2013

2013 South Dakota Beef Report

Department of Animal Sciences, South Dakota State University

Agricultural Experiment Station, South Dakota State University

Cooperative Extension Service, South Dakota State University

SOUTH DAKOTA
BEEF
REPORT
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South Dakota State University
College of Agriculture and Biological Sciences
Animal Science Department

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Department of Animal Science

Biological Variation and Treatment Differences

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

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

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

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

Elaine Grings, Beef Report Editor

Conversion Tables

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

Metric	English
0 C	32 F
1 milliliter (mL)	0.03 ounces (oz)
1 Liter (L)	0.26 gallons (gal)
100 grams (g)	0.22 pounds (lb)
1 kilogram (kg)	2.2 pounds (lbs)
1 meter (m)	3.28 feet (ft)

Commonly Used Abbreviations

ADG	Average daily gain
ADF	Acid detergent fiber
AI	Artificial Insemination
BCS	Body condition score
BW	Body weight
cDNA	Complementary deoxyribonucleic acid
CIDR	Controlled internal drug releasing device
cM	Centimorgan
CP	Crude protein
d	Days
DE	Digestible energy
DM	Dry matter
DMI	Dry matter intake
DNA	Deoxyribonucleic acid
EE	Ether extract
F:G	Feed to gain
g	Gravity
GE	Gross energy
GnRH	Gonadotropin releasing hormone
GLM	General linear model
h	Hours
HCW	Hot carcass weight
In	Inches
IVDMD	In vitro dry matter disappearance
KPH	Kidney, pelvic, and heart fat
Kcal	Kilocalories
lb	Pound
LM	Longissimus muscle
LMA	Longissimus muscle area
LW	Live weight
m	Meter
mm	Millimeter
Mcal	Megacalories
ME	Metabolizable energy
min	Minutes
mo	Months
MP	Metabolizable protein
NDF	Neutral detergent fiber
NEg	Net energy gain
NEm	Net energy maintenance
OM	Organic Matter
PCR	polymerase chain reaction
PG	prostaglandin
PPAR	peroxisome proliferator activated receptor
Ppb	Parts per billion
Ppm	Parts per million
QG	Quality grade
QTL	Quantitative trait locas (Singular) or loci (plural)
r^2	Coefficient of determination
REA	Ribeye area
RNA	Ribonucleic acid
s	Seconds
SAS	Statistical Analysis System
SEM	standard error of the mean
TDN	Total digestible nutrients
USDA	United States Department of Agriculture
wk	Weeks
wt	Weight
WW	Weaning weight
YG	Yield grade
Yr	Years
YW	Yearling weight

DEPARTMENT OF ANIMAL SCIENCE

Mission

Educate, research, and disseminate the many aspects of animal agriculture and rangeland management to improve the well being of the citizens of South Dakota and the region.

Faculty

The faculty members of the Animal Science Department are always ready to answer your questions. Our Brookings phone number is (605) 688-5165. Staff members in Rapid City (RC) may be reached at (605) 394-2236. Please feel free to give any one of us a call, or check out our departmental website: http://ars.sdstate.edu.

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2013 South Dakota Beef Report
Table of Contents

BEEF 2013-01

The influence of maternal energy status during mid-gestation on beef offspring carcass characteristics and meat quality[1]

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SUMMARY

Research has suggested that maternal under-nutrition may cause the development of a thrifty phenotype in the offspring, potentially resulting in greater adiposity and reduced muscle mass. These alterations in fat and muscle development could have lasting impacts on offspring growth, carcass characteristics, and meat quality. Thus, the objective of this study was to determine the influence of maternal energy status during mid-gestation on offspring carcass characteristics and meat quality. To alter maternal energy status, cows either grazed pasture or were fed in a dry-lot at 80% of the energy requirements for body weight maintenance during a mean period of 109 to 207 d of gestation. Changes in body condition score (BCS), body weight, ribeye area (REA), and 12th rib backfat were measured throughout mid-gestation and were used to determine cow energy status [Positive (PES) or Negative (NES)]. Cows in the NES group had a significantly greater reduction in BCS, body weight, REA, and 12th rib backfat during mid-gestation. Maternal energy status had no influence on offspring hot carcass weight, dressing percent, REA, percent kidney, pelvic, and heart fat, marbling score, percent intramuscular fat, objective color, or Warner-Bratzler shear force. A tendency was seen for NES calves to have improvements in 12th rib backfat and USDA Yield Grade. A greater MRatio and IRatio (calculations used to compare the ratio of marbling (MRatio) and percent intramuscular fat (IRatio) with 12th rib backfat) were discovered in calves from cows experiencing a negative energy status during mid-gestation. These results suggest that maternal energy status during mid-gestation may impact fat deposition in intramuscular and subcutaneous fat depots without impacting muscle mass.

INTRODUCTION

In many places in the U.S., cows graze pastures as the primary source of nutrients during gestation. In the upper Great Plains, beef cattle producers implement low cost feeding programs during mid-gestation wherein cows typically graze dormant forage or other poor quality forages, potentially causing a deficiency in both protein and energy if cows are not supplemented. As a result, this could cause the fetus to receive inadequate nutrients, potentially altering fetal development and, ultimately, body composition of the offspring. Research has suggested that maternal under-nutrition during pregnancy may result in offspring developing a 'thrifty phenotype' that is more prepared to deal with sparse nutrient availability, and, thus, maternal nutrition has the potential to impact the development of muscle and adipose tissue in the offspring (Barker, 1995; Zhu et al., 2004; Du et al., 2011; Yan et al., 2012). In the bovine fetus, the majority of muscle cells are generated during secondary muscle fiber

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development, beginning at about the third month of gestation and lasting until about seven or eight months of gestation (Russell and Oteruelo, 1981; Du et al., 2010). Additionally, adipogenesis is thought to span across the last 5 months of gestation while continuing after birth (Du et al., 2010). Therefore, with the understanding that mid-gestation is a critical period in fetal development, insults to maternal nutritional status during mid-gestation may cause alterations in carcass characteristics and meat quality.

While it has been reported that restricted maternal nutrition can increase adiposity in the offspring of other livestock species (Bispham et al., 2005; Karunaratne et al., 2005), the impact of maternal nutrition on bovine offspring carcass traits remains unclear; thus, predicated by the hypothesis that a negative bovine maternal nutritional status will alter fetal muscle and fat development, the objective of this study was to determine the influence of maternal energy status during mid-gestation on offspring carcass characteristics and meat quality.

MATERIALS AND METHODS

All animal care and experimental protocols were approved by the South Dakota State University Animal Care and Use Committee. One hundred fifty-one crossbred, 3- and 4-year-old cows from 2 South Dakota State University research stations in western South Dakota were bred naturally to Angus and SimAngus bulls over a 60-d breeding period to begin calving at the end of March. Thirty-eight days after bulls were removed from cow pastures, cows were evaluated for pregnancy, length of gestation, calf gender, weight, and BCS, allowing for the allotment of cows into mid-gestation management groups based on conception date, source, body weight, age, and body condition score (BCS; 1 to 9, 1 = extremely emaciated, 9 = obese). At this time, calves from the previous year were weaned and pregnant cows from both research stations were co-mingled to be managed similarly in native range pastures on one research station. At 56 d after bull removal, cows with a mean gestation length of 84 d ± 11.3 (based on pregnancy ultrasound; 109 d ± 10.9 based on calf birth date with a 283-d gestation length) were allotted into 2 management strategies: 1) fed to achieve and/or maintain a BCS of 5.0-5.5 (Maintenance; n=76); or 2) fed to lose 1 BCS over a 98-d period of mid-gestation (Restricted; n=75). Body condition scores were determined by the average of 4 trained evaluators at the beginning and end of the second trimester, while cows were weighed every 28 d throughout mid-gestation. Initial body weights and final body weights of the mid-gestation period were normalized for fill, as cows were managed as a common group for a week prior to and after the mid-gestation treatment. Additionally, ultrasound measurements were collected for 12^{th} rib subcutaneous fat and ribeye area at the beginning and the end of mid-gestation.

Cows managed to maintain BCS were left on dormant, native range pasture consisting primarily of western wheatgrass, with some green needle grass, little bluestem, buffalo grass, and blue grama. The cows on pasture were provided a pelleted supplement (Table 1; 45.7% CP, 0.74 Mcal/lb NE_m) every other day at 0.54% body weight per supplementation delivery. During this study, mid-gestation (October 2010 through January 2011) was unusually mild and dry, resulting in pastures that were free of snowpack until mid-January. In January, cows on pasture were supplemented with grass hay at 21.5 lb DM/head/d. Cows fed to lose 1 BCS were managed in 10 dry-lot pens, blocked by weight, and each day were fed mature brome hay at 1.42% body weight and a protein supplement (Table 1; 31.4% CP, 0.72 Mcal/lb NE_m) at 0.255% body weight. Cows in the dry-lot pens were fed a diet consisting of 84.8% hay and 15.2% supplement (Table 1).

Table 1. Formulations and compositions of mid-gestation treatment diets.[1]

Diet Composition	Maintenance[2]	Restricted[3]
Dormant, Native Range, %[4]	87.50	-
Mature Brome Hay, %	-	84.80
Pelleted Supplement, %[5]	12.50	15.20
Soybean Meal[6]	(52.20)	(2.75)
Sunflower Meal[6]	(20.00)	(20.00)
Wheat Middlings[6]	(19.30)	(69.33)
Urea[6]	(3.06)	(3.04)
Dry Matter Intake, lb/head/d[7]	23.74	16.92

Nutrient Composition	Maintenance[2]		Restricted[3]	
	Dormant Range[4]	Supplement[8]	Mature Brome Hay[8]	Supplement[8]
Dry Matter, %	80.00	95.83	97.25	95.37
Crude Protein, %	4.70	45.65	5.76	31.39
Neutral Detergent Fiber (NDF), %	66.10	22.06	71.80	37.54
Ash, %	10.00	11.55	7.94	9.85

[1]All values except DM on DM basis

[2]Cows managed to maintain BCS during mid-gestation

[3]Cows managed to lose 1 BCS during mid-gestation

[4]Intake and composition estimated using Nutrient Requirements of Beef Cattle (NRC, 2000) estimates for winter range

[5]Fortified with vitamins and minerals to meet or exceed NRC requirements

[6]Values in parentheses are percent of pelleted supplement

[7]Average dry matter intake (DMI) per head per day throughout mid-gestation treatment; Maintenance DMI based on Nutrient Requirements of Beef Cattle (NRC, 2000) estimates for intake of winter range

[8]Analyzed values determined through lab assays

After completion of the 98-d mid-gestation period, all cows were co-mingled and managed as a common group on range through calving. Final body weight was taken 7 d into this phase to normalize fill across treatments. During calving, calf birth weight, date of birth, and gender were recorded and bull calves were banded at birth. Birth dates of the calves in this study spanned from March 30 to May 19, with a median birth date of April 11. After calving, cows and calves were managed as a common group following research station protocol until weaning. At weaning (October 13), calves meeting study protocol (133 head) were shipped to the South Dakota State University Research Feedlot in Brookings, SD. Calves were then sorted into pens by gender and management strategy where each gender/management strategy combination consisted of 4 pens containing 7 or 8 head per pen. Common receiving, backgrounding, and finishing diets were fed across treatment and gender. Calves were marketed when all of the progeny were estimated to average 0.4 in of 12th rib backfat thickness (208 d on feed). Both at 21 d and at 208 d in the feedlot, a subsample (n=12) of steers was harvested at the SDSU Meat Lab reducing the number of animals in this report to 109.

Prior to harvest, calves were weighed in the morning and then shipped approximately 150 mi to a commercial abattoir (Tyson Foods, Dakota City, NE). Calves were allowed free access to water overnight and were harvested the following morning. Calves were tracked through the harvest floor to maintain animal identification throughout harvest, carcass chilling, and carcass fabrication. Hot carcass weight (HCW) for each individual carcass was recorded while ribeye area (REA), 12th rib backfat, and marbling score were determined using camera grading following carcass chilling (approximately 30 h) (n=108 due to inability to rib one carcass). Additionally, percentage of kidney, pelvic and heart fat (KPH) was estimated by a USDA grader. Hot carcass weight, REA, 12th rib backfat, and KPH were then used to calculate USDA yield grades. At 2 d postmortem, carcasses were tracked through the fabrication floor, where full strip loins were collected from one side of each carcass. Recovered strip loins (n=103) were vacuum packaged, boxed, and transported to the SDSU Meat Lab. At 3 d postmortem, strip loins were processed for the analysis of percent intramuscular fat, objective lean color, and tenderness evaluation through Warner-Bratzler shear force (WBSF). Steaks were removed from the anterior end of the strip loin, beginning with a sample for the evaluation of percent intramuscular fat, followed by three 2.54-cm steaks utilized for WBSF while the first of the WBSF steaks was also used for objective lean color measurements. Steaks for the analysis of WBSF were vacuum-packaged and stored at 4°C for postmortem aging periods of 3, 14, or 21 d.

The MRatio and IRatio were determined in order to compare marbling and percent intramuscular fat, respectively, with external carcass fat. MRatio was calculated as:

$$\left[\frac{(Obs\ Marb - Marb\ \bar{x})}{Marb\ S_d}\right] - \left[\frac{(Obs\ BF - BF\ \bar{x})}{BF\ S_d}\right]$$

to allow for the comparison of marbling score and 12th rib backfat as an indicator of the relationship of marbling to subcutaneous fat deposition. Similarly, IRatio was calculated as:

$$\left[\frac{(Obs\ \%IMF - \%IMF\ \bar{x})}{\%IMF\ S_d}\right] - \left[\frac{(Obs\ BF - BF\ \bar{x})}{BF\ S_d}\right]$$

for the comparison of percent intramuscular fat and 12th rib backfat as an additional tool to evaluate changes in fat deposition.

Because some cows within each management strategy were unable to achieve our goals of the study for biological differences in metabolic energy status, cows and the carcasses of their progeny were re-classified based on energy status (positive or negative) calculated from indicators measured during mid-gestation including changes in cow body condition score (BCS Δ), ribeye area (REA Δ), and body weight (BW Δ). The formula used is as follows:

$$\left[\frac{(Obs\ BCS\ \Delta - BCS\ \Delta\ \bar{x})}{BCS\ \Delta\ S_d}\right] + \left[\frac{(Obs\ REA\ \Delta - REA\ \Delta\ \bar{x})}{REA\ \Delta\ S_d}\right] + \left[\frac{(Obs\ BW\ \Delta - BW\ \Delta\ \bar{x})}{BW\ \Delta\ S_d}\right]$$

Means and standard deviations of each variable were from the whole population. The formula resulted in a bimodal distribution of cows around 0. Cows with a positive value were deemed to be in a positive energy status (PES) while cows with a negative value were deemed to be in a negative energy status (NES) during mid-gestation. Two cows between the two groups were removed, leaving the PES group with 79 head and the NES group with 70 head. Overall, the re-classification resulted in 6 cows that were re-classified from the original Restricted group to the PES group and 3 cows that moved from the original Maintenance group to the NES group. Two cows originally part of the Restricted group were removed because their energy status index was 0 and different from either energy status grouping.

Least squares means for cow measurements taken during mid-gestation were computed using PROC GLM procedures of SAS (SAS Inst. Inc., Cary, NC). Cow measurements were analyzed using a randomized, complete block design where cows were blocked by weight. Although Maintenance cows were managed as one group on pasture, cows were blocked into ten groups by weight to match the ten dry-lot pens that were blocked by weight within the Restricted group. Differences due to the main effects of cow energy status and block were tested using the interaction of these main effects as the error term. Means were tested to a predetermined significance level of 0.05.

Statistical analyses on calf carcass data were conducted using each calf as the experimental unit. Least squares means for all data were computed using PROC GLM procedures of SAS, determining differences due to the main effects of cow energy status and calf gender, as well as the interaction, cow energy status x calf gender. Means were tested to a predetermined significance level of 0.05.

