use of the protein supplement when frequency of supplementation is less than daily. A low rumen degradable protein source may increase nitrogen retention and therefore efficiency of supplement utilization by reducing the ruminal NH_3-N surge postfeeding and increasing amino acids absorbed postruminally for use in nitrogen recycling.

Several studies have shown that urinary nitrogen loss is lower and nitrogen retention is higher when high escape protein supplements are fed with low quality forages. Most of these studies added urea to the high escape protein supplements to allow for adequate rumen ammonia levels.

The objective of this study was to determine if high escape protein (corn gluten meal) without added urea would sustain ruminal fermentation comparable to soybean meal when fed at 24-hour and 48-hour intervals.

Materials and Methods

Four ruminally fistulated crossbred wether lambs (75 kg) were used in a Latin square designed experiment. Treatments consisted of corn stalk diets supplemented with corn gluten meal (CGM) and soybean meal (SBM) at 24-hour (SBM24 and CGM24) and 48-hour (SBM48 and CGM48) intervals. Supplements were formulated to be isonitrogenous (Table 1) and fed at 8.89% DMI to supply 50% of the 8.0% crude piotein for maintenance requirement. Corn stalks, 4.6% crude protein and 71% NDF, were ground

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through a 1.5 in. screen. Stalks were fed ad libitum at 7:00 a.m. and 5:00 p.m. daily. Lambs were housed in individual slotted floor pens under constant illumination and temperature (70 °F). Feed and feed refusals were weighed daily and recorded.

TABLE 1. COMPOSITION OF SOYBEAN MEAL AND CORN GLUTEN MEAL SUPPLEMENTS

Ingredient, %	SBM[a]	CGM[a]
Corn gluten meal		66.70
Soybean meal	92.01	
Dicalcium phosphate	3.37	3.37
Trace mineral salt	3.37	3.37
Vitamin A/D/E premix[b]	.22	.22
Vegetable oil	.51	.51
Bovatec[c]	.51	.51
Corn starch	.25	.31

[a] Supplements differ only by frequency (24 hours vs 48 hours) of feeding.
[b] Premix contained 1,000,000 IU/lb vitamin A, 500,000 IU/lb vitamin D and 1,000 IU/lb vitamin E.
[c] Added to prevent coccidiosis.

Lambs were adapted to corn stalk diets during a 7-day preliminary phase. Periods consisted of a 14-day adaptation followed by a 2-day collection. At the beginning of each period feed offered was restricted and gradually increased to ad libitum intake to ensure acceptance of the supplements. Jugular venous blood samples were collected at 0, 24 and 48 hours and analyzed for plasma urea nitrogen. Ruminal fluid was collected prior to feeding (0 hours) and at 3, 6, 9, 12, 24, 27, 30, 33 and 36 hours after feeding on day 15 of each period. Ammonia nitrogen (NH_3-N) and volatile fatty acid (VFA's) concentrations and pH were determined on these samples. Feed samples collected during each period were dried in a forced air oven at 100 °C for 48 hours for dry matter determination and ground through a Wiley mill. Samples were analyzed for Kjeldahl-N, acid detergent fiber (ADF) and neutral detergent fiber (NDF) content.

Data were arranged and analyzed as a 4 x 4 Latin square split plot design. Main effects of diet, period and lamb were tested by treatment x period x lamb interaction. Hour was tested by the hour x lamb interaction. Mean separations within hour were completed using least significant differences by PDIFF in SAS.

Results and Discussion

Supplements were accepted with minimal problems. Total dry matter intake for 16-day periods was affected ($P<.05$) by diet. No differences ($P>.10$) in DMI occurred during the last 7 days of each period. Total period differences may have reflected carryover effects from the previous period or initial acceptability of supplements. Daily DMI for the last 7 days of each period were 1310, 1231, 1198 and 1330 g $\pm$ 48.5 for SBM24, SBM48, CGM24 and CGM48, respectively.

Ruminal NH_3-N was affected ($P<.05$) by diet and a diet by hour interaction existed. RNH_3-N concentrations were higher ($P<.05$) when SBM48 was fed, reflecting quantity of protein and degradability supplied to the rumen. The diet by hour interactions (Table 2) that were observed ($P<.05$) for RNH_3-N may be due to differing fermentation rates as a result of protein source and frequency of supplementation. RNH_3-N concentrations on CGM diets were relatively low but did not drop below the 2 mg/dl suggested as a fermentation requirement. The lower RNH_3-N concentrations may reflect efficient bacterial growth, although VFA concentrations were not increased. Plasma urea nitrogen (PUN) as a possible indicator of ruminal NH_3-N spillover was not affected ($P>.10$) by diet (Table 3).

Diet did not affect total VFA concentration (Table 3), but a diet by hour interaction was present ($P<.05$). SBM48 caused a quicker ($P<.05$) peak in total VFA concentrations than CGM48 (Table 4), probably because of different protein degradation rates. CGM48 caused lower ($P<.05$) total VFA concentrations than SBM24 at 27 hours and 30 hours.

The molar proportions of the major VFA, acetate:propionate:butyrate, were 74:18:7, 74:18:7, 74:18:8 and 74:18:8 for SBM24, SBM48, CGM24 and CGM48, respectively. This suggests protein source or frequency of supplementation did not affect the type of fermentation that occurred.

Treatment effects on individual VFA concentrations (Table 3) were observed ($P<.05$). Isobutyrate concentrations were lower on the CGM24 diet. Individual VFA concentrations were affected ($P<.05$) by diet and hour interactions, reflecting total VFA diet by hour interactions.

TABLE 2. LEAST SQUARES MEANS FOR RUMINAL AMMONIA-N BY TREATMENT AND HOUR

Hour	Treatments[a]			
	SBM24	SBM48	CGM24	CGM48
	mg/dl			
0	5.56	6.74	7.31	6.67
3	12.24[b]	16.99[c]	8.17[d]	12.54[b]
6	6.71[b]	14.76[c]	2.82[de]	4.93[be]
9	5.60[b]	13.05[c]	2.48[de]	3.11[be]
12	7.14[b]	12.38[c]	2.73[d]	3.52[d]
24	5.64[b]	11.07[c]	5.63[b]	6.60[b]
27	13.84[b]	9.70[c]	7.42[cd]	6.52[d]
30	8.11[b]	6.55[bc]	3.70[d]	5.14[cd]
33	6.82[b]	6.13[b]	2.54[c]	4.80[bc]
36	7.16[b]	7.00[b]	3.60[c]	4.72[bc]

[a] Error mean square = 22.0.
[b,c,d,e] Means within a row with unlike superscripts differ (P<.05).

TABLE 3. LEAST SQUARES MEANS FOR RUMINAL pH, NH_3-N, PLASMA UREA NITROGEN (PUN), TOTAL VFA AND INDIVIDUAL VFA

Item	Treatment				SEM
	SBM24	SBM48	CGM24	CGM48	
pH	6.45	6.43	6.38	6.44	.03
NH_3-N (mg/dl)	7.88[ac]	10.43[a]	4.64[b]	5.86[bc]	.74
PUN (mg/dl)	7.72	7.23	5.72	7.74	.64
	μmoles/ml				
Total VFA	49.99	47.08	43.70	47.27	1.49
Acetate	36.33	34.13	31.68	34.53	1.04
Propionate	9.12	8.44	7.68	8.14	.29
Isobutyrate	.35[a]	.36[a]	.26[b]	.28[a]	.02
Butyrate	3.47	3.42	3.43	3.68	.19
Isovalerate	.48	.51	.44	.43	.05
Valerate	.24	.23	.21	.21	.01

[a,b,c] Means within a row with unlike superscripts differ (P<.05).

TABLE 4. LEAST SQUARES MEANS FOR TOTAL VFA BY TREATMENT AND HOUR

Hour	Treatments			
	SBM24	SBM48	CGM24	CGM48
	μmoles/ml			
0	41.09	35.61	38.05	39.67
3	54.51[bd]	55.66[b]	44.47[c]	47.44[cd]
6	52.64[be]	46.80[bd]	40.23[cd]	54.88[e]
9	52.50[b]	51.80[b]	44.22[cd]	49.76[bd]
12	47.36	51.86	45.14	51.63
24	42.30[bc]	45.89[c]	36.02[b]	44.81[c]
27	56.83[b]	46.20[c]	46.79[c]	43.90[c]
30	55.37[b]	46.52[c]	47.29[c]	47.41[c]
33	54.14[b]	45.29[c]	48.14[bc]	50.15[bc]
36	43.19	45.22	46.63	43.02

[a] Error mean square = 88.81.
[b,c,d,e] Means within a row with unlike superscripts differ (P<.05).

Treatment did not affect ruminal fluid pH, but a diet by hour interaction was observed (P<.05). Values for pH were well within the 6.2 to 7.0 range normally associated with high roughage diets.

In summary, CGM48 performed comparably to SBM24, suggesting it will support adequate ruminal fermentation, although some differences in fermentation did occur. SBM48 and CGM48 had similar total VFA concentrations, even though SBM48 had a higher RNH_3-N peak. It is unclear why feeding CGM at 48-hour intervals provided more constant RNH_3-N concentrations over time than feeding at 24-hour intervals. Alternative day supplementation did not result in any adverse ruminal fermentation effects, suggesting the possible use of this regimen with low quality forages.

EFFECTS OF AMINO ACID AND BRANCHED-CHAIN VOLATILE FATTY ACID ADDITIONS ON IN VITRO FERMENTATION OF DORMANT RANGE GRASSES

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CATTLE 89-8

Summary

Two-stage in vitro fermentation was used to screen five amino acids and three branched-chain volatile fatty acids as potential additions to a grain urea supplement for cows grazing dormant winter range. Urea addition alone increased dry matter and fiber digestibility of dormant cool season grasses. Methionine addition improved fiber digestibility and rate of fermentation of cool season grasses over urea alone. Compared to urea addition, the branched-chain volatile fatty acids did not increase dry matter or fiber disappearance or improve rate of fermentation of dormant range grasses. None of the buffer additions tested or urea increased digestibility of the dormant warm season grasses. This preliminary laboratory study indicates that methionine offers the greatest potential for addition to a grain urea supplement to increase utilization of dormant range grasses.

(Key Words: In Vitro Fermentation, Amino Acids, Branched-chain Volatile Fatty Acids, Dormant Range Grass.)

Introduction

In vitro fermentations are laboratory procedures designed to mimic rumen and/or lower gut digestion of ruminant animals. A single stage in vitro fermentation would indicate digestion of a feedstuff that occurs in the rumen. Rumen fluid from a rumen fistulated donor animal and buffers similar to those which are normally present in the rumen are mixed with a feed sample and maintained in a warm, oxygen-free environment for 48 hours. A two-stage in vitro fermentation would include the above first stage followed by an acid-pepsin digestion simulating feed breakdown that occurs in the abomasum and small intestine. These laboratory procedures allow for cost-effective preliminary screening of potential feed additives that may affect diet digestibility and animal performance.

Previous research has suggested that supplementation of amino acids, branched-chain volatile fatty acids or minerals may improve ruminal fermentation of low protein, dormant forages. Isolation of those beneficial components normally found in natural protein supplements could lead to enhanced utilization of lower cost nonprotein nitrogen sources. The objective of this study was to screen single amino acids and branched-chain volatile fatty acids as potential additions to a grain-urea supplement for cows grazing dormant winter range grasses.

Materials and Methods

Two-stage in vitro studies (replicated twice) were conducted separately for each of the predominant grass species inhabiting winter grazing areas located at the SDSU Range and Livestock Research Station near Cottonwood. Samples of cool season western wheatgrass and Japanese brome and a warm season shortgrass mixture of buffalograss and blue grama were hand-clipped from dormant standing vegetation in mid-March and oven dried at 60 °C prior to in vitro digestions. Rumen fluid was obtained from fistulated cows fed a mature grass hay composed of 63% (±10) western wheatgrass, 35% (±11) Japanese brome and 2% (±3) unidentified forage as determined by sorting 15 random subsamples. Analytical composition of grass samples and hay are listed in Table 1. Triplicate tubes consisting of additions of single amino acids (arginine, histidine, isoleucine, leucine and methionine), branched-chain volatile fatty acids (isobutyric, isovaleric and 2-methylbutyric acids), sodium sulfate, starch or urea alone were examined. All treatments except

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TABLE 1. CHEMICAL COMPOSITION OF DORMANT RANGE GRASSES AND GRASS HAY FED TO RUMEN FLUID DONORS[a]

Item	Western wheatgrass	Japanese brome	Shortgrass mixture	Grass hay
Dry matter, %	96.4	93.5	95.3	91.5
Crude protein, %	2.7	3.0	4.1	5.9
Ash, %	8.7	6.8	15.2	10.2
Calcium, %	.33	.24	.47	.40
Phosphorus, %	.05	.04	.06	.11
Sulfur, %	.07	.05	.07	.10
Neutral detergent fiber, %	69.9	68.7	65.1	63.9
Acid detergent fiber, %	43.6	50.6	35.9	33.7
Lignin, %	2.7	2.0	3.2	-

[a] Dry matter basis.

controls were balanced with urea to be isonitrogenous (50 mg of nitrogen/100 ml of buffer) and amino acids provided 25% of the total nitrogen/tube. Amino acid and branched-chain volatile fatty acid molar concentrations for each tube were the same. Sulfur levels were equal (7.14 mg/tube) for methionine and sodium sulfate treatments. Corn starch was provided at the same weight (33.3 mg/tube) as methionine and served as an energy control. Cumulative gas production as determined by a water displacement system was used to monitor in vitro fermentation rate of each tube over the first 48 hours. Neutral detergent fiber analysis was conducted on second stage in vitro residues to determine fiber digestibility.

Nonlinear iterative least squares regression procedures were used to generate estimated rate kinetics (lag time, fermentation rate and time of maximum rate, Figure 1) from cumulative gas production curves (Figure 2). Treatment effects were analyzed by least squares procedures using General Linear Model (GLM) of the Statistical Analysis System (SAS). Least squares means were separated by the Predicted Difference option.

Results and Discussion

The warm season shortgrass mix was slightly more digestible than western wheatgrass when no additional urea was added (Table 2). This difference can be explained by a greater disappearance of the fiber fraction for the shortgrass. When urea was provided, dry matter and neutral detergent fiber disappearance of western wheatgrass and Japanese

TABLE 2. EFFECTS OF UREA ADDITION ON IN VITRO DRY MATTER AND FIBER DISAPPEARANCE OF DORMANT RANGE GRASSES

Item	Western wheatgrass	Japanese brome	Shortgrass mixture
Dry matter disappearance, %			
Without urea	39.4^{a}	42.1^{b}	42.7^{b}
With urea	49.6^{d}	59.5^{c}	43.1^{b}
NDF disappearance, %			
Without urea	49.5^{a}	50.1^{a}	60.7^{b}
With urea	62.3^{b}	69.9^{c}	61.6^{b}

[a,b,c,d] Means within item without a common superscript differ (P<.05).

FIGURE 1
In vitro fermentation kinetics of western wheatgrass with methionine addition (example).

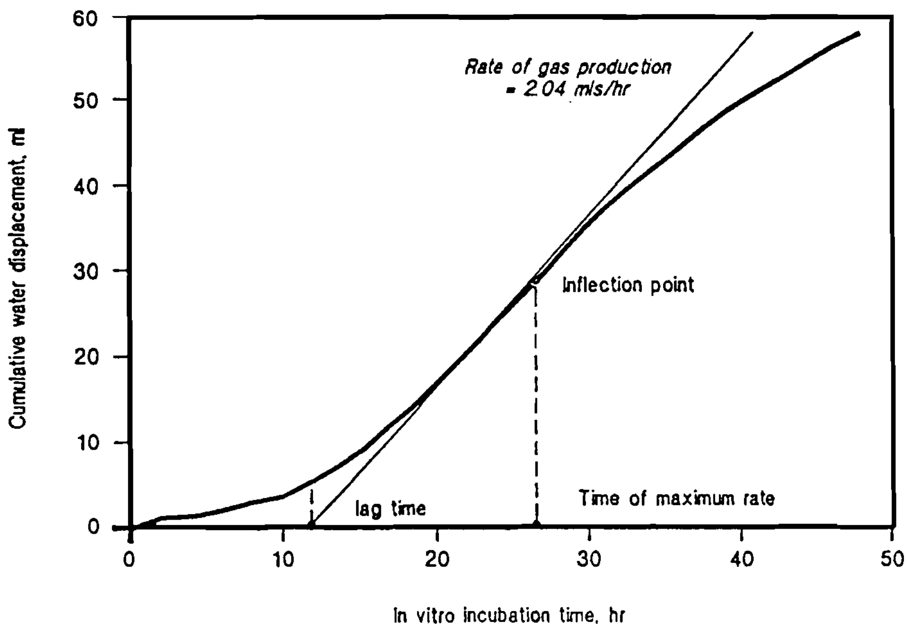
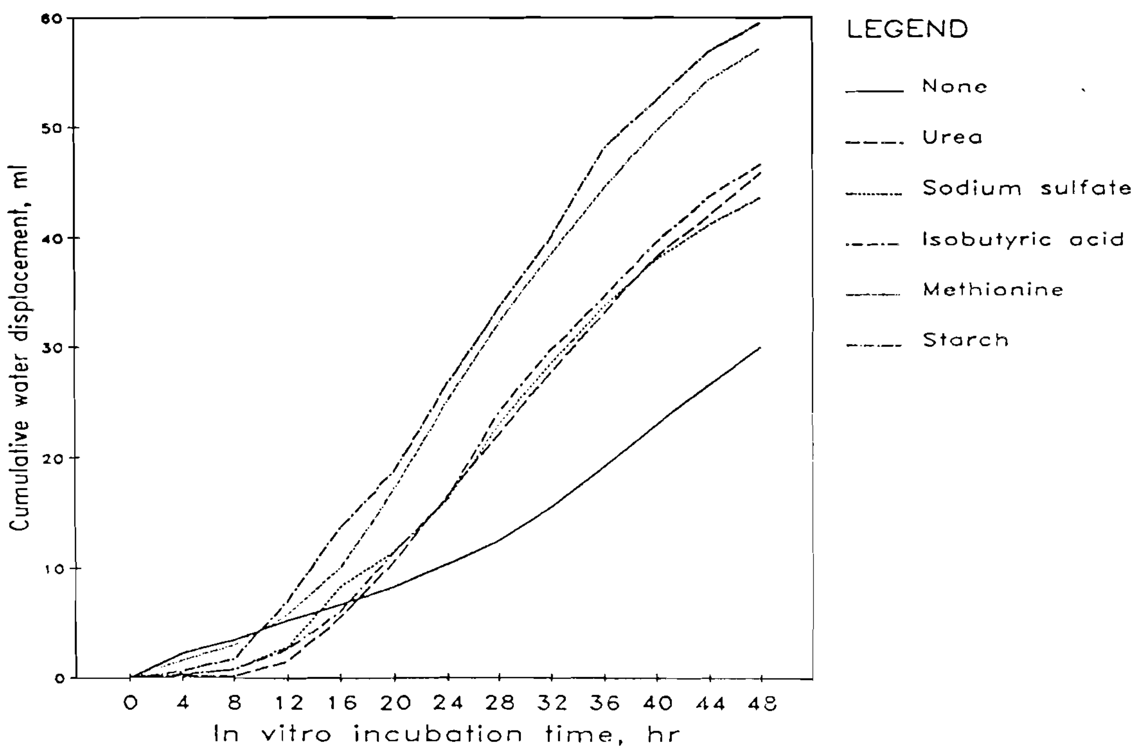


FIGURE 2
GAS PRODUCTION CURVES OF WESTERN WHEATGRASS WITH IN VITRO BUFFER ADDITIONS (example).



brome were increased ($P<.05$; 10 and 17%, respectively) suggesting that nitrogen was limiting for the cool season grasses. Urea addition did not improve digestibility of the warm season grasses which could be explained by its higher protein concentration (Table 1). Lignin and ash (primarily silica) content of the shortgrass mix were also higher than the cool season grasses which could limit digestibility.

Dry matter disappearance of western wheatgrass was not increased by in vitro buffer additions over urea alone and was lower ($P<.05$) when arginine was added (Table 3). Methionine improved ($P<.05$) neutral detergent fiber disappearance of western wheatgrass over urea alone and increased ($P<.05$) dry matter and fiber digestibility of Japanese brome (Table 4). Sodium sulfate increased ($P<.05$) neutral detergent fiber disappearance of Japanese brome over urea alone. Compared to grass alone none of the buffer amendments or urea affected digestibility of the warm season shortgrasses (Table 5).

Methionine addition increased ($P<.05$) rate of fermentation of western wheatgrass and methionine or isoleucine increased ($P<.05$) fermentation rate of Japanese brome (Tables 3 and 4). Fermentation rate was increased ($P<.05$) when histidine was added to shortgrasses. An increase ($P<.05$) in fermentation rate of dormant range forage when applied to the live animal grazing winter range could increase rate of passage and increase forage intake resulting in greater cow weight gains or reduced weight losses.

Lag time (the time prior to rapid microbial growth) was shortened ($P<.05$) by histidine addition and histidine, isoleucine, methionine or 2-methylbutyric acid decreased ($P<.05$) time of maximum fermentation rate for Japanese brome over urea alone. Amino acid or branched-chain volatile fatty acid buffer additions did not decrease lag phases or time of maximum fermentation rate for western wheatgrass or the shortgrasses. Sodium sulfate had no effect on in vitro rate kinetics of dormant range grasses. Corn starch increased ($P<.05$) in vitro fermentation rates of all grasses and shortened ($P<.05$) lag phases and the time at which maximal in vitro fermentation occurred (Tables 3, 4 and 5). Starch may have been used initially as a preferred energy source by some cellulolytic bacteria over the grass itself resulting in improved fermentation parameters as measured by gas production. This delay in forage digestion could explain why starch plus urea addition did not affect digestibility of dormant range grasses.

In vitro digestions for screening amino acid, branched-chain volatile fatty acid and sulfur buffer additions to dormant range grasses suggest that methionine supplementation offers the greatest potential for improving digestibility and rate of fermentation of dormant cool season grasses. None of the amendments tested or urea improved digestibility of the warm season shortgrasses. Currently grazing studies are being conducted to determine the effects of a methionine/grain-urea supplement on digestibility and intake of dormant winter range and cow performance.

TABLE 3. EFFECTS OF IN VITRO BUFFER ADDITIONS ON DIGESTIBILITY OF WESTERN WHEATGRASS

Addition	Dry matter disappearance, %	NDF disappearance, %	Lag time, hr	Fermentation rate, ml H_2O/hr	Time of maximum rate, hr
Urea	49.0^{a}	60.4^{ab}	16.9^{a}	1.70^{bcde}	30.6^{ab}
Amino acids					
Arginine	45.2^{b}	62.9^{bc}	16.6^{ab}	1.54^{def}	31.2^{a}
Histidine	48.0^{ab}	61.8^{abc}	14.9^{abc}	1.88^{abc}	28.9^{abc}
Isoleucine	48.6^{a}	61.6^{abc}	15.3^{abc}	1.77^{abcd}	28.7^{bc}
Leucine	47.9^{ab}	63.2^{bc}	16.2^{ab}	1.77^{abcd}	30.1^{abc}
Methionine	49.8^{a}	64.6^{c}	15.3^{abc}	1.92^{a}	29.8^{abc}
Branched-chain volatile fatty acids					
Isobutyric acid	49.4^{a}	61.2^{abc}	16.6^{ab}	1.68^{cde}	29.8^{abc}
Isovaleric acid	47.1^{ab}	61.5^{abc}	15.5^{abc}	1.56^{def}	29.5^{abc}
2-methylbutyric acid	48.3^{ab}	62.7^{bc}	15.9^{ab}	1.43^{f}	29.3^{abc}
Na_2SO_4	48.6^{a}	60.5^{ab}	16.6^{ab}	1.50^{ef}	30.4^{abc}
Starch	47.6^{ab}	62.8^{bc}	13.4^{c}	1.94^{a}	28.1^{c}

[a,b,c] Means within column without a common superscript differ ($P<.05$).

TABLE 4. EFFECTS OF IN VITRO BUFFER ADDITIONS ON DIGESTIBILITY OF JAPANESE BROME

Addition	Dry matter disappearance, %	NDF disappearance, %	Lag Lag time, hr	Fermentation rate, ml H_2O/hr	Time of maximum rate, hr
Urea	58.1^{bc}	68.8^{cde}	15.7^{ab}	1.81^{a}	31.4^{a}
Amino Acids					
Arginine	56.4^{cd}	68.2^{def}	13.5^{abc}	1.82^{a}	31.0^{ab}
Histidine	54.4^{de}	67.2^{ef}	12.1^{c}	1.93^{ab}	29.3^{bc}
Isoleucine	59.0^{bc}	71.4^{abc}	13.3^{bc}	2.05^{b}	29.5^{bc}
Leucine	52.7^{e}	65.6^{f}	14.4^{abc}	1.71^{a}	32.1^{a}
Methionine	63.0^{a}	74.0^{a}	14.2^{abc}	2.81^{d}	26.9^{d}
Branched-chain volatile fatty acids					
Isobutyric acid	58.9^{bc}	69.8^{bcde}	15.7^{ab}	1.84^{ab}	30.9^{ab}
Isovaleric acid	55.8^{cde}	69.2^{cde}	13.5^{abc}	1.81^{a}	30.4^{abc}
2-methylbutyric acid	57.2^{bcd}	70.0^{bcde}	13.5^{abc}	1.77^{a}	29.7^{bc}
Na_2SO_4	60.4^{ab}	72.55^{ab}	16.1^{a}	1.90^{ab}	30.6^{abc}
Starch	57.5^{bcd}	70.6^{bcd}	12.1^{c}	2.29^{c}	29.0^{c}

^{a,b,c,d,e,f} Means within column without a common superscript differ ($P<.05$).

TABLE 5. EFFECTS OF IN VITRO BUFFER ADDITIONS ON DIGESTIBILITY OF SHORTGRASS MIXTURE

Addition	Dry matter disappearance, %	NDF disappearance, %	Lag time, hr	Fermentation rate ml H_2O/hr	Time of maximum rate, hr
Urea	43.8^{ab}	64.1^{ab}	9.3^{abc}	1.13^{ab}	22.4^{b}
Amino Acids					
Arginine	41.0^{bc}	63.6^{ab}	9.6^{abc}	1.10^{a}	25.3^{cde}
Histidine	43.6^{abc}	63.9^{ab}	8.9^{ab}	1.41^{cd}	22.4^{ab}
Isoleucine	44.0^{ab}	64.5^{ab}	10.4^{abcd}	1.22^{abc}	24.0^{bcd}
Leucine	44.1^{a}	65.2^{a}	11.5^{cd}	1.33^{bcd}	25.2^{cde}
Methionine	42.8^{abc}	63.8^{ab}	12.3^{d}	1.32^{bc}	26.5^{de}
Branched-chain volatile fatty acids					
Isobutyric acid	43.3^{abc}	64.7^{ab}	10.6^{bcd}	1.26^{abc}	23.1^{abc}
Isovaleric acid	42.9^{abc}	64.5^{ab}	10.2^{abcd}	1.16^{ab}	23.4^{abc}
2-methylbutyric acid	44.2^{a}	64.3^{a}	9.2^{abc}	1.11^{a}	22.3^{ab}
Na_2SO_4	41.7^{abc}	62.6^{ab}	10.5^{abcd}	1.05^{a}	22.5^{ab}
Starch	42.7^{abc}	64.1^{ab}	7.9^{a}	1.53^{d}	21.1^{a}

^{a,b,c} Means within column without a common superscript differ ($P<.05$).

EFFECT OF METHIONINE ADDITION TO A UREA-GRAIN BASED SUPPLEMENT ON DIGESTIBILITY OF MATURE PRAIRIE GRASS HAY

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CATTLE 89-9

Summary

A digestibility trial was conducted to determine the effect of methionine addition to a grain-urea based supplement on the digestibility of mature prairie hay. Ad libitum hay supplemented with .1 lb supplemental crude protein from either a (1) soybean meal, (2) methionine + urea-grain, (3) sulfur + urea-grain or (4) urea-grain supplement was fed to 20 Hampshire ram lambs. Dry matter, neutral detergent fiber and acid detergent fiber disappearances tended to be higher with methionine or sulfur-urea supplements over urea alone. Diet digestibilities between soybean meal, methionine and sulfur treatments were similar. Methionine increased apparent nitrogen digestibility of the diet compared to other treatments. Dry matter intake, urinary nitrogen excretion and nitrogen retention were not affected by supplementation. It appears that methionine and sulfur enhance utilization of mature prairie grass hay when added to a urea-grain based supplement.

(Key Words: Methionine, Urea, Prairie Hay, Digestibility.)

Introduction

Nonprotein nitrogen supplementation of ruminant animals consuming dormant low protein forages has met with limited success. Sulfur which is associated with the microbial fixation of ammonia has been shown to increase utilization of urea when added to the diet. Recent studies have suggested that methionine (a sulfur containing amino acid) when added to urea based protein supplements may increase dry matter and fiber disappearance of mature low protein forages. The objective of this trial was to determine the effects of methionine addition to a grain-urea based protein supplement on digestibility of mature prairie hay.

Materials and Methods

Hampshire ram lambs (mean weight 116.5 lb ± 7.3) fed mature prairie grass hay were assigned to one of four supplemental protein treatments (Table 1). Supplements were balanced to meet crude protein requirements for a mature 120-lb ewe during maintenance assuming 1.2 lb of crude protein were derived from the prairie hay (2.5 lb of 5.5% crude protein hay per head each day). Urea-grain supplements were balanced to provide equal daily intake of energy, calcium, phosphorus and sulfur as the soybean meal supplement (Table 2). Methionine and sulfur urea-grain supplements were balanced to provide equal levels of sulfur per head each day. Mature prairie grass hay was fed ad libitum and intakes were stabilized over a 21-day pretrial period. Hay was composed of 63% (±10) western wheatgrass, 35% (±11) Japanese brome and 2% (±3) unidentified forage as determined by sorting 15 random subsamples. Prairie hay composition is listed in Table 3. Total fecal and urine collections were carried out over two 3-day collection periods. Fecal subsamples were frozen and later oven dried at 60 °C. Ten percent aliquots of HCl treated urine were frozen for later Kjeldahl nitrogen determinations. Feed refusals were incorporated into the next days feed during the collection periods. Final feed refusals were weighed and oven dried for later lab analysis. Dry matter, acid detergent fiber, neutral detergent fiber and Kjeldahl nitrogen analyses were completed on feed and fecal samples.

Data was pooled over the two collection periods. Treatment effects were analyzed by least squares procedures using General Linear Model (GLM) of the Statistical Analysis System (SAS). Means were separated by the Predicted Difference option (Pdiff). Dry matter intake was included in the model as a

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TABLE 1. SUPPLEMENTS FED TO LAMBS DURING DIGESTIBILITY TRIAL[a]

	Supplements			
	1	2	3	4
Ingredients	Soybean meal	Urea + methionine	Urea + sulfur	Urea
Soybean meal	91.0	20.0	20.0	21.5
Corn	3.5	58.5	58.75	60.0
d-L-methionine	--	3.0	--	--
Urea	--	7.5	7.5	7.5
Na_2SO_4	--	--	2.75	--
Binder	1.5	5.0	5.0	5.0
Liquid molasses	4.0	4.0	4.0	4.0
Potassium chloride	--	1.0	1.0	1.0
Dicalcium phosphate	--	1.0	1.0	1.0

[a]Percent, dry matter basis.

TABLE 2. NUTRIENT INTAKE FROM SUPPLEMENTS FED LAMBS DURING DIGESTIBILITY TRIAL[a]

	Supplements			
Item	Soybean meal	Urea + methionine	Urea + sulfur	Urea
Dry matter, %	87.79	88.61	89.68	87.99
Crude protein	.10	.10	.10	.10
Nonprotein nitrogen	.0002	.0089	.0095	.0094
Calcium	.0009	.0010	.0011	.0011
Phosphorus	.0013	.0012	.0013	.0014
Potassium	.0053	.0036	.0037	.0038
Sulfur	.0010	.0019	.0020	.0005
Methionine	.0015	.0085	.0007	.0008
Mcal ME[b]	.257	.259	.263	.261

[a] Lb per head each day.
[b] Calculated values.

TABLE 3. COMPOSITION OF PRAIRIE HAY FED LAMBS DURING DIGESTIBILITY TRIAL[a]

Item	%
Dry matter	84.10
Crude protein	5.83
Calcium	.40
Phosphorus	.11
Sulfur	.10
Neutral detergent fiber	70.2
Acid detergent fiber	39.0
Alkaline peroxide lignin	1.57

[a] Percent, dry matter basis.

covariate for all digestibility and nitrogen utilization analyses except nitrogen biological value.

Results and Discussion

Dry matter intake was not affected by supplemental treatments (Table 4). Average intake of prairie hay during the collection period was highly variable between lambs and ranged from 1.8 to 3.0 lb dry matter per day. Apparent dry matter digestibility tended (P = .16) to be lower for lambs supplemented with urea alone. Diet digestibility between methionine, sulfur and soybean meal supplemented lambs were similar. Differences in diet digestibility can be explained by fiber digestibility differences between treatments. Neutral detergent fiber and acid detergent fiber digestibilities of the urea fed lambs tended (P = .11 and .08, respectively) to be higher when methionine or sulfur were added to the supplements. Diet fiber digestibilities for soybean meal supplemented lambs were similar to the methionine and sulfur treatments.

TABLE 4. EFFECT OF SUPPLEMENTATION ON INTAKE AND DIGESTIBILITY OF MATURE PRAIRIE GRASS HAY

	Supplements				
Item	Soybean meal	Urea + methionine	Urea + sulfur	Urea	Prob.[a]
No. of lambs	5	5	5	5	
Dry matter intake, lb/day	2.25	2.33	2.39	2.28	
Dry matter disappearance, %	45.5[b]	46.7[b]	46.8[b]	43.4[c]	.16
Neutral detergent fiber disappearance, %	53.8[bc]	55.2[b]	55.6[b]	51.9[c]	.11
Acid detergent fiber disappearance, %	51.3[bc]	52.6[b]	52.8[b]	49.1[c]	.08
Apparent nitrogen digestibility, %	58.2[b]	60.3[c]	58.0[b]	55.8[d]	.01
Fecal nitrogen, g/day	7.0	6.7	6.9	7.0	
Urinary nitrogen excretion, g/day	8.5	9.2	8.6	8.9	
Nitrogen retention, g/day	1.2	.9	.9	.0	
Nitrogen biological value[e]	11.0	9.4	10.0	-1.0	

[a] Prob. = probability of a significant treatment effect.
[b,c,d] Means within row with uncommon superscripts differ (P = listed value).
[e] Biological value = 100 x (1 - (g urinary N/(g N intake - g fecal N).

Nitrogen digestibility of the diet for lambs fed urea supplements was higher (P<.01) with methionine or sulfur addition (Table 4). Urea was fed at similar levels for all three diets and nitrogen from urea would be nearly 100% degradable, resulting in higher apparent nitrogen digestibility. Methionine supplementation increased (P<.05) nitrogen digestibility over sulfur treatment. Nitrogen retention (dietary nitrogen retained in the body), urinary nitrogen and fecal nitrogen were not different between treatments. Biological value of dietary nitrogen (percentage of nitrogen absorbed in the gastrointestinal tract that is retained in the body) reflected nitrogen retention values and were not different between supplements.

It appears that the usefulness of urea-grain based protein supplements for ruminants fed low protein mature forages can be improved with the addition of methionine or sulfur. Diet dry matter and fiber digestibility tended to be higher compared to urea alone supplementation. With an increase in diet utilization an animal's ability to maintain body weight while grazing dormant winter forage would be improved. Ongoing research will study the effects of these same four supplemental treatments on diet digestibility and intake for cows grazing dormant winter range.

EFFECT OF METHIONINE, LEUCINE AND ISOVALERIC ACID ON IN VITRO DIGESTIBILITY OF CORN STOVER

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CATTLE 89-10

Summary

Two-stage in vitro fermentation was used to evaluate the amino acids methionine and leucine and a branched chain volatile fatty acid, isovaleric acid, as potential additives to a grain-urea supplement for cattle consuming corn stover. Dry matter and fiber digestibility were higher for the husks and leaves than the stalk portion of the corn plant. Providing urea as a source of nitrogen improved dry matter and fiber digestibility. There were no improvements in digestibility or fermentation rate with addition of the amino acids or volatile fatty acid evaluated.

(Key Words: Corn Stover, Urea, Methionine, Leucine, Isovaleric Acid.)

Introduction

Enhanced digestibility, increased dry matter intake and an improvement in animal performance can be realized from providing an all natural protein supplement to cattle consuming mature, low protein forages like corn stover. Although cheaper, urea and other nonprotein nitrogen supplements are not as effective as natural proteins in improving animal performance. Recent SDSU research demonstrated the potential for improving the effectiveness of grain-urea supplements for cattle consuming mature, low protein prairie hay by adding the amino acids methionine and leucine and the branched chain volatile fatty acid isovaleric acid. This laboratory study was conducted to evaluate the potential of these compounds when urea is the major source of supplemental crude protein fed to cattle consuming corn stover.

Materials and Methods

Corn stover was separated into the stalk component and the husks and leaves component (Table 1). Two replications of a two-stage in vitro fermentation were conducted with triplicate forage samples. Rumen fluid was obtained from two fistulated cows fed corn stover ad libitum.

TABLE 1. COMPOSITION OF CORN STOVER COMPONENTS IN IN VITRO FERMENTATIONS[a]

Item	Stalks	Husks and leaves
Dry matter, %	89.25	89.27
Crude protein, %	5.04	4.61
Ash, %	4.87	3.91
Calcium, %	.31	.19
Phosphorus, %	.05	.10
Sulfur, %	.07	.08
ADF, %	47.2	36.2
NDF, %	74.3	78.1

[a] All values except dry matter are expressed on a dry basis.

The fermentation tubes included .5 g ground forage and 25 ml buffer per tube plus one of the following additives: (1) forage alone, (2) 26.6 mg urea, (3) 26.6 mg urea and 33.3 mg starch, (4) 20 mg urea and 33.3 mg methionine, (5) 26.6 mg urea and 7.14 mg sulfur supplied by Na_2SO_4 (6) 20 mg urea and 29.3 mg leucine and (7) 26.6 mg urea and 22.8 mg isovaleric acid. The added amino acids supplied 25% of the supplemental nitrogen, with urea supplying the other 75%. Treatment 5 contained the same amount of sulfur as the methionine treatment. Starch added at an equal weight to methionine was used as an energy control. All other amino acids and branched chain fatty acids were isomolar to methionine. Treatments 2 through 7 were isonitrogenous. Cumulative gas

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production measured by a water displacement system was recorded at 4-hour intervals for the 48-hour incubation period. Neutral detergent fiber analysis was conducted on the second stage in vitro residues to determine fiber digestibility.

Least squares means of dry matter and neutral detergent fiber disappearance were determined by General Linear Model procedures of SAS. Nonlinear procedures of SAS were used to calculate lag phase, time to maximum fermentation and rate of fermentation (during the rapid microbial growth phase) from gas production. Further details of analysis are described in another article in this publication (CATTLE 89-8).

Results and Discussion

Dry matter and neutral detergent fiber (NDF) disappearance were greater ($P<.05$) for husks and leaves than for the stalk component of the corn stover (Table 2). Although there was an interaction between treatment and stover component for both dry matter ($P<.001$) and NDF ($P<.01$) disappearance, this interaction relates primarily to a greater improvement by addition of urea for the husks and leaves than for stalks. The addition of starch, methionine, sulfur, leucine or isovaleric acid did not increase disappearance of dry matter or NDF.

The time of the lag phase and time to maximum fermentation presented in Table 3 describe the fermentation characteristics. Rate of fermentation (during the rapid microbial growth phase) is the most meaningful comparison of the treatments and stover components. There were no interactions for these variables. Husks and leaves were fermented more rapidly ($P<.001$) than stalks. The greater fermentation rate of the urea + starch treatment would be expected since starch is rapidly degraded. The lack of improvement in dry matter and NDF disappearance by starch addition would indicate that the improvement in fermentation rate was due to the starch itself rather than its effect on fermentation of the forage. Other additions did not increase fermentation rate over urea.

The results of this laboratory study confirm that the husk and leaf portions of corn stover are more digestible than the stalk. The potential advantages of adding methionine, leucine or isovaleric acid to a grain-urea supplement for cattle consuming corn stover are not as great as observed in previous studies with mature prairie grasses.

TABLE 2. DRY MATTER AND FIBER DISAPPEARANCE

	Dry matter disappearance, %		Neutral detergent fiber disappearance, %	
	Stalks	Husks and leaves	Stalks	Husks and leaves
Additives				
Forage alone	37.5^a	26.6^a	43.6^a	44.6^a
Urea	49.1^b	51.7^b	55.8^c	64.3^b
Urea + starch	48.9^b	50.3^b	54.7^{bc}	65.3^b
Urea + methionine	47.2^b	54.2^b	52.3^{bc}	65.7^b
Urea + Na_2SO_4	46.2^b	51.0^b	52.3^{bc}	63.8^b
Urea + leucine	47.1^b	51.4^b	51.7^b	64.1^b
Urea + isovaleric acid	47.3^b	52.3^b	53.4^{bc}	64.8^b
Standard error of means	1.3	1.3	1.2	1.2
Stover component				
Overall means	46.2^d	48.2^e	52.0^d	61.8^e
Standard error of means	.5	.5	.5	.5

^{a,b,c} Means within a column without a common superscript differ ($P<.05$).

^{d,e} Means within a row for the same variable without a common superscript differ ($P<.05$).

TABLE 3. FERMENTATION CHARACTERISTICS

	Time of lag phase, hour	Time to maximum fermentation, hour	Rate of fermentation, ml gas/hour
Additives			
Urea	11.0^{ab}	25.3^{ab}	1.32^{b}
Urea + starch	9.0^{c}	23.7^{b}	1.77^{a}
Urea + methionine	11.6^{a}	26.8^{a}	1.43^{b}
Urea + Na_2SO_4	9.1^{c}	23.3^{b}	1.40^{a}
Urea + leucine	11.7^{a}	24.8^{ab}	1.51^{b}
Urea + isovaleric acid	9.8^{bc}	24.5^{b}	1.36^{b}
Standard error of the mean	.5	.7	.07
Stover component			
Stalks	8.8^{d}	23.6^{d}	1.18^{d}
Husks and leaves	12.0^{e}	25.9^{e}	1.75^{e}
Standard error of the mean	.3	.4	.04

[a,b,c] Means within a column without a common superscript differ ($P<.05$).
[d,e] Means within a column without a common superscript differ ($P<.01$).

EVALUATION OF CONTROLLED RELEASE CHROMIC OXIDE BOLUSES AND ALKALINE PEROXIDE LIGNIN AS MARKER METHODS TO DETERMINE FORAGE INTAKE OF GRAZING RUMINANTS

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CATTLE 89-11

Summary

Twenty Hampshire ram lambs used in a digestibility trial were administered controlled release chromic oxide intraruminal boluses to evaluate chromic oxide and alkaline peroxide lignin in combination as potential markers for determining intake of ruminants grazing dormant winter range. Lambs were fed ad libitum mature prairie grass hay and provided .1 lb crude protein from one of four supplements. The ability to predict fecal output using chromic oxide boluses and diet digestibility using alkaline peroxide lignin were not affected by supplemental treatments. Chromic oxide concentration in the feces was not affected by the time of sampling. The amount of chromium oxide excreted averaged 224 mg/day and was not affected by treatment. The amount of lignin consumed that was recovered in the feces was 97.8 $\pm$ 11.6%. Predicted fecal output was closely related to actual values (R^2 = .83, c.v. = 8.4%). Predicted digestibility and dry matter intake were similar to actual values (P = .77 and .90, respectively). Controlled release chromic oxide boluses and alkaline peroxide lignin procedures may be used to predict dry matter intake of ruminants grazing mature forages.

(Key Words: Chromium, Alkaline Peroxide Lignin, Markers, Grazing, Mature Forages.)

Introduction

Forage consumption by grazing animals is difficult to estimate. Understanding factors affecting forage intake is important, however, when conducting research on the nutritional management of grazing animals. Forage intake can be calculated by the equation Dry matter intake = Fecal output/(1 - forage digestibility) if accurate measurements of daily fecal output and digestibility of the forage grazed can be made. Diet digestibility and fecal output have often been determined through the use of internal (indigestible fractions of the forage) and external (indigestible foreign compounds introduced into the diet or animal) markers. New technology has led to a controlled release chromic oxide bolus that allows accurate estimates of fecal output in grazing animals to be made with less labor than previous methods. An indigestible fraction of the diet such as lignin could be used to determine digestibilty of the grazed forage. Recent methods of analysis have incorporated an alkaline peroxide predigestion into the typical lignin procedure which may improve estimates of diet digestibility.. The objective of this study was to evaluate controlled release chromic oxide boluses and alkaline peroxide lignin procedures for use in estimating forage intake in grazing ruminants.

Materials and Methods

Hampshire ram lambs (mean weight 116.5 lb $\pm$ 7.3) fed mature prairie grass hay ad libitum were assigned to one of four protein supplemental treatments (see page 31, Tables 1 and 2). Hay was weighed and fed twice daily with feed refusals incorporated into the next day's feed. Five days prior to fecal collections, lambs were orally administered a chromic oxide bolus[3] designed to release 204 mg/day of chromium oxide (chromium sesquioxide) at a constant rate. Fecal samples were collected over two 3-day collection periods, subsampled, pooled within collection period and oven dried at 60 °C for later laboratory analyses. After the final collection period, four fecal grab samples were taken at 6-hour intervals from two lambs on each of the four treatments to determine if fecal chromic oxide concentration was affected by time of sampling. Fecal samples were analyzed for chromic oxide using a microdigestion-oxidation procedure and flame atomic absorption

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spectrophotometry. Alkaline peroxide lignin levels (APL) of hay and fecal samples were determined using an alkaline peroxide predigestion followed by standard lignin analysis. Equations used to ultimately derive dry matter intake are expressed in Table 1.

Data were analyzed by least squares procedures using General Linear Model (GLM) of the Statistical Analysis System (SAS). Least squares means were separated by the Predicted Difference option (Pdiff). Data from both collection periods were pooled for actual vs predicted models. Actual vs predicted values were also compared using MEANS procedure with the paired t-test option (T PRT).

TABLE 1. EQUATIONS USED IN THE PROCESS OF ESTIMATING DRY MATTER INTAKE

Cr_2O_3 excretion rate, mg/day =
(mg Cr2O3/g fecal dry matter) x (g fecal dry matter/day)

Predicted fecal dry matter output, g/day =
(mean Cr_2O_3 excretion rate[a])/(mg Cr_2O_3/g fecal dry matter)

Percent lignin recovery =
(% fecal APL x g fecal dry matter/day)/(% dietary APL x g dry matter intake/day)

Predicted digestibility = (% fecal APL)/(% dietary APL)

Predicted dry matter intake =
(predicted fecal dry matter/day)/(1 - predicted digestibility)

[a] Average excretion rate for 20 lambs = 224 mg Cr_2O_3.

Results and Discussion

Mean excretion rate of the 20 chromic oxide boluses based on total fecal collections was 224 $\pm$ 24.5 mg Cr_2O_3 per day. Manufacturer validation tests indicated that 201 mg Cr_2O_3 per day disappeared in similar boluses in the rumen each day. Excretion values in this study ranged from 171 to 267 mg Cr_2O_3 per day. Predicted fecal output estimates were closely associated (R^2 = .83; C.V. = 8.4%) with actual fecal output determinations for individual lambs. Supplemental treatments had no effect on chromic oxide release rates or prediction of fecal output (Table 2). Time of sampling did not affect fecal chromic oxide concentrations (P = .98; Table 3).

Average fecal recovery of alkaline peroxide lignin (APL) for the 20 lambs was 97.8 $\pm$ 11.6%. Recovery values for APL ranged from 82.4 to 129.3%. Pooled data from the two collection periods resulted in poor predictions of apparent digestibility (R^2 = .009; C.V. = 18.3%) for individual lambs. This can be partially explained by the small range in actual apparent digestibility values found in this trial (mean digestibility = 45.6 $\pm$ 2.7%; range = 41.2 to 50.2%) compared to the error associated with determining digestibility using marker procedures. Predicted vs actual digestibility values were not different (P = .77), however, when analyzed using a paired T-test. Supplemental treatments had no effect on fecal recovery of APL or prediction of apparent digestibility (Table 2).

The relationship between predicted and actual dry matter intake (R^2 = .540; C.V. = 17.0%) was influenced by the error associated with determining digestibility. However, predicted vs actual dry matter intake values were similar (P = .90) using paired comparisons. The ability to predict dry matter intake was not influenced by supplemental treatments (Table 2).

TABLE 2. EFFECT OF SUPPLEMENTAL TREATMENTS ON PREDICTIVE VALUE OF MARKER PROCEDURES

Item	Supplements			
	Soybean meal	Urea + methionine	Urea + sulfur	Urea
Recovery of alkaline peroxide lignin, %[a]	96.4	102.1	92.4	98.1
Chromic oxide release rate, mg/day	225	218	216	236
Predicted minus actual				
Fecal dry matter, g	11.9	15.6	30.7	-25.6
Apparent digestibility, %	-2.6	.9	-4.3	-1.3
Dry matter intake, g	11.7	94.3	2.7	-47.9

TABLE 3. EFFECT OF SAMPLING TIME ON FECAL CHROMIC OXIDE CONCENTRATIONS

Sampling time, hr	Cr_2O_3,mg/g[a]
0	39.6 ± 2.4
6	39.1 ± 2.3
12	39.6 ± 2.7
18	38.5 ± 2.4

[a] Mean ± standard errors.