RESULTS AND DISCUSSION

The cows used in this study were manipulated to be in either a positive or negative energy status during the important developmental period of mid-gestation. Changes in cow body weight, BCS, fat thickness, and ribeye area due to mid-gestation energy status were determined using measurements taken at the beginning and end of the mid-gestation period (Table 2). Cows in the NES group displayed a significantly greater reduction in BCS, body weight, 12th rib fat thickness, and REA relative to the PES cows ($P < 0.05$) during mid-gestation (Table 2).

Table 2. Least squares means for days of gestation at mid-gestation and cow body condition score (BCS), body weight (BW), ribeye area (REA), and fat thickness at the beginning and end of the mid-gestation treatment period.[1]

	Cow Energy Status			***P*-value**	
Trait	**Positive**	**Negative**	**SEM**	**Status**	**Block**
Days of Gestation[2]	84	84	1.3	0.9730	**0.0215**
Initial BCS	4.78	4.94	0.051	0.1028	**0.0076**
Final BCS	4.92	4.29	0.046	**0.0001**	**0.0128**
Change in BCS	0.14	-0.65	0.050	**<0.0001**	0.4076
Initial BW, lb	1017	1017	5.2	0.9907	**<0.0001**
Final BW, lb	1126	967	6.7	**<0.0001**	**<0.0001**
Change in BW, lb	109	-50	5.6	**<0.0001**	0.3197
Initial REA, in^2	8.85	9.24	0.146	0.1035	**0.0007**
Final REA, in^2	9.38	8.25	0.155	**0.0003**	**0.0004**
Change in REA, in^2	0.53	-0.99	0.111	**<0.0001**	0.4460
Initial 12th Rib Fat Thickness, in	0.15	0.16	0.005	0.7228	**0.0081**
Final 12th Rib Fat Thickness, in	0.16	0.14	0.004	**0.0251**	**0.0418**
Change in 12th Rib Fat Thickness, in	0.01	-0.02	0.004	**0.0083**	0.2907
Energy Status[3]	2.09	-2.32	0.146	**<0.0001**	0.9888

[1]Measurements taken at beginning and end of mid-gestation period normalized by fill

[2]Days of gestation at beginning of mid-gestation treatment as estimated by pregnancy ultrasound

[3]Energy status = $\left[\frac{(Obs\ BCS\ \Delta - BCS\ \Delta\ \bar{x})}{BCS\ \Delta\ S_d}\right] + \left[\frac{(Obs\ REA\ \Delta - REA\ \Delta\ \bar{x})}{REA\ \Delta\ S_d}\right] + \left[\frac{(Obs\ BW\ \Delta - BW\ \Delta\ \bar{x})}{BW\ \Delta\ S_d}\right]$

Carcass characteristics of progeny from this study can be found in Table 3. As expected, steers were harvested with a heavier HCW, less 12th rib backfat and KPH, reduced marbling score and percent intramuscular fat, and a larger REA than their heifer contemporaries ($P < 0.05$). At the same time, no differences in HCW, dressing percent, REA, KPH, marbling score, and percent intramuscular fat ($P > 0.05$) occurred due to mid-gestation energy status. Of note, maternal energy status had no influence on the degree of muscling as measured by REA, although alterations in maternal energy status occurred during what has been suggested to be the period of maximal fetal muscle fiber development. There were no cow status by calf gender interactions for carcass traits ($P > 0.05$). Tendencies for reduced 12th rib backfat and lower USDA Final Yield Grade were observed in calves from NES cows ($P < 0.06$), indicating that maternal nutritional status may have an impact on beef carcass characteristics.

Calves from NES dams in this study produced a significantly improved MRatio and IRatio ($P < 0.05$) when compared to calves from PES dams. The significant improvements found in calves from dams in a negative energy status during mid-gestation for both MRatio and IRatio highlight the potential for significant alterations to occur in adipogenesis *in utero* that persist throughout life and could improve carcass value. Additionally, alterations in fat deposition may create new management opportunities to positively impact marbling and subcutaneous fat thickness relative to lean muscle during prenatal development.

Further analysis of quality attributes can be found in Table 4, highlighting differences in objective color measurements (L*, a*, and b* values) and WBSF of *Longissimus dorsi* steaks with various aging periods. In this study, 10 head were classified as dark cutters by USDA graders, including 8 heifers and 2 steers. Of these, 6 head were from NES cows and the other 4 from PES cows, indicating that the incidence of dark cutters was unlikely to be related to maternal energy status. Still, to prevent skewed results in objective color and WBSF, we removed 15 head (12 heifers and 3 steers; 9 NES and 6 PES calves) based on L* value. Criteria followed guidelines set by Wulf and Wise (1999), who concluded that beef carcasses with an L* value below 36.5 should be classified as dark cutters. Removal of these 15 head from this portion of the analysis resulted in the evaluation of objective color and WBSF consisting of samples from 86 head. Objective color measurements performed at 3 d postmortem indicated a tendency for increased L* values ($P < 0.10$) and a higher a* value ($P < 0.05$) in the strip loins of steers when compared to heifers. Meanwhile, no differences due to maternal energy status were discovered for L*, a*, and b* values ($P > 0.05$). At 3, 14, and 21 d postmortem, WBSF of steaks from steers were lower than WBSF of steaks from heifers ($P < 0.05$). No differences were observed for WBSF at any aging period when comparing steaks from calves of NES or PES ($P > 0.05$).

Table 3. Carcass characteristics of calves from dams in a positive or negative energy status during mid-gestation.

	Cow Energy Status			Gender			*P*-value		
Trait	**Positive**	**Negative**	**SEM**	**Heifers**	**Steers**	**SEM**	**Status**	**Gender**	**S x G**
Hot Carcass Weight, lb[1]	728	714	8.9	682	761	9.0	0.2373	**<0.0001**	0.7968
Dressing Percent[1, 4]	63.12	62.97	0.194	63.23	62.86	0.196	0.5500	0.1563	0.3510
12th Rib Backfat, in [2]	0.49	0.44	0.018	0.50	0.43	0.018	**0.0585**	**0.0084**	0.8652
REA, in^2 [2]	13.00	13.10	0.172	12.78	13.32	0.172	0.6839	**0.0205**	0.5890
KPH, %[2]	2.09	2.10	0.029	2.25	1.94	0.029	0.8722	**<0.0001**	0.9601
USDA Yield Grade[2]	2.86	2.64	0.084	2.82	2.69	0.084	**0.0502**	0.2635	0.8688
Marbling Score[2, 5]	430	440	8.6	451	418	8.6	0.3857	**0.0053**	0.8287
MRatio[2, 6]	-0.24	0.29	0.178	0.04	0.01	0.178	**0.0275**	0.8888	0.7563
Intramuscular Fat, %[3]	4.09	4.46	0.184	4.58	3.97	0.181	0.1332	**0.0136**	0.1673
IRatio[3, 7]	-0.32	0.33	0.167	-0.02	0.04	0.164	**0.0044**	0.7956	0.2568

[1]Positive: n = 59; Negative: n = 48; Heifers: n = 60; Steers: n = 47

[2]Positive: n = 59; Negative: n = 47; Heifers: n = 59; Steers: n = 47

[3]Positive: n = 57; Negative: n = 44; Heifers: n = 55; Steers: n = 46

[4]Calculated using final live body weight with 4% shrink

[5]300 = Slight^{00}; 400 = Small^{00}

[6]MRatio = ratio of marbling score to 12th rib fat thickness

[7]IRatio = ratio of % intramuscular fat to 12th rib fat thickness

Table 4. Maternal energy status effects on offspring objective color (Minolta L*, a*, b* values) and Warner-Bratzler shear force (WBSF) of *longissimus dorsi* steaks.

	Cow Energy Status			Gender			*P*-value		
Trait	Positive[4]	Negative[5]	SEM	Heifers[6]	Steers[7]	SEM	Status	Gender	S x G
L*[1]	42.02	42.11	0.345	41.66	42.48	0.318	0.8428	**0.0700**	0.9078
a*[2]	22.75	22.58	0.214	22.39	22.95	0.198	0.5369	**0.0493**	0.6502
b*[3]	8.07	8.00	0.170	7.89	8.17	0.157	0.7362	0.2092	0.7145
3-d WBSF, kg	4.17	4.18	0.188	4.63	3.73	0.173	0.9553	**0.0004**	0.9688
14-d WBSF, kg	3.14	3.08	0.103	3.26	2.96	0.096	0.6604	**0.0279**	0.4716
21-d WBSF, kg	3.16	3.10	0.116	3.29	2.97	0.106	0.6654	**0.0322**	0.7000

[1]L*: 0 = Black, 100 = White; taken 3 d postmortem
[2]a*: Negative values = green; Positive values = red; taken 3 d postmortem
[3]b*: Negative values = blue; Positive values = yellow; taken 3 d postmortem
[4]n=51
[5]n=35
[6]n=43
[7]n=43

LITERATURE CITED

Barker, D.J.P. 1995. Fetal origins of coronary heart disease. BMJ Clinical Research ed. 311: 171-174.

Bispham, J., D.S. Gardner, M.G. Gnanlingham, T. Stephenson, M.E. Symonds, and H. Budge. 2005. Maternal nutritional programming of fetal adipose tissue development: differential effects on messenger ribonucleic acid abundance for uncoupling proteins and peroxisome proliferator-activated and prolactin receptors. Endocrinology 146: 3943-3949.

Du, M., J.X. Zhao, X. Yan, Y. Huang, L.V. Nicodemus, W. Yue, R.J. McCormick, and M.J. Zhu. 2011. Fetal muscle development, mesenchymal multipotent cell differentiation, and associated signaling pathways. J. Anim. Sci. 89: 583-590.

Du, M., J. Tong, J. Zhao, K.R. Underwood, M. Zhu, S.P. Ford, and P.W. Nathanielsz. 2010. Fetal programming of skeletal muscle development in ruminant animals. J. Anim. Sci. 88: E51-E60.

Karunaratne, J.F., C.J. Ashton, and N.C. Strickland. 2005. Fetal programming of fat and collagen in porcine skeletal muscles. J. Anat. 207: 763-768.

NRC. 2000. Nutrient requirements of beef cattle. 7th Rev. Ed. National Acad. Press, Washington, DC

Russell, R.G. and F.T. Oteruelo. 1981. An ultrastructural study of the differentiation of skeletal muscle in the bovine fetus. Anat. Embryol. (Berl.) 162: 403-417.

Wulf, D.M., and J.W. Wise. 1999. Measuring muscle color on beef carcasses using the L*a*b* color space. J. Anim. Sci. 77: 2418-2427.

Yan, X., M.J. Zhu, M.V. Dodson, and M. Du. 2012. Developmental programming of fetal skeletal muscle and adipose tissue development. Journal of Genomics 1: 29-38.

Zhu, M.J., S.P. Ford, P.W. Nathanielsz, and M. Du. 2004. Effect of maternal nutrient restriction in sheep on the development of fetal skeletal muscle. Biol. Reprod. 71: 1968-1973.

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The influence of growth stage on carcass composition and factors associated with marbling development in beef cattle[1]

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SUMMARY

There are many cellular regulatory factors that ultimately determine the intramuscular fat, or marbling content and quality of beef carcasses. Identifying factors which play a critical role in the development of intramuscular fat throughout the feeding period and determining how cattle feeders can manipulate these factors will be crucial to continue improving beef quality. Ideally, marbling must increase without excess accumulation of adipose in depots that are undesirable and economically detrimental (subcutaneous and visceral). The results of this study are novel as they show not only what cellular factors play a role in marbling development, but also how their expression and presence change as an animal grows in an American-style production system. The increase in both expression and presence of peroxisome proliferator-activated receptor γ (**PPARγ**) at the end of the feeding phase suggest the proliferation and differentiation of additional cells to adipocytes is required in order to increase intramuscular fat content. This does not mean that adipocyte filling (lipogenesis) does not play a key role as well. However marbling content will reach a plateau without the recruitment of additional adipocytes. While it has been previously established that intramuscular adipocytes have a pattern of metabolism unique to other adipocytes, further research into how the metabolism of intramuscular fat differs from other fat depots and how this metabolism changes throughout the feeding phase will enhance the ability to produce high quality carcasses while limiting undesirable carcass fat.

INTRODUCTION

Intramuscular fat, or marbling, in the cross sectional area of the *Longissimus* muscle (**LM**) at the 12th rib is the primary factor used to determine the quality grade of young beef animals in the United States. Consumers are willing to pay a premium for beef products with increased marbling content (Platter et al., 2005) as marbling positively impacts flavor and juiciness (Mcbee and Wiles, 1967). However, a strong correlation between marbling content and subcutaneous fat thickness has been identified (McPhee et al., 2006) and excess subcutaneous fat serves as an economic detriment to the beef industry. Postnatal adipose tissue development was previously thought to occur in the following order: internal, intermuscular, subcutaneous, and lastly intramuscular (Andrews, 1958). Yet, this has been contested by recent studies suggesting postnatal adipose tissue deposition occurs simultaneously among these depots during growth (Wang et al., 2009) and marbling is not a late developing tissue as previously believed (Bruns et al., 2004). A better understanding of how and what causes marbling to develop throughout the finishing phase is required to continue to improve this economically important trait.

Previous marbling research in cattle has explored the effect of various enzymes and transcription factors and how their expression or presence impacts marbling. However, many of these factors identified were

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only measured near the end of the feeding phase, so a lack of knowledge remains as to how these factors change throughout the finishing phase. Therefore, our hypothesis is that marbling is an early developing tissue and cellular factors influencing marbling development are growth stage dependent. The objective of this study was to determine whether cellular factors associated with marbling development change with growth stage throughout the feeding period and whether they are related to marbling relative to carcass composition.

MATERIALS AND METHODS

All animal procedures were approved by the South Dakota State University Institutional Animal Care and Use Committee. In November 2011, 66 steer calves from a single source with predominately Angus breeding were received at the South Dakota State University Ruminant Nutrition Unit (Brookings, SD). Backgrounding and finishing diets are presented in Table 1. Seven days after arrival, blood was collected from the jugular vein for leptin genotype determination. The leptin c.73 C>T polymorphism was genotyped by PCR-restriction fragment length polymorphism according to the procedure by Buchanan et al. (2002). Only steers possessing the CT genotype (heterozygous genotype) were selected for this study. Twenty four steers were selected and randomly assigned to one of three harvest groups based upon harvest point (8 steers per harvest group, one harvest group per pen): early-feeding period (**EF**), mid-feeding period (**MF**), and late-feeding period (**LF**). Point of harvest was predetermined for each treatment as follows: 35 days on feed (EF), average live weight (**LW**) of 1000 lb (MF, 111 days on feed), and 0.4 inch 12^{th} rib subcutaneous fat thickness (LF, 188 days on feed). Individual weights were measured every 28 days to monitor growth throughout the feeding period. Steers were implanted with a Synovex-S implant on d 29 and reimplanted with a Revalor-S implant on d 113.

Table 1. Diet formulations for backgrounding and finishing phases[a]

	Backgrounding Diets			Finishing Diets		
Ingredients	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 1**	**Diet 2**	**Diet 3**
Dry rolled corn	40.01	40.01	31.00		45.00	42.20
Chopped ear corn			38.00			
High moisture ear corn				80.00	40.75	40.85
WDGS[b]	14.00					
DDGS[c]		14.00	12.00	12.55	10.00	10.00
Sorghum silage	31.49	31.49	15.00	3.20		
Alfalfa hay	10.00	10.00				
Dry supplement 1[d]	4.50	4.50				
Dry supplement 2[d]						6.95
Liquid supplement[d]			4.00	4.25	4.25	
Days fed	34	27	33	19	38	37

[a] Percent inclusion; dry matter basis
[b]WDGS = Wet distillers grains with solubles
[c]DDGS = Dried distillers grains with solubles
[d] Supplements fortified to meet or exceed NRC (1996) requirements for vitamins and minerals. Monensin added to provide 22g/T in backgrounding diets and 29g/T in finishing diets.

The six steers most representative of each harvest group based upon LW were harvested at the South Dakota State University Meat Laboratory (Brookings, SD) using accepted slaughter methods. Immediately following exsanguination, a 3-inch section of the LM was excised from the left side of the carcass between the 12^{th} and 13^{th} rib. A portion of the LM section was cut into small pieces, snap frozen in liquid nitrogen, and stored at -80°C for western blot and real-time PCR analysis. The remaining LM section was stored at -20°C for later determination of water, fat, protein, and ash.

After cooling for 48 h postmortem at 4°C, the right side of each carcass was ribbed between the 12^{th} and 13^{th} rib. REA and 12^{th} rib subcutaneous fat (**FT**) were measured and USDA Yield Grades were calculated. Marbling scores, lean and skeletal maturity were assessed by trained university personnel. Additionally, the 9-10-11 rib section was fabricated from the right side of each carcass as described by Hankins and Howe (1946). Soft tissue was separated from bone and both were weighed. The soft tissue was mixed and homogenized using a bowl chopper. Water, fat, protein, and ash content of the soft tissue were determined. From these values, Hankins and Howe (1946) equations for steers were used to predict composition of the carcass soft tissue as well as total carcass composition.

Real-Time PCR

Muscle tissue from the 12^{th} rib LM was frozen in liquid nitrogen and powdered using a mortar and pestle. RNA was extracted from the powdered muscle tissue using TRI Reagent® RT (Molecular Research Center, Inc. Cincinnati, OH). RNA concentration was determined and samples were diluted to a standard RNA concentration. RNA was converted to cDNA through a high-capacity cDNA reverse transcription kit (Applied Biosystems, Carlsbad, CA) using a thermal cycler (My Cycler, Bio-Rad Laboratories, Hercules, CA) according to the manufacturer's instructions. Real-time quantitative PCR analysis using reverse transcribed cDNA was performed in triplicate using a SYBR Green RT-PCR kit (Bio-Rad Laboratories, Hercules, CA) to determine the relative expression of; AMP activated protein kinase α (**AMPKα**), CCAAT/enhancer binding protein β (**C/EBPβ)**, lipoprotein lipase (**LPL**), myostatin, PPARγ, and stearoyl-CoA desaturase (**SCD**).

Western Blot Analysis

Frozen LM tissue was subsequently powdered using a mortar and pestle. Powdered LM samples were added to a homogenizing solution and protein concentration was determined. Samples were diluted to a constant protein concentration, mixed with sample buffer, denatured at 100°C, and stored at -20°C. Samples were subjected to SDS-PAGE and western blotting to determine the relative abundance of AMPKα, C/EBPβ, LPL, myostatin, PPARγ, and SCD.

Warner-Bratzler Shear Force (WBSF)

Strip loins were excised from the right side of each carcass. Four 1-inch steaks were cut and allotted for WBSF at 2, 7, 14, and 21 d postmortem aging. Steaks were stored at -20°C after their predetermined postmortem aging period. Shear force was then conducted as described by Mohrhauser et al. (2011).

Statistical Analysis

Carcass characteristics, carcass composition, muscle composition, and western blot data were analyzed as a complete randomized design using GLM (General Linear Model, SAS Inst. Inc., Cary, NC) with individual animal as the experimental unit. Orthogonal contrasts were used to determine linear and quadratic effects for harvest groups. WBSF data were analyzed using repeated measure (PROC MIXED DATA) procedures (SAS Inst. Inc., Cary, NC). Means for each harvest group, postmortem aging period and their interactions were compared by the Tukey's multiple comparison. The relationships between the relative quantity of proteins of interest as determined by western blotting and 12th rib LM fat content (**IMF**), as well as the relationship between HCW and IMF, were determined using PROC REG (SAS Inst. Inc., Cary, NC). REST 2008 (Relative Expression Software Tool V2.0.07, Corbett Research Pty, Ltd., Sydney, Australia) was utilized to calculate the fold change in gene expression through the incorporation of reaction efficiencies, reference gene normalization, and cycle thresholds values to determine statistical differences. Statistical significance was considered as $P < 0.05$ with trends considered at $P < 0.10$.

RESULTS

Actual points of harvest corresponded well with predetermined harvest points as MF was harvested at 1023 lb LW (target was 1000 lb) and LF at 0.46 in FT (target was 0.4 inch FT, Table 2). The time between harvest for EF and MF steers was 76 d with a live weight difference of 273 lb and the time difference between MF and LF was 77 d with a difference of 280 lb. Therefore, slaughter points were not only equally distributed between time on feed, but by LW as well. Both FT and KPH increased at similar rates between harvest points. Moreover, estimated carcass fat increased at a steady rate between harvest points and estimated carcass protein percentage only differed for EF carcass (Table 2). Collectively, these data contradict standard growth curves where lean muscle accretion slows and adipose deposition accelerates as an animal approaches its mature body size.

Table 2. Carcass data and estimated carcass composition by growth stage[a]

	Growth Stage				Significance of contrasts	
	EF	**MF**	**LF**	**SEM**	**Linear**	**Quadratic**
Live weight, lb	750	1023	1303	14.24	**<0.0001**	**<0.0001**
HCW, lb	417	609	810	7.25	**<0.0001**	**<0.0001**
Dressing percent	55.56	59.65	62.19	0.52	**<0.0001**	**<0.0001**
REA, in^2	9.1	10.3	13.0	0.34	**<0.0001**	**0.0227**
12th rib fat thickness, in	0.11	0.29	0.46	0.04	**<0.0001**	**0.0075**
Adjusted fat thickness, in	0.10	0.32	0.48	0.04	**<0.0001**	**0.0007**
KPH, %	2.10	2.37	2.88	0.18	**0.0070**	0.2944
USDA Yield Grade	1.88	2.85	3.26	0.13	**<0.0001**	**<0.0001**
Marbling score[b]	282	322	427	16.57	**<0.0001**	0.1084
Intramuscular fat, %	1.85	3.53	5.40	0.27	**<0.0001**	**0.0005**
M-ratio[c]	0.17	-0.32	0.15	0.30	0.9684	0.2620
Edible Portion,%[d]	83.53	85.26	86.49	0.36	**<0.0001**	**0.0042**
Water, %	52.06	48.47	44.89	0.63	**<0.0001**	**0.0011**
Fat, %	15.97	22.13	27.72	0.88	**<0.0001**	**0.0002**
Protein, %	14.43	13.75	13.22	0.18	**0.0003**	**0.0180**
Ash, %	0.85	0.75	0.66	0.02	**<0.0001**	**0.0021**
Bone, %	16.47	13.75	13.22	0.36	**<0.0001**	**0.0042**

[a] Least square means.

[b] Marbling score: 200=Traces^0, 300=Slight^0, 400=Small^0, 500=Modest^0.

[c] M-ratio calculated by the following equation where means and standard deviations used were for the whole population; variable 1 = marbling score and variable 2 = 12th rib fat thickness

$$\left[\frac{(\text{Obs Var}_1 - \text{Var}_1\ \overline{\text{X}})}{\text{Var}_1\ \text{S}_\text{d}}\right] - \left[\frac{(\text{Obs Var}_2 - \text{Var}_2\ \overline{\text{X}})}{\text{Var}_2\ \text{S}_\text{d}}\right]$$

[d] Values calculated from proximate analysis of 9-10-11 rib sections using equations for carcass composition outlined by Hankins and Howe (1946).

Recent studies have conflicted with more classical research in regard to the timing of intramuscular fat deposition. Evidence from this study supports the theory that there is an increased priority for intramuscular fat deposition and it is subsequently accumulated throughout the feeding period. Both marbling score and IMF (Table 2) began to increase from the time steers were placed on feed. Marbling score increased linearly throughout the finishing phase ($P < 0.0001$, Table 2). Additionally, IMF, an objective and less variable measure of intramuscular fat, revealed a both a linear and quadratic increase throughout the feeding period ($P < 0.0001$ and $P = 0.0005$, Table 2). Furthermore, IMF was found to increase in a linear fashion with HCW ($P < 0.01$; $r^2 = 0.8373$), giving additional evidence of the linear nature of IMF deposition throughout the feeding phase.

Gene expression of PPARγ and SCD was down-regulated in EF steers relative to the other two harvest groups ($P = 0.046$ and $P < 0.01$, respectively). This indicates increased adipogenesis (PPARγ) and lipogenesis (SCD) later in the feeding period relative to the early stages. Furthermore, expression of SCD was up-regulated in LF steers relative to the first two harvest groups ($P = 0.02$) indicating increased lipogenesis and adipose cell hypertrophy at the end of the feeding phase. Additionally, AMPKα expression was down-regulated in the LF group relative to the two earlier growth stages ($P < 0.01$). AMPK acts as the "fuel gauge" of the cell and its presence and subsequent activation acts to cease ATP consuming processes (i.e. lipogenesis) and activate ATP regeneration pathways. Thus, this decreased expression of AMPKα would indicate that anabolic pathways in LM cells were active resulting in energy storage and adipose accumulation.

The previous changes in gene expression did not all result in a difference in the relative amount of the respective protein present. There was a linear increase in PPARγ throughout the feeding period ($P = 0.03$) driven by a sharp increase in PPARγ present in the LF group relative to the first two growth stages. This agrees with the gene expression results presented previously, which indicates an up regulation of PPARγ in both MF and LF groups. There was a linear ($P = 0.07$) and quadratic ($P = 0.08$) trend for myostatin to increase throughout the feeding period. Myostatin acts as an inhibitor of skeletal muscle growth. Therefore, the increased presence of myostatin at the end of the feeding phase would coincide with the standard growth curve in which muscle growth begins to slow and fat accumulation rapidly increases, however, these findings are somewhat contradicted by the large increase in REA between the MF and LF groups (Table 2). Nonetheless, this may be due to the fact that steers in this study were implanted which may have resulted in a skewed growth curve. The relative abundance of the other proteins of interest did not differ between other growth stages. Only PPARγ was found to have a significant correlation to IMF ($P = 0.04$, $R^2 = 0.2382$). Therefore, the relative abundance of PPARγ present in muscle at harvest may serve as an indication of the marbling content of the LM. Additionally, targeting and increasing PPARγ expression may serve as a mechanism to increase marbling deposition.

Tenderness improved between two and seven days postmortem ($P = 0.03$), but no significant decrease in WBSF was detected when postmortem aging was extended beyond seven days. This suggests that much of the postmortem proteolysis relevant to tenderness improvement was complete after seven days of aging. Steaks from the chronologically oldest, most mature harvest group, LF, were found to be the most tender ($P = 0.01$). This differs from past findings, which support a decrease in tenderness with increased physiological maturity, but concurs with other research which supports increased tenderness with increased days on feed.

LITERATURE CITED

Andrews, F. N. 1958. Fifty years of progress in animal physiology. J. Anim. Sci. 17:1064-1078.

Bruns, K. W., R. H. Pritchard, and D. L. Boggs. 2004. The relationship among body weight, body composition, and intramuscular fat content in steers. J. Anim. Sci. 82:1315-1322.

Buchanan, F. C., C. J. Fitzsimmons, A. G. Van Kessel, T. D. Thue, D. C. Winkelman-Sim, S. M. Schmutz. 2002. Association of a missense mutation in the bovine leptin gene with carcass fat content and leptin mRNA levels. Genet. Sel. Evol. 34:105-116.

Hankins, O. G. and P. E. Howe. 1946. Estimation of the composition of beef carcasses and cuts. USDA Tech. Bull. 926:20.

McBee, J. L., and J. A. Wiles. 1967. Influence of marbling and carcass grade on physical and chemical characteristics of beef. J. Anim. Sci. 26:701-704.

McPhee, M. J., J. W. Oltjen, T. R. Famula, and R. D. Sainz. 2006. Meta-analysis of factors affecting carcass characteristics of feedlot steers. J. Anim. Sci. 84:3143-3154.

Mohrhauser, D. A., K. R. Underwood, and A. D. Weaver. 2011. In vitro degradation of bovine myofibrils is caused by μ-calpain, not caspase 3. J. Anim. Sci. 89:798-808

Platter, W. J., J. D. Tatum, K. E. Belk, S. R. Koontz, P. L. Chapman, and G. C. Smith. 2005. Effects of marbling and shear force on consumers' willingness to pay for beef strip loin steaks. J. Anim. Sci. 83:890-899.

Wang, Y. H., N. I. Bower, A. Reverter, S. H. Tan, N. De Jager, R. Wang, S. M. McWilliam, L. M. Cafe, P. L. Greenwood, and S. A. Lehnert. 2009. Gene expression patterns during intramuscular fat development in beef cattle. J. Anim. Sci. 87:119-130.

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Comparison of two different methods to harvest drought-damaged corn[1]

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SUMMARY

Two methods of harvesting drought-stressed corn as large round bales were compared in this study. Three acres of drought-stressed corn were cut and either baled as high-moisture bales and wrapped in plastic (BALEAGE), or allowed to completely dry and baled with a conventional large round baler (DRY). Core samples were analyzed for moisture, CP, ADF, NDF and in vitro NDF and DM digestibility. Samples from the BALEAGE treatment were lower in CP than those from the DRY treatment. Concentrations of ADF and NDF did not differ between BALEAGE and DRY. Dry matter and NDF digestibility were also similar between the treatments. The challenges of physically handling the bales from the BALEAGE treatment and in maintaining the integrity of the plastic barrier limit the usefulness of this technique compared to either chopping the corn for silage or harvesting the corn as dry, large round bales.

INTRODUCTION

During drought conditions, it sometimes becomes necessary to salvage drought-stressed corn for forage rather than grain. The most common harvesting method and standard recommendation in these instances is to harvest the corn as silage. However, there can be obstacles and challenges to harvesting a failed corn crop as silage. The necessary equipment is not always available at the optimal time for harvesting silage, plus in some cases the distance from field to livestock feeding facility poses logistical challenges.

These challenges lead some producers to consider harvesting standing corn in large round bales. The major obstacle with this method is that the forage must cure in the field for an extended period of time (30 days or more) before the plant material is dry enough (≤ 20% moisture, ideally < 15%) to safely be baled. This long drying period leads to a greater risk of deterioration because of weather exposure and limits opportunities to plant either cover crops or winter cereal grains to take advantage of any fall precipitation.

The purpose of this study was to examine if drought-stressed corn could be harvested at higher moisture content when processed as baleage. Baleage harvesting involves using a standard large round baler to harvest forage at high moisture content after a short wilting period rather than allowing the crop to completely dry down. The resulting bales are then wrapped in plastic to limit oxygen and promote anaerobic fermentation.

[1] This project was funded by SDSU Extension and by the SDSU Agricultural Experiment Station

MATERIALS AND METHODS

Three acres of drought injured corn plants at the Southeast Research Farm, Beresford, SD, were cut by a mower-conditioner on August 15, 2012. One half of the resulting windrows were baled on August 17 with a large round baler using net wrap. These bales were then wrapped in plastic (Figure 1). The remaining windrows were allowed to dry for 30 days and then baled with the same large round baler using only net wrap. Samples were taken from each individual BALEAGE bale on August 17 (INITIAL). Individual samples were taken from both the BALEAGE and DRY bales on October 15, 2012. Because the ends of the row of wrapped bales were exposed, the first and last bales from the BALEAGE treatment were excluded from the analysis.

Forage samples were sent to a commercial testing laboratory (Dairyland Laboratories, Inc., Arcadia, WI) for analysis. Samples were analyzed for moisture content, CP, ADF and NDF using NIR procedures and the same equations for all samples. In vitro digestibility for NDF and dry matter were also determined using a 48-hour incubation. Because the nitrate-nitrogen levels in the corn (20 to 185 ppm NO_3N, AgLab Express, Sioux Falls, SD, B. Rops, personal communication) were not high enough to warrant concern in feeding to cattle, nitrate concentrations were not analyzed in this experiment. Differences in composition between INITIAL, BALEAGE and DRY were determined by using the GLM procedure of SAS (PROC GLM, SAS Inst. Inc., Cary, NC) with bale representing the experimental unit.