These preliminary results indicate that controlled release chromic oxide boluses can be used to predict fecal dry matter output for individual lambs. The relationship between predicted and actual digestibility as determined by alkaline peroxide lignin procedures is more variable and inflates the error associated with predicting dry matter intake. While effective estimates of dry matter intake for a group of lambs can be made using these procedures, limitations remain for predicting an individual's consumption. Present research will involve assessment of these same techniques with mature cows in drylot and under range conditions.

COMPARISON OF MELENGESTROL ACETATE AND PROSTAGLANDIN WITH TWO INJECTIONS OF PROSTAGLANDIN FOR ESTROUS SYNCHRONIZATION IN BEEF HEIFERS

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CATTLE 89-12

Summary

Crossbred beef heifers were used to compare conception rate when synchronizing estrus with melengestrol acetate (MGA) and prostaglandin or two injections of prostaglandin. Melengestrol acetate was fed to one group of heifers for 16 days and prostaglandin injected 16 days after MGA removal or two injections of prostaglandin given 11 days apart in the other group. The MGA group had a higher conception rate ($P<.05$) to timed AI, but there was no difference between the two groups for the breeding season. It appears MGA with prostaglandin results in increased conception to a timed insemination.

(Key Words: Beef Heifers, Synchronization, Melengestrol Acetate, Prostaglandin.)

Introduction

Considerable research has been conducted over the past years controlling the estrous cycle in cattle with varying results. For artificial insemination (AI) to be implemented on a large scale in the beef cattle industry estrous control becomes more important. Low conception rate following estrous synchronization has been due to noncycling animals due to inadequate management or nutrition. Several products are presently available for estrous synchronization and results are satisfactory when good management and nutritional regimes are utilized. Melengestrol acetate has been used in the feedlot to improve gain and efficiency and suppress estrus in intact open females but is not presently cleared for estrous synchronization. It is a synthetic hormone with similar activity and structure of progesterone. Recently research with MGA and prostaglandin has indicated its possible use to synchronize estrus. The purpose of this study was to evaluate the effectiveness of MGA in controlling the estrous cycle of beef heifers when used in conjunction with a prostaglandin.

Materials and Methods

Two methods of synchronization were compared to determine the effectiveness of MGA as a synchronizing agent. In July, 62 head of yearling, crossbred beef heifers were started on trial at the SDSU Research Farm near Centerville. The heifers were purchased as fall calves and fed a ration of corn silage, corn and alfalfa:grass hay to gain 2 lb per day. All heifers were maintained in small lots of 7 to 9 head per pen. In October, MGA was fed for 16 days in the ration to heifers in four of the eight pens. Sixteen days after MGA withdrawal a prostaglandin (Lutalyse[4]) was administered to the heifers that had been fed MGA. The other four pens were injected with Lutalyse 11 days apart, with the second injection given at the same time the Lutalyse injection was given to the MGA-fed heifers. Seventy hours after administering Lutalyse the heifers were inseminated. Eighteen days after AI, clean-up bulls were put with the heifers and remained for 28 days. The heifers were palpated for pregnancy 140 days after AI. Conception data to AI and clean-up bulls were analyzed by Chi-square analysis.

Results and Discussion

Having heifers conceive early in the breeding season results in older, heavier calves at weaning. In the MGA group a higher number ($P<.05$) of heifers conceived to AI than in the group given two prostaglandin injections (Table 1). There was no difference between the two groups in conception rate for the breeding season which included AI and the clean-up period.

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TABLE 1. CONCEPTION RATE IN HEIFERS WHEN SYNCHRONIZED WITH MGA AND PROSTAGLANDIN OR PROSTAGLANDIN ALONE

	Conception rate	
	Synchronized estrus	Breeding season
MGA and prostaglandin	17/30 (56.7%)	21/30 (70.0%)
Two prostaglandin injections	11/32 (34.4%)	20/32 (62.5%)

Since the AI conception rate for MGA-fed heifers was larger, this would indicate an advantage for that group. However, in this study an additional 16 days were used for MGA feeding and 16 more days until the heifers were synchronized. The 16 days after MGA withdrawal were used so one estrus following MGA administration had occurred before synchronization. Research has indicated the second estrus after MGA is more fertile. This adds 32 days to the MGA-fed heifers and may eliminate the advantage of the higher conception rate early in the breeding season for MGA-fed heifers. However, conception rate to time insemination was higher probably because more heifers were cycling at breeding in the MGA group.

ESTROUS SYNCHRONIZATION OF HEIFERS USING MGA AND PROSTAGLANDIN: RANCH RESULTS

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CATTLE 89-13

Summary

A total of 315 yearling heifers were exposed to an estrous synchronization program which consisted of feeding MGA for 14 consecutive days (.5 mg per head per day), followed by a prostaglandin injection 17 days after the last day of MGA feeding. Two hundred forty-seven (78%) of the heifers were detected in heat and artifically inseminated within 5 days after the prostaglandin injection. Response rate ranged from 75 to 84% between ranches and years.

(Key Words: Estrous Synchronization, Heifers, MGA, Prostaglandins.)

Introduction

Calving difficulty in first-calf heifers continues to decrease production output and increase production costs. Expected Progeny Difference (EPD) makes for more accurate identification of bulls that will help reduce calving difficulty without sacrificing a great deal of growth. However, bulls which possess a highly desirable set of EPD with high accuracy are usually only available to most cattlemen through artificial insemination (AI).

Artificial insemination is only practical for most cattlemen when combined with an estrous synchronization program. The management practice of synchronizing and inseminating heifers can increase returns through:

1) Use of predictable genetics
2) Earlier conception, with a shorter breeding season
   a) leading to heavier (older) calves at weaning
   b) cows have more time to cycle back and rebreed
3) Shorter calving season, concentrates labor
4) Allows improved nutritional management

Researchers at Colorado State University have developed a highly effective estrous synchronization program using the feed additive melengesterol acetate (MGA) and a prostaglandin injection.

MGA is a synthetic progesterone that is delivered orally as a relatively inexpensive feed additive. MGA is added to diets of feedlot heifers to suppress heat and improve growth and feed efficiency. Cattle will come into heat within 2 to 5 days after MGA is removed from the diet. Reproductive data show that the longer MGA is fed the tighter the degree of synchrony following removal, but fertility at first heat is reduced as well. Fertility is not reduced beyond the first heat.

Prostaglandins are a class of naturally occurring hormones. One function of naturally occurring prostaglandins is to regress the corpus luteum on the ovary, which sets the stage for the next estrous cycle. Commercially available prostaglandins, such as Lutalyse, Estrumate and Bovilene, also regress the corpus luteum when given by injection. Prostaglandin injection is effective for heat synchronization only if a corpus luteum is present on the ovary, which would be days 6 to 17 of the estrous cycle. Research has shown that a prostaglandin injection late (days 10 to 15) in the estrous cycle gives a higher percentage response and better fertility than if given early (days 5 to 9) in the estrous cycle.

This report describes a method of heat synchronization using MGA and prostaglandin and documents experiences of South Dakota producers who have used this program.

Materials and Methods

Results were made available by Blair Ranches, Sturgis, (1989 breeding season) and Quinn Cow Company, Shannon County (1988, 1989 breeding season). Both ranches used the same procedure as outlined below.

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[1] Assistant Professor.

Beginning 33 days prior to the start of breeding heifers are fed .5 mg per head per day of MGA for 14 consecutive days. Seventeen (17) days after the last day of MGA feeding, heifers are injected with prostaglandin.

In this program the MGA and prostaglandin are utilized in a manner capitalizing on the strength of each compound while minimizing the weaknesses. The 14 days of MGA feeding synchronizes the heifers; but, since the first heat is subfertile, it is passed over. By waiting 17 days to give the prostaglandin, then the corpus luteum from the previous ovulation is at the stage where it will be most beneficial to give the injection.

Results and Discussion

The number of heifers treated, percentage responding within 5 days of injection and number of heifers in heat each day for each ranch are presented in Table 1.

The percentage of heifers in heat within a 5-day period ranged from 75 to 84%, with the peak number of heifers coming in 2 to 3 days after injection of prostaglandin.

TABLE 1. DEMONSTRATION OF MGA-PROSTAGLANDIN EFFECTIVENESS FOR ESTROUS SYNCHRONIZATION OF HEIFERS

	Blair Ranches	Quinn Cow Co.			
No. heifers	109	95	(1988)	111	(1989)
Percent in heat[a]	75	76		84	
No. heifers in heat on day[b]					
0	-	-		-	
1	-	2		1	
2	29	22		6	
3	38	35		72	
4	13	11		12	
5	2	2		2	

[a] Percent in heat within 5 days of prostaglandin injection.
[b] Heifers were injected on day 0.

The estrus response observed on the two ranches is consistent with research results and experiences of producers in other states (Table 2). When the individual results from the three states are combined, a total of 1393 heifers were exposed to MGA-prostaglandin treatment with 968 (69%) coming into heat over a 5- to 7-day period. The response ranged from 33 to 95%.

The low response observed at Kansas locations B and D was considered a function of a high percentage of prepuberal heifers (associated with young heifers), improper heifer development and breed effects. If these two locations are not included in a summary of Tables 1 and 2, then the average response was 80% (1105/1380) with a range of 58 to 95%.

TABLE 2. ESTRUS RESPONSE TO MGA-PROSTAGLANDIN TREATMENT

Location		Estrus response
Kansas Ranch Demonstrations[a]		
Location:	A	36/50 = 72
	B	39/117 = 33
	C	15/22 = 68
	D	71/211 = 34
	E	89/117 = 76
	F	26/45 = 58
	G	265/330 = 80
	H	21/22 = 95
	I	71/81 = 88
	J	32/36 = 89
	K	71/81 = 88
Nebraska[b] - 1 trial		52/60 = 87
Colorado[c] - 5 trial summary		131/157 = 83
- 1 trial		49/64 = 77

[a] Houghton, 1988. Kansas Beef Report, p. 10. Five day estrus response to 14 days MGA, injection 17 days later.

[b] Deutscher, 1988. Nebraska Beef Report, p. 3. Seven day estrus response to 14 days MGA, injection 16 days later.

[c] Odde, 1987. Proceedings, Range Beef Cow Symposium, p. 32. Five to 7 day estrus response to 14-16 days MGA, injection 16-17 days later.

Collectively, these results suggest that feeding .5 mg per head per day of MGA for 14 days followed by a prostaglandin injection 17 days later is effective for synchronizing heifers, provided they have received adequate nutrition and are of proper breeding age. Producers could realistically expect to synchronize about 75 to 85% within a 5-day period.

Calving Data. Calving records for 87 heifers were made available from the Quinn Ranch for the heifers synchronized in 1988. Fifty-five head of the 72 inseminated conceived for a 76% first-service conception rate. This compares quite favorably to the 65 to 70% conception rate reported in the Nebraska and Colorado studies. The fertility of heifers synchronized with this procedure appears to be quite good. Producers could realistically expect conception rates to run 60% or higher.

Some producers have the misconception that cattle inseminated over a 2- to 5-day period will calve out in that tight of period. This is simply not true, as there will be more variation than that in gestation length. At the Quinn ranch, the AI-sired calves were dropped over a 16-day period. Dispersion over a somewhat longer period, up to 20 days, could be expected.

During the peak 7 days of the calving season, 41% (36/87) of the calves were dropped. With this concentrated of a calving season, concerns for calf losses during a bad storm become quite valid. Large groups of heifers should probably be synchronized in two groups to help prevent disastrous storm losses.

Cumulative calving distribution by 21-day periods was as follows:

1st 21 days of calving:	57/87 =	65%
By 42 days:	78/87 =	90%
By 63 days:	87/87 =	100%

The short calving season combined with calving the heifers ahead of the cows should maximize the chance of conceiving early in the subsequent breeding season.

EFFECT OF DIETARY ENERGY SOURCE ON AGE AND WEIGHT AT PUBERTY OF BEEF HEIFERS

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CATTLE 89-14

Summary

Forty-four Angus and Simmental sired crossbred heifers were fed two diets of differing composition (high forage or high concentrate). Diets were fed to achieve the same average daily gain to evaluate the effect of energy source on age and weight at puberty. Age at puberty, conception rate, pregnancy rate, weight at puberty, glucose and insulin were not significantly different between treatments.

(Key Words: Heifers, Puberty, Diets, Glucose, Insulin.)

Introduction

Previous research suggests that higher levels of blood glucose may decrease age at puberty in beef heifers. Increased blood glucose level may be accomplished by feeding a high grain diet versus a high forage diet. The objective of this research was to examine the effects of feeding two diets, a high grain diet and a high forage diet, of the same energy level per day on age at puberty, weight at puberty, and blood glucose level.

Materials and Methods

Forty-four Angus and Simmental sired, crossbred heifers were allotted to two dietary treatments by age and breed of sire. The dietary treatments (Table 1) were calculated to meet NRC requirements for NE_m and NE_g for 1.1 lb of gain. The amount of feed offered was adjusted periodically to achieve equal gains per treatment. Weights were taken every 28 days after 14 hours off feed and water, with the final shrunk weight obtained after the heifers were on a common ration for 3 days. Percentage fat of live weight was estimated by the change in urea blood concentration following jugular infusion of a urea solution of each heifer on day 160 or 164 of the trial at an average age of 364 days.

Blood samples were collected, via jugular puncture, every 7 days for 28 weeks to determine cycling activity by serum progesterone. Heifers with serum progesterone >1 ng/ml for two consecutive weeks or that were observed in estrus during the breeding period were considered puberal. Serum levels of glucose and insulin were determined on samples collected on days 1, 95, and 172 by colorimeter and radioimmunoassay, respectively.

TABLE 1. DIETARY TREATMENTS (LB/HEAD/DAY)

	Treatment					
	High forage			High concentrate		
	Period (days)					
Item	1-53	54-116	117-172	1-53	54-116	117-172
Alfalfa-brome hay	11.7	14.2	14.1	.9	1.1	1.2
Corn	2.6	3.2	3.2	6.3	7.6	8.4
Soybean meal				.2	.3	.3
Limestone				.1	.1	.1
TM salt	.1	.1	.1	.1	.1	.1

[1]Graduate Research Assistant.
[2]Associate Professor.

After 172 days of the trial the treatments were discontinued. The heifers were fed as one group a diet containing 68% corn silage, 28% mixed grass hay, and 4% soybean meal based supplement for the remaining 40-day breeding season. They were observed for estrus and bred by artificial insemination. After 5 days of observation and insemination, the heifers were injected with prostaglandin to synchronize estrus. Sixty-two days following the end of the breeding season, they were rectally palpated to determine pregnancy.

Results and Discussion

Percentage body fat, age at puberty or the percentage of heifers reaching puberty at various times on trial was not affected by treatment (Table 2). Other research suggests that if glucose or insulin level increases that age at puberty will be younger. Since diet did not affect glucose or insulin, it would not be expected that age at puberty would be affected.

Although puberal status was not affected by treatment, the initial (day 1) glucose level was related to whether the heifers were cycling at 116 days (Table 3). Those heifers cycling had higher initial glucose levels than those that were not (P<.05).

Simple correlations indicated that heifers that were older at the beginning of the trial had higher initial (day 1) glucose (r = .33, P<.05) and lower final (day 172) insulin levels (r = -.38, P<.05). Heifers that reached puberty at an earlier age had higher initial (r = -.44, P<.01) and final (r = -.35, P<.05) glucose levels. Final glucose was positively correlated with initial glucose (r = .38, P<.05). The same was true for insulin (r = .49, P<.001). Heifers that were fatter at an average age of 364 days were younger at puberty (r = -.29, P = .05) and had higher initial glucose (r =.30, P = .05).

TABLE 2. EFFECTS OF DIETARY TREATMENTS

Item	Dietary treatments: High forage	Dietary treatments: High concentrate
Number of animals	23	21
Initial age, days	202.0 ± 3.1	202.4 ± 3.2
Initial weight, lb	546.6 ± 9.4	550.7 ± 9.7
Final weight, lb	805.7 ± 10.9	789.8 ± 11.3
Body fat, %[a]	13.8 ± .3	13.6 ± .3
Age at puberty, days	354.0 ± 12.6	352.6 ± 13.2
Weight at puberty, lb	728.4 ± 26.8	671.3 ± 28.3
Puberal heifers, %		
Day 53	17.4	14.3
Day 116	56.5	61.9
Day 178[b]	87.0	90.5
Conception to first service, %	39.1	25.0
Pregnancy rate, %	60.9	65.0
Glucose, mg/dl		
Day 1	86.9 ± 3.7	87.8 ± 3.8
Day 95	96.9 ± 3.7	94.7 ± 3.8
Day 172	67.4 ± 1.5	64.6 ± 1.5
Insulin, ng/ml		
Day 1	.2 ± .0	.2 ± .0
Day 95	.7 ± .1	.7 ± .1
Day 172	.8 ± .1	.8 ± .1

[a] Estimated by urea dilution at an average age of 364 days.
[b] Beginning of the breeding season.

TABLE 3. GLUCOSE AND INSULIN LEVELS RELATED TO CYCLICITY ON DAY 116[a]

Item	Cyclicity	
	Nonpuberal	Puberal
Glucose, mg/dl		
Day 1	79.0 ± 3.7[b]	91.3 ± 3.1[c]
Day 95	94.6 ± 4.1	95.6 ± 3.4
Day 172	63.6 ± 1.7	66.7 ± 1.4
Insulin, ng/ml		
Day 1	.2 ± .0	.2 ± .0
Day 95	.6 ± .1	.7 ± .1
Day 172	.8 ± .1	.8 ± .1

[a] The statistical model included puberal status and age as independent variables.
[b,c] Means within a row with uncommon superscripts differ ($P<.05$).

Substituting concentrates for roughage had no obvious beneficial effect on sexual development of the heifers in this trial. The lack of a detrimental effect indicates that, when economics dictate, a high concentrate diet could be used to develop heifers.

RELATIONSHIP OF RELATIVE CALVING DATE OF BEEF HEIFERS TO PRODUCTION EFFICIENCY AND SUBSEQUENT REPRODUCTIVE PERFORMANCE

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CATTLE 89-15

Summary

Relative date of first calving of beef heifers was studied in relation to production efficiency and subsequent reproductive performance. Crossbred heifers were managed in drylot for 1 year, providing for measurement of feed intake through weaning of the first calf. Production traits were evaluated by calving group (CG), where CG1 included records of heifers calving (and calves born) in the first 21 days of the calving season for a particular year, CG2 included those calving from 22 through 42 days and CG3 included those calving after 42 days. Calving groups did not differ significantly for preweaning calf average daily gain, while weaning age differences resulted in heavier weaning weights for CG1 compared to CG2 and CG3. Earlier relative calving date was associated with increased cumulative feed energy intake of heifers and their calves during the 1-year test period. In terms of production efficiency, the weaning weight advantage of earlier calving was only partly offset by increased feed energy intake of the dam-calf unit, resulting in .9 Mcal metabolizable energy (ME) less per lb calf weaning weight for CG1 vs CG2 and 2.9 Mcal ME less per lb calf weaning weight for CG1 vs CG3 for the 1-year period. Results suggested that within a limited calving season, earlier calving dams tended to be biologically and economically more efficient, apparently at least in part because a greater proportion of an annual production cycle consisted of a productive (lactating) mode, diluting maintenance costs as a fraction of all costs. Heifers in CG1 tended to calve earlier than CG3 heifers for the second calf. Calving interval was a biased measure under the management conditions of a limited breeding season and culling of open cows.

(Key Words: Beef Cattle, Calving Date, Production Efficiency, First Calf Heifers.)

Introduction

Efficiency of feed utilization and reproductive performance are among the most important factors that affect economic efficiency of commercial beef production. Because of the relatively low reproductive rate of cattle, a larger proportion of the total energy used for production goes to maintenance of the breeding herd for beef cattle than for other common meat-producing species. It is important to identify factors that might affect production efficiency and investigate the possible manipulation of such factors.

Use of a limited breeding season has been commonly recommended to make efficient use of labor resources, to match herd feed requirements to forage production and to improve calf uniformity. Calving interval, the time between successive calvings, has been recognized as an important characteristic of economic efficiency of the breeding herd but is more prone to be a biased measurement than is calving date in herds with fixed breeding seasons. Recent interest in incorporating cow reproductive measures in cattle genetic evaluation programs has been associated with investigation of genetic aspects of calving date. Since the feasibility of selecting for calving date depends on costs-benefits considerations, it is important to learn as much as possible about the relationship of relative calving date to other traits and to economic efficiency.

Previous research has evaluated the effect of relative calving date on calf weaning weight. However, to adequately assess the relationship of relative calving date to economic efficiency of production, it is also necessary to evaluate any potential increase in feed costs associated with earlier relative calving date. The objectives of this study were to evaluate the relationship of relative calving date to efficiency of feed

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utilization for first calf production and subsequent reproductive performance.

Materials and Methods

The data used in this study were obtained from a comprehensive project designed to evaluate genetic aspects of feed utilization efficiency by beef cattle. The data were collected in a drylot management system which allowed measurement of feed intake along with the performance traits that are more commonly collected. The study included data from first-calf females and their calves for calf birth years 1981 through 1988. These females were born in the spring and weaned in October at the Antelope Range Livestock Station located in northwestern South Dakota.

After weaning, the heifers were transported to Brookings in late fall or late winter (all heifers born in the same year were handled alike) and were managed to calve at approximately 2 years of age. Pregnant heifers were placed in a drylot facility in October, 1 year following weaning, where feed intake was measured on each heifer for 1 year through weaning of her first calf the following October. Heifer breed types included crossbred Hereford-Angus, Hereford-Simmental, Hereford-Tarentaise and Hereford-Salers produced in rotational crossbreeding systems and straightbred Hereford. A combination of artificial insemination and natural mating was used to breed first-calf heifers, while 2-year-old cows were bred by artificial insemination only.

The breeding season for heifers and 2-year-old cows began in late May and was limited to approximately 55 days each year, resulting in an overall average calving date of March 30. Within each year, the date of the first birth was identified, and 21-day increment periods were computed for the calving season. Average performance was evaluated by calving group (CG), where CG1 included records of heifers calving (and calves born) in the first 21 days of the calving season for a particular year, CG2 included those calving from 22 through 42 days and CG3 included those calving after 42 days. The number of cow-calf pairs analyzed varied somewhat for different traits, with 419 records available for most traits. Of these, 260 were assigned to CG1, 101 were assigned to CG2 and 58 were assigned to CG3.

Under the drylot management system, the heifers were placed in individual feeding stalls twice daily and provided access to predetermined amounts of pelleted hay, chopped hay and grain. Feed not consumed by a heifer was periodically weighed and discarded. Feeding level was adjusted for each individual at 28-day intervals to provide gains that were assumed to be desirable for typical replacement heifer development and acceptable rebreeding performance. Daily feed metabolizable energy (ME) averaged 18.7, 18.8 and 18.8 Mcal for CG1, CG2 and CG3, respectively, from entry into the drylot up to calving. During lactation, daily feed ME for heifers averaged 27.3, 27.3 and 27.1 Mcal for CG1, CG2 and CG3, respectively. While daily feed levels for heifers were dictated by experimental protocol, cumulative feed energy intake of heifers (Table 1) depended on relative calving date. Calves were allowed to nurse their dams during the two daily periods when the dams were in the individual feeding stalls but were otherwise kept separate from dams to prevent cross-nursing. Calves were allowed access to individual creep feeders, which provided a high-roughage diet intended to replace forage which calves would have consumed from pasture under conventional management. Creep feed intake of calves is expressed as total ME from creep feed up to weaning.

Estimated milk production was evaluated by the calf weigh-suckle-weigh procedure and is expressed as milk yield after an overnight separation of calf and dam averaging about 14 hours. Calves were separated from their dams in the evening. The following morning, calves were weighed, allowed to nurse for approximately 15 minutes and then reweighed. Estimated milk production was computed as the difference between the two successive calf weights. This procedure did not create an especially unusual situation for the animals, since calves were separated overnight from their dams every day under the drylot management system. Estimated milk production was evaluated on four to six different dates each year and is presented as the average of those measurements.