RESULTS AND DISCUSSION

Sixteen BALEAGE bales and 8 DRY bales were harvested from 3.6 acres. Differences in bale numbers were attributed to shrinkage and wind loss during the 4-wk drying period, as well as less capture of plant material by the baler when dry compared to BALEAGE (B. Rops, personal communication). The results of the forage analyses are shown in Table 1. As expected the DRY samples contained the least moisture with the INITIAL samples having the highest moisture content with the BALEAGE intermediate ($P < 0.05$). The BALEAGE and DRY treatments were lower in pH compared to the INITIAL samples ($P < 0.05$). Crude protein content was also lower in the BALEAGE treatment compared to either INITIAL or DRY (6.4% compared to 8.6 and 8.0%, respectively, $P < 0.05$).

One explanation for the lower CP content observed in the BALEAGE treatment is that some of the nitrogen was carried by water movement into the lower portion of the bale. The moisture content when the BALEAGE bales were made is at the upper end of recommended moisture contents for silage harvesting. Seepage losses more commonly occur under higher moisture conditions. It's possible that if seepage occurred, the concentration of nitrogen-containing compounds might have been higher in the lower part of the bale where the hay probe did not reach. Another possible explanation for the observed differences in CP content could be that as protein was degraded by microbial action and/or fermentation, increased amounts of ammonia (NH_3-N) were produced (Kung and Der Bedrosian, 2010) that might not have been captured in the subsequent core sample.

The BALEAGE treatment was significantly less ($P < 0.05$) than the INITIAL treatment for both ADF (31.0 vs. 39.0%) and NDF (51.6 vs. 59.8%) concentrations, but not different than DRY. Both the BALEAGE and DRY treatments were higher in NDF digestibility (58.0 and 56.4%, respectively) compared to INITIAL treatment which was 51.1% ($P < 0.05$). The BALEAGE samples were also higher ($P < 0.05$) in IVDMD compared to INITIAL (78.3% compared to 70.6%) but not significantly different than the DRY treatment. The changes observed in the BALEAGE and DRY treatments are consistent with microbial activity and fermentation. The pH for samples taken in October was lower compared to samples taken immediately at harvest, similar to what happens during the ensiling process. If microbial activity had degraded a portion of the cell wall constituents, changes in both fiber concentration and digestibility would be expected (Kung and Der Bedrosian, 2010).

Although results of this small experiment suggest that harvesting drought damaged corn as either baleage or dry large round bales is possible, they do not support changing the standard recommendation of chopping and ensiling as the preferred method to salvage a failed corn crop. The dry bales required 30 days drying time to reach what would be considered the maximum acceptable moisture content for safe baling. If moisture levels inside the bale were higher, extensive amounts of spoilage would be likely. Additionally, staff noted that a portion of the leaves and cobs were lost during the drying and baling process.

Whereas harvesting as baleage eliminates the extended waiting time and offers some degree of preservation, there are several practical challenges to this harvest method. First, if these bales are made to the same dimensions as a standard round bale, physically handling the bales is difficult because of the additional weight caused by higher moisture content (B. Rops, personal communication). Second, maintaining the integrity of the plastic is critical to avoid spoilage. As seen in Figure 2, spoilage occurred following core sampling in this study even when the holes had been patched with tape immediately after sampling. Based on these challenges, combined with the reduced CP levels seen in this study, the usefulness of this harvesting method as a way of salvaging drought-stressed corn is limited. Chopping and ensiling is still the best method of utilizing this feedstuff for ruminants.

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LITERATURE CITED

Kung, Jr. L., and M. Der Bedrosian. 2010. How well do we really understand silage fermentation? Proc. Cornell Nutrition Conference. Pg 87-93. Oct. 19-21, 2010. Syracuse, NY. Dept. of Animal Science, Cornell University, Ithaca. Available at: http://www.ansci.cornell.edu/cnconf/2010proceedings/CNC2010.9.Kung.pdf

Table 1. NIR analysis and in vitro digestibility of corn hay samples

	INITIAL	BALEAGE	DRY	SEM	P Value
Moisture, %	68.2[a]	63.1[b]	16.2[c]	0.85	<0.0001
DM, %	31.8[a]	36.9[b]	83.8[c]	0.85	<0.0001
pH	5.26[a]	4.35[b]	4.44[b]	0.1	<0.0001
CP, %	8.6[a]	6.4[b]	8.0[a]	0.46	0.0035
ADF, %	39.0[a]	31.0[b]	36.0[a,b]	2.25	0.027
NDF, %	59.8[a]	51.6[b]	57.4[a,b]	2.48	0.036
NDFD[d], %	51.1[a]	58.0[b]	56.4[b]	1.73	0.011
IVDMD[e], %	70.6[a]	78.3[b]	75.0[a,b]	1.8	0.009

[a,b,c] Means within a row having different superscripts are different ($P < 0.05$)
[d] NDFD = Neutral detergent fiber digestibility
[e] IVDMD = In vitro dry matter digestibility

Figure 1. Processing BALEAGE bales.
Picture courtesy of Brad Rops

Figure 2. Picture of BALEAGE after plastic wrap was removed.
Picture courtesy of Brad Rops

BEEF 2013-04

Nitrogen excretion from beef cattle for 6 cover crop mixes as estimated by a nutritional model[1]

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SUMMARY

Excretion of nitrogen (N) from cattle within crop-livestock systems is an important component of nutrient cycling, but measuring fecal and urinary N excretion in grazing cattle is a difficult and time-consuming task. Nutritional models are available to estimate feed utilization and have been used to predict N excretion in grazing cattle. Using the Large Ruminant Nutrition Model, we predicted N losses from mature pregnant beef cows and growing beef heifers from compositional analysis of cover crop mixes grown in central South Dakota. All of the mixes used contained crude protein (CP) concentrations greater than cattle requirements. Estimates of both total fecal and urinary N excretion were greater for cows than heifers due to the greater BW and N intake of cows, however, the proportion of total N intake excreted in the feces was not predicted to differ between cattle maturities. Urinary excretion of N was predicted to be less for heifers, both when expressed as lb/d of N excreted or as a percentage of N intake. When accounting for potential stocking rate differences, it was predicted that slightly less urinary N excretion per acre could be expected by grazing younger cattle that utilize some N for growth compared to a mature animal.

INTRODUCTION

Cover crops can be used in rotational cropping systems to improve soil tilth and soil nutrient cycling, decrease wind erosion, and potentially help with weed control (Gardner and Faulkner, 1991. Cover crops can also be grazed by livestock to fill nutrient gaps for beef production (McCartney et al., 2009). Livestock can be used to speed up nutrient cycling in some crop-livestock settings, providing more benefit than leaving fields ungrazed (Carvalho et al., 2010). Use of forage protein by cattle is affected by its solubility and degradability in the rumen and use for microbial growth. Excess ruminal N supply may result in absorption of ammonia into the bloodstream and excretion in the urine. Urinary N, the majority of which is the form of urea, is easily volatilized and may be a nutrient loss in a crop-livestock system. In contrast, lowly degradable protein may pass through the ruminant unutilized and be excreted in the feces. Research addressing the partitioning of N use and excretion for cattle can add to our understanding of N conversion efficiencies in crop-livestock systems. Nutritional models such as the Cornell Net Carbohydrate and Protein System (CNCPS; Fox et al., 2004) and the Large Ruminant Nutrition System have been successfully used to monitor and manage nutrient excretion at the farm level for dairy cattle (Higgs et al., 2012). The objective of this study was to predict fecal and urinary N excretion for different maturities of beef cattle using model simulations based on compositional analysis of cover crop mixes grown in South Dakota.

[1] Research was supported by the South Dakota Agricultural Experiment Station

MATERIALS AND METHODS

Samples were obtained from the study of Hansen (2012) and analyzed for additional nutrient composition. Only 2 of 4 replications were analyzed for the current study. Forages had initially been grown under dryland conditions at Dakota Lakes Research Farm near Pierre SD in 2010 and 2011. Six forage mixes were evaluated (Table 1). Samples were collected on 3 dates in each year, approximately Oct 1, Nov 1 and Dec 1. Full description of the growth and harvesting conditions can be found in Hansen (2012). Samples were submitted to a commercial laboratory (Dairy One Forage Testing Laboratory, Ithaca NY) for analysis of dry matter (DM), CP, soluble CP, acid detergent fiber, neutral detergent fiber, acid detergent insoluble CP, neutral detergent insoluble CP, lignin, starch, simple sugars and crude fat. Average CP concentrations used in the model predictions are presented in Table 2.

Data was entered into the Large Ruminant Nutrition System (LRNS) model (http://nutritionmodels.tamu.edu/lrns.html) for estimation of N excretion. Two animal scenarios were analyzed: 1) a non-lactating, pregnant beef cow and 2) replacement beef heifer. Animal inputs used in the model are described Table 3. All environment and management conditions were similar for cows and heifers. The model was set to use default options. A randomly selected feed was entered and DM intake estimated by the model. All remaining scenarios were set to the same DMI. Dry matter intake was 2.33% of BW (31.4 lb/d for cows and 13.9 lb/d for heifers) for all simulations comparing mixes.

Nitrogen excretion outputs from the LRNS model were analyzed using PROC MIXED in SAS (SAS Inst. Inc., Cary NC). This experiment was designed as a split-plot arrangement of a randomized complete block with animal type and cover crop mixture as the whole plot and harvest date as the sub-plot. Cover crop mixture and harvest date were treated as fixed factors and replications were considered random. Student's t-test was used to separate mean effects when an *F* test was significant (P=0.05).

RESULTS AND DISCUSSION

Crude protein concentrations of cover crops mixes were always at least 14% (Table 2) and met nutrient requirements for both classes of animal (NRC, 1996). Mixes differed (P < 0.01) in CP content with differences affected by month within year (P < 0.01). Differences in mix CP content then affected N intake estimates for cattle. Predictions of N utilization, except lbs/d of fecal N excreted, were affected by cover crop mix (Table 4). Fecal N excretion ranged for 33.6 to 43.7% of N intake and urinary excretion from 52.5 to 58.8 % of N intake for the six cover crop mixes.

Predicted N intake was greater for cows than heifers due to the increased body weight of cows (Tables 4 and 5). Predicted N intake varied by month within year due to varied CP concentration of the mixes, with N intake in Oct 2010 being greater than for other months for both animal maturities and was less for cows in Dec 2011 than other months. Differences in N intake resulted in difference in the amount (lb/d) of predicted N excreted for cows, but not heifers. The predicted percentage of N intake excreted in feces did not differ by animal maturity. There was an animal maturity by month within year interaction for urinary excretion both when expressed as total lb/d excreted and percentage of N intake. Urinary nitrogen excretion varied from a low of 43.8 % of intake for heifers in Dec 2011 to a high of 66.4% for cows in Oct 2010. The estimates suggest that delaying grazing until November or December 2010 would have decreased urinary N excretion compared to Oct 2010 but this relationship did not hold for 2011 and a general conclusion about delaying grazing date cannot be made.

The amount of N excreted on a unit of land will be affected by stocking rate. In this example, heifers weighed 598 lb compared to 1346 lb for cows. Therefore, 2.25 heifers would provide the same BW/acre as one cow. Multiplying the estimate of N excretion (lb/d) for heifers by 2.25 gives a predicted fecal N excretion of 0.41 lb/d and a range in urinary N excretion of 0.38 to 0.72 lb/d on a specific land area. One cow on the same unit of land is predicted to excrete about 0.40 lb/d fecal N and 0.51 to 0.90 lb/d urinary N Therefore, slightly less urinary N excretion per acre could be expected by grazing younger cattle that may retain greater amounts of N for growth compared to cows.

Cover crop mixes that are lower in CP than those used in this study could potentially be used to limit urinary N excretion. This might be accomplished by planting cover crop mixes with less legumes or, at times, by delaying the time of grazing. This exercise was conducted with complete mixes and did not account for differences in diet selection by cattle for specific species in the mixes. Additionally, intake will be affected by diet characteristics and would likely differ by both mix and dates. Further research is needed to evaluate the actual N intake and utilization for cattle grazing cover crop mixes, but estimates can be made using modeled values.

LITERATURE CITED

Carvalho, P. C. F., I. Anghinoni, A. Moraes, E. D., Souza, R. M. Sulc, C.R. Lang, J. P. C. Flores, M. L. T. Lopes, J. L. S. Silva, O. Conte, C. L. Wesp, R. Levien, R. S. Fontaneli, and C. Bayer. 2010. Managing grazing animals to achieve nutrient cycling and soil improvement in no-till integrated systems. Nutr. Cycl. Agroecosyst. 88:259-273.

Fox, D.G., L.O. Tedeschi, T. P. Tylutki, J. B. Russell, M.E. Van Amburgh, L.E. Chase, A. N. Pell., and T. R. Overton. 2004. The Cornell Net Carbohydrate and Protein System model for evaluating herd nutrition and nutrient excretion. Anim. Feed Sci. Technol. 112:29-78.

Gardner, J. C. and D. B. Faulkner. 1991. Use of cover crops with integrated crop-lives tock production systems. In: Cover Crops for Clean Water. W.L. Hargrove (ed.). Ankeny, IA: Soil and Water Conservation Society.

Hansen, M.J. 2012. Evaluation of cover crops for late season forages and their effect on corn yields in South Dakota. M. S. Thesis. South Dakota State University.

Higgs, R.J., L.E. Chase, and M.E. Van Amburgh. 2012. Case Study: Application and evaluation of the Cornell Net Carbohydrate and Protein System as a tool to improve nitrogen utilization in commercial dairy herds. Prof. Anim. Sci. 28:370-378.

Large Ruminant Nutrition System available at http://nutritionmodels.tamu.edu/lrns.html

McCartney, D., J. Fraser, and A. Ohama. 2009. Potential of warm-season annual forages and Brassica crops for grazing: A Canadian review. Can. J. Anim. Sci. 89: 431-440.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th Revised Edition. National Academy Press. Washington DC.

Table 1. Cover crop mixtures planted at the Dakota Lakes Research Farm in central South Dakota in 2010 and 2011, including species, cultivar, and seeding rates (from Hansen 2012).

Mixture	Crop	Cultivar	Seed Rate lbs/acre
Mixture 1	Chickling Vetch	AC Greenfix	33.0
	Lentil	Redberry	6.3
	Cowpea	Red Ripper	3.6
	Flax	Golden	7.1
Mixture 2	Chickling Vetch	AC Greenfix	33.0
	Lentil	Redberry	6.3
	Cowpea	Red Ripper	3.6
	Flax	Golden	7.1
	Rape	Dwarf Essex	3.6
Mixture 3	Chickling Vetch	AC Greenfix	23.2
	Lentil	Redberry	9.8
	Field pea	Austrian winter	7.1
	Flax	Golden	5.4
Mixture 4	Chickling Vetch	AC Greenfix	23.2
	Lentil	Redberry	9.8
	Field Pea	Austrian winter	7.1
	Flax	Golden	5.4
	Rape	Dwarf Essex	3.6
Mixture 5	Field Pea	Austrian winter	17.0
	Soybean	Pioneer 93M11	23.2
	Flax	Golden	9.8
Mixture 6	Field Pea	Austrian winter	17.0
	Soybean	Pioneer 93M11	23.2
	Flax	Golden	9.8
	Rape	Dwarf Essex	3.6

Table 2. Average crude protein concentration of cover crops mixes on three dates in two years used in the LRNS model. SE = 1.33.