Results and Discussion

On the average, calves in CG2 and CG3, respectively, were born 16.2 and 38.1 days later than calves in CG1 (Table 1). These same differences were reflected in calf age at weaning, since all calves within a year were weaned on the same day. Calving groups did not differ significantly for calf birth weight or average daily gain from birth to weaning. Weaning weights for CG1 calves averaged 23.5 and 69.6 lb heavier compared to CG2 and CG3 calves, respectively, reflecting weaning age differences. Earlier-born calves consumed more creep feed, with

TABLE 1. LEAST SQUARES MEANS AND STANDARD ERRORS FOR FIRST-CALF PRODUCTION TRAITS BY CALVING GROUP

Item	Calving group F-test	Calving group 1[a]			2[b]			3[c]		
				Traits of the Calf						
Calf birth date, Julian	**	78.5	±	.65	94.7	±	.90	116.6	±	1.41
Calf birth wt, lb	NS	75.0	±	.8	76.5	±	1.2	76.9	±	1.7
Calf preweaning ADG, lb/day	NS	1.73	±	.020	1.75	±	.029	1.68	±	.043
Calf age at weaning, day	**	220	±	.7	204	±	.9	182	±	1.4
Calf weaning wt, lb	**	455.4	±	4.8	431.9	±	6.9	385.8	±	10.1
Calf creep feed ME, Mcal	**	461	±	6.9	402	±	9.4	335	±	14.4
				Traits of the Heifer						
Yearling wt, lb	NS	657	±	5.2	653	±	7.3	650	±	9.8
Drylot on-test age, day	NS	572	±	1.1	572	±	1.6	573	±	2.1
Drylot on-test wt, lb	NS	880	±	5.2	873	±	7.4	866	±	10.0
Age at 1st calving, day	**	723	±	1.2	743	±	1.7	766	±	2.2
Wt at 1st calving, lb	**	953	±	7.2	982	±	10.2	998	±	13.6
Drylot off-test wt, lb	+	1,040	±	5.7	1,059	±	8.1	1,058	±	10.9
Avg drylot test wt, lb	NS	970	±	5.2	985	±	7.3	986	±	9.8
Overnight milk production, lb	NS	7.70	±	.134	7.49	±	.190	7.53	±	.255
Cumulative heifer feed ME, Mcal										
Beginning of test to calving	**	2,677	±	17	3,072	±	24	3,521	±	32
Lactation	**	6,001	±	30	5,475	±	42	4,788	±	57
Total 1-year drylot period	**	8,684	±	36	8,554	±	52	8,298	±	69
				Production Efficiency						
Heifer and calf ME/calf weaning wt, Mcal/lb	**	20.2	±	.22	21.1	±	.31	23.1	±	.46

[a] Heifers calving in the first 21 days of the calving season.
[b] Heifers calving from day 22 through day 42.
[c] Heifers calving after day 42.
** P<.01.
[+] P<.10.
NS = nonsignificant (P>.10).

mean cumulative differences of 59 Mcal ME for CG1 vs CG2 and 126 Mcal ME for CG1 vs CG3.

Average yearling weight and age and weight of heifers when entering the drylot test were similar for the three calving groups. Earlier calving (CG1) heifers averaged 20 days younger at first calving than CG2 heifers and 43 days younger than CG3 heifers. Heifers in CG1 weighed less at first calving than heifers in the other groups, reflecting their younger age. Cumulative feed ME during the entire 1-year test period was significantly greater for earlier calving heifers with differences of 130 Mcal for CG1 vs CG2 and 386 Mcal for CG1 vs CG3. When the cumulative feed ME is subdivided and analyzed separately for lactation vs nonlactation, it is clearly evident that a larger proportion of the 1-year feed energy was utilized during lactation for earlier calving heifers. Although feed intake was not measured prior to the drylot test, a strong argument can be made for assuming that feed energy intakes were similar across calving groups prior to the drylot test. One point supporting such an argument is that means were very similar across calving groups for on-test age, yearling weight and on-test weight. Furthermore, even though earlier calving heifers would have been pregnant for a longer time period prior to the drylot test, pre-test differences in feed requirements due to differences in stage of pregnancy would be expected to be negligible that early in gestation.

The weaning weight advantage of earlier calving was only partly offset by increased feed energy intake of the dam-calf unit, resulting in significant differences between calving groups for the production efficiency ratio of total ME intake of the heifer and calf to calf weaning weight. Dam-calf pairs in CG1 were the most efficient, averaging .9 Mcal ME less per lb calf weaning weight compared to CG2 and 2.9 Mcal ME less per lb calf weaning weight compared to CG3. Earlier calving dams tended to be more efficient, apparently at least in part because a greater proportion of the 1-year production period was spent in a productive (lactating) mode, diluting the proportion of total feed energy utilized for maintenance, compared to later calving dams.

Results from a pooled intra-year-sire regression of selected traits on calving date are presented in Table 2. Interpretation of results based on regression analyses provides essentially the same interpretation as when based on calving group least squares means. Regression analyses suggest that, for each day that calving occurs earlier within a fixed season, weaning weight is increased 1.66 lb, cumulative calf creep feed ME increases by 2.63 Mcal and cumulative heifer feed ME for the 1-year period increases by 11.2 Mcal.

TABLE 2. REGRESSION OF VARIOUS PRODUCTION TRAITS ON CALVING DATE

Trait	Regression coefficient ± SE
Calf preweaning ADG	NS
Calf weaning wt, lb	-1.66 ± .238**
Cumulative calf creep ME, Mcal	-2.63 ± .39**
Cumulative total heifer feed ME, Mcal	-11.2 ± 2.54**
Heifer and calf ME/calf weaning wt, Mcal/lb	.061 ± .0109**

** $P<.01$.
NS = nonsignificant ($P>.10$).

To interpret results of this study from an economic perspective, one should consider possible differences between calving groups in costs and returns prior to, as well as during, the 1-year drylot test period. Assuming that differences between calving groups in costs prior to the drylot test period were negligible, based on reasons mentioned previously, the performance differences between calving groups during the drylot test period should be closely related to total economic differences through weaning of the first calf. Relative economic differences through weaning of the first calf were estimated, assuming base price coefficients of $.029 per Mcal of ME and $.718 per lb of calf weaning weight (based on average prices over the period 1981 through 1988), and utilizing calving group means for calf creep and heifer feed ME and calf weaning weight. No attempt was made to consider subsequent reproductive performance in economic analyses. Under the conditions of the present study, calving in CG1 resulted in an estimated average $14.81 per dam-calf pair more in feed costs to attain an extra 69.6 lb in calf weight weaned compared to CG3. Assuming equal price coefficients for CG1 and CG3 for calving weaning weight, the 69.6 lb difference in weaning weight amounts to $50.62. An assumed price premium of 4% for the lighter weight calves of CG3 would reduce the difference to $39.51. These figures reflect an average difference of 38 days for relative calving date. A larger difference in calving dates within a limited calving season would perhaps result in larger economic differences. These figures were based on production of the first calf sold at weaning, and no attempt was made to consider future performance from an economic standpoint. Other factors potentially affecting economic differences, including labor requirements and interest costs, were ignored.

Rebreeding performance is presented in Table 3. Cows that had calved in CG1 or CG2 for their first calf also tended to calve earlier than CG3 females for the second calf. Rebreeding pregnancy rates were similar for the three groups. Open cows were culled from the herd after weaning of their first calf. Therefore, among the 312 cows remaining in the herd for the second calf, late calving cows had shorter intervals between birth dates of their first and second calves. The late calvers either rebred relatively quickly or were open and culled.

Heavier weaning weights associated with earlier relative calving date more than offset increased cumulative feed energy intakes. Within a limited calving season, earlier calving dams tended to be more efficient, apparently at least in part because a greater proportion of an annual production cycle was spent in a productive (lactating) mode, diluting maintenance costs as a fraction of total costs. Calving interval was a biased measure under the management conditions of a limited breeding season with open cows culled. Results support the common suggestion that producers should attempt to have a high proportion of females calving early within a limited calving season, although the increase in calf weight associated with early calving was partly offset by increased feed costs.

TABLE 3. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SUBSEQUENT REPRODUCTIVE PERFORMANCE BY INITIAL CALVING GROUP

Trait	Calving group F-test	Calving group		
		1[a]	2[b]	3[c]
Rebreeding pregnancy rate, %	NS	78.1 ± 2.9	72.7 ± 4.1	76.7 ± 5.6
Second calf birth date, Julian	**	80.8 ± 1.3	81.6 ± 1.9	90.3 ± 2.5
Calving interval, days	**	367 ± 1.3	348 ± 1.9	335 ± 2.5

[a] Heifers calving in the first 21 days of the calving season.
[b] Heifers calving from day 22 through day 42.
[c] Heifers calving after day 42.
** P<.01.
NS = nonsignificant (P>.10).

CHARACTERIZATION OF HEREFORD AND TWO-BREED ROTATIONAL CROSSES OF HEREFORD WITH ANGUS AND SIMMENTAL CATTLE: CALF PRODUCTION THROUGH WEANING

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CATTLE 89-16

Summary

Cow size, reproductive traits and calf performance through weaning were evaluated in a range environment for Simmental (S) x Hereford (H) and Angus (A) x H crosses in two-breed rotations and straightbred H. Data were grouped into seven dam breed categories: straightbred Hereford (H), crossbred F1 S x H cows (SH), S x H cows of low percentage H (SHS), S x H cows of high percentage H (HSH), F1 A x H cows (AH), A x H cows of low percentage H (AHA) and A x H cows of high percentage H (HAH). Hereford, SH, AH, SHS and AHA cows were mated to H bulls, HSH cows were mated to S bulls and HAH cows were mated to A bulls. Simmental-cross cows were heavier and taller and produced heavier calves at birth and weaning than A-cross or H cows. Pregnancy rate, calf preweaning survival rate, calf birth date and percentage of difficult births did not vary significantly among dam breed groups. Within the A x H and S x H rotations, dam breed group rankings for calf birth weight were inverse to rankings for proportion of H in the breed makeup of the calf. However, in comparisons of SHS vs HSH and AHA vs HAH dam breed groups, calf average daily gain to weaning averaged higher in matings where H was the sire breed (dams were of lower percentage H). Evaluation of different breed groups within the two-breed rotational crossbreeding systems suggested acceptable compatibility of both S with H and A with H in rotational breeding systems with regard to mature size and calving difficulty.

(Key Words: Beef, Breed Evaluation, Rotational Crossbreeding, Preweaning.)

Introduction

Selection of breeds or breed crosses is an important decision for cost efficient beef production. Since breeds may rank differently for different traits, it is important to characterize breeds for a wide spectrum of traits affecting net economic efficiency. While numerous cattle breed evaluation studies have been reported, relatively few have evaluated specific breed types in rotational crossbreeding systems.

A primary advantage of rotational crossbreeding is utilization of heterosis in all dams and progeny. In addition, replacement females are produced within a self-contained herd. However, since breed composition fluctuates over generations, utilization of complementarity is limited and compatibility of breeds is an important consideration. A common concern with compatibility is that use of breeds varying widely in mature weight might result in unacceptable levels of calving difficulty. Another concern is that use of breeds varying widely in mature size and(or) milk production might result in intergenerational differences in nutrient requirements, creating possible management difficulties since generations will generally be partially overlapping. Furthermore, since each breed used in a conventional rotational system will contribute over half of the genetic makeup of some of the dams and calves, it is important that all breeds perform adequately with respect to maternal and growth traits.

The present study is a portion of a comprehensive research project designed to investigate genetic aspects of efficiency of beef production. Production of

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calves to weaning is an important component of total system efficiency. The objective of this study was to characterize performance of Simmental x Hereford and Angus x Hereford crosses in two-breed rotations and straightbred Hereford for calf production through weaning under western South Dakota range conditions.

Materials and Methods

Population Description. This analysis included data from straightbred Hereford (H), Simmental (S) x H cross and Angus (A) x H cross cows managed under range conditions at the Antelope Range Livestock Station in northwest South Dakota. Monfore (1984) summarized weaning production of this herd up through 1983, while Marshall and Dinkel summarized weaning production for calf crops born from 1984 through 1986. This paper includes calf crops from 1975 through 1987.

Formation of breed groups was initiated with a purchase of 50 H and 50 F1 S x H heifers after weaning in 1972. In 1975, 60 F1 A x H and 10 additional S x H heifers were added to the herd. Following these initial introductions, all additional replacement females were produced within the herd as offspring of the initial females or their descendants. The two crossbred groups were managed in traditional two-breed rotational crossbreeding systems, eventually resulting in various levels of H breeding and heterosis within each rotation from overlapping among generations. Selected sires were assumed to be representative of their respective breed, with emphasis on high growth rate relative to frame size. Cleanup sires were purchased from various seedstock producers throughout South Dakota. Semen used in artificial insemination was obtained through commercial outlets from bulls whose semen was widely available.

Animal Management and Data Description. All purchased and home-grown replacement heifers were managed to calve first at 2 years of age. However, since many of these heifers produced their first calf in Brookings as part of another study, only data from 3- through 10-year-old cows calving at the Antelope Range Livestock Station were included in this analysis.

Cows were maintained on native pastures the entire year and supplemented, primarily with alfalfa hay during the winter when forage was sparse or unavailable. For calf birth years 1975 through 1979, two winter supplement levels were applied, stratified by breed groups. In subsequent years, all cows were managed as similarly as possible, although breed groups had to be maintained in separate pastures during part of the breeding season.

The total breeding season averaged about 8 weeks. In 1980, matings were by natural service only, whereas all other years included both artificial and natural matings. Cows were culled for failure to be pregnant, poor health or at random to provide space for replacements. Pregnancy rate was based on palpation since some of the cows were sold between breeding season and calving. For analysis of pregnancy rate and calf survival from birth to weaning, scores of 0 or 1 were assigned for failure or success, respectively. Calves were born in the spring and male calves were castrated at birth. Calving difficulty was closely observed by herdsmen and scored as 1 = no difficulty, 2 = minor assistance without use of mechanical puller, 3 = moderately difficult pull, 4 = hard pull and 5 = Caesarian birth. For purposes of analysis, each birth was coded as 0 (calving score of 1 or 2), or 1 (calving score of 3, 4 or 5). Calves were weaned in the fall when the entire group averaged approximately 7 months of age. Cow weights and hip height measurements were obtained near the end of calving season and at weaning.

Data from each rotation were sorted into three dam breed groups so that records within a group were from cows of similar breed composition (Table 1). Data collected from calf birth years 1975 through 1987 were categorized into a total of seven dam breed groups: straightbred H cows (H), F1 S x H cows (SH), S x H cows of low percentage H (SHS), S x H cows of high percentage H (HSH), F1 A x H cows (AH), A x H cows of low percentage H (AHA) and A x H cows of high percentage H (HAH). Calf sire breed was confounded with dam breed group. Hereford, SH, AH, SHS and AHA cows were mated to H bulls, HSH cows were mated to S bulls and HAH cows were mated to A bulls. Cows in the SHS and AHA groups were expected to range from 25 to 38% H and their calves from 62 to 69% H. Cows within the HSH and HAH groups were expected to range from 62 to 75% H and their calves from 31 to 38% H.

Results and Discussion

Least squares means (averages) are presented by dam breed group. However, it is important to keep in mind that dam breed group and sire breed are confounded, so dam breed group comparisons are actually comparisons among dam breed group-sire breed combinations. Stated differences were significant at the .05 probability level unless stated otherwise.

TABLE 1. MATING DESIGN AND BREED COMPOSITION OF BREED GROUPS[a]

Dam breed group	Dam breed composition % S	% A	% H	Sire breed	Calf breed composition % S	% A	% H
H	0	0	100	H	0	0	100
S x H Rotation							
SH	50	0	50	H	25	0	75
HSH	25 to 38	0	62 to 75	S	62 to 69	0	31 to 38
SHS	62 to 75	0	25 to 38	H	31 to 38	0	62 to 69
A x H Rotation							
AH	0	50	50	H	0	25	75
HAH	0	25 to 38	62 to 75	A	0	62 to 69	31 to 38
AHA	0	62 to 75	25 to 38	H	0	31 to 38	62 to 69

[a]H = Hereford, S = Simmental and A = Angus.

Least squares means by breed group for cow size traits and weight/height ratio are presented in Table 2. Significant differences among breed groups were observed for cow weight and height in both spring and fall and for spring weight/height ratio. Cow weights and weight/height ratios were consistently greater in fall than in spring, reflecting seasonal differences in nutrient availability. Averaged over spring and fall, cow weights averaged 1035, 1121 and 1007 lb for H, S-cross and A-cross cows, respectively. Cow heights averaged 49.6, 52.2 and 48.9 inches for H, S-cross and A-cross cows, respectively. Within the S x H rotation, SHS cows were 28 lb heavier and 2.2 inches taller than HSH averaged over spring and fall. Within the Angus rotation, HAH cows were slightly heavier and taller than AHA cows. Intergenerational variation for cow size within a rotation appeared sufficiently small so that cows of varying breed compositions within a rotation could be adequately managed as a single group.

Variation among breed groups was significant for gestation length but not for the other reproductive traits presented in Table 3. The H mean for gestation length was intermediate compared to crossbred groups. Simmental crosses averaged 2.4 days longer for gestation length than A crosses. Within the S x H rotation, gestation length was .8 days longer for HSH cows producing S-sired calves than for SHS cows producing H-sired calves. Within the A x H rotation, gestation length was .8 days (P = .07) longer for AHA cows producing H-sired calves than for HAH cows producing A-sired calves. Compatibility between breeds within each rotation was quite acceptable with regard to calving difficulty. Of particular interest was the comparison of HSH cows producing S-sired calves vs SHS cows producing H-sired calves, for which the difference was nonsignificant.

Breed group was a significant source of variation for each of the birth and preweaning traits presented in Table 4. Calf birth weights averaged 8.0 lb heavier for crossbred groups than for straightbred H calves. Birth weights of S-cross calves averaged 6.9 lb heavier than those of A-cross calves. Within the S x H rotation, calves from HSH cows mated to S sires averaged 3.8 lb heavier at birth than calves from SHS cows mated to H sires. Within the A x H rotation, calves from HAH cows mated to A sires averaged 2.0 lb heavier at birth than calves from AHA cows mated to H sires.

Average daily gains from birth to weaning were .28 lb/day greater for calves from crossbred dams than for straightbred H calves. Preweaning gains of S-cross calves averaged .18 lb/day greater than those of A-cross calves. Within the S x H rotation, calves from SHS cows mated to H sires gained .13 lb/day more than calves from HSH cows mated to S sires. In the comparison of SHS vs HSH, it is interesting to note heavier calf weaning weights were attained in matings where the service sire was of the breed of smaller mature size (dams were of higher percentage S). Within the A x H rotation, calves from AHA cows mated to H sires gained .06 lb/day more than calves from

TABLE 2. LEAST SQUARES MEANS AND CONTRASTS FOR COW WEIGHT AND HEIGHT TRAITS

Dam breed group[a]	No. records	Cow wt, lb		Cow ht, in.		Cow wt/ht, lb/in.	
		Spring	Fall	Spring	Fall	Spring	Fall
H	211	974	1095	49.5	49.7	19.9	20.9
SHS	120	1065	1196	53.4	53.6	19.4	21.5
SH	252	1086	1173	51.9	51.9	20.8	21.3
HSH	262	1029	1176	51.2	51.4	19.8	22.1
AHA	123	933	1108	48.7	49.3	19.2	22.1
AH	251	914	1015	48.0	47.8	19.5	20.0
HAH	230	950	1121	49.6	50.0	19.2	21.4
Avg SE of mean		20.1	25.9	.28	.31	.37	.63
Contrasts							
H vs 1/2 ($\bar{S}$ + $\bar{A}$)[b]		-22**	-36**	-.9**	-1.1**	NS	NS
$\bar{S}$ vs $\bar{A}$		128**	100**	3.4**	3.3**	.7**	.7**
SHS vs HSH		36**	20**	2.2**	2.2**	NS	NS
AHA vs HAH		-17**	-13*	-.8**	-.7**	NS	NS

[a] H = Hereford, S = Simmental and A = Angus. Hereford, SHS, SH, AHA and AH dams were mated to H sires, HSH dams were mated to S sires and HAH dams were mated to A sires.

[b] Straightbred vs crossbred.

*P<.05.

**P<.01.

HAH cows mated to A sires. The sign of contrast values for calf weaning weight was the same as for preweaning ADG.

It is interesting to note that rankings of SHS and HSH dam breed groups were different for calf birth weight than for calf rate of gain from birth to weaning. Calf birth weights were higher in matings where S was the sire breed. On the other hand, rankings of SHS and HSH for calf ADG were the same as rankings for proportion of S in the dam.

Based on other studies, one might expect S to have a positive individual additive effect for prenatal growth and positive individual additive and maternal environmental effects for growth from birth to weaning relative to H. Assuming such was the case in the present study, then different rankings among the S-cross groups for birth weight vs preweaning ADG might result if the importance of maternal environmental effects compared to individual effects were larger for calf preweaning ADG than for prenatal growth. Grandmaternal effects could have also played a role, assuming higher milk production for dams of higher percentage S and recognizing that HSH cows were daughters of SHS or SH dams. Also, the range environment might not have provided sufficient available energy to S-sired calves to make up for any lack of energy from milk production of lower percentage S dams. Previous studies have suggested a negative relationship sometimes exists between maternal and grandmaternal effects for some preweaning traits, particularly those related to lactation. A possible explanation for the results of the present study is that a relatively large negative relationship between maternal and grandmaternal effects existed for ADG and a smaller (not necessarily negative) relationship existed for birth weight. Breed group rankings of AHA and HAH for calf birth weight and ADG to weaning were related to proportion of H in a similar manner to that of the S-cross groups, although the magnitudes of differences between groups were less for A crosses.

TABLE 3. LEAST SQUARES MEANS AND CONTRASTS FOR COW REPRODUCTIVE TRAITS AND CALF SURVIVAL

Dam breed group[a]	No. births[b]	Pregnancy rate,%	Survival rate to weaning, %	Gestation length, days	Birth date	Calving difficulty, %
H	215 (194)	88.8	96.3	285.1	87.6	.76
SHS	124 (101)	84.7	94.3	286.9	87.4	1.44
SH	261 (238)	84.7	94.2	286.4	88.0	2.17
HSH	265 (184)	88.4	94.9	287.7	87.9	4.16
AHA	122 (90)	94.0	97.2	285.1	82.7	1.32
AH	255 (180)	91.3	95.8	284.5	88.0	.02
HAH	232 (185)	87.4	95.9	284.3	87.1	3.14
Avg SE of mean		3.07	1.50	.8	1.7	1.39
Contrasts						
$H - 1/2(\bar{S} + \bar{A})^{b}$				$-.7^{+}$		
$\bar{S} - \bar{A}$				2.4^{**}		
SHS - HSH				$-.8^{+}$		
AHA - HAH				$.8^{+}$		

[a] H = Hereford, S = Simmental and A = Angus. Hereford, SHS, SH, AHA and AH dams were mated to H sires, HSH dams were mated to S sires and HAH dams were mated to A sires.
[b] Number in parentheses is the number of observations for gestation length.
[c] Straightbred vs crossbred.
$^{+}$ P<.10.
** P<.01.

In conclusion, differences in cow size and calf weaning production characteristics are important to consider when attempting to match cow biological type to environmental conditions. Acceptable cow reproductive performance was attained across breed groups under the northern plains range environment. Significant differences among straightbred Hereford and crossbred Simmental x Hereford and Angus x Hereford for cow size and calf growth to weaning were observed. It is important to keep in mind that differences between crossbreds and straightbred Hereford were due at least in part to hybrid vigor of the crossbreds. Performance of the crossbred groups was quite desirable and indicates consideration of Hereford for use in crossbreeding is certainly warranted. The Simmental x Hereford rotation produced heavier average weaning weights than the Angus x Hereford rotation, but cow size was larger as well for Simmental x Hereford. Studies conducted in drylot at Brookings indicate that differences between these breed-types in efficiency of feed utilization for weaned calf production seem to be quite small. Evaluation of different breed groups within the two-breed rotational crossbreeding systems suggest acceptable compatibility of Simmental with Hereford and Angus with Hereford in rotational breeding systems with regard to mature cow size and calving difficulty. In general, desirable performance for production through weaning was attained within both rotations.

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TABLE 4. LEAST SQUARES MEANS AND CONTRASTS FOR CALF GROWTH TRAITS

Dam breed group[a]	No. calves weaned	Calf birth wt, lb	Calf preweaning ADG, lb/day	Calf weaning wt, lb
H	207	79.6	1.77	448
SHS	116	90.6	2.22	547
SH	245	88.2	2.13	530
HSH	252	94.4	2.09	526
AHA	119	85.3	2.00	499
AH	245	80.0	1.95	483
HAH	222	87.3	1.94	487
Avg SE of mean		1.5	.037	8.2
Contrasts				
H - 1/2 ($\bar{S}$ + $\bar{A}$)[b]		-8.0**	-.28**	-64**
$\bar{S}$ - $\bar{A}$		6.9**	.18**	45**
SHS - HSH		-3.8**	.13**	21**
AHA - HAH		-2.0*	.06**	12**

[a] H = Hereford, S = Simmental and A = Angus. Hereford, SHS, SH, AHA and AH dams were mated to H sires, HSH dams were mated to S sires and HAH dams were mated to A sires.

[b] Crossbred vs straightbred.

* P<.05.

** P<.01.

CHARACTERIZATION OF HEREFORD AND TWO-BREED ROTATIONAL CROSSES OF HEREFORD WITH ANGUS AND SIMMENTAL CATTLE: CARCASS TRAITS OF STEERS

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CATTLE 89-17

Summary

Calf carcass traits were evaluated for Simmental (S) x Hereford (H) and Angus (A) x H cross cows in two-breed rotations and for straightbred H. Data were grouped into seven dam breed categories: straightbred Hereford (H), F1 S x H cows (SH), S x H cows of low percentage H (SHS), S x H cows of high percentage H (HSH), F1 A x H cows (AH), A x H cows of low percentage H (AHA) and A x H cows of high percentage H (HAH). Straightbred H and crossbred SH, AH, SHS and AHA cows were mated to H bulls, HSH cows were mated to S bulls and HAH cows were mated to A bulls. Calves from S x H dams produced heavier carcasses with less fat, lower quality grade, larger longissimus area and increased estimated cutability compared to calves from H or A x H dams. Some significant intergenerational differences were observed within rotations, particularly within S x H. Calves from HSH cows mated to S bulls produced carcasses with less fat cover, lower quality grade, larger longissimus muscle area and higher estimated cutability compared to calves from SHS dams mated to H bulls. Within both rotations, evaluation of carcass weight per day of age indicated lower postweaning rate of gain for generations in which H was the sire breed. A separate analysis evaluated carcass traits of calves from SHS, HSH, AHA and HAH dam breed groups from the last 3 years of the study when calves were fed under two different postweaning management systems. With Management System One, the concentrate to roughage ratio was increased less rapidly and calves averaged 122 days older at slaughter and carcass weights averaged 128 lb heavier compared to calves fed under Management System Two. The breed group x postweaning management system interaction effect approached significance only for marbling score, estimated cutability and kidney, pelvic and heart fat.

(Key Words: Beef, Breed Evaluation, Rotational Crossbreeding, Carcass.)

Introduction

It is important to characterize breeds for a wide spectrum of traits affecting net economic efficiency, since breed-types may rank differently for different traits. In rotational crossbreeding systems, breed composition fluctuates over generations within a rotation and utilization of complementarity can be limited. Each breed used in a conventional rotational system will contribute over half of the genetic makeup of some dams and calves. Thus, it is important the breeds perform adequately with respect to maternal, growth and carcass characteristics.

The present study is a portion of a comprehensive research project designed to investigate genetic aspects of efficiency of beef production. Characterization of the breed groups evaluated in this study for calf production to weaning was reported by Marshall et al. (1989). Production of carcasses with acceptable composition and quality is also an important component of total system efficiency. The objective of this study was to characterize performance of Simmental x Hereford and Angus x Hereford crosses in two-breed rotations and straightbred Hereford for carcass traits of steers.

Experimental Procedures

Data Collection and Description. This study included data from steers born to straightbred

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Hereford (H), Simmental (S) x H cross and Angus (A) x H cross cows managed at the Antelope Range Livestock Station in northwest South Dakota. The two crossbred groups were managed in traditional two-breed rotational crossbreeding systems, eventually resulting in various levels of H breeding within each rotation. Management of the cow herd at the Antelope Station was described by Marshall et al. (1989). Calves were weaned in the fall when the entire group averaged approximately 7 months of age. Following weaning, steer calves remained at the Antelope Station for a preconditioning period. Although the length of the preconditioning period varied from 3 to 6 weeks over years, it was the same for all calves within a year.

For calf birth years 1975 through 1984, all steers were fed in a single feedlot in eastern South Dakota (Management System One = MS1). For birth year 1985 through 1987, half of the steers were fed under MS1 and half were fed at a commercial feedlot in western South Dakota (Management System Two = MS2). The primary difference between the two management systems was the postweaning diet, although effects due to location could have contributed to observed differences in performance. Primary feedstuffs used for both postweaning management systems were corn grain, corn silage and alfalfa hay. The diet fed to MS1 steers initially included relatively high levels of roughage, followed by a gradual increase in the concentrate to roughage ratio. Management System One resulted in a relatively long postweaning period (average 362 days) and relatively heavy carcass weight (average 844 lb) and older slaughter age (average 566 days). Under MS2, the concentrate to roughage ratio was increased relatively sooner, resulting in averages of 241 days postweaning, 716 lb carcass weight and 444 days of age at slaughter.

Within calf birth years 1975 and 1976, all calves were slaughtered on the same day. Calves were slaughtered on two dates each year from 1977 through 1982. Within birth years 1983 and 1984, calves were slaughtered on three dates. For 1985 through 1987, all calves within a year-management group were slaughtered on the same day. Steers were slaughtered at commercial slaughter facilities and carcass data were collected after a minimum 24-hour chill. External fat thickness and longissimus muscle area were measured at the 12th rib. Percentage of kidney, pelvic and heart (KPH) fat was visually estimated. Quality grade was assigned according to a scale where 18 = Select, 19 = low Choice, 20 = average Choice, etc. The longissimus muscle area interface was traced and the area measured with the use of a planimeter. Percentage of boneless, closely trimmed retail cuts was estimated by the USDA cutability equation (USDA, 1981).

Data from two-breed rotations were sorted so that cows within a group were of similar breed composition (Table 1). Data collected from calf birth years 1975-87 were categorized into seven dam breed groups: straightbred H cows (H), F1 S x H cows (SH), S x H cows of low percentage H (SHS), S x H cows of high percentage H (HSH), F1 A x H cows (AH), A x H cows of low percentage H (AHA) and A x H cows of high percentage H (HAH). Calf sire breed was confounded with dam breed group. Calves from H, SH, AH, SHS and AHA dams were sired by H bulls, calves from HSH dams were sired by S bulls and calves from HAH dams were sired by A bulls. Cows in the SHS and AHA groups were expected to range from 25 to 38% H and their calves from 62 to 69% H. Cows in the HSH and HAH groups were expected to range from 62 to 75% H and their calves from 31 to 38% H.

Distribution of observations by breed group is given in Table 2. Data were collected from a total of 742 calves, although estimated KPH fat and cutability were not available for 34 calves. Since replacements for the H, SH and AH dam groups were not continuously brought into the herd, these groups were eventually displaced completely by the HSH, SHS, AHA and HAH dam breed groups, representing subsequent generations of the two rotations.

The entire data set (birth years 1975 through 1987) was used in three sets of analyses: (1) without adjustment for carcass weight or slaughter age, (2) adjusted to a common carcass weight and (3) adjusted to a common slaughter age. Adjustment to a common slaughter age yielded similar results as without adjustment and so results of the age-adjusted analysis are not presented.

A subset of these data which included only the last three calf birth years (1985 through 1987) was analyzed in an additional analysis. The subset of data included observations only from the last 3 years of the study when calves were fed under two postweaning management systems. The purpose of analyzing this subset of data separately was to determine if breed group rankings varied under the two postweaning management systems. Only the SHS, HSH, AHA and HAH dam breed groups were included in this analysis because of a lack of available data for other groups during this period.

TABLE 1. MATING DESIGN AND BREED COMPOSITION OF BREED GROUPS[a]

Dam breed group	Dam breed composition % S	Dam breed composition % A	Dam breed composition % H	Sire breed	Calf breed composition % S	Calf breed composition % A	Calf breed composition % H
H	0	0	100	H	0	0	100
S x H rotation							
SH	50	0	50	H	25	0	75
HSH	25 to 38	0	62 to 75	S	62 to 69	0	31 to 38
SHS	62 to 75	0	25 to 38	H	31 to 38	0	62 to 69
A x H rotation							
AH	0	50	50	H	0	25	75
HAH	0	25 to 38	62 to 75	A	0	62 to 69	31 to 38
AHA	0	62 to 75	25 to 38	H	0	31 to 38	62 to 69

[a]S = Simmental, A = Angus and H = Hereford.

TABLE 2. NUMBERS OF OBSERVATIONS BY DAM BREED GROUP[a]

Dam breed group[b]	Total number
H	110 (104)
SHS	65 (63)
SH	130 (124)
HSH	138 (135)
AHA	55 (50)
AH	132 (120)
HAH	112 (112)
Total	742 (708)

[a]Second number (in parentheses) is for KPH fat and estimated cutability. First number is for all other traits.

[b]H = Hereford, S = Simmental and A = Angus. Hereford, SHS, SH, AHA and AH dams were mated to H sires, HSH dams were mated to S sires and HAH dams were mated to A sires.

Results

Least squares means are presented by dam breed group (Tables 3 through 6). However, it is important to keep in mind that dam breed group and sire breed are confounded; thus, dam breed group comparisons are actually comparisons among dam breed group-sire breed combinations.

Table 3 includes least squares means from the complete data set not adjusted for continuous effects. Breed group was a significant source of variation for all traits. Breed group least squares means for slaughter age ranged from 540.8 days for calves from HAH dams mated to A sires to 552.2 days for calves from HSH dams mated to S sires. Carcass weights averaged 750, 819 and 771 lb for H, S-cross and A-cross calves, respectively. Average days from weaning to slaughter ranged from 338 for calves from HAH dams mated to A sires to 350 for calves from HSH dams mated to S sires. Carcass weight per day of age was the best available measure of cumulative growth rate through slaughter and averaged 1.41, 1.54 and 1.45 lb/day for H, S-cross and A-cross, respectively. Rankings of H, S x H rotation and A x H rotation were the same for carcass weight per day of age as for preweaning growth rate (Marshall et al., 1989). Within-rotation dam breed group contrasts of SHS minus HSH and AHA minus HAH for carcass weight per day of age were not significant but of the opposite sign compared to significant contrasts for preweaning growth rate (Marshall et al., 1989). This indicates faster average postweaning gains for calves from HSH vs SHS dams and for calves from HAH vs AHA dams, although postweaning gain per se was not actually measured.

Average longissimus muscle area was smaller and estimated cutability was lower for H calves compared to the average of crossbred groups (Table 3). Quality grade and estimated KPH fat were similar for H compared to the average of crossbred groups. Angus-cross calves exceeded S crosses for average external fat thickness, estimated KPH fat and carcass quality grade, while S crosses exceeded A crosses for longissimus muscle area and estimated cutability. The HSH dam breed group which produced S-sired calves differed from other breed groups for most traits. This group averaged .42 inch for external fat thickness compared to an average of .61 inch across all other groups. Among other traits, this group ranked highest for carcass weight, carcass weight per day of age, longissimus muscle area and estimated cutability and lowest for quality grade.

Least squares means adjusted to a common carcass weight are presented in Table 4. Breed group was a significant source of variation for all traits except slaughter age. Contrasts were alike in sign to those presented in Table 3, although some contrast values and significance levels were somewhat different. The difference in fat thickness of H calves vs crossbreds was .077 inch (P = .003) when adjusted to a common carcass weight vs .039 inch when unadjusted (P = .098). The difference in cutability of H vs crossbreds was -.84% (P = .001) when adjusted for carcass weight vs -.47% (P = .049) when unadjusted. The difference in cutability for AHA vs HAH dam breed groups was .34% (P = .17) when adjusted for carcass weight vs .45% (P = .088) when unadjusted.

Table 5 includes least squares means for the SHS, HSH, AHA and HAH dam breed groups computed from the last 3 years of the study when calves were split into two management groups after weaning. Means presented in Table 5 were not adjusted for carcass weight.

Dam breed group was a significant source of variation for all traits except slaughter age. Averaged across postweaning management systems, dam breed group rankings among SHS, HSH, AHA and HAH were consistent to those presented in Table 3 for the complete data set.

The effect of postweaning management system was significant for all traits except quality grade and marbling score. Calves fed under MS1 were in the feedlot an average 121 days longer and averaged 122 days older at slaughter compared to calves fed under MS2. Carcasses of MS1 calves were heavier, fatter and had larger absolute longissimus muscle areas, while carcass weight per day of age and estimated cutability were greater for MS2 calves.

The breed group x postweaning management system interaction effect approached significance only for marbling score (P = .064), KPH fat (P = .033) and estimated cutability (P = .17). Calves from the A x H rotation had higher carcass marbling scores and quality grades than calves from the S x H rotation under MS1, but S and A crosses were similar for these traits under MS2. Interpreted another way, A crosses had higher average carcass marbling score and quality grade under MS1 than under MS2, while S crosses had similar values across management systems for these two characteristics. Estimated percent cutability of S crosses exceeded that of A crosses by 1.45% under

TABLE 3. LEAST SQUARES MEANS AND CONTRAST VALUES FROM COMPLETE DATA SET, UNADJUSTED FOR COVARIATES

Dam breed group[a]	Days postweaning	Slaughter age, days	Carcass wt, lb	Carcass wt/day of age, lb/day	Carcass quality grade[b]	External fat thickness, in.	Est. KPH fat, %	Longissimus muscle area, in.^{2}	Est. cuta-bility %
H	343.4	550.5	750	1.41	19.0	.62	2.20	12.1	48.7
SHS	340.4	544.8	810	1.54	18.7	.59	2.33	13.3	48.9
SH	344.5	551.7	814	1.52	18.8	.56	2.18	13.4	49.3
HSH	349.9	552.2	832	1.56	18.3	.42	2.29	14.5	50.6
AHA	341.3	550.1	779	1.45	18.9	.65	2.27	13.3	49.0
AH	341.5	548.3	763	1.44	19.2	.65	2.38	12.5	48.5
HAH	338.1	540.8	770	1.47	19.2	.61	2.52	12.5	48.5
Avg SE of mean	1.7	2.8	11.3	.021	.12	.022	.088	.19	.23
Contrasts									
H - 1/2 ($\bar{S}$ + $\bar{A}$)[c]	NS	NS	-44.8^{**}	$-.086^{**}$	NS	$.039^{+}$	NS	-1.12^{**}	$-.5^{*}$
$\bar{S}$ - $\bar{A}$	4.6^{**}	NS	48.1^{**}	$.084^{**}$	$-.5^{**}$	$-.114^{**}$	$-.12^{*}$	$.93^{**}$	$.9^{**}$
SHS - HSH	-9.5^{**}	-7.4^{*}	-21.4^{*}	NS	$.4^{**}$	$.169^{**}$	NS	-1.24^{**}	-1.8^{**}
AHA - HAH	NS	9.3^{**}	NS	NS	$-.3^{*}$	NS	$-.26^{*}$	$.79^{**}$	$.5^{+}$

[a] H = Hereford, S = Simmental and A = Angus. Hereford, SHS, SH, AHA and AH dams were mated to H sires, HSH dams were mated to S sires and HAH dams were mated to A sires.

[b] 18 = Select, 19 = low Choice, 20 = average Choice, etc.

[c] Straightbred vs crossbred.

$^{+}$ P<.10.

* P<.05.

** P<.01.

TABLE 4. LEAST SQUARES MEANS AND CONTRAST VALUES FROM COMPLETE DATA SET, ADJUSTED FOR CARCASS WEIGHT

Dam breed group[a]	Slaughter age, days	Quality grade[b]	External fat thickness, in.	Estimated KPH fat, %	Longissimus muscle area, $in.^2$	Estimated cutability, %
H	551.8	19.1	.66	2.31	12.4	48.1
SHS	543.2	18.7	.58	2.29	13.0	48.8
SH	552.1	18.8	.60	2.16	13.3	49.2
HSH	546.9	18.3	.40	2.22	13.9	50.7
AHA	550.6	19.0	.65	2.26	13.4	48.7
AH	548.9	19.3	.67	2.46	12.7	48.2
HAH	544.0	19.3	.62	2.53	12.7	48.3
Avg SE of mean	2.6	.12	.028	.089	.167	.23
Contrasts						
H - 1/2 ($\bar{S}$ + $\bar{A}$)[c]		NS	.077**	NS	-.76**	-.84**
$\bar{S}$ - $\bar{A}$		-.6**	-.117**	-.19**	.47**	1.2**
SHS - HSH		.4**	.180**	NS	-.97**	-1.9**
AHA - HAH		-.3+	NS	-.28**	.67**	NS

[a] H = Hereford, S = Simmental and A = Angus. Hereford, SHS, SH, AHA and AH dams were mated to H sires, HSH dams were mated to S sires and HAH dams were mated to A sires.
[b] 18 = Select, 19 = low Choice, 20 = average Choice, etc.
[c] Straightbred vs crossbred.
+ P<.10.
* P<.05.
** P<.01.

TABLE 5. LEAST SQUARES MEANS AND CONTRAST VALUES FOR 1985 THROUGH 1987 BY DAM BREED GROUP AND POSTWEANING MANAGEMENT SYSTEM

Dam breed group[a]	No. steers	Days from weaning to slaughter	Slaughter age, days	Carcass wt, lb	Carcass wt/day of age, lb/day	Quality grade[b]	Marbling score[c]	External fat thickness, in.	Est. KPH fat, %	Longissimus muscle area, in.^{2}	Est. cutability, %
					Management System One (MS1)						
SHS	27	359.6	567.8	862	1.56	18.7	10.6	.61	2.37	14.2	49.2
HSH	26	359.7	562.1	853	1.56	18.8	10.4	.43	2.14	15.1	51.0
AHA	16	369.1	568.7	826	1.49	19.1	11.1	.68	2.34	14.0	48.7
HAH	38	359.7	564.2	831	1.51	19.7	12.9	.61	2.35	13.3	48.6
Avg SE of mean		1.3	3.0	13.7	.028	.20	.45	.035	.119	.299	.34
					Management System Two (MS2)						
SHS	20	239.9	444.5	723	1.67	19.0	11.6	.51	1.52	12.3	49.9
HSH	32	240.3	444.5	745	1.72	18.8	10.7	.36	1.55	13.3	51.5
AHA	17	244.0	444.8	681	1.57	18.6	10.6	.47	1.59	12.7	50.7
HAH	38	240.1	442.8	715	1.66	19.3	11.8	.49	2.06	12.2	50.0
Avg SE of mean		1.4	3.1	13.7	.028	.20	.45	.036	.122	.31	.35
					Main Effect Contrasts						
S vs A		-3.3**		32.6**	.070**	-.3*	-.8*	-.089**	-.19*	.68**	.9**
SHS vs HSH		NS		NS	NS	NS	NS	.166**	NS	-.89**	-1.7**
AHA vs HAH		6.6**		NS	-.053^{+}	-.64**	-1.5**	NS	-.24^{+}	.61*	NS
					Interaction Contrasts						
S vs A[d]		NS		NS	NS	-.509^{+}	-1.41*	NS	NS	NS	1.07*
SHS vs HSH[e]		NS		NS	NS	NS	NS	NS	NS	NS	NS
AHA vs HAH[f]		-5.54*		NS	NS	NS	NS	NS	.46^{+}	NS	NS

[a] H = Hereford, S = Simmental and A = Angus. Hereford, SHS, SH, AHA and AH dams were mated to H sires, HSH dams were mated to S sires and HAH dams were mated to A sires.

[b] Scale: 18 = high select, 19 = low Choice, 20 = average Choice, etc.

[c] Scale: 9 = slight^{+} through 15 = modest^{+}.

[d] (S - A for MS1) - (S - A for MS2).

[e] (SHS - HSH for MS1) - (SHS - HSH for MS2).

[f] (AHA - HAH for MS1) - (AHA - HAH for MS2).

$^{+}P<.10$. $^{*}P<.05$. $^{**}P<.01$.

MS1 but only by .35% under MS2. The longer postweaning period of MS1 resulted in a greater reduction in estimated cutability compared to MS2 for A-cross calves than for S-cross calves. Within the S x H rotation, differences between SHS and HSH were quite consistent over the two management systems for all traits evaluated. Within the A x H rotation, calves from HAH dams exceeded calves from AHA for KPH fat under MS2 (2.06 vs 1.59%) but not under MS1 (2.35 vs 2.34%).

Discussion

In the previous paper summarizing calf weaning production for the present study, Marshall et al. (1989) reported lighter calf birth weights but increased gains from birth to weaning for generations in which H was the sire breed within the S x H and A x H rotations. The possible influence of maternal and(or) grandmaternal effects on breed group rank changes for the two traits were discussed. Although postweaning gain was not directly measured, evaluation of carcass weight per day of age in the present study indicated lower postweaning ADG for generations in which H was the sire breed, suggesting compensatory gain during the postweaning period for calves produced by the HSH and HAH dam breed groups (S- and A-sired calves). Assuming greater preweaning maternal value (i.e., milk production) for S and A compared to H, the change in rankings for preweaning vs postweaning calf rate of gain could be explained by a negative relationship between maternal effects on calf preweaning vs postweaning gain.

In conclusion, important differences among straightbred Hereford and two-breed rotations of Simmental x Hereford and Angus x Hereford for carcass traits were observed, as were intergenerational differences within each rotation for some traits. With a few exceptions, breed group rankings were quite consistent over the two postweaning management systems. Breed group rankings differed some across various traits. Of particular interest was a different ranking for preweaning vs postweaning gains among groups within a rotation. Such changes in rankings over traits indicate the importance of characterizing breed types for a wide spectrum of economically important traits to evaluate net merit for commercial production.

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EFFECTS OF RESTRICTING INTAKE ON CARCASS TRAITS OF YOUNG STEERS

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CATTLE 89-18

Summary

Feedlot performance and carcass characteristics were compared when steer calves were fed energy dense diets ad libitum (AL) or restricted (RI) to achieve constant growth rates. AL steers grew more rapidly ($P<.10$) than RI steers, 2.93 vs 2.74 lb per head per day. For the period from 98 days to slaughter (AL = 89 days, RI = 99 days), AL steers consumed more dry matter daily than RI steers. Restricting intake did not affect feed conversions or total dry matter consumed while in the feedlot. Steers were slaughtered at similar final weights. Intake level did not affect carcass weight, rib fat thickness or rib eye area. RI resulted in depressed ($P<.05$) marbling scores and increased ($P<.05$) percentage KHP. Failure to achieve maximal rates of gain appears to be a primary factor affecting marbling scores in steers 13 to 14 months of age.

(Key Words: Steer Calves, Feedlot, Dry Matter Intake, Carcass, Marbling.)

Introduction

One of the challenges facing the beef industry today is to produce trim carcasses (<.4" rib fat) that will consistently have a minimum quality grade of low choice. This is particularly difficult when cattle achieve slaughter weight at 14 months of age or younger. In an earlier experiment, we found that, if steers were fed to produce similar carcass weights, restricting intake to achieve a constant growth rate resulted in lower marbling scores, although rib fat thickness and 9-10-11 rib composition did not differ. Gain of restricted growth steers was 3.14 lb per day over 178 days. Those data suggest that managing calves for good rather than maximal growth rates may be a principal limitation to producing choice carcasses in young cattle. Since marbling scores are sensitive to many variables, we felt it was important to repeat those comparisons.

Materials and Methods

The Simmental and Angus-sired crossbred calves used in this study were weaned off cows at Ft. Meade in late October and shipped directly to Brookings. Calves were vaccinated using a combination modified live virus vaccine including IBR, BVD, PI_3, BRSV and a 7-way clostridia vaccine. Ivermectin was administered for parasite control. Synovex-C implants were administered in August so implanting was delayed until calves had been on feed 98 days. Calves were individually weighed 36 hours after arriving at the feedlot and allotted to restricted intake (RI) or ad libitum (AL) groups based upon weight, age and breed of sire. The 56 calves, mean weight 595 lb, were placed in four pens of 14 head each.

The receiving diet (Table 1) was fed for 21 days. The switch to the finishing diet was abrupt. Dry matter intake was limited to 8 lb per head per day for 3 days and then gradually increased. Steers in the AL group were fed to appetite. Feed delivery for the RI group was based upon diet NE content and steer weight using the NRC equation for large framed steer calves. The ADG target was 3.3 lb per day. Intake was adjusted at 14-day intervals and was based on actual weights obtained at the same intervals. At 98 days, steers were implanted with Synovex-S[4] separated into smaller pens containing 7 head each. Feeding was scheduled to end when a treatment group averaged 1,145 lb. The AL group was fed for 187 days and the RI group was fed for 197 days. Hot carcass weights were recorded. Rib eye area, rib fat thickness, percent kidney, pelvic and heart fat and marbling score were determined 24 hours after cattle were slaughtered. Calf

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[3]Manager, Beef Cattle and Sheep Nutrition Unit.
[4]Provided by Syntex Corp., Des Moines, IA.