	2010			2011		
Mix	Oct	Nov	Dec	Oct	Nov	Dec
	------CP, % of DM------					
1	25.8^{Aa}	23.1^{ABab}	23.5^{Aa}	22.3^{b}	26.2^{Aa}	19.4^{ABb}
2	25.0^{Aa}	21.6^{ABab}	21.9^{ABa}	18.8^{bc}	16.6^{BCc}	15.3^{Cc}
3	32.2^{Ba}	25.4^{Ab}	23.4^{Aa}	21.3^{c}	23.9^{Abc}	22.0^{Abc}
4	30.5^{Ba}	21.3^{Bb}	22.8^{ABa}	19.4^{bc}	16.9^{BCc}	15.6^{BCc}
5	25.9^{Aa}	21.5^{Bbc}	21.9^{ABa}	20.1^{bc}	19.0^{Bbc}	17.8^{BCc}
6	22.3^{Aa}	20.4^{Ba}	19.5^{Ba}	20.4^{a}	13.9^{Cb}	14.3^{Cb}

^{abc} Means in rows (months) with differing superscripts differ, $P < 0.05$.
^{ABC} Means in columns (mixes) with differing superscripts differ), $P < 0.05$

Table 3. Model conditions for animals used in the LRNS evaluation of cover crop mixes

Animal type	Dry Cow	Growing/ Finishing
Animal age, mo	60	10
Current BW, lb	1346	598
Expected weight at 22% Body fat	1393	1393
Days pregnant	162	-
Days since calving	245	-
Lactation number	5.0	-
Calving interval, mon	12	-
Expected calf birth weight, lb	86	-
Age at first calving, mo	23	-
Breed type	Beef	Beef
Breeding system	2-Way cross	2-Way Cross
Dam Breed	Hereford	Hereford
Sire Breed	Angus	Angus
Condition score	5.0	5.0

Table 4. Effect of date and year on predicted fecal and urinary nitrogen excretion for 2 beef cattle types consuming a diet of cover crops in the autumn

	Cover Crop Mix						
	1	2	3	4	5	6	SE
N Intake, lbs/d							
Cow	1.78^{Aa}	0.99^{Abc}	1.24^{Aa}	1.06^{Ad}	1.05^{Acd}	0.94^{Ab}	0.03
Heifer	0.52^{Bab}	0.44^{Bc}	0.55^{Bb}	0.47^{Bac}	0.46^{Bac}	0.42^{Bc}	0.03
Fecal N excretion							
lbs/d	0.29	0.29	0.30	0.30	0.29	0.29	0.01
% of N intake	35.4^{a}	41.4^{bc}	33.6^{a}	39.9^{b}	39.6^{b}	43.7^{c}	1.23
Urinary N excretion							
lbs/d	0.49^{a}	0.39^{b}	0.56^{c}	0.45^{ad}	0.42^{bd}	0.38^{b}	0.02
% of N intake	56.9^{ab}	52.5^{c}	58.8^{a}	54.8^{bd}	53.2^{cd}	52.9^{cd}	0.78

^{abcd} Means in rows with differing superscripts differ, P < 0.05.

^{AB} Means in columns for N intake with differing superscripts differ for animal maturity, P < 0.05.

Table 5. Effect of date and year on predicted fecal and urinary nitrogen excretion for female beef cattle of 2 maturities consuming a diet of cover crops in the autumn

	2010			2011			
	Oct	Nov	Dec	Oct	Nov	Dec	SE
Cow							
N Intake, lbs/d^{A}	1.35^{a}	1.12^{b}	1.11^{b}	1.00^{c}	0.98^{d}	0.88^{e}	0.02
Fecal N Excretion							
lb/d^{A}	0.42^{a}	0.40^{ab}	0.41^{a}	0.40^{ab}	0.38^{c}	0.40^{b}	0.01
% of N intake	31.6^{a}	36.6^{b}	37.4^{bc}	39.4^{c}	42.4^{d}	46.7^{e}	1.01
Urinary N excretion							
lbs/d^{A}	0.90^{a}	0.70^{b}	0.68^{b}	0.61^{c}	0.56^{cd}	0.51^{d}	0.02
% of N intake^{A}	66.4^{a}	61.5^{b}	61.2^{b}	59.2^{bc}	60.0^{bc}	58.3^{c}	0.92
Heifer							
N Intake, kg/d^{B}	0.60^{a}	0.50^{b}	0.49^{bc}	0.46^{cd}	0.43^{de}	0.39^{e}	0.02
Fecal N Excretion							
lbs/d^{B}	0.18	0.18	0.18	0.18	0.18	0.18	0.01
% of N intake	31.6^{a}	36.3^{b}	37.4^{bc}	39.4^{c}	42.4^{d}	46.6^{e}	1.01
Urinary N excretion							
g/d^{B}	0.32^{a}	0.26^{b}	0.25^{b}	0.21^{bc}	0.20^{bc}	0.17^{c}	0.02
% of N intake^{B}	54.7^{a}	52.3^{ab}	50.2^{b}	45.5^{c}	44.9^{c}	43.8^{c}	0.92

^{abcd} Means in rows with differing superscripts differ, P < 0.05.

^{AB} Overall mean differs between cows and heifers, P < 0.01.

BEEF 2013-05

The effect of handler personality type on feedlot cattle behavioral responses[1]

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SUMMARY

The ability to readily identify individuals that may have a greater innate ability to handle cattle in a low-stress manner would be useful in feedlots and on ranches. This study was conducted to determine whether handler personality type would be a useful tool to predict stockman abilities. To accomplish this, 3 cattle handling exercises were created to observe human-cattle interactions. A scoring system was developed to investigate cattle handling proficiency based on cattle behavioral responses. Handler personality type was classified using two assessments. Some cattle handling exercises did not differentiate handler personality types. Introverted handlers tended to have higher scores than Extraverts in Exercise 3. When Exercises 2 and 3 were pooled, the same tendency occurred for Introverted handlers to have more favorable scores. These results indicate that a relationship between handler personality type and the behavioral responses of cattle may exist. The scoring system created to quantify cattle handling proficiency was useful, but needs further development.

INTRODUCTION

The cattle industry continues to promote the importance of low-stress handling because of the benefits on cattle performance and health. The benefits of low-stress handling also show up in the quality of the meat with a reduction of dark cutters and less trimming of bruises from the carcass. Additionally, minimizing stockman injuries is imperative for the success of an operation.

Cattle behavioral responses can vary widely when different individuals move cattle through facilities in preparation for processing or daily management tasks. This general observation raises the question whether the resulting cattle responses were due to the experience level, or training of the individual, or other personal characteristics. Since individual experiences are diverse, and may include poorly learned stockmanship skills or low performance expectations, it was necessary to look for indicators other than experience level. Personality type was investigated to classify stockman characteristics since personality type of an individual tends to be stable over time and influences many aspects of behavior and decision making.

The industry currently lacks a consistent method to assess cattle handling proficiency. This experiment created a scoring method to quantify the behavioral responses of cattle to use in investigating the differences between the abilities of handlers to effectively manipulate cattle.

[1]The authors wish to thank B. Holland, Merck Animal Health, and E. Grings, SDSU, for their assistance with the development and evaluation of the scoring system.
[2]Project funded by the Beef Nutrition Program, SDSU.

MATERIALS AND METHODS

This experiment was performed at the Ruminant Nutrition Center, SDSU, Brookings, SD during August through September 2011. Cattle used were long yearling steers (n = 42 head) housed in 3 drylot pens (154 ft x 59 ft) with 14 steers per pen.

Twelve handlers with prior cattle handling experience were recruited for this experiment. The Myers-Briggs Type Indicator (MBTI) and the Virtues in Action Inventory of Strengths (VIA-IS) were chosen to classify personality type of the handlers.

Three exercises were created to directly observe human-cattle interactions without the use of equipment. Exercise 1 challenged the handler to get close enough to 4 predetermined steers with paint-brands on their left hip to read and record the identification on an ear tag. The intent being to measure a response when the personality type penetrated the animal's flight zone. Exercise 2 required handlers to manipulate cattle activity by more invasively penetrating the flight zone to sort the steers within their home pen into 2 equal groups that remained clearly separated by a nominal distance (16 ft), for at least 10 seconds. Exercise 3 involved handlers moving the steers out of the pen to a dead-end alley 262 ft to 459 ft from the pens. The handler then sorted back steers individually before returning them to the home pen.

Handlers performed the 3 exercises consecutively on 2 pens of steers, for 2 handling episodes per handler. The random assignment of handlers to pens was blind to personality type. Handlers were videotaped and 4 reviewers (3 beef cattle specialists and a graduate student) evaluated the footage. The initial cattle handling proficiency scoring system was comprised of 9 cattle behaviors: Attention, Fence contact, Curiosity, Excitability, Flight zone, Footing, Gregariousness, Movement, and Pace (Table 1).

Table 1. Cattle behavior descriptions for cattle handling proficiency scoring system.

Behavior	+3 Desirable	-3 Undesirable
	Cattle Response	
Attention	Toward handler	Away from handler
Fence contact	No contact	Occasional to continuous contact
Curiosity	Approach to investigate handler	Ignore handler, maintain normal/previous behavior
Excitability	Calm/relaxed, easy to handle	Nervous/stressed, difficult to handle
Flight zone[1]	Move away from handler at safe distance	Stay as far away from handler as possible
Footing	Sure footed	Fall
Gregariousness[1]	Maintain manageable, relaxed herd	Scattered, unmanageable herd
Movement	Maintain desired motion (or lack of motion) handler is working toward	Continuously uncooperative motion
Pace[1]	Relaxed/quick walk	Nervous/stressed run

[1]Behaviors removed from scoring system.

To minimize the conditioning of steers to the exercises, each pen was limited to 8 handling episodes with a maximum of 2 episodes per day. All handlers completed 1 handling episode before any handler began their second episode. The order of handlers was determined by schedule availability and arranged to prevent consecutive handling of a pen.

Each cattle behavior was assigned a score (+3, +2, +1, -1, -2, -3) that reflected the desirability of the cattle behavioral response. Positive scores were desirable cattle behavioral responses and negative scores were undesirable responses. Only cattle responses were used to quantify cattle handling proficiency. Handler actions/behaviors were not scored. This scale was converted to a six-point Likert scale for data analyses (-3 = 1 and +3 = 6). The individual cattle behavior trait scores comprising the scoring system were summed (Prelim SCORE) for each exercise giving a range from 9 to 56.

Prelim SCORE = Attention + Fence contact + Curiosity + Excitability + Flight zone + Footing + Gregariousness + Movement + Pace.

The data were screened for potential biases caused by including highly correlated behaviors ($r > 0.70$) into the scores. When correlated behaviors were identified, the behavior that accounted for less variation in the statistical model was deleted. We presumed that if there were reviewer biases toward specific personality types, this would be reflected by a significant Reviewer x Personality type interaction. This interaction was evaluated in the statistical model after correlated behaviors were removed. Since the interaction was not significant ($P > 0.05$) for any of the 3 exercises, reviewer scores were averaged and the mean score (SCORE) was used in the final statistical model.

The effect of personality type on cattle behavioral responses was analyzed as a randomized block design using the GLM procedure. The block was Pen and Handler was the experimental unit representing a replication within Personality type. The model included the fixed effects of Personality type and Exercise, and the random effect of Pen with error = Personality type x Pen. Least squares means were calculated to separate Personality types within each exercise.

RESULTS AND DISCUSSION

The cattle behavior traits of Flight zone, Gregariousness, and Pace were found to be highly correlated with other behavior traits used in scoring, and were deleted from the model. The final model for scoring cattle responses was:

SCORE = Attention + Fence contact + Curiosity + Excitability + Footing + Movement.

The possible range of the SCORE was 6 to 36.

The audit of the exercises led to the removal of Exercise 1 from further evaluation because the full range of scores (1 to 6) for cattle behaviors were not observed, and Exercise 1 did not differentiate personality types. The full range of cattle behavior scores were observed within Exercises 2 and 3. Personality types explained approximately 40% of the variation in scores.

Personality type of the handlers was not normally distributed. Given the small sample size, not all types were available to be tested. Handlers used in this study were more Introverted than Extraverted, more Sensing than Intuitive, more Thinking than Feeling, and more Judging than Perceiving in the MBTI assessment (Table 2). Since there was only one Intuitive handler, the S/N dichotomy could not be tested. The VIA-IS showed limited potential as a useful classification of handlers in this study due to the small sample size and large number of personality classifications. In studies with larger sample sizes the VIA-IS assessment may potentially prove to be useful.

Table 2. MBTI personality type distributions[1]

Personality type	Handlers	Handler population
	n	%
I/E dichotomy		
Extrovert	4	34
Introvert	8	66
Total	12	100
S/N dichotomy		
Sensing	11	92
Intuition	1	8
Total	12	100
T/F dichotomy		
Thinking	7	58
Feeling	5	42
Total	12	100
J/P dichotomy		
Judging	8	66
Perceiving	4	34
Total	12	100
Temperament		
Intuition & Feeling	0	0
Intuition & Thinking	1	8
Sensing & Judgment	7	58
Sensing & Perceiving	4	34
Total	12	100

[1]Myers-Briggs Type Indicator Profile, Form M, 2004.

The effect of Exercise on the SCORE was significant. MBTI personality types did not differentiate handlers in Exercise 2 ($P \geq 0.20$, Table 3). Although Exercise 2 did not differentiate handlers, the scoring system still explained 39% of the variation in the SCORE. Introverts tended ($P = 0.07$) to have higher SCORES than Extraverts in Exercise 3 (Table 4). Introverts also tended ($P = 0.08$) to have higher SCORES than Extraverts when Exercises 2 and 3 were pooled (Table 5). A trend existed for Judging types to have higher SCORES than Perceiving types. The same trend existed for Thinking over Feeling types and SJ types over SP types. Exercise 3 alone, and Exercises 2 and 3 pooled, tended to differentiate handler personality types using the SCORE. Pooling Exercises 2 and 3 raised the explained variation in the SCORES to 49%. Directly observing the behavioral responses of feedlot cattle, as quantified by the SCORE, may be a useful measure of cattle handling proficiency. However, the exercises may not create enough differentiation between personality types to draw definite conclusions about stockman handling abilities. Also, the cattle used in this study were already conditioned to handling, so this could have limited separation of scores. Further research is needed to determine the pertinent cattle handling exercises and cattle behaviors to include in a cattle handling proficiency scoring system.

Table 3. Effects of handler MBTI personality types on SCORE for Exercise 2

Item	**Personality Type**			r^2	***P*-value**[1]
I/E dichotomy	Introvert		Extravert		
Handlers[2]	8		4		
SCORE[3]	31 ± 1.2[4]		29 ± 1.7	0.63	NS[5]
T/F dichotomy	Thinking		Feeling		
Handlers[2]	7		5		
SCORE[3]	31 ± 0.8		30 ± 1.0	0.42	NS
J/P dichotomy	Judging		Perceiving		
Handlers[2]	8		4		
SCORE[3]	31 ± 0.8		30 ± 1.2	0.39	NS
Temperament[6]	NT	SJ	SP		
Handlers[2]	1	7	4		
SCORE[3]	—[7]	31 ± 0.7	30 ± 0.9	0.40	NS

[1]Probabilities calculated using personality type x pen as an error term.
[2]Each handler tested on 2 pens of steers.
[3]SCORE = Attention + Fence contact + Curiosity + Excitability + Footing + Movement.
[4]Least squares means ± SEM.
[5]NS = $P \geq 0.20$.
[6]NT = Intuition & Thinking, SJ = Sensing & Judging, SP = Sensing & Perceiving.
[7]Inestimable.

Table 4. Effects of handler MBTI personality types on SCORE for Exercise 3

Item	**Personality Type**			r^2	***P*-value**[1]
I/E dichotomy	Introvert		Extravert		
Handlers[2]	8		4		
SCORE[3]	29 ± 0.4[4]		26 ± 0.6	0.47	0.07
T/F dichotomy	Thinking		Feeling		
Handlers[2]	7		5		
SCORE[3]	28 ± 0.9		27 ± 1.0	0.41	NS[5]
J/P dichotomy	Judging		Perceiving		
Handlers[2]	8		4		
SCORE[3]	29 ± 0.4		27 ± 0.6	0.41	0.12
Temperament[6]	NT	SJ	SP		
Handlers[2]	1	7	4		
SCORE[3]	—[7]	28 ± 0.4	27 ± 0.6	0.43	0.13

[1]Probabilities calculated using personality type x pen as an error term.
[2]Each handler tested on 2 pens of steers.
[3]SCORE = Attention + Fence contact + Curiosity + Excitability + Footing + Movement.
[4]Least squares means ± SEM.
[5]NS = $P \geq 0.20$.
[6]NT = Intuition & Thinking, SJ = Sensing & Judging, SP = Sensing & Perceiving.
[7]Inestimable.