TABLE 1. RECEIVING AND FINISHING DIETS[a]

Ingredient	Receiving[b]	Finishing[c]
Cracked corn	54.10	
Whole shelled corn		23.55
High moisture corn		47.10
Brome-alfalfa hay	40.00	
Corn silage		20.00
Molasses	3.00	2.00
Soybean meal, 44%	2.50	6.05
Limestone		1.00
Trace mineralized salt[c]	.40	.30
Composition[e]		
Crude protein	13.60	11.98
NEm, Mcal/cwt	82.0	92.3
NEg, Mcal/cwt	50.1	61.0

[a] Percentage dry matter basis unless otherwise noted.
[b] Provided >1500 IU vitamin A[5]/lb and 37.5 g lasalocid/T diet.
[c] Provided >1000 IU vitamin A[5]/lb and 26 g monensin[6]/T.
[d] Contains 97% NaCl, .007% I, .24% Mn, .24% Fe, .05% Mg, .032% Cu, .011% Co, .032% Zn and .5% Ca.
[e] Estimated from tabular data.

weight gains and carcass data were statistically analyzed using calf as the experimental unit. Intake and feed conversion data were analyzed on a pen basis for data after 98 days on feed.

Results and Discussion

Overall, steers did not perform as expected. Cumulative ADG of 2.84 ± .0576 lb was well below the projected rate and tended (P<.10) to be higher among the AL group (Table 2). The AL steers consumed more (P<.05) dry matter daily but did not consume more feed while in the feedlot. Feed conversion was not affected (P>.10) by feeding program. Interim body weights were heavier for AL steers, but this weight advantage had diminished by 182 days on feed. Final live weights were not affected by management group. Restricting intake slightly has been recommended by some researchers as a means to improve feed efficiency during high grain feeding. In this experiment restricting intake merely prolonged the time necessary to reach slaughter weight. Bunk maintenance during inclimate weather is simplified by restricting feed intake, but no other production efficiencies were evident.

Carcass weight, rib fat thickness and rib eye area were not affected (P>.10) by treatment (Table 3). The percentage kidney, pelvic and heart fat was estimated to be higher and marbling score lower for the RI group (P<.05). The percentage of carcasses grading low choice or better was not affected by management when Chi square analysis was used. The difference in the two statistical evaluations occurred because of those carcasses that had at least small⁻ marbling scores, the AL group had higher scores. In the previous experiment, we may have slaughtered cattle at a slightly lower degree of fatness based upon rib fat thickness (.393 vs .347 in.) which could have a significant impact on percentage choice data.

Most previous research has involved feeding relatively higher roughage diets when considering energy intake effects on quality grades and it is generally recognized that energy dense diets are necessary to produce choice cattle. These experiments indicate that the relative intake level of high grain diets is also important. Management that does not allow for adequate caloric intake will result in lower marbling scores. Cumulative ADG of 2.8 or 3.0 lb per day which is generally considered to be a good level of performance may not be adequate to ensure choice grades in some cattle unless the feeding period is extended. The steers in this experiment averaged 391 days of age at slaughter and produced 693-lb carcasses. Including regraded carcasses, there were 78% choice carcasses and 78% yield grade 2 carcasses. By feeding adequate energy levels, it is feasible to produce choice carcasses from cattle less than 14 months of age without causing them to be overly fat.

[5]Provided by Hoffman-LaRoche, Nutley, NJ.
[6]Provided by Elanco, Indianapolis, IN.

TABLE 2. FEEDLOT PERFORMANCE OF STEERS FED AT AD LIBITUM OR RESTRICTED LEVELS OF INTAKE

Item	Treatment		SEM
	Restricted	Ad libitum	
Number of steers	27	29	
Initial weight, lb	594	597	6.6
Final weight, lb	1,133	1,145	10.4
Days fed	197	187	
Average daily gain, lb[a,c]	2.74	2.93	.06
Daily dry matter intake, lb[b,d]	19.57	21.25	.31
Feed/gain[b]	7.15	7.27	.24

[a] Entire feeding period.
[b] Includes only data after 98 days on feed.
[c] Means differ (P<.10).
[d] Means differ (P<.05).

TABLE 3. CARCASS TRAITS OF RESTRICTED INTAKE AND AD LIBITUM INTAKE STEER GROUPS

Item	Treatment		SEM
	Restricted	Ad libitum	
Carcass weight, lb	689	697	10.9
Rib fat thickness, in.	.390	.395	.023
Rib eye area, $in.^2$	12.29	12.32	.20
KPH, %[a]	2.61	2.11	.069
Marbling score[b]	12.22	12.47	.119
Choice, %	74	83	
Yield grade	2.68	2.61	.10

[a] Means differ (P<.05).
[b] Means differ (P<.01); 12.0 = Sm°, 13.0 = Modest°.

EFFECT OF DECCOX[1] AND AUREOMYCIN[2] ON PERFORMANCE OF FEEDLOT STEERS DURING THE RECEIVING PERIOD

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CATTLE 89-19

Summary

One-hundred thirty Angus steer calves (492 lb) were utilized in a study to determine the effect of feeding Deccox, Aureomycin or a combination of Deccox and Aureomycin on feedlot performance during the feedlot receiving period (29 days). All cattle were fed diets consisting of 50% concentrate on a dry matter basis. No clinical symptoms of respiratory illness or coccidiosis were observed for any of the cattle in this study. There were no significant differences in average daily dry matter intake due to medication treatment. Feeding Deccox improved (P = .0161) average daily gain about 10.9%. Feeding Aureomycin tended to improve (P = .0771) average daily gain. These data support the use of Deccox in feedlot receiving programs even in the absence of clinical coccidiosis.

(Key Words: Receiving Programs, Deccox, Aureomycin, Feedlot.)

Introduction

The first month in the feedlot is an extremely critical time for recently weaned calves. Performance during the first month on feed is highly related to performance throughout the entire feeding period. In order to reduce the stresses associated with starting new cattle, many producers use antibiotics such as Aureomycin in their receiving diets. Deccox is also often included in the receiving diet to control coccidiosis in newly arrived feedlot cattle.

The objective of this experiment was to determine the effect of Deccox and Aureomycin, fed either singly or in combination, on feedlot performance of newly weaned calves during the feedlot receiving period.

Materials and Methods

One-hundred thirty Angus steers were purchased in western South Dakota and transported 400 miles to the Southeast South Dakota Experiment Farm near Beresford. Upon arrival cattle were allowed access to long stem grass hay and water overnight. For the next 5 days cattle were fed ad libitum amounts of long stem grass hay and increasing amounts of a 50% concentrate receiving diet (Table 1) starting with 1.7 lb of dry matter on day 1 and ending with 7.7 lb dry matter on day 5.

After 5 days in the feedlot, feed and water were withheld from the cattle overnight (16 hours). Cattle were then individually weighed, implanted with Ralgro[5], vaccinated for IBR, BVD, PI_3, BRSV, injected with 7-way clostridial bacterin and treated for parasites using Ivomec[6]. Cattle were then randomly assigned to eight pens, six pens of 16 head and two pens of 17 head.

Starting on day 6, cattle were offered ad libitum amounts of the receiving diet (Table 1) fed once daily. Two pens of cattle received no medicated feed additive, two pens received Deccox at a rate of .114 grams of active ingredient (decoquinate) per head and two pens received 2 grams of Aureomycin (active ingredient chlortetracycline) per head for 1 week and 1 gram per head for the rest of the trial. The two remaining pens received .114 grams per head of decoquinate and 2 grams per head of Aureomycin for the first week and 1 gram per head for the rest of the trial. All Deccox and Aureomycin used in the experiment was fed as a top dress. Total trial period was 29 days (6 to 34 in the feedlot).

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[1]Deccox is a product of Rhone-Poulenc, Inc., Atlanta, GA.
[2]Aureomycin is a product of American Cyanamid, Inc., Wayne, NJ.
[3]Assistant Professor.
[4]Cattle Manager, Southeast South Dakota Experiment Farm.
[5]Product of IMC-Pitman-Moore, Terre Haute, IN.
[6]Product of MSDAGVET, Merck and Co., Inc., Rahway, NJ.

TABLE 1. RECEIVING DIET FED STEER CALVES

Ingredient	Level[a]
Alfalfa-grass hay, %	12.50
Corn silage, %	37.50
Rolled corn, %	17.44
Ground high moisture corn, %	17.44
Supplement, %	15.12
Nutrient composition[b]	
Net energy for maintenance, Mcal/cwt	80.50
Net energy for gain, Mcal/cwt	52.40
Crude protein, %	14.00
Calcium, %	.67
Phosphorus, %	.45
Vitamin A, IU/lb	2000

[a] Dry matter basis.
[b] Tabular values.

Data were analyzed as a completely randomized design with a factorial arrangement of treatments. Experimental units were individual steers for average daily gain data and pen means for dry matter intake and feed/gain data.

Results and Discussion

Performance of cattle is displayed in Table 2. Daily dry matter intake averaged 14.35 lb per head and was similar for all treatments. Average daily gain was improved 10.9% by providing Deccox (3.55 vs 3.20 lb/ per head per day). Daily gains tended (P = .0771) to be greater for cattle fed Aureomycin (3.50 vs 3.24 lb per head per day).

Interactions between the Deccox and Aureomycin treatments were not significant (P = .4661), indicating that cattle responded to Deccox or Aureomycin independent of whether the other additive was present in the diet or not. Cattle fed the combination of Deccox and Aureomycin achieved 19.6 and 14.1% faster rates of gain (P<.05) than cattle fed no feed additive or only Aureomycin, respectively (3.73 vs 3.12 and 3.27 lb per head per day). Cattle fed the combination of Deccox and Aureomycin tended to gain (P = .0780) more rapidly than cattle fed only Deccox (3.73 vs 3.37 lb per head per day).

The differences in feed/gain are not statistically significant. Feed intake and efficiency data were analyzed on a pen mean basis. Only two pens of cattle per treatment combination were utilized in the study, limiting the ability to detect statistical differences in feed efficiency.

These data support the use of Deccox in feedlot receiving programs, even though no symptoms of clinical coccidiosis were observed during this study. No symptoms of respiratory disease were observed during this study, either. Aureomycin feeding tended to improve performance, although this response was not as consistent as what was observed for Deccox.

TABLE 2. PERFORMANCE OF STEER CALVES, DAY 6-34 IN THE FEEDLOT

	Main effects				Treatment combinations			
	Deccox		Aureomycin					Deccox +
Item	o	+	o	+	Control	Deccox	Aureomycin	Aureomycin
Numbers of steers	65	65	65	65	32	32	32	32
Initial wt., lb	493	491	493	491	493	494	493	488
ADG, lb/head/day[a]	3.20	3.55	3.24	3.50	3.12[b]	3.37[bc]	3.27[b]	3.73[c]
DMI, lb/head/day	14.35	14.34	14.36	14.33	14.29	14.42	14.42	14.25
Feed/gain	4.57	4.22	4.58	4.21	4.71	4.44	4.42	3.99

[a] Deccox effect, P = .0161; Aureomycin effect, P = .0771.

[b,c] Means in same row with unlike superscripts differ (P<.05).

FEEDING PRACTICES IN SOUTH DAKOTA CATTLE FEEDLOTS

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CATTLE 89-20

Summary

During March 1989, a mail survey of South Dakota cattle feedlot managers was undertaken. The purposes of the survey were to characterize the nature of the cattle feeding industry in South Dakota and to determine the relationships between (i) each of size-of-feedlot and geographic location within the state and (ii) management practices followed by cattle feeders. Direct relationships exist between size-of-feedlot and the following: (1) rate of feedlot utilization in each quarter of the year ($P<.10$); (2) percentage grain relative to roughage in both growing and finishing diets ($P<.10$); (3) percentage of feedlots feeding high moisture grain, cracked grain, and ground hay ($P<.01$); (4) percentage of feedlots using rumen stimulants and growth implants ($P<.01$); and (5) percentages of managers testing feeds for nutrient composition, using feed scales to control feeding rates, maintaining feed records for separate pens of cattle, and hiring consultants to formulate rations ($P<.01$). On the other hand, inverse relationships exist between size-of-feedlot and the following: (6) days on feed for heifer calves, yearling steers, and yearling heifers ($P<.10$); (7) slaughter weight of steers ($P<.10$); (8) percentage of home-raised hay and dry grain ($P<.10$); (9) percentage of feedlots feeding ground grain and unprocessed hay ($P<.01$); and (10) percentage of feedlots not using feed additives ($P<.10$). Average days on feed for steer and heifer calves are lower ($P<.05$) in the West than in other areas of the state. More milo is fed in the West; more barley is fed in the North Central region; and less home-raised corn silage and haylage are fed in the West than in other regions ($P<.05$).

(Key Words: Feedlot, Survey, Size, Technology, Management Practices, Diet Ingredients.)

Introduction

The cattle feeding industry has undergone tremendous change in recent years. There has been a shift in the location of the industry from small, farmer feedlots located in the corn belt toward larger, more specialized feeding operations located in the central and southern plains regions of Nebraska, Kansas, Colorado, Oklahoma, and Kansas.

Tremendous technological advances have been associated with this shift in size and location of the feeding industry. Growth promotants, feed additives, feed testing, the electronic media, and microcomputers have radically impacted the industry.

Cattle feeding is an important segment of the South Dakota economy. Approximately 600,000 fed cattle are marketed annually. In order to more effectively plan and conduct extension, research, and teaching activities, a more thorough understanding of the cattle feeding industry in South Dakota is needed.

The objectives of this research were to characterize the nature of the cattle feeding industry in South Dakota and to determine the relationships between (1) each of size-of-feedlot and geographic location within the state and (2) the feeding and other management practices followed by cattle feeders. In this paper, that part of the research dealing with steer and heifer feeding practices is covered. For a comprehensive report of the study findings, contact the senior author, SDSU Economics Department, Box 504A, Brookings, SD.

Materials and Methods

During March 1989, a mail survey of South Dakota cattle feedlots was conducted. The mail questionnaire was sent to the managers of feedlots with a capacity of 499 head or less (a 12% sample) and all the state's

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150 feedlots with a capacity of 500 head or more. Taking into account feedlots reported to be no longer in operation, the overall survey response rate was 35.5%. This includes 145 and 30 usable questionnaires for cattle finishing and cattle backgrounding operations, respectively. For the cattle finishing feedlots, the response rate for <500 head capacity feedlots was about 17%; for >500 head capacity feedlots, it was 45%. The responses cover about 1.4% of the state's feedlots with <500 head capacity and 32% of the state's feedlots with >500 head capacity.

The cattle finishing survey responses were analyzed for all 145 feedlot respondents collectively and then by region within the state and size-of-feedlot. Five regions were defined as shown in Figure 1. Size-of-feedlot was defined by feedlot design capacity (total reported feed bunk space divided by 1.5 foot per head), and four feedlot size categories were established:

- "Small" with < 200 head;
- "Intermediate I" with 200-999 head;
- "Intermediate II" with 1,000-2,499 head; and
- "Large" with 2,500 head or more.

Two types of averages for various feedlot characteristics and management practices were calculated: (1) "feedlot" averages, in which the unit of analysis is the individual feedlot, and (2) "head-day" averages, in which the unit of analysis is the estimated average number of head of cattle on feed during 1988. In calculating the latter, of course, greater weight is given to larger feedlots. Readers with a primary interest in feedlot managers will find the "feedlot" averages of most interest. Those with a primary interest in cattle feeding industry economics will find the "head-day" averages of greater interest.

The statistical significance of differences among regions and among sizes-of-feedlot categories was determined using the standard Pearson Chi-Square statistic or the GLM (general linear model) LSMEANS test and an associated Waller-Duncan test. Resulting from these tests was a determination of whether the value for a particular variable for one or more regions (or size-of-feedlot categories) differs significantly from the values for that same variable in other regions (size-of-feedlot categories).

In the ensuing discussion, attention is drawn to all pertinent instances in which differences were shown

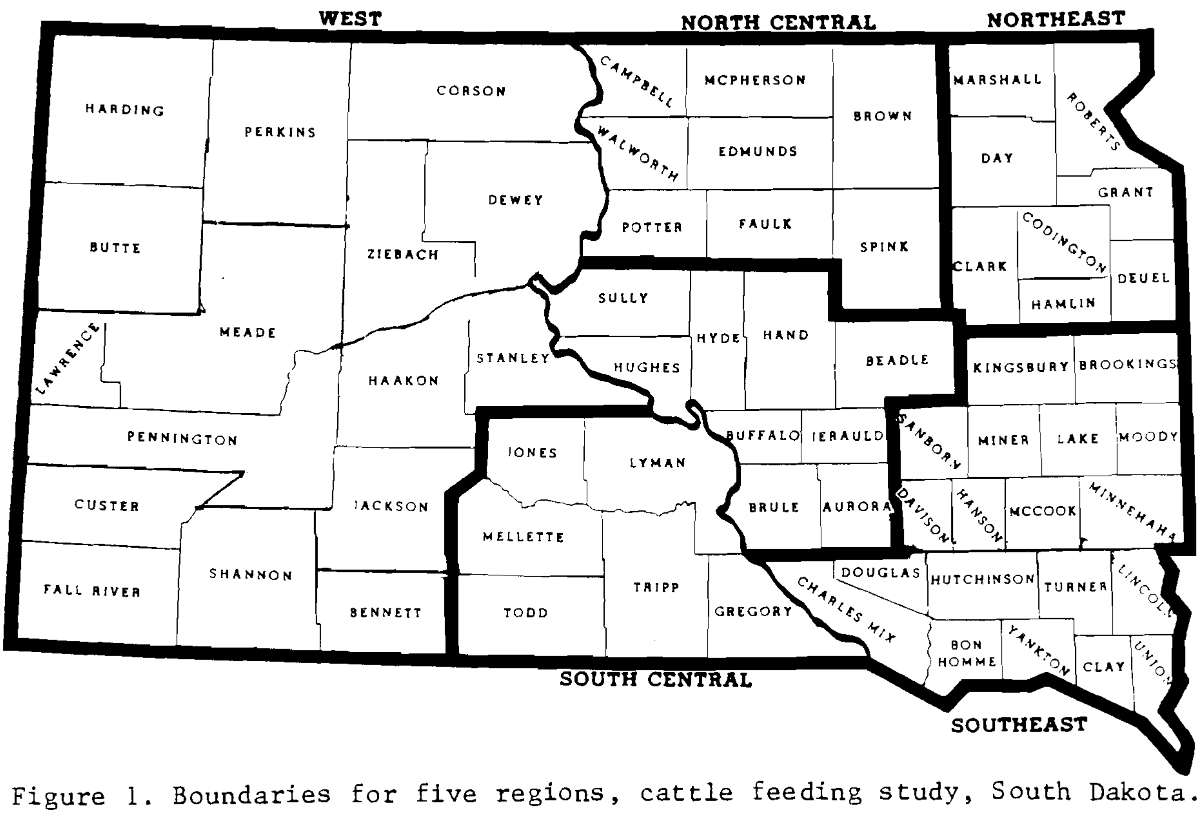

Figure 1. Boundaries for five regions, cattle feeding study, South Dakota.

to be statistically significant. Sometimes instances of no statistically significant differences are noted in the text. If so, the test of significance is always P<.10. If mention about the significance of differences for a particular variable is omitted in the text, one should conclude that the differences among the means being tested are insignificant for P<.10.

Results and Discussion

The design capacities of the 145 feedlots studied range from 20 to 12,000 head and average 900 head per feedlot (Table 1). By region, the mean feedlot sizes range from 690 in the Southeast to 1,585 in the West. Within-region variations are sufficiently great, however, that differences among regions in the mean feedlot design capacities are not collectively significant.

On the average throughout 1988, the reported feedlot utilization was 72% to 80% of design capacity, depending on whether calculations are based on averages with respect to feedlots or head-days. The quarter of highest utilization is January-March (average utilization rates of 84% to 90%, respectively) and of lowest utilization is July-September (54% to 67%). About 62% of all feedlot managers reported their 1988 utilization to be typical of the past 5 years. Almost identical percentages of managers reported their utilization rates in 1988 to be either higher or lower than typical.

Differences among regions in quarterly feedlot utilization rates are not statistically significant. Differences among sizes of feedlots in quarterly utilization rates, however, are statistically significant (P<.05 for the first three quarters and P<.10 for the fourth quarter), with a direct relationship between size-of-feedlot and rate of utilization. Rates of feedlot utilization in "large" feedlots are from 20 to 35 percentage points higher than in "small" feedlots in the respective quarters.

Feeding practices

Days cattle on feed. Steer calves and yearling steers are reported to be on feed typically for averages of 208 to 229 days and 129 to 145 days, respectively, with the shorter average period lengths being head-day based and the longer period lengths feedlot-based (Table 2). Steer calves are typically kept on feed for 4 to 5 days longer than heifer calves and yearling steers for 10 to 13 days longer than yearling heifers.

The feeding periods are widely variant among feedlots, but generally they are somewhat greater than the normally recommended practice. At the long end of the ranges, about 25% of the feedlots keep steer and heifer calves on feed for 275 days or longer and 20% and 14% of feedlots keep yearling steers and heifers, respectively, on feed for 180 days or longer.

Differences among regions in typical average feeding periods are quite substantial, but only the average days that steer and heifer calves are on feed in the West (133 days each) are significantly (P<.05) different from those in the other regions. In general, feeding periods vary inversely with size-of-feedlot, with the clearest statistically significant (P<.10) pattern being for heifer calves, namely, average days of 255, 229, 208, and 176 for "small," "intermediate I," "intermediate II," and "large" feedlots, respectively. For both yearling steers and yearling heifers, differences in the average feeding period among sizes-of-feedlot are statistically significant (P<.01), with the greatest differences being between "small" feedlots in which the average days on feed exceed 190 and the "intermediate II" feedlots in which the average days on feed are less than or equal 125. While the pattern for

TABLE 1. NUMBER AND SIZE OF FEEDLOTS BY REGION IN SOUTH DAKOTA, 1989 CATTLE FEEDER SURVEY

Region	Number of feedlots	Design capacity of feedlot (head): Mean	Range
West	4	1,585	135 - 3,000
South Central	20	1,220	20 - 12,000
Northeast	22	1,145	85 - 5,335
North Central	16	1,080	135 - 2,000
Southeast	83	690	30 - 5,335
State	145	900	20 - 12,000

TABLE 2. AVERAGE DAYS CATTLE ARE TYPICALLY ON FEED BY TYPE OF CATTLE AND REGION, SOUTH DAKOTA FEEDLOTS

	Average days on feed by type of cattle			
Region	Steer calves	Heifer calves	Yearling steers	Yearling heifers
West	133	133	110	115
North Central	203	206	123	121
South Central	201	210	121	120
Northeast	248	238	138	142
Southeast	241	237	159	135
State averages				
Feedlot-based	229	225	145	132
Head-days-based	208	203	129	119

steer calves is very similar to that for heifer calves, differences among size-of-feedlot categories in feeding period lengths for steer calves are not statistically significant.

Closely related to days on feed is the targeted finishing weight for animals placed on feed. The average (head-based) targeted finishing weights for steers and heifers in the feedlot are 1,220 lb and 1,100 lb, respectively. These weights, too, are somewhat greater than normally expected (e.g., one recent report indicates an average slaughter weight for steers in the Great Plains of 1,140 lb). The slaughter weights of cattle in "small" feedlots are somewhat higher than those for the other three size-of-feedlot categories. For steers, however, the differences (34-38 lb) are statistically significant ($P<.10$).

Grains versus roughages in cattle diets. Feedlot managers report an average of 34% to 39% grain--relative to the total dry matter weight of feed--in the diets of cattle during the growing period. At the extremes, 10% of the feedlots report less than 20% grain being fed during the growing period and 11% more than 60% grain.

The average percentages of grain in the total diets range from 27% in the South Central region to 45% in the West, but differences among regions are not statistically significant. A direct, statistically significant ($P<.10$) relationship exists between size-of-feedlot and percentage of grain in growing cattle diets, however, with about 10 percentage points difference between cattle in "small" and in "large" feedlots.

During the finishing period, the percentages of grain in cattle diets average 75% to 80% of total feed intake. At the extremes, 12% of the feedlots report feeding less than 60% grain during the finishing period and 20% of the feedlots more than 90% grain.

The average percentages of grain in the total finishing diets vary from 69% in the South Central region to 85% in the West, but interregional differences are not statistically significant. Size-of-feedlot differences are again statistically significant ($P<.10$), however, with the proportion of grain fed cattle in "large" feedlots being about 11 percentage points higher than that in "small" feedlots.

Types of grain fed. Total grains typically fed to cattle average 91-92% corn, followed by 3-4% barley, 2-3% milo, 1-2% oats, and 0.1-0.3% wheat. About 60% of the feedlot managers report corn as the only grain used in their cattle rations. As little as 20% and 30% corn are reported by two feedlot managers. The other grains individually represent more than 40% of total grains fed for only 3% of the feedlots for milo and 2% of the feedlots for barley. At the other extreme, the following percentages of feedlot managers report using none of the following grains in their rations: 79% barley, 83% oats, 94% milo, and 97% wheat.