Table 5. Effects of handler MBTI personality types on the SCORE for Exercises 2 and 3 pooled

Item	Personality Type			r^2	***P*-value**[1]
I/E dichotomy	Introvert		Extravert		
Handlers[2]	8		4		
SCORE[3]	30 ± 0.4[4]		28 ± 0.6	0.54	0.08
T/F dichotomy	Thinking		Feeling		
Handlers[2]	7		5		
SCORE[3]	30 ± 0.6		29 ± 0.7	0.49	NS[5]
J/P dichotomy	Judging		Perceiving		
Handlers[2]	8		4		
SCORE[3]	30 ± 0.5		28 ± 0.7	0.50	NS
Temperament[6]	NT	SJ	SP		
Handlers[2]	1	7	4		
SCORE[3]	—[7]	30 ± 0.4	28 ± 0.6	0.51	0.17

[1]Probabilities calculated using personality type x pen as an error term.
[2]Each handler tested on 2 pens of steers for each exercise.
[3]SCORE = Attention + Fence contact + Curiosity + Excitability + Footing + Movement.
[4]Least squares means ± SEM.
[5]NS = $P \geq 0.20$.
[6]NT = Intuition & Thinking, SJ = Sensing & Judging, SP = Sensing & Perceiving.
[7]Inestimable.

BEEF 2013-06

Walking distance and performance of drylot developed beef heifers following being moved to a grazing situation[1]

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SUMMARY

Research has shown that heifers moved from a drylot to grass after AI have decreased weight gains and pregnancy success compared to heifers developed on range. This effect could potentially be due to inexperience in a specific grazing environment, which could result in greater time spent exploring a new environment. In this study beef heifers were moved from a drylot to spring grass at two different times and their activity compared. Heifers in a drylot walked less than heifers grazing spring forage. However, following being moved to spring forage heifers that had been adjusted to grass for about a month took fewer steps during their first four days of grazing then did the heifers that did not have previous grazing experience. Heifers without prior grazing experience also lost weight during this period. In summary, moving drylot developed heifers to spring forage affected performance and activity.

INTRODUCTION

Reproductive failure costs the U.S. beef and dairy industry approximately $1 billion annually (Bellows et al., 2002), and the economic value of reproduction for commercial beef producers was reported to be five times greater than calf growth (Trenkle and Willham, 1977). Previous research has indicated that moving drylot-developed heifers to spring forage immediately after AI impacted ADG and AI conception rates (Perry et al., 2013). However, after 27 d of grazing experience there was no difference in ADG between heifers developed in a drylot and heifers developed on forage (Perry et al., 2013). Grazing skills and dietary habits are learned early in life (Provenza and Balph, 1988). This learning resulted in the development of motor skills necessary to harvest and ingest forages (Provenza and Balph, 1987) and allows animals to increase their consumption of forage (Lyford, 1988). Skills learned between weaning and breeding have been reported to carry through to the next grazing season (Olson et al., 1992). The objective of this study was to determine the impact of prior grazing experience on weight change and activity when heifers were moved to spring forage.

MATERIAL AND METHODS

All procedures were approved by the South Dakota State University Animal Care and Use Committee. Angus-cross beef heifers were developed in a single pen following weaning until 14 mo of age. At the start of treatment (d 0) heifers were blocked by weight and allotted to one of two treatments. Heifers either remained in the drylot (LOT; n = 34) or were moved to spring forage (GRASS; n = 35). Body weights were collected on d 0, 9, 20, 41, 53, and 74. Pedometers (IceCubes by IceRobotics Edinburgh, Scotland) were placed on 5 heifers per treatment on d 25 for 27 d to measure number of steps taken and amount of time standing and lying down. On d 44 all heifers were moved to new pastures of spring

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[1] This research was supported by the South Dakota Agricultural Experiment Station.

forage, but were maintained in their respective group (12.1 ha/group). The period of time when heifers were being moved to and from pastures for data collection (i.e. weights) was removed from the analysis.

The effects of grazing experience on ADG, number of steps taken, and amount of time standing and lying down were analyzed by analysis of variance for repeated measures using the MIXED procedures in SAS as described by Littell et al. (1998). All covariance structures were modeled in the initial analysis. The indicated best-fit covariance structure: compound symmetry for BW, Ante-Independent for ADG, and Heterogeneous Compound Symmetry for pedometer data; was used for the final analysis. The model included the independent variables of treatment, day, and treatment x day. When a significant ($P \leq 0.05$) effect of treatment, day, or treatment x day was detected, LS means were separated by the PDiff option of SAS.

RESULTS AND DISCUSSION

There were treatment ($P < 0.01$), time ($P < 0.01$), and a treatment by time ($P < 0.01$) interaction effects on ADG (Figure 1). GRASS heifers had decreased ($P < 0.01$) ADG from d 0 to 9 compared to LOT heifers. There was no difference between treatments in ADG from d 9 to 20 or from d 20 to 41. After being moved to spring forage LOT heifers had decreased ($P < 0.01$) ADG from d 41 to 53 and from d 53 to 74 compared to GRASS heifers. In the present study naïve heifers lost weight and had increased activity compared to heifers that had an adaption period to grazing. This loss in weight was similar to previously reported losses when heifers were moved to a spring grazing situation after being developed in a drylot from weaning to breeding (Perry et al., 2014). The majority of grazing behavior is learned when an animal transitions from maternal care to independence (Provenza and Balph, 1988), this learning resulted in the development of the motor skills necessary to harvest and ingest forages efficiently (Provenza and Balph, 1987). Furthermore, the willingness to try novel food declined as an animal aged (Provenza and Balph, 1988). Thus livestock usually ingest small amounts of novel food and gradually increase the amount ingested if no adverse effects occur (Chapple and Lynch, 1986; Burritt and Provenza, 1987). Therefore, when introduced to a novel food or environment, livestock may spend more time and energy foraging (Osuji, 1974), but ingest less food (Arnold and Maller, 1977; Hodgson and Jamieson, 1981; Curll and Davidson, 1983).

From d 25 to 38, there was an effect of treatment ($P < 0.01$), time ($P < 0.01$), and a treatment by time ($P = 0.03$) interaction on the number of steps taken each day (Figure 2), with GRASS heifers taking more ($P < 0.05$) steps per d than LOT heifers. Following being moved to spring forage, LOT heifers took more ($P < 0.05$) steps per day on d 44, 45, 46, and 47 compared to GRASS heifers (Figure 3). However, across the entire experiment there was no treatment effect on the amount of time a heifer spent standing and lying down per day. The increase in activity was similar to dairy heifers that did not have prior grazing experience compared to heifers that had previously grazed pastures (Lopes et al., 2013). When dairy heifers that had been developed in confinement were moved to pasture it took 5 d for them to develop a similar grazing pattern as experienced animals (Lopes et al., 2013). Similarly, in this study on d 5 after being moved to pasture, LOT heifers took a similar number of steps as GRASS heifers. In summary, after being moved to spring forage drylot developed heifers had decreased ADG compared to heifers that had prior grazing experience. This decrease in ADG is likely due to decreased nutrient intake and increased activity as unexperienced heifers took more steps per day compared to experienced heifers.

LITERATURE CITED

Arnold, G. W., and R. A. Maller. 1977. Effects of nutritional inexperience in early and adult life on the performance and dietary habits of sheep. Appl. Anim. Ethology 3: 5-26.

Bellows, D. S., S. L. Ott, and R. A. Bellows. 2002. Review: cost of reproductive diseases and conditions in cattle. The Prof.Anim. Sci. 18: 26-32.

Burritt, E. A., and F. D. Provenza. 1987. Ability of lambs to discriminate between safe and harmful foods. In: 40th Annual Meeting of the Society for Range Science, Boise, Idaho

Chapple, R. S., and J. J. Lynch. 1986. Behavioral factors modifying acceptance of supplementary foods by sheep. Res. Dev. Agric. 3: 113-120.

Curll, M. L., and J. L. Davidson. 1983. Defoliation and productivity of a Phalaris-subterranean clover sward, and the influence of grazing experience on sheep intake. Grass Forage Science 38: 159-167.

Hodgson, J., and W. S. Jamieson. 1981. Variations in herbage mass and digestibility, and the grazing behaviour and herbage intake of adult cattle and weaned calves. Grass and Forage Sci. 36: 39-48.

Littell, R. C., P. R. Henry, and C. B. Ammerman. 1998. Statistical analysis of repeated measures data using SAS procedures. J. Anim. Sci. 76: 1216-1231.

Lopes, F., W. Coblentz, P. C. Hoffman, and D. K. Combs. 2013. Assessment of heifer grazing experience on short-term adaption to pasture and performance as lactating cows. J. Dairy Sci. 96:3138-3152.

Lyford, S. J., Jr. 1988. Growth and development of the ruminant digestive system. In: D. C. Church (ed.) The Ruminant Animal. p 44-63. Prentice Hall, Englewood Cliffs, NJ.

Olson, K. C., J. R. Jaeger, and J. R. Brethour. 1992. Growth and reproductive performance of heifers overwintered in range or drylot environments. J. Prod. Agric. 5: 72-76.

Osuji, P. O. 1974. The physiology of eating and the energy expenditure of the ruminant at pasture. J. Range Manage. 27: 437-443.

Perry G.A., B.L. Perry, J.A. Walker, C.L. Wright, R.R. Salverson, and H.H. Patterson. 2013. Evaluation of prior grazing experience on reproductive performance in beef heifers. Prof. Anim. Sci. 29:595-600.

Provenza, F. D., and D. F. Balph. 1987. Diet learning by domestic ruminants: Theory, evidence and practical implications. Appl. Anim. Beh. Sci. 18: 211-232.

Provenza, F. D., and D. F. Balph. 1988. Development of dietary choice in livestock on rangelands and its implications for management. J. Anim. Sci. 66: 2356-2368.

Trenkle, A., and R. L. Willham. 1977. Beef production efficiency. Science 198: 1009-1015.

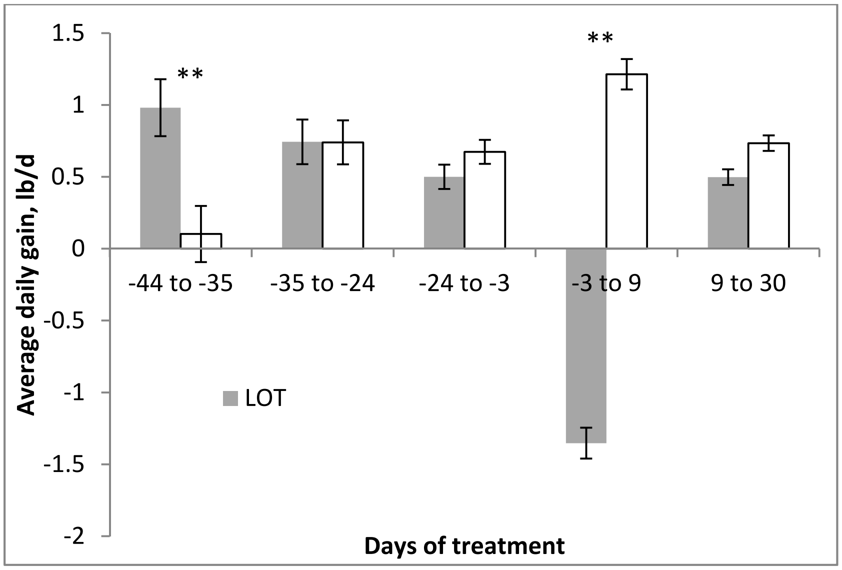

Figure 1. Average daily gain for heifers during the study. GRASS heifers were moved from the drylot to forage on d 0 and LOT heifers were moved from the drylot to forage on d 44. **P < 0.01 within day.

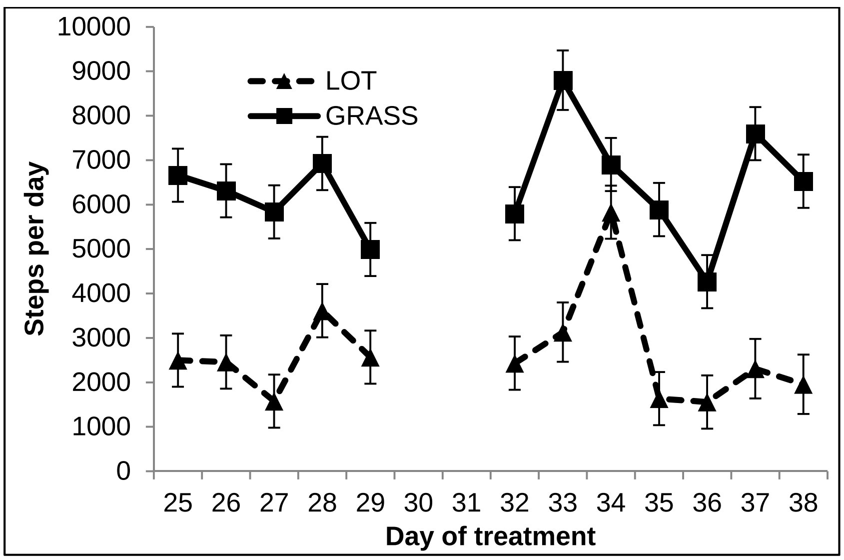

Figure 2. Number of steps taken per day from d 25 to 38 of treatments. GRASS heifers were moved from the drylot to forage on d 0. LOT heifers were still in the drylot (P < 0.05).

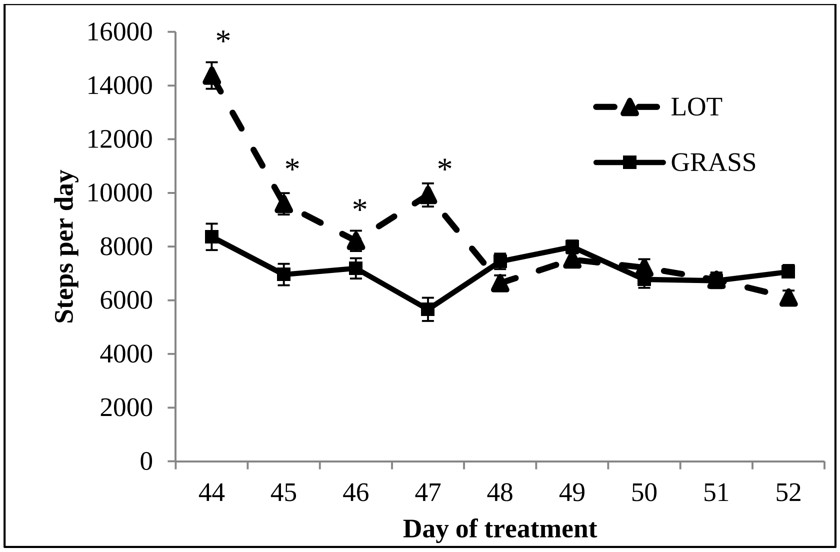

Figure 3. Number of steps taken per day from d 44 to 52 of treatment. GRASS heifers were moved from the drylot to forage on d 0. LOT heifers were moved from the drylot to forage on d 44. (*P < 0.05)

BEEF 2013-07

SDSU Calf Value Discovery 2012/2013 Summary Report[1]

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INTRODUCTION

The Calf Value Discovery Program (CVD) allows cow-calf producers to gain knowledge of the finishing segment of the beef cattle industry and the marketing of fed cattle. Specifically, CVD provides an opportunity for cow-calf producers to learn how their calves perform in a feedlot and their carcass value when sold in a value-based marketing system. Each producer taking part in the program could consign 5 or more steers weighing between 500 and 800 pounds to the CVD program. Animals were finished at VanderWal Yards (Bruce, SD) in a calf-fed program using typical diets and management protocols. Carcass and feedlot performance information from calves were returned to producers for use in making future management decisions to improve profitability.