The mean percentages of different grains fed to cattle do not vary significantly among regions or sizes-of-feedlot except for the following. (1) The 11.6% barley fed in the North Central region is significantly ($P<.05$) higher than the corresponding percentage in any other region. (2) The 2.5% barley fed cattle in the West and in the South Central region and the 1.8% barley fed in the Southeast are significantly (P<.05) lower than the corresponding percentage fed in either other region. (3) The 15.0% milo fed in the West is significantly (P<.01) higher than the corresponding percentage in any other region. (4) The 4.1% oats fed in "small" feedlots, the 1.8% oats in "intermediate I" feedlots, the 0.2% oats in "intermediate II" feedlots, and the 0% oats in "large" feedlots differ significantly (P<.05) with each other.

Types of roughage fed. The following percentages of feedlot managers report feeding the respective types of roughages: 91% hay, 85% corn silage, 40% haylage, 17% grazing pasture, 8% grazing residues, and 13% other (oatlage and milo/sorghum/sudan silage).

The percentage of feedlots feeding corn silage differs significantly (P<.01) among size-of-feedlot categories, but not with a clear pattern relative to size-of-feedlot: 70% for "small" feedlots, 91% for "intermediate I" feedlots, 100% for "intermediate II" feedlots, and 67% for "large" feedlots. In addition, a statistically significant (P<.05) direct relationship exists between size-of-feedlot and the percentages of other roughages fed, ranging from 2% of "small" feedlots to 44% of "large" feedlots feeding other roughages.

Source of roughages and grains. The percentages of feeds typically home-raised (i.e., raised on the farm that has the feedlot) are as follows[4]:

- Corn silage: 97% to 99%;
- Haylage: 95% to 97%;
- Hay: 83% to 58%;
- High moisture grain: 75% to 53%; and
- Dry grain: 65% to 43%.

The percentages of feedlots that home-raise 100% of their feedstuffs are as follows: 95% corn silage, 94% haylage, 70% hay, 54% high moisture grain, and 40% dry grain. At the other extreme, the percentages of feedlots that home-raise none of their feedstuffs are as follows: 15% dry grain, 7% high moisture grain, 4% haylage, 4% hay, and 2% corn silage.

The mean percentages of home-raised roughages and grains do not differ significantly among regions or sizes-of-feedlot except as follows. (1) The percentages of home-raised corn silage (48%) and haylage (50%) in the West are significantly (P<.05) lower than in any other region. (2) A clear pattern of a statistically significant (P<.01) inverse relationship exists between size-of-feedlot and the percentage of home-raised hay, with a difference of over 40 percentage points in home-raised hay between the "small" and the "large" feedlots. (3) Statistically significant (P<.01) differences exist among sizes-of-feedlot in percentages of home-raised dry grain, with the percentages for the respective feedlot-sizes as follows: 91% "small", 65% "intermediate I," 35% "intermediate II," and 38% "large." (4) A statistically significant (P<.01) generally inverse relationship exists between the percentages of home-raised high moisture grain and size-of-feedlot, with the range of differences between "small" and "large" feedlots being about 40 percentage points.

Forms of feeds fed to cattle. About 90% of the feedlot managers report feeding dry grain and 57% high moisture grain. The relationship between the percentage of high moisture grain and size-of-feedlot is direct and statistically significant (P<.01), with the relative importance of high moisture grain 67 percentage points greater for "large" than "small" feedlots. Further, less than 12% of "small" and "intermediate I" feedlots use both dry and high moisture grain, whereas between 87% and 89% of "intermediate II" and "large" feedlots do.

The following percentages of feedlot managers report feeding dry grain in the following forms: 59% cracked, 44% ground, 36% whole kernel, 3% steam flaked, and 1.4% reconstituted. Only for cracked and ground grain do the percentages differ significantly (P<.10) for different sizes of feedlots. Cracked grain tends to be more common for larger feedlots, as evidenced by the following percentages of cracked grain use for different sizes-of-feedlots: 26% "small," 66% "intermediate I," 84% "intermediate II," and 80% "large." Ground grain, on the other hand, is most common with the "small" feedlots (63% of them feed ground grain) in contrast

[4] In the following pairs of average figures, the first one is calculated with feedlots as the unit of analysis and the second one with head-days as the unit of analysis.

with 38 to 40% for the other three size-of-feedlot categories.

The following percentages of feedlot managers report feeding hay in the following forms: 67% ground, 49% unprocessed, and 4% other (haylage, green chop). For both ground and unprocessed hay, the percentages differ significantly (P<.01) for different sizes-of-feedlots. Ground hay tends to be more common with larger feedlots, as evidenced by the following incidences of ground hay feeding for different sizes-of-feedlots: 26% "small," 78% "intermediate I," 96% "intermediate II," and 90% "large." The converse tends to hold with unprocessed hay: 84% "small," 46% "intermediate I," 7% "intermediate II," and 30% "large."

The following percentages of feedlot managers report feeding protein supplements in the following forms: 66% dry only, 18% liquid only, and 16% both dry and liquid. In general, patterns of relationship appear to exist between size-of-feedlot and the form of protein supplement fed, with smaller feedlots more commonly using dry protein supplement and larger feedlots using relatively more liquid protein supplement. However, the apparent patterns of difference are not statistically significant.

Feed additives and growth promotants. About 73% of the feedlot managers report the continuous use of rumen stimulants (e.g., Rumensin, Bovatec) and 59% the continuous use of growth implants (e.g., Ralgro, Compudose, Synovex) [Table 3]. Fewer than 14% of the feedlots report not using either rumen stimulants or growth implants.

Between about 45% and 70% of the feedlot managers report using, at selected times only, each of (1) antibiotics at therapeutic levels, (2) antibiotics at sub-therapeutic levels, and (3) coccidiosis control (e.g., Deccox, Bovatec, Amprollium). About 47% of the feedlot managers report not using antibiotics at sub-therapeutic levels, 40% not controlling coccidiosis, and 30% not using antibiotics at therapeutic levels.

For none of the various feed additives and growth promotants do incidences of usage differ significantly by region of the state. In several cases, however, usage levels are significantly related to size-of-feedlot.

Clear direct relationships exist between size-of-feedlot and the continuous use of (1) rumen stimulants, with 43 percentage points more for "large" than "small" feedlots (P<.01) and (2) growth implants, with 65 percentage points more for "large" than "small" feedlots (P<.01). A clear direct relationship also exists between size-of-feedlot and the use at selected times only of antibiotics at therapeutic levels, with 43 percentage points more for "large" than "small" feedlots (P<.01).

On the other hand, clear inverse relationships exist between size-of-feedlot and not using each of (1) rumen stimulants, with 29 percentage points more

TABLE 3. USE OF FEED ADDITIVES AND GROWTH PROMOTANTS SOUTH DAKOTA FEEDLOTS

Feed additive and growth promotant	Percent of reporting feedlots indicating feed additives and growth promotants: Used continuously	Used at selected times only	Not used
Rumen stimulants (e.g., Rumensin, Bovatec)	72.9	13.2	13.9
Growth implants (e.g, Ralgro, Compudose, Synovex)	59.1	29.5	11.4
Coccidiosis control (e.g., Deccox, Bovatec, Amprollium)	15.7	45.4	38.9
Antibiotics at sub-therapeutic levels	8.3	44.9	46.8
Antibiotics at therapeutic levels	.9	69.1	30.0

for "small" than "Intermediate I" and "large" feedlots (P<.01), (2) antibiotics at sub-therapeutic levels, with 23 percentage points more for "small" than "large" feedlots (P<.10), and (3) antibiotics at therapeutic levels, with 43 percentage points more for "small" than "large" feedlots (P<.01).

Other feed management practices. Feedlot managers indicate the following usage of six other feed management practices (Table 4): 64% test for nutrient composition at least once each year, 57% use feed scales to monitor and control feeding rates, 34% keep feed records for separate pens of cattle, 27% hire consultants to formulate rations, 14% use microcomputers to formulate rations, and 14% use microcomputers to keep feed records. A statistically significant direct relationship exists between use of the first four practices and size-of-feedlot (P<.01).

TABLE 4. OTHER FEED MANAGEMENT PRACTICES, SOUTH DAKOTA FEEDLOTS

Management practice	Percent of reporting feedlots that follow practice: Small	Inter I	Inter II	Large	State	Signif level
Feeds tested for nutrient composition at least once a year	40	66	84	100	64	.01
Feed scales used to monitor and control feeding rates	19	64	84	90	57	.01
Feed records kept for separate pens of cattle	7	25	65	90	34	.01
Consultants hired to formulate rations	14	14	61	50	27	.01
Microcomputers used for formulating rations	5	9	36	20	14	n.t.
Microcomputers used for keeping feed records	0	9	36	40	14	n.t.

n.t. = not tested statistically.

COMPARISON OF YEARLING STEER GAINS IN EARLY SUMMER UNDER SEASON-LONG NATIVE, SEASON-LONG CRESTED WHEATGRASS AND JUNE-DEFERRED NATIVE GRAZING SYSTEMS

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CATTLE 89-21

Summary

Season-long native, season-long crested wheatgrass and June-deferred native grazing systems were compared with regard to average daily gains, gains per acre and total gains. Due to drought conditions, the typical 4-month spring-summer season was reduced to a season of approximately 2 months beginning in June. Few differences were detected between the systems for ADG in each month or over the season. Gains per acre were greatest ($P<.05$) on crested wheatgrass pastures (33.75 lb/acre), but no differences were detected between native pastures (10.61-16.61 lb/acre) regardless of whether they had been grazed for 2 months or one (using similar stocking rates). This study indicates that, using weight gain data from 1989 and a 2-month grazing season, the greatest potential gain for the season is realized with a system where cattle graze crested wheatgrass in June and native pastures in July. If this system was applied on 320 acres crested wheatgrass and 640 acres excellent condition native pasture, it would have the potential to produce approximately 23,196 lb of gain on yearling steers compared with season-long (June-July) production of 9,408 lb on 640 acres and 14,112 lb on 960 acres native pasture.

(Key Words: Native Range, Crested Wheatgrass, Spring Deferment, Grazing Systems.)

Introduction

Rangelands in South Dakota are made up of both native and introduced plant communities. Native range vegetation occupies vast acreages in the state and is well suited to the relatively dry, unpredictable climate typical of the Great Plains. Native range vegetation is generally made up of both cool- and warm-season species, providing green forage throughout most of the growing season. Introduced cool-season grasses, especially crested wheatgrass, occupy much less extensive acreages than native vegetation but have long been recognized as a valuable source of rangeland forage, producing high quality forage in early spring and maturing in early summer. These grasses typically produce much greater amounts of forage per acre than native species.

Native rangeland in western South Dakota is generally most susceptible to grazing damage in spring, when green nutritious forage is in relatively short supply and cool-season plants are often overgrazed. An early season or spring deferment of native pastures may reduce or reverse deterioration of the range, and thereby sustain the productivity of the range over the long term. The nutritional requirements of cattle may be met during the deferment period by grazing other native pastures not being deferred or grazing crested wheatgrass (or other introduced cool-season grass) pastures.

The objective of this study is to evaluate the value of spring deferment on western South Dakota rangeland and to compare several options for grazing cattle during the deferment period with respect to cattle performance and vegetation responses. This paper provides a report of the cattle performance data for only one year of the study.

Materials and Methods

This study was conducted at the South Dakota Range and Livestock Research Station, Cottonwood. Two condition classes of native mixed prairie rangeland, excellent and fair (EXC and FAIR), were utilized in this study comparing two grazing systems: June deferment (DF) and season-long (SL) grazing. Crested wheatgrass (CW) pastures

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(interseeded with alfalfa) provided grazing in June for cattle which were moved onto June-deferred native pastures in July. The CW pastures also provided grazing for additional cattle throughout the grazing season. Native pastures were 17 acres in size with three replicates of each combination of pasture condition and grazing system. CW pastures were 25 to 30 acres in size with four replicates.

The study began June 8, 1989 and was projected to continue for 4 months. Inadequate forage supplies due to drought conditions resulted in the study being terminated after approximately 2 months. The pastures were grazed by yearling black baldy steers. Average weights at the beginning of the study were 659 and 728 lb for steers which grazed native pastures (both SL and DF) and for those which remained on the CW pastures the entire grazing season, respectively. Steers were removed from CW and native SL pastures on August 3. Additional steers were added to each of the DF native pastures on August 6 and grazing continued through August 9 in order to provide similar numbers of animal unit days (AUD) of grazing (118 and 111 AUD for SL and DF native pastures, respectively). Stocking rates (assuming each steer is approximately .7 AU) for native pastures were approximately .25 animal units months per acre (AUM/acre), with 3 steers on each pasture grazed season-long and 4 steers on each pasture receiving a June deferment. CW pastures were stocked with 12 steers per pasture in June and reduced to 6 head per pasture beginning July 6. Stocking rates were .43 and .51 AUM/acre for 30- and 25-acre pastures, respectively. The 6 animals removed from each of the CW pastures on July 6 (24 head total) were randomly allotted to the fair and excellent condition June-deferred pastures (FAIR-DF and EXC-DF). Cattle were weighed at the beginning of the study and at 28-day intervals. Weights were taken following overnight removal of water and forage to reduce variability due to rumen fill.

Results and Discussion

Average daily gains (ADG) were significantly lower (P<.05) in June for EXC-SL pastures than for FAIR-SL pastures (Table 1). Excellent condition pastures used in this study had not been grazed since 1985, leaving a considerable amount of standing dead material interspersed with current year's growth. Consumption of the older, rank forage was generally unavoidable and likely reduced the overall quality of the diet compared with grazing only current year's growth. Average daily gain in July for cattle grazing FAIR-SL pastures was significantly lower (P<.05) than for cattle grazing EXC-SL, FAIR-DF and EXC-DF pastures. By this time, cattle on FAIR-SL pastures may have been forced to graze primarily lower quality forages, having consumed most of 1989 cool-season forage in June. The forage available on EXC-SL, FAIR-DF and EXC-DF pastures, however, was likely of higher quality in July due to species composition differences and/or greater availability of cool-season grasses due to a June deferment. The cattle on EXC-DF pastures, which were first grazed in July, showed significantly greater (P<.05)

TABLE 1. AVERAGE DAILY GAINS[1] (LB) FOR CATTLE GRAZING NATIVE AND INTRODUCED PASTURES UNDER TWO GRAZING SYSTEMS

Pasture	June	July	June-August
CW			
Heavy steers[2]	2.43[a]	.88[ac]	1.65[ac]
Light steers[2]	1.84[ac]		
FAIR-SL	2.24[a]	.39[a]	1.32[a]
EXC-SL	1.41[bc]	1.59[bc]	1.50[ac]
FAIR-DF[2]		1.39[bc]	1.59[ac]
EXC-DF[2]		1.86[b]	1.87[bc]

[1] Average daily gains within each column followed by the same letter are not significantly different (P<.05).

[2] Heavy steers remained on CW for the entire grazing season. Light steers were moved to native deferred pastures July 6. June-August ADG for cattle on native deferred systems is the average of the ADGs for June on CW and July/August on native.

ADG during that month than did cattle on CW, which had been grazed the month prior. Forage did not appear to be limiting on CW pastures (approximately 730 lb/acre on July 30), but it is likely the highest quality and most available forage had already been consumed. Significant differences (P<.05) in ADG for cattle over the entire grazing period (June 8 to August 3 for CW, FAIR-SL and EXC-SL and June 8 to August 9 for FAIR-DF and EXC-DF) were found only between FAIR-SL and EXC-DF, with the latter producing an advantage of approximately .5 lb gain/head/day.

Gains per acre (Table 2) were significantly greater for CW than all other pastures and grazing treatments. This may be explained, in part, by the very productive nature of crested wheatgrass compared to native grasses in spring. This allowed us to stock the CW pastures at double the stocking rate of the native pastures (.5 AUM/acre on CW compared with .25 AUM/acre on native) and, thereby double the gains per acre. The difference in gains is also attributable to inadequate moisture (Figure 1) which resulted in reduced total forage production in all pastures and a severe reduction in warm season production on native pastures. Under 1989 climatic conditions, gains per acre (and in this case gains/pasture) were the same on the native pastures whether the forage was consumed in 2 months (June 8 to August 3) or one (July 6 to August 9).

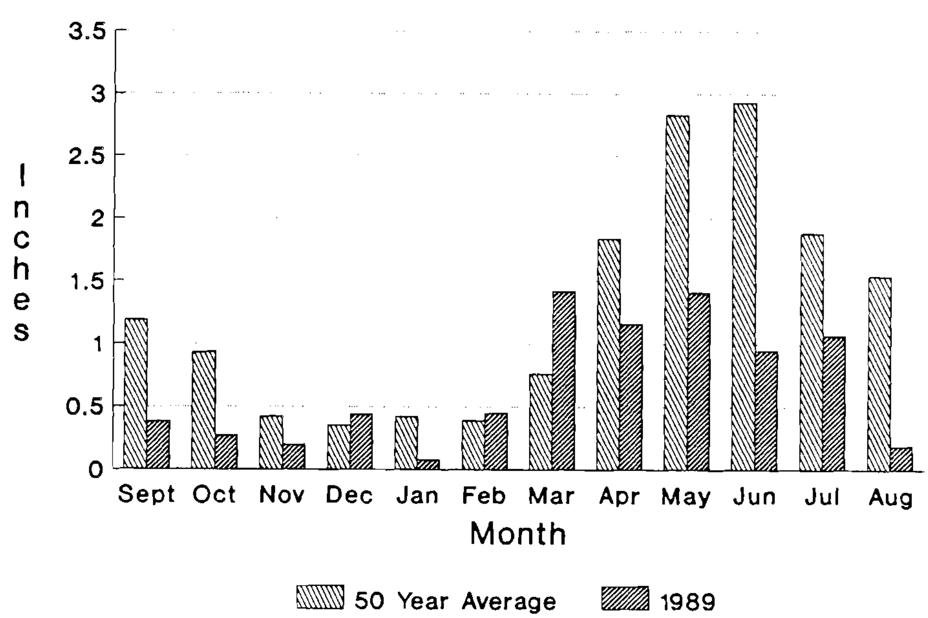
TABLE 2. WEIGHT GAINS PER ACRE[1] (LB) FOR CATTLE GRAZING NATIVE AND INTRODUCED PASTURES

Pasture	Gains/acre (lb)
CW[2]	33.75[a]
FAIR-SL[3]	13.81[b]
EXC-SL[3]	15.75[b]
FAIR-DF[4]	10.61[b]
EXC-DF[4]	16.61[b]

[1] Weight gains followed by the same letter are not significantly different (P<.05).
[2] Gains based on grazing from June 8 to August 3 for heavy steers (initial weight 728 lb) and from June 8 to July 6 for light steers (initial weight 659 lb).
[3] Gains based on grazing from June 8 to August 3.
[4] Gains based on grazing from July 6 to August 9.

Stock density (number of animals per acre) was 33% greater on June-deferred pastures versus season-long grazed native pastures. Thus, although ADG's were not markedly different between grazing systems, total gains were greater if cattle grazed crested wheatgrass pastures in June and native pastures in the July-August period rather than grazing native pastures throughout the grazing season. The majority of the

FIGURE 1. VEGETATION YEAR PRECIPITATION



additional pounds of beef produced under a deferment system, then, are a result of increased stock numbers rather than increased individual gains.

Based on the stocking rate used (.25 AUM/acre) and the ADG observed, the data from this study were, for the purpose of discussion, translated to more realistic pasture sizes and a 2-month (June-July) grazing season (Table 3). Total weight gains were calculated for both season-long and June-deferred grazing systems involving fair and excellent condition native pastures. June deferment of a 640-acre native pasture allows an increase in the number of steers which could be grazed but also requires the use of a 320-acre pasture of crested wheatgrass for June grazing. Total gains under this type of system would be 11,969 to 13,788 lb greater compared with season-long grazing on 640 acres native pastures for the same 56-day grazing period. At a value of $.70/lb, the additional weight gains represent $8,378 to $9,652 additional gross income. If the additional 320 acres of land were native pasture instead of CW, total gains for the 56-day grazing period would be 7,840 to 9,084 lb less than the CW-native deferment system. At a value of $.70/lb, this represents an advantage of $5,488 to $6,359 for the June deferment system (320 acres CW and 640 acres native) compared to season-long (960 acres native). Costs associated with leasing, buying or establishing crested wheatgrass pastures would determine the cost-effectiveness of this program for ranchers not already having them. We are currently in the process of subjecting these data to a comprehensive economic analysis.

Under normal climatic conditions the grazing season at the Cottonwood Station is about 4 months long, however, a drought during the spring and summer of 1989 reduced the grazing season to 2 months. The relative benefits of the deferred system are greatly enhanced with a short grazing season. For example, if the deferred pastures were grazed 3 months and the season-long pastures were grazed for 4, stock density should be increased on deferred pastures by approximately 33% (112 steers increased to 150 steers on deferred pastures in our example). This would effectively reduce the early season (first 2 months) weight gain advantage for the DF pastures in our example to 3,990 to 4,596 lb and would require only 107 acres of CW. The deferred treatment would have an early season 2,589 to 3,000-lb advantage over season-long grazing of 747 acres (640 acres plus 107 acres) of native pasture. Gains for the last 2 months of the 4-month grazing season should also be greater on the deferred pastures due to the greater number of animals.

The advantages of implementing early season deferment extend beyond increased weight gains during the grazing season. Improved range condition on native pastures in southwestern and south central South Dakota may occur, over time, as a result of delaying grazing until late spring or early summer. A deferment period in April or May could be more appropriate than June in most years, although this is likely to vary with climatic conditions. The timing of the move of cattle from crested wheatgrass to native pastures is also likely to vary with climatic conditions. Studies are planned at the Range and Livestock Research Station at Cottonwood to further evaluate the effect of deferment period on cattle diets and performance and to develop methods for determining when to move livestock in an early season deferment system.

TABLE 3. WEIGHT GAIN POTENTIAL (LB) FOR STEERS DURING A JUNE-JULY GRAZING SEASON UNDER SEASON-LONG GRAZING AND JUNE DEFERMENT

Pasture	Native (640 acres) 56 days 112 steers	CW (320 acres) 28 days Native (640 acres) 28 days 224 steers	Native (960 acres) 56 days 168 steers
FAIR	8258	20227	12387
EXC	9408	23196	14112

GRAZING PUBLIC LANDS IN WESTERN SOUTH DAKOTA - WHAT'S IT WORTH?

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CATTLE 89-22

Summary

South Dakota has relatively few acres of public rangeland when compared to other western states. However, public grazing in South Dakota can have a major impact on local area economies in which public grazing occurs.

Total harvested AUMs have declined over the study period. The total value of public land grazing has climbed mainly due to higher cattle prices.

In 1988, South Dakota public lands participated in the production of approximately $35 million in gross livestock production. This gross production generated an estimated $66 million in economic activity to the region.

In 1988, public lands accounted for an estimated $22.8 million of the $35 million in gross livestock production. This $22.8 million generated an estimated $42.6 million in economic activity to the economies in which public grazing occurred. The gross value of public land's contribution to the value of grazing was estimated in 1988 to be $55.71/AUM with an economic value of $104.17/AUM.

(Key Words: Public Lands, Grazing, Economic Analysis.)

Introduction

Livestock grazing on public lands in South Dakota and in other parts of the west are facing growing competition from other uses of the rangeland. Public lands are by federal mandate "multiple-use" lands. The U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) are required to manage for all expected uses of the land. Conflicts have risen when reallocations of traditional uses are made to accommodate expected future nongrazing uses.

One such conflict is between livestock grazing and prairie dog management. The conflict occurs when ranchers, many of whom depend upon public grazing land to make their ranches economically viable, are asked to reduce or eliminate grazing on a particular tract of land in favor of increasing the number of acres of prairie dogs. The increased acres of prairie dogs are then available for recreationists to hunt with gun and camera or for use in the proposal to reintroduce the black footed ferret into South Dakota.

The outcome of these types of conflicts can have great impacts on local communities as well as specific businesses within those affected communities. For example, decreasing the allowable number of animal unit months (AUMs--the amount of forage required to feed a cow with calf for one month) on a given grazing allotment could result in: (1) a reduction in the number of livestock that the affected rancher(s) can support on the remaining private and public land under their stewardship; (2) the possible loss of a ranch operation (i.e., ranch family) to the local community; (3) the reduction in expenditures for livestock related goods and services provided to the rancher by local agricultural businesses; and (4) a reduction in the expenditures of the rancher for nonagricultural goods and services (i.e., household goods, fast foods, movie tickets, clothing, other entertainment, etc.). Increasing the opportunities for recreation on public lands may result in: (1) an increase in the number of "tourists" to the local community; (2) an increase in expenditures for recreational equipment and supplies; (3) an increase in expenditures for gasoline, fast foods, and other local entertainment; and (4) the creation of new local business which cater to tourist type activities (guide services, motels, etc.).

The total impact that any given change of public land use will have on a local economy depends upon how much of the total expenditures of each industry (local grazing, recreation and tourism) remain in the local community and how much "leaks out" to other areas of the region or country.