MATERIALS AND METHODS

Eleven cow-calf operations in South Dakota and Minnesota consigned calves to the 2012-2013 CVD program. The number of animals consigned by producers ranged from 5 to 72. Calves were received on October 23 and 24, 2012. Upon receipt, calves were vaccinated against viral and bacterial respiratory (Bovi-Shield Gold BVD, Inforce 3, One-Shot, Zoetis, Florham Park, NJ) and clostridial pathogens (Ultrabac-7, Zoetis), dewormed (Dectomax Pour-On, Zoetis), individually identified, and weighed. Calves were implanted on d 29 (Revalor-XS, Merck Animal Health, Summitt, NJ). Cattle were fed as a group in a single pen and received a finishing diet based on high moisture ground ear corn, modified wet distillers grains, and corn silage (final diet composition; 0.61 Mcal NE_g/lb feed, 13.2% CP). Cattle were visually evaluated for degree of finish and sold in semi-load lots when deemed to have approximately 0.4 inches of backfat. Slaughter dates were May 3, 17, and 30, 2013 (191, 205, and 218 days on feed, respectively). Animals were sold on a quality/yield grid at Tyson Fresh Meats (Dakota City, NE).

For each animal, individual BW was recorded at arrival at the feedyard, on d 29, d 127, and on the day of shipment to slaughter. A shrink factor of 4% was applied to all weights. Since cattle were fed in a single pen, individual feed intake was calculated based on animal performance and diet energy content using NRC (2000) equations. At slaughter, individual identification was tracked through the plant and individual carcass data, including hot carcass weight (HCW), 12th-rib fat thickness, ribeye area, percent kidney, pelvic, and heart fat (KPH), marbling score, and USDA Quality and Yield Grades, were reported by the plant.

Feeding expenses included feed costs, which were based on calculated individual intake as a fraction of actual feed delivery, yardage ($0.35 per animal per day), and veterinary expenses.

To estimate initial feeder calf values, weighted average feeder steer prices were obtained from the South Dakota Auction Market Summary report (USDA Agricultural Market Service report SF_LS795) for

[1] Project supported by registration fees paid by participants.

the week ending October 26, 2012. These prices were regressed on selling weights resulting in the following equation:

Price ($/100 lb.) = 299.52 – ((BW/100) × 34.66) + ((BW/100)^2 × 2.01); r^2 = 0.96.

Using that equation and the actual weight at arrival, the estimated initial value of each calf was determined.

The Nebraska weighted average carcass price for negotiated direct sales was used (USDA Agricultural Market Service report LM_CT158) for the weeks animals were sold to estimate carcass value and profitability had the animals been sold on a dressed basis. Actual grid prices received were used to calculate carcass value and feeding period profitability for the grid based marketing method.

To estimate what factors were associated with feeding performance or profit and quality grade for calves that finished the 2012-2013 CVD program, calves were divided into thirds based on net profit from the feeding period. Profit or loss for this analysis was determined by subtracting feeding expenses and the estimated initial calf value from the actual carcass value received. A general linear model was used to separate means between groups (PROC GLM, SAS Inst. Inc., Cary, NC). The association of USDA Quality Grade among profit groups was determined by χ^2 (PROC FREQ, SAS). Means were considered different when $P \leq 0.05$.

RESULTS AND DISCUSSION

Two calves (1.10%) were removed from the program due to chronic health issues and are excluded from the analysis. Overall cattle performance data is included in Table 1. Calves were placed with an average weight of 590 ± 84 lbs. Some calves were accepted into the program whose initial weights were outside the recommended range of 500 to 800 pounds. Average final BW for steers (average DOF = 201) was 1,285 ± 96.4 lb, and ADG was 3.41 lb/d. Averages for daily dry matter intake (DMI) and F:G ratio were 19.4 lb and 5.74, respectively. On average, steers were slaughtered slightly less than the target fat thickness (0.4 in).

Expenses and returns are summarized in Table 2. On average, feeding costs were $550.84 per animal resulting in a total cost of gain of $98.65/100 lb. When carcasses were sold on a grid basis, carcass value ranged from $953.85 to $1,992.78. Had the carcasses been sold on a dressed basis this range would have been smaller ($1,180.85 to $1,992.02). When including the value of the feeder calf, individual returns ranged from a loss of $500.91 to a profit of $273.78. Average return was a loss of $73.73 per steer. If these cattle had been sold on a dressed basis, average returns would have improved to a loss of $48.65 per steer. There would also have been a narrower range between the steers with the highest profit and greatest losses.

As shown in Table 3, the top 1/3 most profitable steers (High profit) had heavier placement and final weights, had a greater ADG and lower DMI and improved F:G compared to the Middle and Low profit groups ($P < 0.001$). Based on NRC (2000) models the High profit group would be expected to have lower DMI and improved F:G compared to the Middle and Low profit groups. Using these estimates of DMI, High profit steers had lower total costs than either the Middle or Low profit groups due to improved feed efficiency and reduced yardage expenses (Table 5, $P < 0.001$). These estimates of individual feed intake and feed efficiency should be interpreted with caution as actual individual feed intake was not measured.

Steers in the High profit group had greater HCW and dressing percentage (Table 3, $P < 0.001$), and higher marbling scores than Low profit steers, with Middle profit steers intermediate (Table 3, $P < 0.002$). Ribeye area was higher for the High profit steers compared to the Middle and Low group ($P < 0.001$). No differences between profit groups were found for KPH fat or USDA Yield Grade. Twelfth-rib fat thickness was lower in the Low profit group compared to the High and Middle profit groups ($P < 0.001$).

A greater proportion of the steers in the High profit group graded Choice or higher compared to the Middle and Low profit groups (Table 4, P < 0.001). The premiums captured due to higher quality grades combined with an advantage in HCW resulted in significant differences in carcass values, $1,710.85, $1,587.08 and $1,397.50 for High, Middle, and Low profit group steers, respectively (Table 5, $P < 0.001$). Even though the steers in the High profit group were heavier and thus more valuable at the start of the feeding period, the combination of greater carcass value and reduced feeding expenses resulted in an net return of $86.51 for the High profit steers compared to $-101.96 and $-207.93 for the Middle and Low groups, respectively.

The differences in profit groups would have been less pronounced if these steers had been marketed on a dressed basis. The High profit group were still profitable with a net return of $77.18 compared to losses of $-89.80 and $-134.75 for the Middle and Low profit groups, respectively. The largest magnitude of profit differences between the two marketing methods was seen in the Low profit steers. Selling those cattle on a dressed basis would have reduced the losses by an average of $73.18 per steer.

These results for calf-fed steers agree with similar data sets showing that the most profitable cattle were those that were the fastest gaining with the heaviest HCW and a greater percentage grading Choice or higher (Walter and Hale, 2011). Conversely those steers with the greatest losses were those with the poorest feedlot performance that had carcasses that were lighter and less likely to grade Choice.

For cow/calf producers, the Calf-Value Discovery Program provides feedback on feeding performance and carcass characteristics of calves and an opportunity to benchmark their calf crop to a larger group of cattle when placed in a calf fed system. Ultimately, market conditions and input prices can greatly impact feeding profitability from year to year, but these data provide useful guidelines for making selection and marketing decisions in the future.

LITERATURE CITED

NRC. 2000. Nutrient requirements of beef cattle. 7th Ed. Update 2000. National Academies Press. Washington, D.C.

Walter, S., and R. Hale. 2011. Profit profiles: factors driving cattle feeding profitability. Available: http://www.cabpartners.com/news/research/CABProfitProfiles.pdf. Accessed October 10, 2013

Table 1. Overall performance and carcass characteristics of cattle enrolled in the 2012-2013 South Dakota Calf-Value Discovery Program.

Item	Mean	Standard Deviation	Minimum	Maximum
Days on feed	201	11.6		
BW, lb				
D 0	590	83.8	360	810
D 29	657	94.1	378	884
D 127	1043	115.5	722	1,354
Final	1,285	96.4	1030	1,574
ADG, lb/d	3.41	0.32	2.66	4.26
DMI, lb/d	19.4	1.89	16.7	24.2
F:G	5.74	0.74	4.03	7.74
HCW, lb	777	63.0	582	967
Dress., %	62.2	2.06	56.4	67.1
12-th rib fat thickness, in.	0.37	0.13	0.09	0.73
Rib eye area, $in.^2$	13.0	1.69	5.54	18.0
KPH, %	1.83	0.22	0.93	2.38
Marbling score[a]	416	83.9	180.0	690
USDA Yield Grade	2.18	0.74	1.0	4.0
USDA Quality Grade distribution	N	Percent		
Prime, %	0	0.0		
Choice, %	102	56.0		
Premium Choice, %	19	10.4		
Select, %	72	39.6		
Dark cutter, %	3	1.6		
No roll, %	5	2.7		

[a] Marbling score: 300-399 = Slight, 400–499 = Small, 500-599 = Modest.

Table 2. Feeding expenses and carcass values of cattle enrolled in the 2012-2013 South Dakota Calf-Value Discovery Program.

Item	Mean	Standard Deviation	Minimum	Maximum
Feeder calf cost, $/steer	949.04	82.97	704.33	1180.55
Feeding costs, $/steer				
Feed cost	550.84	68.93	454.60	686.31
Treatment costs	3.55	12.45	0.00	110.75
Total feeding cost	670.91	74.42	562.40	818.63
Grid marketing returns				
Carcass value, $/steer	1,546.22	162.93	953.85	1,992.78
Carcass price, $/100 lb	201.44	10.04	151.00	214.50
Feeding profit, $/steer	875.31	195.64	298.05	1,424.53
Grid net profit, $/steer	(73.73)	145.49	(500.81)	273.78
Dressed marketing returns				
Carcass value, $/steer	1,591.14	133.01	1,180.85	1,992.02
Dressed price, $/100 lb	204.82	1.31	203.00	206.00
Feeding profit[a], $/steer	900.38	167.82	501.64	1,405.19
Dressed net profit, $/steer	(48.65)	114.47	(365.67)	250.97

[a] Feeding profit is carcass value minus feeding cost.

Table 3. Feedlot performance and carcass characteristics of steers enrolled in the 2012-2013 South Dakota Calf-Value Discovery Program according to profit group.

	Profit Group				
Item	High	Middle	Low	SEM	*P*-Value
Number of head	61	61	60	-	-
Days on feed	190[a]	202[b]	210[b]		<0.001
BW, lb					
D 0	622[a]	582[b]	486[c]	7.85	<0.001
D 29	702[a]	643[b]	546[c]	8.23	<0.001
D 127	1,104[a]	1,005[b]	894[c]	9.08	<0.001
Final	1,305[a]	1,236[b]	1,159[c]	9.19	<0.001
ADG, lb/d	3.58[a]	3.33[b]	3.31[b]	0.038	<0.001
DMI, lb/d[d]	17.9[a]	20.5[b]	20.0[c]	0.191	<0.001
F:G	4.99[a]	6.17[b]	6.08[b]	0.065	<0.001
HCW, lb	826[a]	782[b]	722[c]	5.99	<0.001
Dressing %	63.3[a]	62.4[b]	60.7[c]	0.227	<0.001
12-th rib fat thickness, in.	0.42[a]	0.39[a]	0.32[b]	0.016	<0.001
Rib eye area, in.^{2}	13.6[a]	12.9[b]	12.4[b]	0.211	<0.001
KPH, %	1.82	1.84	1.82	0.028	0.88
Marbling score[e]	462[a]	414[b]	371[c]	8.42	<0.002
USDA Yield Grade	2.28	2.23	2.02	0.095	0.12

[a,b,c] Means within a row differ; P-values noted in table.

[d] Calculated from BW and ADG

[e] Marbling score: 300-399 = Slight, 400-499 = Small, 500-599 = Modest.

Table 4. USDA Quality and Yield Grade Distributions of steers enrolled in the 2012-2013 South Dakota Calf-Value Discovery Program according to profit group.

	Profit Group						
	High		**Middle**		**Low**		
Quality Grade	**n**	**Percent**	**n**	**Percent**	**n**	**Percent**	***P*-Value**
Prime	0	0	0	0	0	0	<0.001
Choice	49	80.3	41	67.2	12	20.0	
Premium choice, %	13	21.3	5	8.1	1	1.6	
Select	12	19.7	20	32.8	40	66.7	
No roll	0	0	0	0	5	8.3	
Dark cutter	0	0	0	0	3	5.0	
Yield Grade							
1	11	18.0	10	16.4	11	18.3	0.28
2	23	37.7	34	55.7	33	55.0	
3	26	42.6	16	26.2	14	23.3	
4	1	1.6	1	1.6	2	3.3	
5	0	0	0	0	0	0	

Table 5. Feedlot performance and carcass characteristics of steers enrolled in the 2012-2013 South Dakota Calf-Value Discovery Program according to profit group.

	Profit Group				
Item	**High**	**Middle**	**Low**	**SEM**	***P*-Value**
Feeder calf cost, $/steer	1,008.03[a]	964.65[b]	873.19[b]	7.92	<0.001
Feeding costs, $/steer					
Feed costs	485.19[a]	582.38[b]	585.51[b]	6.57	<0.001
Treatment costs	1.87	4.71	4.06	1.61	0.42
Total costs	597.75[a]	704.55[b]	711.09[b]	6.89	<0.001
Grid marketing returns					
Carcass value, $/steer	1,710.85[a]	1,587.08[b]	1,397.50[c]	12.78	<0.001
Carcass price, $/100 lb	207.15[a]	203.15[b]	193.89[c]	1.09	<0.001
Feeding profit[d], $/steer	1,094.53[a]	862.68[b]	665.25[c]	11.17	<0.001
Grid net profit, $/steer	86.51[a]	(101.96)[b]	(207.93)[c]	10.28	<0.001
Dressed marketing returns					
Carcass value, $/steer	1,701.52[a]	1,599.25[b]	1,470.68[c]	12.15	<0.001
Dressed value, $/100 lb	205.98[a]	204.64[b]	203.82[c]	0.12	<0.001
Feeding profit[a], $/steer	1,085.21[a]	874.85[b]	738.44[c]	11.42	<0.001
Dressed net profit, $/steer	77.18[a]	(89.80)[b]	(134.75)[c]	8.94	<0.001
Grid advantage/disadvantage[e]	9.33[a]	(12.17)[a]	(73.18)[b]	8.56	<0.001

[a,b,c] Means within a row differ; P-values noted in table.

[d] Feeding profit is carcass value minus feeding cost.

[e] Grid advantage/disadvantage[e]= grid net profit – dressed net profit. Negative values indicate an advantage to dressed basis marketing.

BEEF 2013-08

SDSU Cow/Calf Teaching and Research Unit[1]

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SUMMARY

The SDSU Cow/Calf Unit (CCU) is a multi-purpose facility that provides resources for Animal Science courses and research projects. Cattle produced at the facility are also utilized by Little International, Block and Bridle, and livestock judging teams. The facility is managed by Kevin Vander Wal and generally employs 4 to 5 undergraduate students.

BREEDING PROGRAM

Although the CCU has a multi-purpose mission, the breeding program is primarily centered on the production of bulls and females that can be used for teaching purposes and sold to the general public. Artificial insemination is used extensively. The program primarily utilizes proven sires; however, each year a percentage of the females are bred to younger, lower accuracy sires. The objective of the breeding program is to produce docile cattle that have excellent calving ease, growth, and carcass characteristics. Average expected progeny differences of the cows, heifers, and AI sires used in 2012 are included in Tables 1 and 2.

Table 1. Average expected progeny differences of Angus cows, heifers, and AI sires used in 2012.

	Expected progeny differences[a]									Value Indexes[b]	
	CED	**BW**	**WW**	**YW**	**SC**	**Milk**	**Marb**	**REA**	**Doc**	**$W**	**$B**
Cows	6.9	1.6	50.4	93.3	0.76	27.8	0.46	0.51	11.8	31.46	73.25
Heifers	7.3	1.6	53.9	99.1	0.80	28.7	0.46	0.60	12.8	31.52	77.69
AI sires	6.8	1.1	65.0	116.0	0.95	27.4	0.48	0.68	17.3	34.79	72.24

[a]CED = calving ease direct; BW = birthweight; WW = weaning weight; YW = yearling weight; SC = scrotal circumference; Milk = maternal milk; Marb = marbling score; REA = ribeye area; Doc = docility
[b]$W = wean value; $B = beef value

[1] The authors would like to acknowledge Zoetis Animal Health for product donations (Eazi-Breed CIDRs, Lutalyse, and Factrel) toward the synchronization research projects. Salaries and research support also provided by state and federal funds appropriated to South Dakota State University.

Table 2. Average expected progeny differences of SimAngus™ cows, heifers, and AI sires used in 2012.

	Expected progeny differences[a]								Indexes[b]	
	CE	BW	WW	YW	MLK	Marb	REA	Doc	API	TI
Cows	14.6	-1.3	56.3	92.9	23.0	0.51	0.64	11.7	140.0	74.4
Heifers	14.2	-1.5	62.8	101.8	25.1	0.45	0.83	11.3	140.3	75.6
SimAngus™ AI Sires	16.7	-4.3	39.3	74.0	6.7	0.67	0.62	15.0	163.3	85.7
Simmental AI Sires	9.8	-0.64	48.4	88.2	0.6	0.35	0.71	10.4	132.4	80.0

[a]CE = calving ease; BW = birthweight; WW = weaning weight; YW = yearling weight; MLK = milk; Marb = marbling score; REA = ribeye area

[b]API = all-purpose index; TI = terminal index

REPRODUCTIVE PERFORMANCE

In 2012, 110 cows and 41 heifers were bred using one of two synchronization protocols. All of the females are bred at least one time via artificial insemination (AI) and followed by clean-up bulls. The females were synchronized using the 7-day CO-Synch + CIDR protocol with or without an injection of prostaglandin $f_{2\alpha}$ (Lutalyse) on the day the CIDR was inserted (Figure 1).

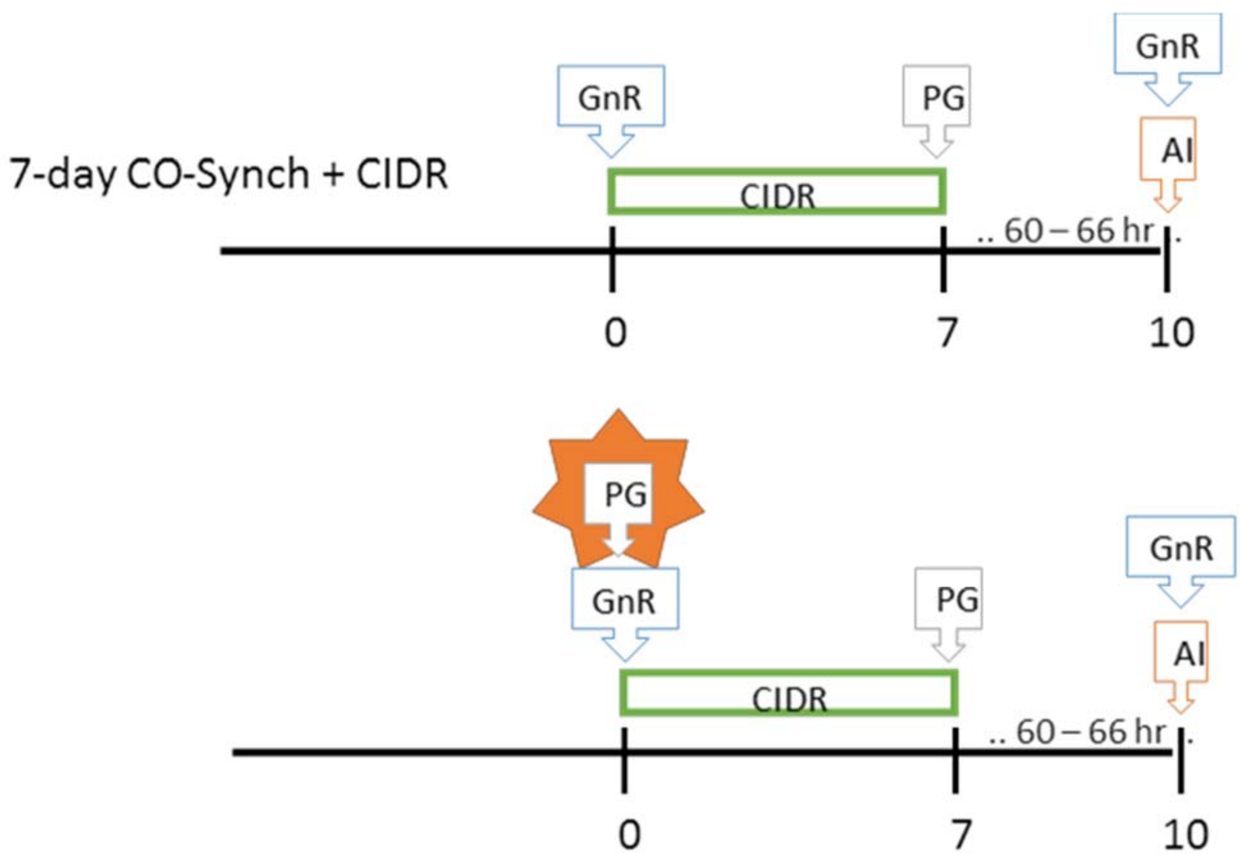


Figure 1. 7-day CO-Synch + CIDR synchronization protocol used on cows and heifers during the 2012 breeding season. The females either did or did not receive an injection of prostaglandin $f_{2\alpha}$ (Lutalyse) on the day of CIDR insertion. GNR = gonadotropin releasing hormone.

Regardless of treatment, the cows achieved an overall 57.3% first service conception rate (60.0% and 54.5%, for with and without prostaglandin $f_{2\alpha}$, respectively) to timed AI. The overall first service conception rate among the heifers pregnancy rates was 58.5% (52.4% and 65.0%, for with and without prostaglandin $f_{2\alpha}$, respectively).

SALES

Each April, the SDSU Seedstock Merchandising class coordinates an annual bull sale at the CCU. The sale is designed to be a learning experience for the students and they are responsible for advertising, promotional videos, developing the sale catalog, and customer service. In 2013, the bull sale attracted customers from SD, IA, and MN. The sale included 20 Angus and 11 SimAngus™ yearling bulls. Results of the sale are presented in Table 3.

Table 3. Results from 2013 annual bull sale.

	Lots	Average	Range
Angus bulls	20	$4425.00	$2500-$7900
SimAngus™ bulls	11	$3781.82	$3000-$5500
Overall bull average	31	$4196.77	
Sire groups			
Connealy Consensus 7229	1	$3900.00	
Hooks Shear Force 38K	2	$3500.00	
Hoover Dam	3	$5866.67	
MR NLC Upgrade U8676	5	$3920.00	
S A V Bismarck 5682	1	$4400.00	
S Chisum 6175	1	$2500.00	
S D S Graduate 006X	2	$3300.00	
Sitz Upward 307R	1	$4000.00	
TNT Tanker U263	2	$4200.00	
VAR Rocky 80029	7	$3714.29	
WK Power Up 9412	6	$5016.67	

NEW FACILITY

The current CCU was built in 1950 and, while it is a functional facility for managing a cowherd, it has significant limitations as a teaching and research facility. One of the components of the Land-Grant mission is teaching. Our objective is to provide our students with the best education possible and a large component of educational process is experiential learning…learning by doing. The current facility is not well equipped to provide a positive learning experience to students. A second component of the Land-Grant mission is research. Conducting research that answers production related questions and provides new technology to producers is essential to the long-term viability of the beef industry in South Dakota. Other than a small group of replicated pastures, the current CCU is not equipped to support research. The final component of the Land-Grant mission is Extension and outreach. Effective transfer of new knowledge and technology from the university to end users allows for the most current research findings to be adopted by the industry. Our current facility is not conducive to utilization by Extension personnel for meetings or demonstrations.

Plans are in place to build a new facility near campus to support the teaching, research, and Extension efforts in beef cattle production. The new facility will be equipped with individual feeding units that will allow for collection of individual feed intake and application of individual treatments to cattle within the same pen. This equipment will greatly enhance the ability of the facility to support numerous types of research in nutrition, genetics, reproduction, health, and others without having to expand the current cowherd. It will also be constructed to facilitate biosecurity of the cattle fed there. We will be able to facilitate both feedlot cattle and our own cattle in the facility at the same time. The facility will also enhance our ability to teach and conduct Extension and outreach activities. It will be equipped with a classroom and an indoor working facility to allow students and producers to be exposed to hands-on learning experiences throughout the year. An image of the proposed facility is presented in Figure 2.

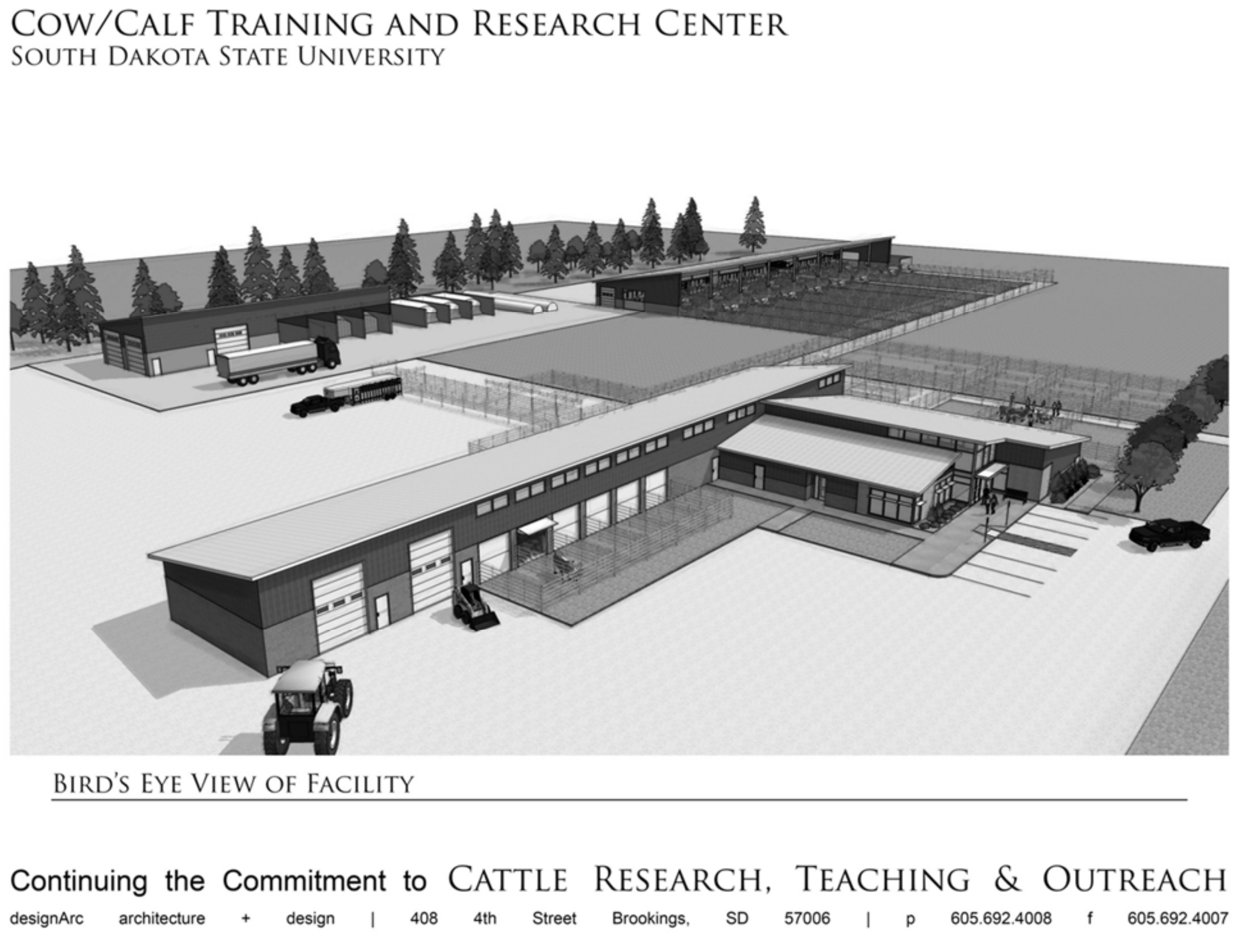
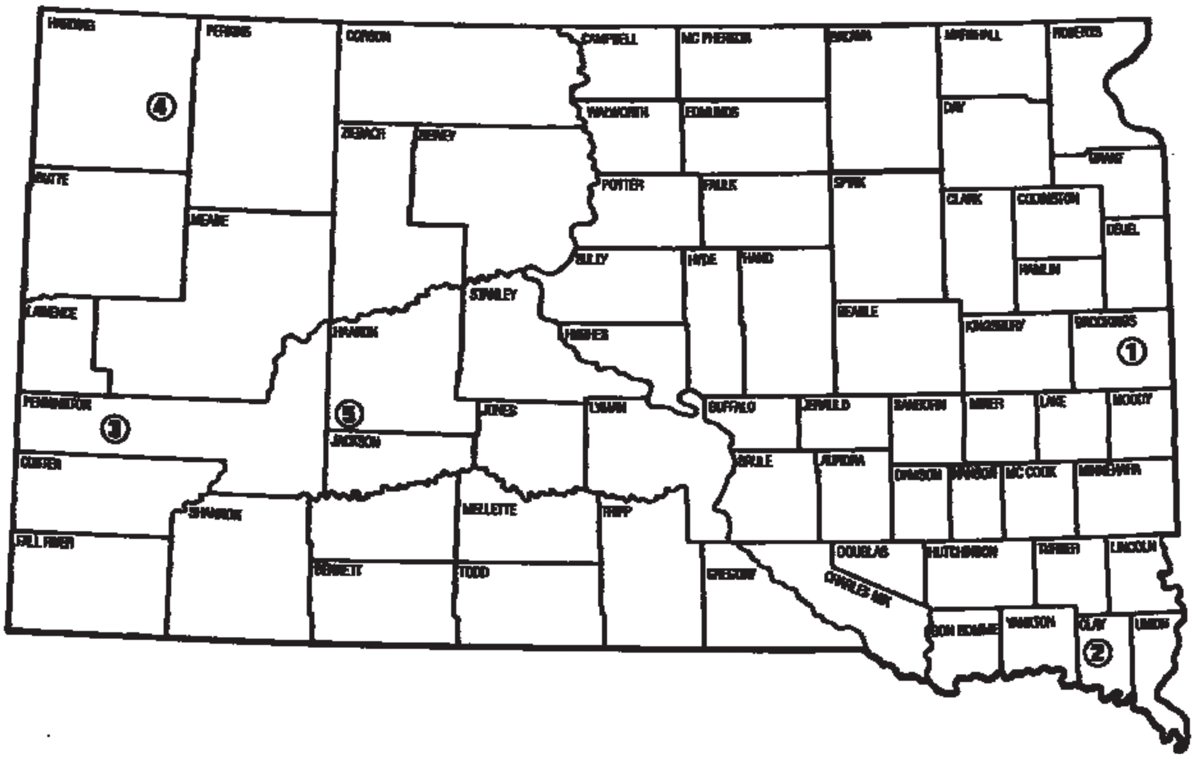


Figure 2. Proposed new cow-calf facility. Image courtesy of DesignARC.

At the time of publication of this document, we are approximately $1.6 million short of our goal. Numerous families and corporate partners have made incredibly generous commitments to the project, but we still need more financial commitments before we can break ground on this facility. If you would like to receive more information on the new facility or if you are interested in contributing to the project, please contact Dr. Cody Wright (cody.wright@sdstate.edu; 605-688-5448) or Mike Barber at the SDSU foundation (mike.barber@sdsufoundation.org; 605-697-7475).

Animal Science Research and Extension Units



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

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

3 Rapid City: West River Ag Center
- Professional research and Extension staff in Animal Science, Range Science, Agronomy, Horticulture, Community Development, Economics, 4-H, and Extension administration

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

5 Phillip: Range and Livestock Research Station
- Range beef nutrition and 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 users, enhance the statewide teaching effectiveness of the Animal Science Department staff, and maintain a close and productive relationship with South Dakota producers and the agribusiness community.

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