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Purpose of the Study

The purpose of this report is to provide information to the general public concerning the economic value of grazing on public rangelands in South Dakota and to discuss in broad terms the relative importance of both grazing and nongrazing uses of these public lands. Thus, while this report does not directly address the economic pros and cons of specific issues such as livestock grazing and prairie dogs, this study presents information which may need to be considered when reallocations are made in grazing permits to accommodate increases in nongrazing uses of public rangelands in South Dakota.

Data Sources

Estimates presented in this report were derived from data provided by the USFS (USFS, 1973-88), BLM (BLM, 1973-88), and individual grazing cooperatives as well as other data already available at South Dakota State University (Dooley et al., 1982; SDSU, 1989). Information on recreational hunting was obtained from the South Dakota Department of Game, Fish, and Parks (SDGFP) and the USFS.

Materials and Methods

Data on the actual number of animal unit months (AUMs) of grazing which were harvested from South Dakota public lands were obtained from the USFS and BLM from 1973 to 1988 (see references). Data included all livestock grazing in South Dakota on the Buffalo Gap National Grasslands, Fort Pierre National Grasslands, Black Hills National Forest, Grand River National Grasslands, and BLM land. Data were unavailable for the Camp Crook Division of the Custer National Forest. Efforts were made to insure that an AUM represented one cow with calf in each database.

All grazing was assumed to be by cow-calf pairs. Data on the actual AUMs harvested from public lands were divided by the average length of permit (in months) by grazing association or direct permit group to estimate the total number of animal units (AUs) which utilized public rangeland for grazing at sometime during the grazing season.

Typical sales per AU were estimated from SDSU data. These sales were multiplied by estimated AUs utilizing public rangeland to estimate total value of livestock produced which utilize public rangeland at sometime during the grazing season. This figure represents the total return to livestock which graze public and private lands but does not indicate public land's share of the value of grazing.

To determine public land's share of the total value of grazing, the total value was divided by a ratio of the length of time cattle graze on public land to the total time cattle graze during any given year. An assumption was made that all sales of grazing livestock were returns to the grazing enterprise. This implies that the grazing enterprise pays for the feed and feeding of the associated livestock during nongrazing months.

The economic value of public land's share of grazing was computed by applying a multiplier to the gross value computed above. The multiplier selected for use in this study was derived from a study of the Impact of Public Land Policies on the Livestock Industry and Adjacent Communities, Big Horn County, Wyoming (Lewis et al., 1977). The value of the multiplier was 1.87. This multiplier implies that $1.87 of business activity was generated in the region by $1.00 of production in the livestock sector. Other multipliers from the same study include 1.86 for food, drink, and lodging; 2.09 for trade (tourists); 1.41 for manufacturing, 1.41; and 1.78 for small grains.

The economic impact of public rangeland grazing to local communities was estimated by allocating public rangeland's share of the value of grazing on public lands over those counties in which public grazing occurs. The allocation was made by multiplying public land's share of the value of grazing by the ratio of the acres of public rangeland to the total acres of rangeland in each county. Total acres of public rangeland in each county as well as the total acres of rangeland by county were computed from 1982 U.S. agricultural census data and information from the USFS (USFS, 1988) and BLM (BLM, 1988). To facilitate this analysis, the value of an acre of public grazing was assumed to be the same in each county.

Results

Animal Unit Months Harvested from SD Public Rangelands

Actual AUMs harvested from South Dakota public rangeland have followed a downward trend from the early 1970's (Figures 1 and 2). The peak year for harvested AUMs was 1974 at 478,526 AUMs. The low years were 1981 at 406,909 AUMs and 1988 at 408,542. Both 1981 and 1988 were considered

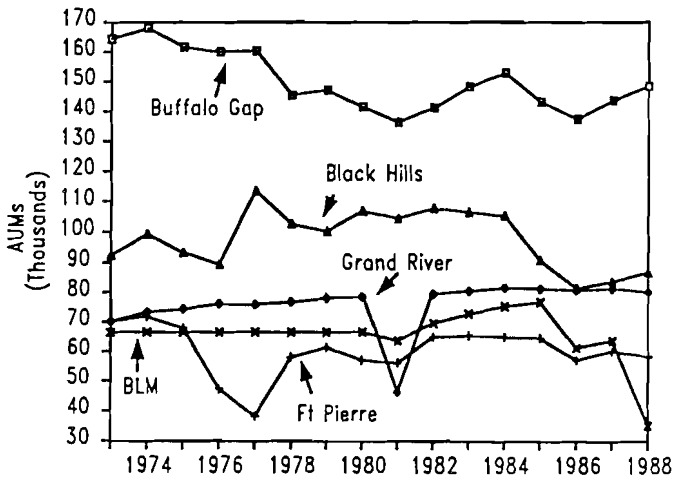

Figure 1. AUMs harvested from SD public rangeland and jointly administered private land by land agency, 1973-88.

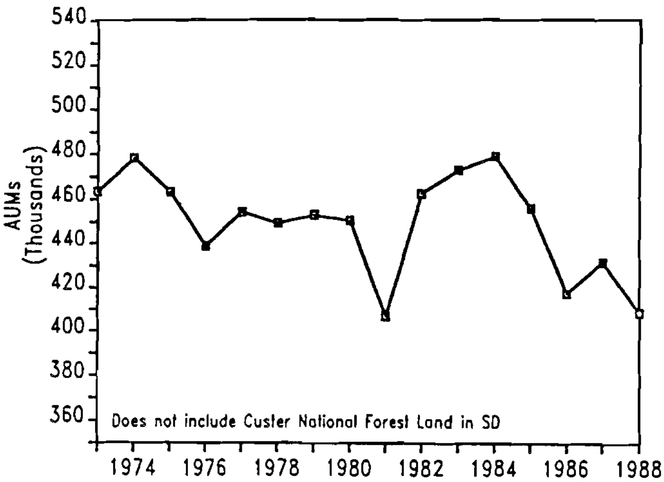

Figure 2. AUMs harvested from SD public rangeland and jointly administered private land, 1973-88.

drought years. The Buffalo Gap National Grasslands provide the largest amount of public land grazing in the state (148,542 AUMs in 1988). Grazing on the Grand River National Grasslands and on BLM land had an increase in actual harvested AUMs from 1973 until the mid 1980's.

Much of the decrease in AUMs utilized between 1985 and 1988 are the result of several factors, one of which is voluntary "nonuse" by permittees. "Nonuse" represents the difference between the permitted number of AUMs of grazing allotted by the governing agency and what is actually used. Often another permittee will "fill-in" behind someone's nonuse to take advantage of the available grazing. In drought years nonuse may go unused due to the lack of available grass.

For the 1985-88 period the reduction in the actual AUM's utilized were a result of one or more of the following: (1) voluntary reductions by permittees due to drought or economic conditions of the livestock industry and (2) agency mandated reductions resulting from the unavailability of grass (Butch Ellis, Steve Libby, and Mark Stiles, personal communication).

The average length of time cattle are permitted to be on public lands ranged from 6 months (BLM and Grand River National Grasslands) to 4.7 months (Black Hills Nation Forest) with an average of 5 months.

Estimated Animal Units Utilizing SD Public Rangelands

The number of animal units (AUs) grazing public lands ranged from 78,909 in 1988 to 92,479 in 1975 (Table 1). The second highest number of cow/calf pairs (AUs) was 92,231 in 1984.

Estimated Value of Livestock Sold

The estimated value of livestock sold per animal unit from livestock which graze both public and private rangeland is presented in Table 2. These values were computed as the total sales of steer and heifer calves, cull cows, and cull heifers from a typical South Dakota herd divided by the average number of producing cows in the herd. This analysis assumes a 95% calving percentage (includes replacements of dead calves with purchased calves shortly after birth) with a 1% death loss and 16% of the heifers kept for replacements. Thus, out of 100 cows, 95 live calves are born, 1 calf dies, 44 steers and 33 heifers are available for sale (77 total), and 2 cull heifers are sold as well as 15 cull cows. Average weights for each class of livestock were the same for each year of the analysis (Dooley et al., 1982; SDSU, 1989) and South Dakota average prices by class of livestock were used.

TABLE 1. ESTIMATED AUs ON SOUTH DAKOTA PUBLIC RANGELAND BY LAND AGENCY, 1973-88

Year	Buffalo Gap NG	Fort Pierre NG	Grand River NG	Black Hills NF	BLM	Total
1973	32414	14060	11680	20246	11084	89483
1974	33129	14345	12202	21719	11084	92479
1975	31875	13576	12398	20426	11084	89359
1976	31535	9434	12666	19592	11084	84311
1977	31575	7638	12623	24906	11084	87825
1978	28634	11589	12787	22528	11084	86622
1979	28983	12262	12990	21949	11084	87267
1980	27873	11396	13078	23477	11084	86907
1981	26829	11198	7699	22936	10592	79253
1982	27759	12968	13232	23657	11576	89192
1983	29133	13069	13402	23404	12118	91125
1984	30027	12964	13570	23151	12520	92231
1985	28116	12879	13526	19984	12771	87276
1986	27006	11381	13437	17828	10175	79826
1987	28215	11977	13520	18233	10586	82530
1988	29188	11625	13338	18906	5853	78909

TABLE 2. ESTIMATED GROSS PRODUCTION PER ANIMAL UNIT GRAZING SOUTH DAKOTA PUBLIC LANDS, 1988

	Weight, cwt		Price, $		Percent		Total, $
Calves	4.69	x	101	x	77	=	364.74
Cull heifers	8.50	x	70	x	2	=	11.90
Cull cow	10.0	x	46	x	15	=	69.00
					Total income		445.64

Analysis assumes a 95% calf crop, 1% death loss, 16% replacements

The total sales from livestock which grazed both public and private land in South Dakota are shown in Figures 3 and 4. Figure 3 shows the total value by public land agency. Figure 4 shows the total value. All values have been adjusted for inflation to 1988 values. In Figure 3, the value for livestock sold increases between 1987 and 1988 for each for each public land unit with the exception of BLM grazing land. The value of grazing on BLM land declined due to a large decrease in the total number of AUMs used in 1988 (63,516 AUMs in 1987, 35,115 AUMs in 1988). Voluntary nonuse by permittees rather than mandatory reductions by BLM accounted for the 1988 decline. Total sales from herds grazing both public and private land ranged from $19.4 million in 1975 to $38 million in 1979 (Figure 4, "Gross Value" line). Total value for 1988 was estimated at $35.2 million.

The "Multiplied Value" line in Figure 4 represents the estimated total economic activity generated from the gross sales of livestock grazing both public and private land. The values on this curve reflect the impact that dollars spent on producing livestock on public land have in other parts of the local economy. They were calculated utilizing a multiplier of 1.87 (Lewis et al., 1977). In 1988, the $35.2 million in gross

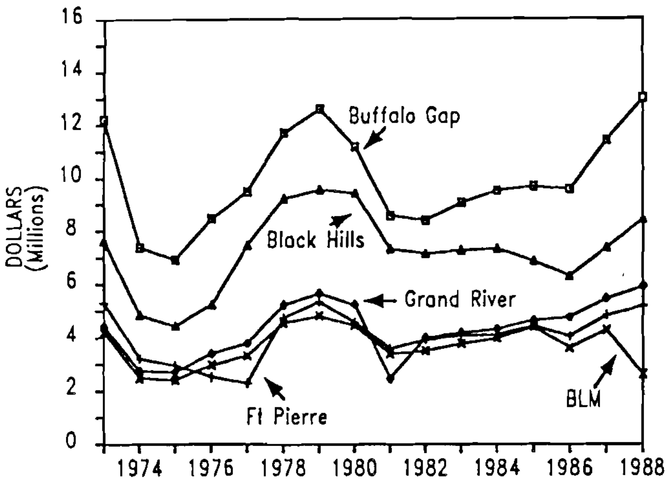

Figure 3. Estimated value of calves sold from herds grazing on both SD public and private rangeland by land agency, adjusted to 1988 dollars, 1973-88.

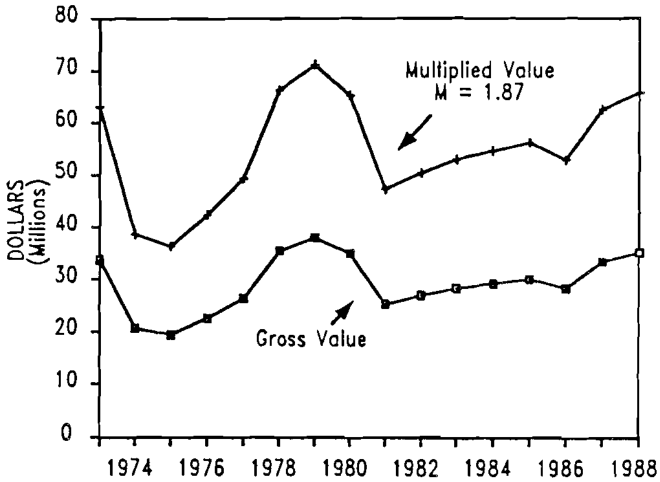

Figure 4. Estimated value of calves sold from herds grazing on both SD public and private rangeland, adjusted to 1988 dollars, 1973-88.

livestock sales from herds grazing both public and private land was estimated to generate $65.8 million in total economic activity to western South Dakota.

Although the total number of AUs utilizing public rangeland have tended to decline, the effects of the recent drought and ongoing herd reduction on livestock prices have resulted in relatively high total value estimates over the last 3 years. Price appears to be more important than the number of AUMs harvested in determining total value of grazing on public lands.

The prices used in Figures 3 and 4 are adjusted for inflation using the Producers' Price Index for livestock (U.S. Department of Commerce, 1989). All prices were adjusted to 1988 values (1988 = base year).

Public Land's Contribution to Total Value of Grazing

The contribution of public land grazing to the total value of grazing was calculated by public land unit (Figure 5) and total (Figure 6). Public land's contribution, in 1988 dollars, ranged from $12.6 million to $22.8 million between 1975 and 1988, respectively (Figure 6). This translates into a return per AUM of grazing on public land of $27.19 in 1975 to $55.71 in 1988. The value of grazing on the Buffalo Gap National Grasslands in 1988 was estimated at $8.3 million (Figure 5). The Black Hills National Forest contributed $4.8 million.

Economic Value of Public Land's Contribution

Public land's contribution to local economies in which public grazing takes place ranged from $23.6 million in 1975 to $46.1 million in 1979 (Figure 6). Public land's contribution in 1988 is estimated at $42.6 million. This translates into an economic return per AUM of $41.93 in 1975 to $83.93 in 1979. The return per AUM of grazing in 1988 was $104.17.

Economic Value to Local Economies

Public vs Private Rangeland in South Dakota

The amount of rangeland in each county that has public grazing land is presented in Table 3. There are an estimated 13.7 million acres of rangeland in the 13 western counties that contain almost all of the public grazing land in South Dakota. Of the 13.7 million rangeland acres, 2.3 million (16.6%) are public acres. Lawrence County has the highest percentage of public rangeland at 64.5%. Custer and Pennington Counties have 49.7 and 42.5% public rangeland, respectively.

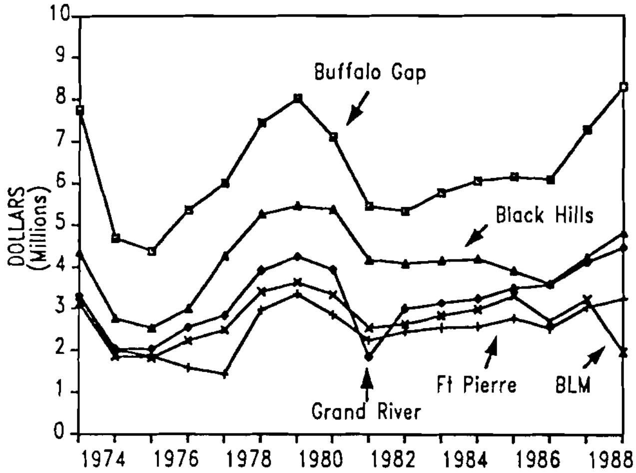

Figure 5. Public land's contribution to the value of calves sold from herds grazing SD rangelands, by land agency, adjusted to 1988 Dollars, 1973–88.

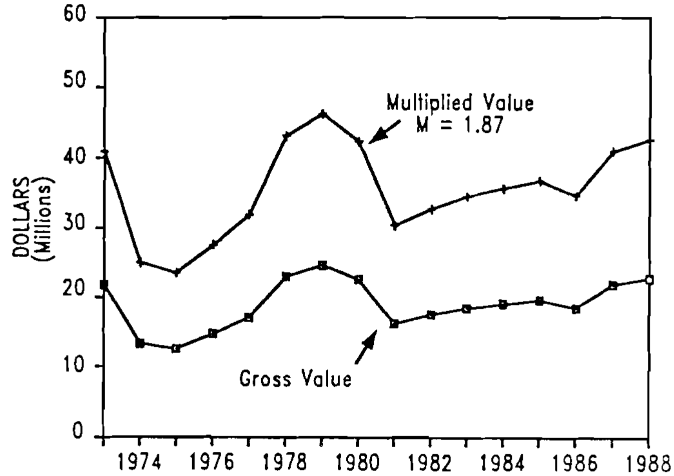

Figure 6. Public land's contribution to the value of calves sold from herds grazing SD rangelands, adjusted to 1988 Dollars, 1973–88.

TABLE 3. COMPARISON OF PUBLIC AND PRIVATE LAND BY COUNTY IN WESTERN SOUTH DAKOTA

County	Private acres	Public acres[a]	Total acres	Percent public
	1000's			
Butte	975	146	1121	13.0
Corson	1293	31	1324	2.4
Custer	378	373	751	49.7
Fall River	900	285	1185	24.0
Harding	1364	103	1467	7.1
Jackson	1045	107	1152	9.3
Jones	332	20	352	5.7
Lawrence	151	274	425	64.5
Lyman	564	61	625	9.7
Meade	1687	79	1766	4.5
Pennington	825	609	1435	42.5
Perkins	1240	132	1372	9.6
Stanley	667	52	719	7.3
Total	11423	2273	13696	16.6

[a] Includes public grazing land on the national forests, national grasslands, and Bureau of Land Management land in South Dakota.

Economic Value by County

Although South Dakota has very little public rangeland as compared to other western states, public grazing can have a major impact on the local communities in which it exists. The value of public land grazing to local communities was estimated for 1988 (Table 4). Table 4 demonstrates how public land's share of the gross value of grazing is distributed by county and by type of public land. Table 5 is similar with the exception that the multiplied or economic value of public land's contribution to the value of grazing was used.

According to this analysis, Pennington County has the highest dollar value of public lands grazing in the state. Pennington County received an estimated $1.8 million in gross revenue from grazing on the Black Hills National Forest, $2.8 million from grazing on the Buffalo Gap National Grasslands, and $123 thousand from grazing on BLM rangeland for a total of $4.7 million in total gross receipts (Table 4). The total economic value of this grazing amounted to over $8.7 million in economic activity in Pennington County in 1988 (Table 5).

TABLE 4. VALUE OF GRAZING BY COUNTY AND BY TYPE OF SOUTH DAKOTA PUBLIC LANDS[a], 1988

County	BH	BG	FP	GR	BLM	Total
	Thousands of Dollars					
Brule					4	4
Butte					1024	1024
Corson				894		894
Custer	1423	800			26	2249
Fall River	213	3224			51	3489
Haakon					10	10
Harding					210	210
Jackson		1499			2	1500
Jones			557			557
Lawrence	1224				38	1262
Lyman			1692		1	1693
Meade	169				294	463
Pennington	1798	2756			123	4676
Perkins				3560	57	3618
Stanley			989		118	1107
Ziebach				3		3
Total	4827	8279	3238	4458	1956	22758

[a] BH = Black Hills National Forest; BG = Buffalo Gap National Grasslands; FP = Fort Pierre National Grasslands; GR = Grand River National Grasslands; and BLM = Bureau of Land Management lands.

This table does not include Custer National Forest land in Harding County.

All values in 1988 dollars.

TABLE 5. ECONOMIC VALUE OF GRAZING BY COUNTY AND BY TYPE OF SOUTH DAKOTA PUBLIC LAND[a], 1988

County	BH	BG	FP	GR	BLM	Total
	Thousands of Dollars					
Brule					7	7
Butte					1915	1915
Corson				1672		1672
Custer	2661	1497			48	4206
Fall River	399	6028			96	6524
Haakon					18	18
Harding					392	392
Jackson		2803			3	2806
Jones			1041			1041
Lawrence	2289				71	2360
Lyman			3164		1	3165
Meade	316				550	866
Pennington	3362	5153			229	8744
Perkins				6658	107	6765
Stanley			1849		221	2070
Ziebach	6			6		6
Total	9027	15481	6055	8336	3658	42557

[a] BH = Black Hills National Forest; BG = Buffalo Gap National Grasslands; FP = Fort Pierre National Grasslands; GR = Grand River National Grasslands; and BLM = Bureau of Land Management lands.

This table does not include Custer National Forest land in Harding County.

All values in 1988 dollars.

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Syntex Corp., Des Moines, IA
Southeast SD Experiment Farm Corporation
SD Beef Cattle Improvement Association
SD Cattlemen's Association
SD Livestock Foundation
SD Stockgrowers Association
SD Veterinary Medical Association
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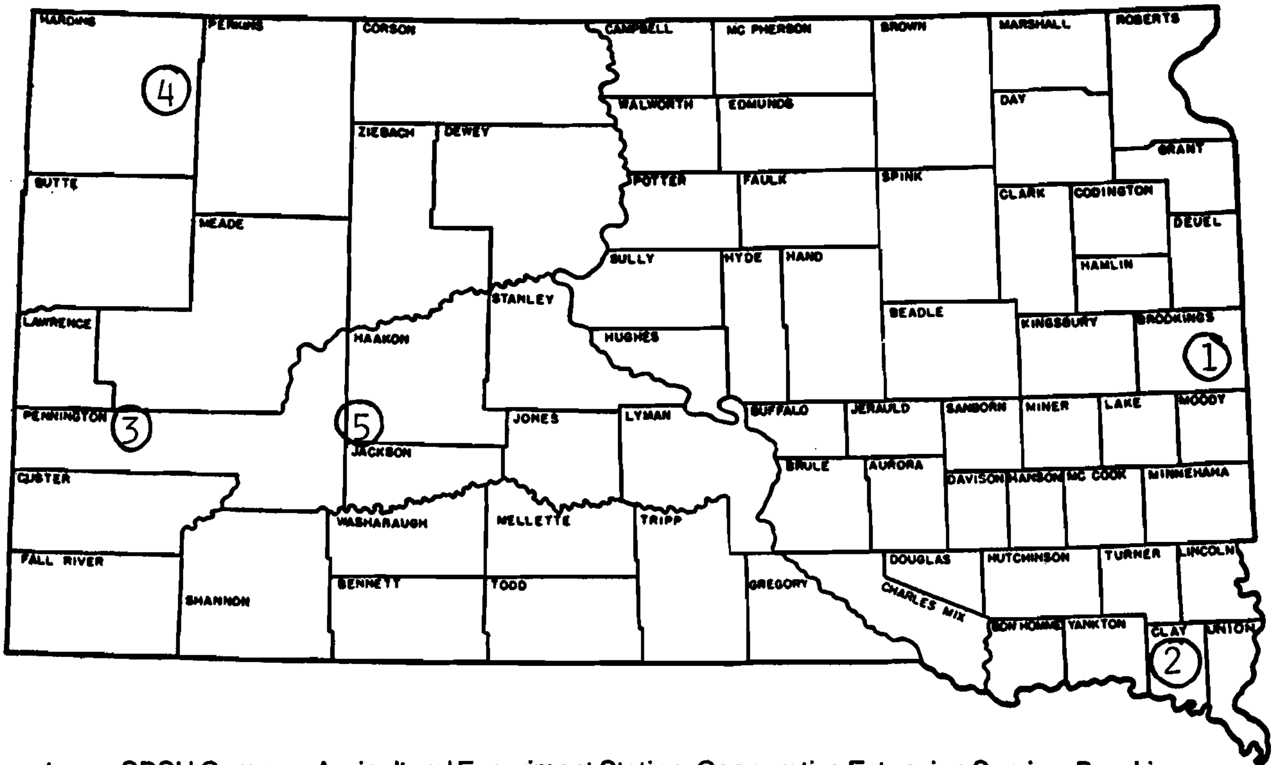

1. SDSU Campus, Agricultural Experiment Station, Cooperative Extension Service, Brookings.

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

3. West River Agricultural Research and Extension Center, Rapid City
   Professional research and extension staff in Animal and Range Sciences, Plant Science, Economics, 4-H and Extension Administration.

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

5. Range and Livestock Research Station, Philip
   Range beef nutrition * Herd management * Range management.

These research and extension units are geographically located in South Dakota to help solve problems, bring the results of livestock and range research to the user, enhance the statewide teaching effectiveness of the Animal and Range Sciences Department staff and maintain a close and productive relationship with South Dakota producers and our agri-business community.

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